Effect of pre-harvest treatment with some nutrients and salicylic acid on some storage characteristics of two strawberry varieties Albion and Camarosa

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Abstract:

The experiment was carried out in a private refrigerated warehouse to study the effect of some nutrients, salicylic acid spray on the storage ability of strawberry fruits. The study included three factors, the first was two strawberry cultivars (Albion, Camarosa), the second factor included five treatments of nutrient solutions (control, the spray of nano-iron at 10, 20 mgL^{-1}, riboflavin at 100, and 200 mgL^{-1}), whereas the third factor is the spray of salicylic acid at three concentrations (0, 100, and 200 mgL^{-1}). Ripen fruits were taken from the previous treatments and stored in plastic boxes for 10 days at a temperature of 0±1°C and 90-95% relative humidity. An evaluation of the studied characteristics was conducted 10 days after the start of storage. The experiment was lay out as A factorial experiment according to a C.R.D design with three factors and three replications. The results were analyzed using the statistical program SAS (2003) and the means were compared according to Duncan's Multiple range test at 0.05 level. The experimental results can be summarized as follows:

The Camarosa variety was significantly superior in preserving stored fruits by giving the lowest percentage of damage, weight loss, and the lowest changes in TSS compared to the Albion variety. Riboflavin spray at 200 mgL^{-1} gave the lowest percentage of fruit damage, weight loss, and the highest TSS content, whereas this treatment gave the lowest amount of changes in total acidity compared with untreated one. Salicylic acid spray at 200 mgL^{-1} was significantly superior in giving the lowest percentage of fruits damage in stored fruits, the least weight loss, and the highest percentage of TSS.

Keywords: *strawberries. Riboflavin, nano-iron, salicylic acid, cold storage*

Introduction:

Strawberry (*Fragaria ananassa* Duch) is one of the most important fruit plants with small fruits that are widespread in the world. The genus *Fragaria* includes about 45 species (1). Strawberry plants grow in wide environmental conditions due to the plant's ability to grow in different climatic and environmental conditions. Strawberry cultivation is widespread in more than 76 countries, and

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global production amounts to about 8.9 million tons annually, (2) As for Iraq, strawberry production was estimated according to the statistics of the Central (3) 4.6668 tons. ha^{-1}. The use of nano-fertilizers is one of the latest agricultural practices that have been proven to be effective in the field of agriculture (4) Nanoparticles work to enhance the absorption of nutrients with high efficiency due to the free passage of nano-sized pores and through carriers. It leads to increased absorption of nutrients inside the plant. Nanoparticles may pass through cytoplasmic bonds, which leads to effective delivery of nutrients. Nanofertilizers can achieve the fastest response of the plant, especially with the problems present in the soil, such as high pH, fixation of nutrients in ways that are not ready for the plant, and lack of efficient root growth (5). Iraqi soils suffer from a lack of availability of some nutrients, including iron, which is a low-mobility element within the plant and is absorbed in the form of Fe^{+3}. It is an intermediate in the formation of chlorophyll. It is also involved in the synthesis of cytochrome and is related to the formation of some enzymes such as the peroxidase enzyme (6) Riboflavin (vitamin B-2), is one of the important B complex vitamins that is involved in photosynthesis and participates in the transfer of electrons (oxidation and reduction processes), the activation of photosynthesis, and the formation of natural auxins that stimulate growth within the plant (7). Salicylic acid is one of the plant hormones of a phenolic nature. It affects the growth, flowering of plants, and the absorption of ions. It works to accelerate the formation of chlorophyll and carotene pigments (8), regulate stomata opening, accelerate the process of photosynthesis, increase the activity of a group of important enzymes, and provide systemic immunity against pathogens (9)In addition, it plays an important role in regulating the response of plants to environmental stress conditions (10) Strawberry fruits are soft fruits that lose their hardness during marketing and storage, which leads to mechanical damage resulting in an increase in fungal infections. The reason for the loss of hardness in the fruits is due to the disintegration of the cell wall and the dissolution of the middle lamina, as the process of pectin decomposition represents a major control point for this process(11), so maintaining the quality specifications of strawberry fruits is an important matter that must be taken into consideration. Strawberries are also considered one of the most susceptible to damage and rapid deterioration if we do not get rid of the heat of the field quickly in a cool, well-ventilated, shaded place (12) Based on the above and the lack of studies related to

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the effects of the previous factors, this study aimed to:

Study the response of two strawberry cultivars fruit to some chemical treatments and their effects on the shelf life of the fruits.

Materials and Methods:

Strawberry fruits from two varieties (Camarosa and Albion) were taken from plants Cultivated in the general nursery of Baqubah, affiliated with the Diyala Agriculture Directorate treated with nutrient solutions of iron Nano-iron at 10 mgL^{-1}, 20 mgL^{-1}, Riboflavin (Vitamin B2) at 100 mgL^{-1}, and 200 mgL^{-1} and control), and sprayed with salicylic acid at 0, 100, 200mgL^{-1}. The fruits were harvested when reached ½ - ¾ red color stage and TSS reached 7% . (12) Fruits that were homogeneous in size and color and free of pathogens and mechanical damage were selected from each experimental unit. The harvested fruits were packed in plastic containers with a perforated capacity of ½ kg. The containers were divided into two groups. The first was left to calculate weight loss until the end of the experiment, and the second group was to measure the characteristics of the fruits after storage. The fruits were stored at 0 ± 1°C. The relative humidity ranged between 95-90%, and an evaluation of the studied characteristics was conducted 10 days after the start of storage. The fruits of both varieties were stored on 2/20/2021 until 2/30/2021.

Studied attributes:

1. weight loss percent
2. Damaged fruits(%)
3. TSS(%)
4. Titrable acidity(TA) percent.

A factorial experiment was carried out according to a C.R.D design with three factors and three replications and two containers per experimental unit. Data were analyzed according to SAS program (2003), and the averages were compared according to Duncan's multiple range test 0.05 level (13)

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Table 1: Initial measurements of the studied traits taken from the main parameters of the field experiment.

	variety	TSS	Acidity
1	Albion	7.297	0.586
2	Camarosa	7.376	0.597
	Nutrients (mg L^{-1})		
1	Untreated fruits(0)	7.082	0.675
2	Nano iron at 10 mgL^{-1}	7.344	0.616
3	Nano iron at 20 mgL^{-1}	7.781	0.574
4	Riboflavin at 100 mgL^{-1}	7.142	0.535
5	Riboflavin at 200 mgL^{-1}	7.334	0.532
	Salicylic acid (mg L^{-1})		
1	Untreated(0)	7.349	0.589
2	Salicylic acid at 100 mgL^{-1}	7.336	0.584
3	Salicylic acid at 200 mgL^{-1}	7.32	0.587

Results and discussion:

Results in Tables 2, 3, and 5 show no significant differences between both varieties after 10 days of storage in studied characteristics. It is noted that the Camarosa variety was significantly superior in giving the lowest percentage of damage to the fruits, amounting to (10.54), and the smallest amount of change in the total acidity of the fruit with the storage method, amounting to (0.465).

compared with the Albion variety, which gave the highest percentage of fruit damage, reaching (11.76) and the highest amount of change in acidity, amounting to (0.495), while there were no significant differences between the two strawberry varieties in the amount of weight loss percentage and the percentage of total dissolved solids. Improving post-harvest quality is considered an important need and requirement for successful and modern agriculture. Choosing varieties that are most capable of being stored and extending the shelf life of fruits are good and important qualities. The main reason for the difference between varieties in ability to store is due to genetic differences that work to reduce the activity of decomposition enzymes and aging in the fruits.(14) and this is consistent with the findings of (15) .

It is noted from the same tables mentioned previously that the spraying treatment with riboflavin at a concentration of 200 mg L-1 is superior in preserving the fruits by giving the least amount of damage to the fruits (8.912)%, the lowest percentage of weight loss (7.544)%, and the highest percentage of total dissolved solids in the fruits (6.547)%. The smallest amount of change in total acidity is (0.456)%

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compared to the rest of the nutrient parameters. The reason for this is due to the ability of riboflavin to prevent the growth of microorganisms and microbes by enhancing the autoimmunity of the fruits, as it is considered a natural antioxidant Powers (16) thus reducing the percentage of total damage and preventing high fluctuation. By weight after storage, it protects the internal contents of the fruit from rapid transformation, through its effect in preventing or inhibiting the production of ethylene and inhibiting the process of oxidation of fats within the cell membrane, thus delaying aging and preserving the fruits. This is consistent with what (17) mentioned. The results presented in Tables, 2, 3, and 5 also showed that the spray treatment with salicylic acid at a concentration of 200 mg L-1 was significantly superior in preserving stored strawberry fruits by giving the lowest percentage of damage to the fruits, amounting to (9.86) and the lowest percentage of weight loss, amounting to (8.047). The smallest amount of change in total soluble solids was (6.489), while there were no significant differences in the percentage of total acidity in the fruits after storage. Spraying salicylic acid had a clear effect in increasing the shelf life of stored fruits through the results presented in the aforementioned tables. The reason is that it is a natural plant hormone that works to provide the plant with acquired internal immunity that prevents the production of ethylene and thus delays aging. It also works to improve resistance against various pathogens and thus prevents biological damage to the fruits. (18) by activating the self-defense and antioxidant response. and (19) It also works to prevent cell wall decomposition and increase the activity of youth enzymes and hormones that work to prolong the life of fruits after harvest and delay the ripening of unpicked fruits, and this is consistent with what was found by (20) and (21) and (22)

The results of the aforementioned tables also showed that there were significant effects of the two-way interaction and the three-way interaction between the treatments on all the traits measured in the experiment.

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Table 2: Effect of spraying with some nutrients and salicylic acid on damaged fruits (%) of two strawberry cultivars.

cultivars	Nutrient solution (mg L^{-1})	Salicylic acid (mg L^{-1})			X cultivar Nutrient solution
		S1	S2	S3	
A1	Z1	11.52 b-g	9.810 e-h	9.573 e-h	10.30 cd
	Z2	14.39 b	12.47 b-g	11.43 b-g	12.77 ab
	Z3	17.53 a	13.80 b-d	11.73 b-g	14.36 a
	Z4	12.93 b-e	12.63 b-f	11.73	12.43 ab
	Z5	9.673 e-h	9.300 f-h	7.833 h	8.936 d
A2	Z1	12.77 b-f	11.53 b-g	10.37 d-h	11.56 bc
	Z2	13.90 bc	12.33 b-g	11.43 b-g	12.56 ab
	Z3	12.90 b-e	10.57 c-h	9.300 f-h	10.92 bc
	Z4	9.583 e-h	9.377 f-h	7.367 h	8.776 d
	Z5	9.767 e-h	9.100 gh	7.800 h	8.889 d
	Cultivars				
Cultivars X Salicylic acid	A1	13.21 a	11.60 ab	10.47 bc	11.76 A
	A2	11.78 ab	10.58 bc	9.25 c	10.54 B
	Nutrient solution				
ntrientsN X Salicylic acid	Z1	12.15 b-d	10.67 c-e	9.970 c-f	10.93 B
	Z2	14.15 ab	12.40 bc	11.45 c-e	12.67 A
	Z3	15.22 a	12.18 b-d	10.52 c-e	12.64 A
	Z4	11.26 c-e	11.01 c-e	9.550 d-f	10.60 B
	Z5	9.720 c-f	9.200 ef	7.817 f	8.912 C
	Salicylic acid	12.50 A	11.09 B	9.86 C	

Means with the same letter didn't differ significantly according to Duncan's multiple ranges test at 0.05 level

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Table 3: Effect of spraying with some nutrients and salicylic acid on two strawberry cultivars fruits weight loss(%).

cultivars	Nutrient solution (mg L^{-1})	Salicylic acid (mg L^{-1})			X cultivar Nutrient solution
		S1	S2	S3	
A1	Z1	13.57 ab	12.47 ab	8.733 c-g	11.59 a
	Z2	12.63 ab	10.70 a-e	8.400 d-g	10.58 ab
	Z3	11.80 a-c	10.87 a-e	8.500 d-g	10.39 ab
	Z4	10.33 b-f	7.800 e-h	7.200 f-i	8.444 bc
	Z5	10.67 a-e	7.933 e-g	7.300 f-i	8.633 bc
A2	Z1	13.87 a	12.80 ab	10.73 a-e	12.47 a
	Z2	13.03 ab	11.77 a-c	11.43 a-d	12.08 a
	Z3	13.20 ab	11.60 a-d	8.800 c-g	11.20 a
	Z4	8.633 c-g	7.333 f-i	4.733 hi	6.900 c
	Z5	8.333 d-g	6.400 g-i	4.633 i	6.456 c
	Cultivars				
Cultivars X Salicylic acid	A1	11.80 a	9.953 ab	8.027 b	9.927 A
	A2	11.41 a	9.980 ab	8.067 b	9.820 A
Nutrient solution					
utrientsN X Salicylic acid	Z1	13.72 a	12.63 ab	9.733 c-e	12.03 A
	Z2	12.83 ab	11.23 bc	9.917 cd	11.33 AB
	Z3	12.50 ab	11.23 bc	8.650 d-f	10.79 B
	Z4	9.483 c-e	7.567 e-g	5.967 g	7.672 C
	Z5	9.500 c-e	7.167 fg	5.967 g	7.544 C
Salicylic acid		11.61 A	9.967 B	8.047 C	

Means with the same letter didn't differ significantly according to Duncan's multiple ranges test at 0.05 level

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Table 4: Effect of spraying with some nutrients and salicylic acid on the TSS (%) of two strawberry cultivars fruit juice

cultivars	Nutrient solution (mg L^{-1})	Salicylic acid (mg L^{-1})			X cultivar Nutrient solution
		S1	S2	S3	
A1	Z1	5.843 c-e	6.080 a-d	6.483 a-d	6.136 bc
	Z2	5.803 de	6.103 a-d	6.050 a-c	5.986 c
	Z3	6.317 a-d	6.483 a-d	6.557 a-d	6.452 ab
	Z4	6.430 a-d	6.637 a-c	6.783 a	6.617 a
	Z5	6.327 a-d	6.407 a-d	6.727 ab	6.487 ab
A2	Z1	5.820 c-e	6.277 a-d	6.493 a-d	6.197 a-c
	Z2	4.773 f	5.273 ef	5.977 a-e	5.341 d
	Z3	5.940 b-e	6.210 a-d	6.530 a-d	6.227 a-c
	Z4	6.457 a-d	6.540 a-d	6.570 a-d	6.522 ab
	Z5	6.503 a-d	6.600 a-d	6.720 ab	6.608 a
	Cultivars				
Cultivars X Salicylic acid	A1	6.144 ab	6.342 a	6.520 a	6.335 A
	A2	5.8987 b	6.180 ab	6.458 a	6.179 A
	Nutrient solution				
utrientsN X Salicylic acid	Z1	5.832 de	6.178 a-e	6.488 a-c	6.166 B
	Z2	5.288 f	5.688 ef	6.013 c-e	5.663 C
	Z3	6.128 b-e	6.347 a-d	6.543 ab	6.339 AB
	Z4	6.443 a-c	6.588 ab	6.677 ab	6.569 A
	Z5	6.415 a-c	6.503 ab	6.723 a	6.547 A
	Salicylic acid	6.021 C	6.261 B	6.489 A	

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Table 5: Effect of spraying with some nutrients and salicylic acid spray on the Titrable acidity (TA)(%) of two strawberry cultivars fruit juice

cultivars	Nutrient solution (mg L^{-1})	Salicylic acid (mg L^{-1})			X cultivar Nutrient solution
		S1	S2	S3	
A1	Z1	0.480 b-e	0.475 b-e	0.486 b-e	0.481 b-e
	Z2	0.529 a-d	0.549 a-c	0.572 ab	0.550 a
	Z3	0.535 a-d	0.491 b-e	0.502 b-e	0.509 a-c
	Z4	0.476 b-e	0.473 b-e	0.485 b-e	0.478 b-e
	Z5	0.451 b-e	0.451 b-e	0.472 b-e	0.455 c-e
A2	Z1	0.462 b-e	0.480 b-e	0.632 a	0.525 ab
	Z2	0.485 b-e	0.482 b-e	0.504 b-e	0.490 a-d
	Z3	0.429 c-e	0.393 e	0.425 c-e	0.416 e
	Z4	0.417 de	0.445 b-e	0.448 b-e	0.437 de
	Z5	0.455 b-e	0.446 b-e	0.468 b-e	0.457 c-e
	Cultivars				
Cultivars X Salicylic acid	A1	0.493 a	0.488 a	0.503 a	0.495 A
	A2	0.450 a	0.449 a	0.496 a	0.465 B
Nutrient solution					
utrientsN X Salicylic acid	Z1	0.471 a-c	0.478 a-c	0.559 a	0.503 AB
	Z2	0.507 a-c	0.516 a-c	0.538 ab	0.520 A
	Z3	0.482 a-c	0.442 c	0.464 bc	0.463 BC
	Z4	0.447 bc	0.459 bc	0.467 bc	0.457 BC
	Z5	0.449 bc	0.449 bc	0.470 a-c	0.456 C
Salicylic acid		0.471 A	0.469 A	0.499 A	

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References:

1. Al-Saidi, Ibrahim Hassan Muhammad (2000). Production of small fruits. Dar Al Kutub Printing and Publishing Foundation. University of Al Mosul. Ministry of Higher Education and Scientific Research. Iraq
2. FAOSTAT.(2021). Strawberry production in 2019. Crops / world list production quantity (pick lists) UN Food and Agriculture organization, corporate statistical Database.
3. Iraqi Central Agency for Agricultural Statistics. (2020). Temporary crop statistics. The Ministry of Planning. The Republic of Iraq.
4. Singh, M. D. ; G. Chirag ; P. O. Prakash ; M. H. Mohan ; G. Prakasha, and Vishwajith .(2017). Nano fertilizers is a new way to increase nutrients use efficiency in crop production. International Journal of Agriculture Sciences, 9(7): 3831-3833.
5. Tanou, G., V. Ziogas. And A. Molassiotis.(2017)a. Foliar nutrition, bio stimulants and prime – like dynamics in fruit tree physiology :new Insightsonan old topic. Frontiers in plant scierce.8(75).
6. Ferreira, C. M., Sousa, C. A., Sanchis-Pérez, I., López-Rayo, S., Barros, M. T., Soares, H. M., and Lucena, J. J. (2019). Calcareous soil interactions of the iron (III) chelates of DPH and Azotochelin and its application on amending iron chlorosis in soybean (Glycine max). *Science of the Total Environment*, *647*, 1586-1593.
7. Guhr, A.; M. A. Horn and A. R. Weig. 2017. Vitamin B2 (riboflavin) increases drought tolerance of *Agaricus isporus*. *Mycologia*, *109*(6), 860-873.
8. Lateef, M. A., Noori, A. M., Saleh, Y. M., and Al-Taey, D. K. (2021). The effect of foliar spraying with salicylic acid and calcium chloride on the growth, yield, and storage traits of two strawberry cultivars, fragaria x ananassa duch. *Int. J. Agricult. Stat. Sci. Vol*, *17*(2), 611-615.
9. Lamnai, K., Anaya, F., Fghire, R., Janah, I., Wahbi, S., and Loutfi, K. (2022). Salicylic Acid and Iron Reduce Salt-Induced Oxidative Stress and Photosynthesis Inhibition in Strawberry Plants. *Russian Journal of Plant Physiology*, *69*(5), 103.
10. Hayat,S. and A. Ahmad. (2007) . Salicylic acid :a plant hormone. Springer. pp.397.
11. Posé, S., J.A. García-Gago, N. Santiago-Doménech, F. Pliego-Alfaro, M.A. Quesada and J.A. Mercado.(2011). Strawberry fruit softening: role of cell wall disassembly and its manipulation in transgenic plants. Genes, Genomes and Genomics, 5(1):40-48.
12. Al-Shammari Ghaleb Nasser Hussein and Namir Najeeb Fadel (2021). Handling

ISSN 2072-3857

and storage of fruits and vegetables, National Library and Archives, Baghdad. Iraq.

13. Al-Rawi, Khashi Muhammad and Abdul Aziz Muhammad Khalaf Allah. (2000). Design and analysis of agricultural experiments. Second edition. Dar Al-Kutub Printing and Publishing Foundation. University of Mosul. Iraq

14. Min, K., Yi, G., Lee, J. G., Kim, H. S., Hong, Y., Choi, J. H., ... and Lee, E. J. (2020). Comparative transcriptome and metabolome analyses of two strawberry cultivars with different storability. *PloS one*, *15*(12), e0242556.

15. Curi, P. N., de Sousa Tavares, B., de Almeida, A. B., Pio, R., Peche, P. M., and de Souza, V. R. (2016). Influence of subtropical region strawberry cultivars on jelly characteristics. *Journal of food science*, *81*(6), S1515-S1520.

16. Powers, H. J. (2003). Riboflavin (vitamin B-2) and health. *The American journal of clinical nutrition*, *77*(6), 1352-1360.

17. Pintos, F. M., Lemoine, M. L., Grozeff, G. G., Hasperué, H. J., Vicente, A. R., and Rodoni, L. M. (2022). Use of riboflavin to reduce decay and extend the shelf-life of fresh-cut sweet pepper. *Postharvest Biology and Technology*, *188*, 111882.

18. Asghari, M. R., Hajitagilo, R., and Jalilimarandi, R. (2009, April). Postharvest application of salicylic acid before coating with chitosan affects the pattern of quality changes in table grape during cold storage. In *6th International Postharvest Symposium, Antalya, Turkey* (pp. 8-12).

19. Xu X. and S. Tian (2008). Salicylic acid alleviated pathogen– induced oxidative stress in harvested sweet cherry fruit. Postharvest Biol. Technol, (49), 379–385.

20. Zhang, Y., Li, S., Deng, M., Gui, R., Liu, Y., Chen, X., ... and Tang, H. (2022). Blue light combined with salicylic acid treatment maintained the postharvest quality of strawberry fruit during refrigerated storage. *Food Chemistry: X*, *15*, 100384.

21. Sayyari, M., Esna- Ashari, M., and Tarighi, T. H. (2022). Impacts of salicylic acid, chitosan, and salicyloyl chitosan on quality preservation and microbial load reduction in strawberry fruits during cold storage. *Journal of Food Processing and Preservation*, *46*(7), e16710.

22. Yonis, A. H., Hawezy, S. M., and Rashad, D. D. (2022). Impact of postharvest treatment with salicylic acid and storage period on Salakhani pomegranate fruit. *Journal Of Kirkuk University For Agricultural Sciences*, *13*(4).

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