OPEN ACCESS J. Plant Environ. 05 (01) 2023. 57-70 DOI: 10.33687/jpe.005.01.4714

Check for updates

Available Online at EScience Press

Journal of Plant and Environment

ISSN: 2710-1665 (Online), 2710-1657 (Print)

https://esciencepress.net/journals/JPE

A study Investigating the Effects of Postharvest Treatments of Sodium Nitroprusside and Potato Starch on the Quality and Storage Life of two Advertised Guava Cultivars

[1]Muhammad Akmal Rana, [2]Hafiz Muhammad Zohaib, [3]Muhammad Anees, [4]Shan Muzamail, [5]Muhammad Ikhlaq, [1]Naheed Akhtar, [1]Faheem Altaf, [6]Muhammad Usman[6]

[1] Horticulture Research sub- station, Dera ghazi Khan, Pakistan.

[2] Department of Chemistry, Beijing Institute of Technology, China.

[3] Institute of Horticultural sciences, University of Agriculture Faisalabad, Pakistan.

[4] Institute Food Science and Technology, Gomal University, Dera Ismail Khan, KPK, Pakistan.

[5] Principal Scientist, Horticulture Research Station, Bahawalpur, Pakistan.

[6] Department of Entomology University of Agriculture Faisalabad, Pakistan.

ARTICLE INFO

Article History

Received: July 22, 2022

Revised: January 15, 2023

Accepted: March 20 2023

Keywords

Postharvest Management

Quality Traits

Antioxidant Enzymes

Biochemical Activity

Statistical Analysis

ABSTRACT

The availability of fresh guava fruit in the domestic, as well as the international market, is limited due to its short postharvest life. Hence, the present research was performed to evaluate the effect of postharvest application of potato starch and sodium nitroprusside on the storage life and quality of guava fruit. Data was examined statistically using ANOVA with Fishers 'least significant difference LSD test using statistics software 8.1 with 5% levels of significance difference. Treated fruits remained in storage for 15 days while the untreated fruit started decaying within 10 days of storage. The physical parameters of guava like fruit firmness, visual quality, marketability index, disease incidence, and fruit decay showed highly significant results when treated with different concentrations of potato starch and sodium nitroprusside. The sensory traits such as texture, taste, flavor, aroma, and overall acceptance were also decreased with the progress of storage days. Biochemical fruit quality traits of guava like TSS, TA, TSS/TA ratio, ascorbic acid, and Ion leakage were significantly influenced when treated with different coatings of potato starch and sodium nitroprusside and subjected to ambient storage. The phytochemical traits of guava like total phenolic contents, total antioxidant contents, and total carotenoid content showed highly significant variations among storage periods and treatments. Activities of various antioxidative enzymes such as superoxide dismutase activity, peroxidase activity POD, and catalase activity CAT exhibited highly significant differences at the end of the storage period. The potato starch and sodium nitroprusside treatments managed the postharvest quality of guava fruit by delaying fruit senescence reduction because of enhanced antioxidant enzymes. Hence, the investigation revealed that the different concentrations of potato starch and sodium nitroprusside coating improved the storage life of guava with retaining better fruit quality attributes.

Corresponding Author: Muhammad Akmal Rana

Email: akmalpervaizrana@gmail.com

INTRODUCTION

Guava is very popular among people from all walks of life because of its low cost and better taste and nutritional value. The ripe guava fruit, freshly picked from the tree, has a delicious and attractive taste. Fruits are consumed as fresh but are also used in jams. Guava fruit contains about 83% water, 12% carbohydrates, and 0.7% proteins. Guava can be containing high vitamin C and mineral content(Kamath *et al.*, 2008). It also contains vitamins A, B, minerals, and pectins. Vitamin C is present in higher amounts. It is more than 6 times as it is present in oranges and 10 to 30 fold more than in bananas. Guava is also a valuable source of nicotinic acid, soluble fiber, phosphorus, and calcium(Cho *et al.*, 2003). These are better for the human immune system and help lower cholesterol and protect the heart.

Other types of guavas, such as Pedro Sato, are observed that harvest ripening occurs without carbon dioxide and climacteric fruit(Azzolini *et al.*, 2005). The main features that reduce the quality of the latest guava are over-ripening, mechanical damage and softening rot, fruit wrinkles, inaccuracies, and lack of proper storage(Kader, 2002).

In Pakistan, the total production of guava has postharvest losses, and the estimated losses are 20 to 40% (Malik, 1993). mechanical injuries and post losses diseases are the main causes that reduce the yield and quality of guava fruit. Yield estimates and future harvests are estimated access to be 40% in other countries, such as Pakistan and Brazil(Khushk *et al.*, 2009). Sweet potatoes are a source of sweet potato starch that we can obtain easily, and it is effective and available all over the world. Biodegradable films are formed from sweet potato starch in this technique, and they have good mechanical qualities(Guo *et al.*, 2019)

Starch is an inexpensive, decomposable natural polythathichhcantherm gel. Various polymers can be synthesized such as cellulose, chitosan, pectin, and alginate, and remain a flexible polymer(Wang *et al.*, 2018). Sodium Nitroprusside SNP is nitric oxide NO donor in plants that protect against lipid oxidation damage. Prevents pigment degradation while also preserving chlorophyll levels(Orfanidou *et al.*, 2017). It is involved in signal transduction, seed germination, stomatal closure, and root growth (Domingos *et al.*, 2015). It can play a role in delivering messages and responding to non-biological and biological challenges, as well as acting as a mediator in interaction pathways between plant growth regulators and ROS metabolism(Asgher *et al.*, 2017). By blocking the formation of ethylene, nitric oxide can slow down the aging process(Liu *et al.*, 2020). No lowers cell membrane degradation and electrolyte leakage, allowing cellular colors, proteins, soluble solids, and antioxidant chemicals to be maintained more efficiently(Zahedyan *et al.*, 2022). Nitric oxide lowers ethylene production and influences the quality of tomato fruit held at room temperature by slowing the reddening of the pericarp. A study was conducted to see how pre-harvest treatment of SNP impacts the physical and biochemical postharvest qualities, as well as the CI, of tomato fruit under cold storage(Bodanapu *et al.*, 2016).

At present, there is less information about postharvest and quality maintenance of locally grown guava verities in Pakistan. So, the objective of the study was to find the influence of postharvest applications of potato starch and Sodium nitroprusside on storage life and quality of two commercial guava cultivars ‘Sadabahar’ and ‘Gola’) at ambient temperature.

MATERIAL AND METHODS

The research trial about the “influence of Sodium Nitroprusside and Potato Starch Coating on Postharvest Life and Quality Attributes of Guava Fruit during Cold Storage” was performed the in pomology laboratory, Institute of Horticulture Science” University of Agriculture Faisalabad, in January 2020. For the experiment, fruits of two commercial cultivars, ‘Sabdhuri and Sada Bahar’ were harvested from nine square orchards31 ° 30’19.0 N 74° 08’10.0” E) situated in the University of Agriculture Faisalabad, packed in cardboard boxes which were lined with newspaper to prevent mechanical injuries) and were transported to the pomology lab. In the lab. Uniform and disease-free Fruits were sorted and washed out with tap water and dried under the shade for half an hour. Fruits were dipped in various concentrations of Sodium Nitroprusside and Potato Starch for five minutes. Each treatment was replicated thrice. Data was taken after five days intervals at ambient storage conditions. Fruits were sorted for 42 days, and various attributes were noted including out colors, maturity, same size, and appearance, and damaged fruits were discarded. The experiment was designed according to a Completely Randomized Design CRD. The means square test was applied to analyze the results.

Treatments

Concentrations of Sodium nitroprusside and Potato Starch

- T0 =Control
- T1 = 0.5% potato starch
- T2 = 0.5% sodium nitroprusside
- T3 = 0.5% potato starch + 0.5% sodium nitroprusside
- T4 = 0.25% potato starch + 0.25% sodium nitroprusside

Days of storage

Data was recorded for up to 24 days of storage. Data about various fruit quality was recorded after 6 days of intervals up to 24 days with the following sequences:

- Day 0 = at the time of storage
- Day 6 = after 6 days of storage
- Day 12 = after 12 days of storage
- Day 18 = after 18 days of storage
- Day 24 = after 24 days of storage

Preparation of sodium nitroprusside and potato starch solution and method of application

Sodium nitroprusside0.5%) and potato starch solution will be prepared according tov/v) percentage, in 1 L of water. At each concentration of the solution, fruits of the same maturity and uniform size were dipped for 10 min. the control fruits were stored without dipping in Solution, The fruits from both varieties were treated separately by using the same method

Physical Analysis

The research included these physical parameters.

Fruit weight loss%)

Fruits weight loss was calculated by the electronic weighing scale model: SHIMADZU, ELB12K) and represented by the grams. The total fruit weight loss was measured in the percentage of fresh fruit loss followed by (Hassan *et al.*, 2018).

$$\text{Fruit weight loss\%)} = \frac{\text{A1Initial weightg)} - \text{finalweightg)}}{\text{Finalweightg)}} \text{X } 100$$

Fruit firmness

The firmness of guava fruit pulp was tested with a handheld penetrometer QA supplies, fruits pressure tester FT-327). Before talking of reading a small strip around 2 mm thick was removed from the outer layer. Two readings were taken from each fruit. Both readings are contrary to different directions of fruits. The pressure needed to pierce the fruit was demonstrated by the penetrometer scale in Newton N. The average value of the two fruits was considered to be the most appropriate value of firmness.

Fruit Visual quality score

Visual quality was measured through scores1-9). A bench of five judges examined the fruits visually and marked the number1 for highly disliked and 9 for highly liked)(Nasef, 2018).

Marketability index%)

The marketability index was measured as a percentage by observing the number of healthy fruits that are physically protected from diseases, blemishes, and deterioration. Each replication was checked for marketability index by using the following formula:

$$\text{Marketability Index\%)} = \frac{\text{Number of healthy fruits}}{\text{Total fruits}} \text{X } 100$$

Disease incidence score

The incidence of the disease was visually measured by using of score 1-51 none and 5 is.>25%). Each experimental unit of all treatments was examined.

Decay score

The fruit's-decay was defined by the score from 1-5. Fruit exhibiting the deterioration has been considered as wasted1 is none and 5 is severe. The panel of five judges examined the fruits visually and filled the assessment chart according to the number. All treatments were examined by the panel(Kader, 2002).

Organoleptic evaluation

Guava palatability scores provide the measurement of fruit taste, flavor, aroma, and overall acceptance of the fruits. The score of 1-91 for highly disliked and 9 for highly liked) was used for the fruit scoring on the grounds of the above*listed parameters. Two sample fruits were arranged randomly in different selected areas, after oral and visual analysis of the fruits, a jury of five judges submitted a report against each treatment, and the mean scores were considered.

Biochemical analysis

For chemical analysis, 4 fruits were taken from every replication being used for analysis, following 6 days of interval. The extracted juice of guava fruit was used for analysis.

Preparation of composite sample

Fruit pulp was blended to make a sample homogenous. The juice was separated from the pulp with the help of a muslin cloth. The juice was filtered and placed inside a beaker.

Total soluble solid TSS °Brix

Total solids were examined by using the guava juice

sample. TSS was determined at room temperature with the use of a handheld digital refractometer ATAGO pocket refractometer PAL-1. The unit of TSS is °Brix.

Titratable acidity%

The Hortwitz,1960) method was used to measure titratable acidity, and commonly expressed in percent 10ml of guava juice was poured in 100 ml of flak and 20 ml was combined with distilled water. Three to four drops of Phenolphthalein were added as an indicator against 0.1 N NaOH till light pink color appeared.

$$\text{Titratable acdity\%}) = \frac{\text{ml of 0.1 N NaOH } 0.0067}{\text{ml of juice used}} \text{X } 100$$

TSS: TA ratio

For every sample, the TSS/Ta was estimated by dividing the TSS and TA-related values(Hortwitz, 1960).

Electrolyte leakage%

Guava's first electrolytes leakage was tested using a method described by Huan *et al*.2017). The EC was calculated in three fruits chosen by each treatment and five equal disks were separated 7mm in diameter with the help a of cork borer. Afterwads, these disks were immersed in a small beaker containing, 50ml, of distilled water at 25°C. After 30 min the first electrical conductivityEC-1 reading was evaluated using the digital E.C meterCD-4301 rd Lutron Inst, CO UK at ambient temperature, After 10 mins the boiling maximum electrolytes EC2 was calculated., EC% was determined by using the formula:

$$\text{Ion leakage } = \frac{\text{EC1}}{\text{EC2}} \text{X } 100$$

Ascorbic acid content mg 100g-1FW

The ascorbic acid content of guava juice was calculated using Ruck's procedure1961). The sample prepared by blending and Filtration of guava pulp for determination of TSS was used for the calculation of ascorbic acid content. A sample of 10ml guava juice was added in a 100ml flask and up to 100ml volume was formed by adding the o.4% of oxalic acid. After 5ml Aliquot was separated from 100ml solution in the clean and dried beaker. Titration was done against 2, 6-dichlorophenol until the light pink color was sustained. The content of ascorbic acid was measured in mg of ascorbic acid in 100g of guava pulp. The procedure for determination of ascorbic acid contras was measured by using the formula:

$$\text{Ascorbic acid content} = \frac{\text{D1xV}}{\text{DxAxB}} \text{X } 100$$

Where:

D1= Dyeml) used to titrate aliquot

D = volume of dye in ml used to titrate ascorbic acid 1 ml), made with dissolving 0.1% ascorbic acid1 ml) and 0.4% oxalic acid1.5 ml)

A = Volume of guava juice in ml

V = Aliquot volume made with alcohol o.4% oxalic acid in ml B = Aliquot volume used for titration in ml

Preparation of dye2,4-Dichlorophenolindophenols

The dye was made by adding 42 mg NAHCO, in 52 mg 2, 4-Dichlorophenol indophenols in 200 ml of the flask. About 200ml volume of solution was formed by dissolving distilled water. After thoroughly mixing the solution was filtered by filtered paper freshly prepared dye was used every time during analysis.

Phytochemical analysis

Total phenolic contentµ100g-1)

The procedure of Folin-Ciocalteu FC was followed for the calculation of the total phenolic content of guava fruit juice, described by (Ainsworth and Gillespie, 2007). Frozen juice samples of guava were used for the analysis of TPC in guava juice.

Preparation of sample for determination of TPC

Guava juice (1 ml with 5 ml) of methanol, HCL (10:8:2) with acetone and completely homogenized by using mortar and pestle, the uniformly homogenized mixture was falling into Eppendorf and centrifuged for 5 min at 10,000 × g for at 4°C temperature in a centrifuge machine SHIMADZU, UV-1800 240V.

Preparation of extraction solution

The extract solution was prepared by mixing the methanol, acetone, and HCL in a ratio of 10:8:2 respectively. For making 100 ml of extraction solution, 50 ml of methanol was added to a 1000 ml beaker. After that 40 ml of acetone and 10 ml of concentrated HCL were added in methanol and the solution was made up to 100 ml. The solution was mixed with the stirrer to homogenize. Preparation of calcium carbonate $Na2C03^{3}$) solution of 700 mM concentration 20ml of distilled water was taken in a 100 ml beaker. Na2C031.06 g) was mixed with water and made 100 ml of solution and was mixed with a stirrer for homogenization.

Determination of TPC

The extracted sample200 ml) was mixed with FC-reagent200 µL) in microcentrifuge tubes Eppendorf) and the mixture was vortexed for 10 s. After homogenization, 700 mM sodium carbonate800 µL) was

added and then vortexed for 10 s. At ambient temperature, this formulation was included for 1 hr. Then 1 ml was added from every sample to the cuvettes and read by spectrophotometer at 765nm.

Total antioxidant contentμ 100g-1)

Total antioxidant contents were measured by following the procedure of (Ainsworth and Gillespie, 2007). Using the sample supernatant), prepared for TPC analysis. The sample supernatant) was taken150μL) and mixed with 0.004% DPPH solution5 ml) and kept for 30 min at ambient temperature. After incubation at room temperature, absorbance was checked at a wavelength of 517 nm by a microplate reader.

Total Anthocyanin

The total anthocyanin content of guava was estimated using the procedure defined by (Saengnil *et al.*, 2006). By the use of mortar and pestle, 1 g of stored guava pulp was grounded in a 10 ml extraction mixture of HCL and methanol15:85). With the use of the incubator, the specimen was incubated for about 4 h at 25°C and the sample was centrifuged at 4000 × g for 5 min Rotofix 46 tabletops, Hettich, Germany). The pellets were dumped, and the supernatant was used, In Eppendorf 200 μL of supernatant was added for determination of anthocyanin content, and the absorbance was observed through spectrometer Shimadzu, UV-1800 24V) at 530, 620, and 650 nm, Anthocyanin content of guava pulp was presented as a tweak in absorption per gram of fresh weight given in formula: μA g-1 FW =A530 – A620)-0.1A650-A620).

Total carotenoids

Extraction was carried out using an extraction buffer of 20 ml acetone: n-Hexane 75:60). The extract was needed for its absorbance at 663,453,645 and 550nm wavelengths.

Enzymes determination

Superoxide dismutase SOD)

The activities of SOD enzymes were determined using the methodology demonstrated by Stajner and Popovic2009). The test was conducted by calculating the inhibition of phytochemicals reduction of nitro blue tetrazolium NBT) by 50%. In the test tube, 500μl phosphate buffer50 mM, pH), 200 μl22 μM) methionine, 100 μL enzymes extract, 200 μL0.1 μM) Triton X,100 μL20 μ nM) NBT,800 μL purified water, and 100 μL0.6 μM) riboflavin were included and blended well. The reading was presented in the form of U mg-1 protein.

Peroxidase (POD)

A mixture of 100 μL of guaiacol20 mM), and 800 μL phosphate buffer pH 5 and molarity 50 mM and 100 μL H2O240 mM) was prepared. A 470 nm micro platform reader was used to record enzymes absorbance extract100μl) and expressed as U mg-1 protein. Figure 3.10) describes the procedure of POD assay for guava fruit.

Catalase (CAT)

CAT assay was calculated using the procedure described by Liu et at2009). To initiate the extraction of enzymes extract100μl) was weighed and diluted with 5.9 mM 100 μL H2O2. CAT activities were measured at 240 nm by using a microplate reader and represented asUmg-1.

Statistical analysis

The experiment was laid out according to a completely randomized design (CRD) under the factorial arrangement, data recorded were subjected to statistical analysis, using 'Statistic 8.1' software. LSD test was applied with a level of significance, less than 5% probability.

RESULTS AND DISCUSSION

Physical Parameters

Fruit Firmness

The effect of various potato starch and sodium nitroprusside coatings on the postharvest shelf life and quality of guava (*Psidium guajava* L.)fruit at ambient temperature was investigated in this research. The statistical analysis of the fruit firmness findings revealed non-significant results for the treatments and the interaction between treatments and storage time, as well as highly significant results among storage periods Annexure 1). The maximum value of firmness72 N) was measured on the first day of storage. The findings revealed that as the number of storage days grew, the fruit firmness steadily reduced. The fruits of T40.25 % potato starch + 0.25 % sodium nitroprusside) had the maximum fruit firmness50.04 N), followed by the fruits of T20.5 %sodium nitroprusside)48.6 N), and the fruits of T0control treatment) had the lowest41 N) on the final day of storage.

The firmness of the fruit is a reliable predictor of the quality of the fruit(Hashimoto et al., 2005). The fruit's firmness reduces with the advancement in storage days. It is also lowered as a result of water loss5-6%) from the fruit surface(Chauhan *et al.*, 2015).The delay in firmness of guava fruits treated with potato starch and sodium

nitroprusside may be attributable to their high concentrations of potato starch and sodium nitroprusside. Postharvest application of potato starch and sodium nitroprusside was effective in lower several physiological disorders and reducing the incidence of fungal pathogens ,as well as maintaining fruit firmness as reported by (Embaby *et al.*, 2012).

So, the postharvest application of 0.25% potato starch + 0.25% sodium nitroprusside showed the best results regarding the firmness of guava fruit.

Annexure 1. Analysis of variance table for firmness.

Source	DF	SS	MS	F	P
Treatment	4	880.7	220.18	1.08	0.3796 NS
Storage Days	3	6140.1	2046.69	10.03	0.0000**
Storage Days X Treatment	12	1839.1	153.26	0.75	0.6942 NS
Error	40	8160.5	204.01		
Total	59	17020.3			

Grand Mean = 61.216, CV = 23.33,** = highly significant at $P \leq 0.001$ and NS = non-significant at $P \leq 0.05$.

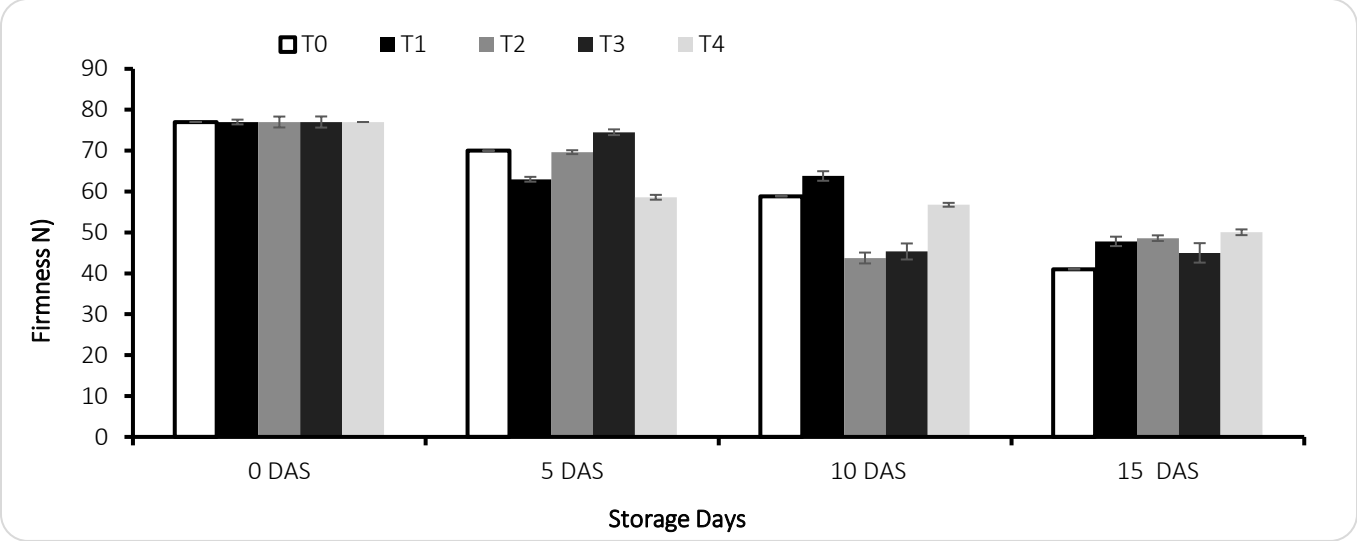

Figure 1. Postharvest management of guava by using different coating materials on fruit firmness N) of the guava fruit. T0 = Control, T1 = 0.5% potato starch, T2 = 0.5% sodium nitroprusside, T3 = 0.5% potato starch + 0.5% sodium nitroprusside and T2 =0.25% potato starch + 0.25% sodium nitroprusside. Vertical bars represent the average standard deviation3 repetitions, n = 24 fruits per treatment).

Fruit weight loss%

At the 5% level of significance, statistical analysis of the data indicated highly significant findings for storage time and the combined impact of treatments and storage period, as well as significant results for treatments Annexure 2). On the pre-storage day, the lowest weight loss%)0.00 %) was observed. As storage time rose, the percentage of weight loss increased. At the end of the storage period, T0Control treatment) fruits have had the most fruit weight loss36 %) when compared to the other treatments. The treatment T20.5% sodium nitroprusside) resulted in the lowest percentage of fruit weight loss9.06%), followed by T30.5% potato starch + 0.5% sodium nitroprusside)10.43%).

Long-term storage at room temperature resulted in the greatest weight loss. This is because the majority of the fruit's weight is determined by the amount of water that is lost via transpiration when it is being prepared and handled after harvest(Mathew, 2010). By functioning as a protective barrier, potato starch and sodium nitroprusside coating can prevent water transfer or dehydration, gas exchange, and nutrient loss and minimize guava weight loss. The findings of(Silip *et al.*, 2014) support our results. As a consequence, the postharvest treatment of 0.5% sodium nitroprusside produced the greatest effects in terms of guava fruit weight loss%).

Annexure 2. Analysis of variance table for weight loss of guava.

Source	DF	SS	MS	F	P
Treatment	4	10.00	2.499	3.74	0.0112*
Storage Days	3	1006.53	335.510	501.73	0.0000**
Storage Days X Treatment	12	63.56	5.296	7.92	0.0000**
Error	40	26.75	0.669		
Total	59	1106.83			

Grand Mean = 5.2755, CV = 15.50,** = highly significant at $P \leq 0.001$ and * = significant at $P \leq 0.05$.

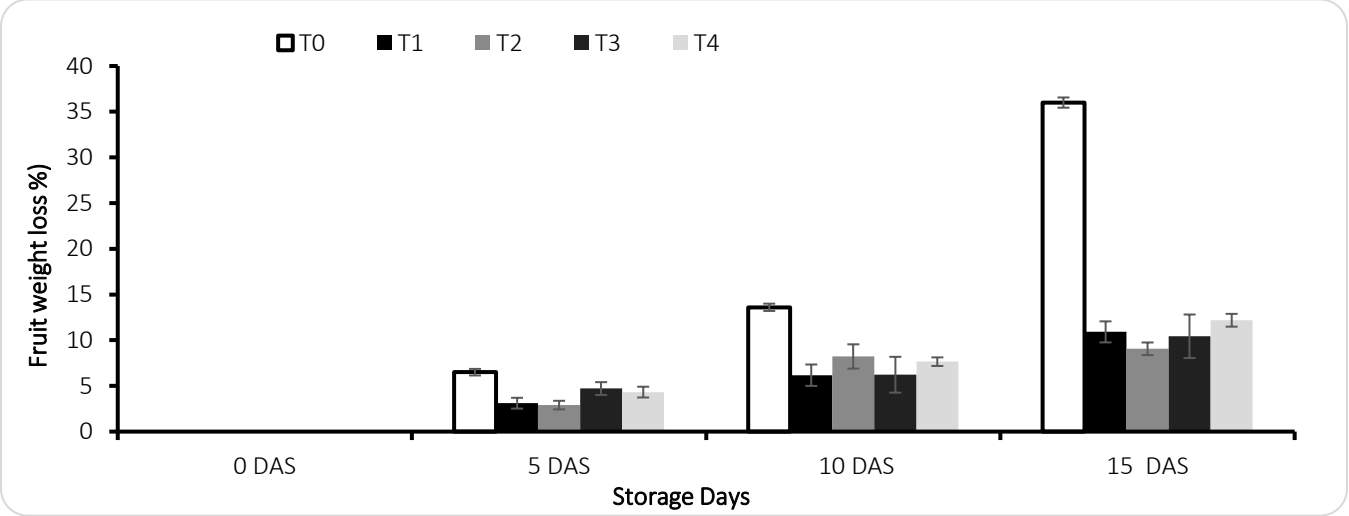

Figure 2. Postharvest management of guava by using different coating materials on fruit weight loss%) of the guava fruit. T0 = Control, T1 = 0.5% potato starch, T2 = 0.5% sodium nitroprusside, T3 = 0.5% potato starch + 0.5% sodium nitroprusside and T2 =0.25% potato starch + 0.25% sodium nitroprusside. Vertical bars represent the average standard deviation3 repetitions, n = 24 fruits per treatment).

Fruit decay Score

The analysis of variance revealed that 'Guava' had highly significant differences between storage days and the interaction between storage days and treatments, while the treatments showed non-significant findings Annexure 3). However, the findings showed that treated fruits had less fruit decay between 2.0 and 4.0 Score) after 15 days of storage, but untreated control fruits had a higher decay rate5 Score) on the last day of storage. The fruits of T20.5 % sodium nitroprusside) and T30.5 % potato starch + 0.5 % sodium nitroprusside) produced the greatest results.

Annexure 3. Analysis of variance table for decay.

Source	DF	SS	MS	F	P
Treatment	4	1.9000	0.47500	2.19	0.0872^{NS}
Storage Days	3	17.1333	5.71111	26.36	0.0000**
Storage Days X Treatment	12	11.0333	0.91944	4.24	0.0003**
Error	40	8.6667	0.21667		
Total	59	38.7333			

Grand Mean = 1.4333,CV = 32.47, ** = highly significant at $P \leq 0.001$ and ^{NS} = non-significant at $P \leq 0.05$.

Fruit spoilage during storage is caused by fungal spores and microbial contamination. Because it lowers fruit quality while it is being stored, fruit decay is one of the most important issues that may arise in the fruit industry(Embaby *et al.*, 2012). Water loss from the fruit's surface is most likely the subsequent source of

crack formation, which gives a location for microbial activity. However, potato starch and sodium nitroprusside can act as an antifungal covering for many fruits and vegetables, dramatically lowering the decay index in this experiment. Overall lower weight loss of fruit, decay, and retention of soluble solid contents as well as titratable acidity contents investigated in guava (Alam *et al.*, 2014) and Kinnow mandarin (Khorram *et al.*, 2017)results support our findings.

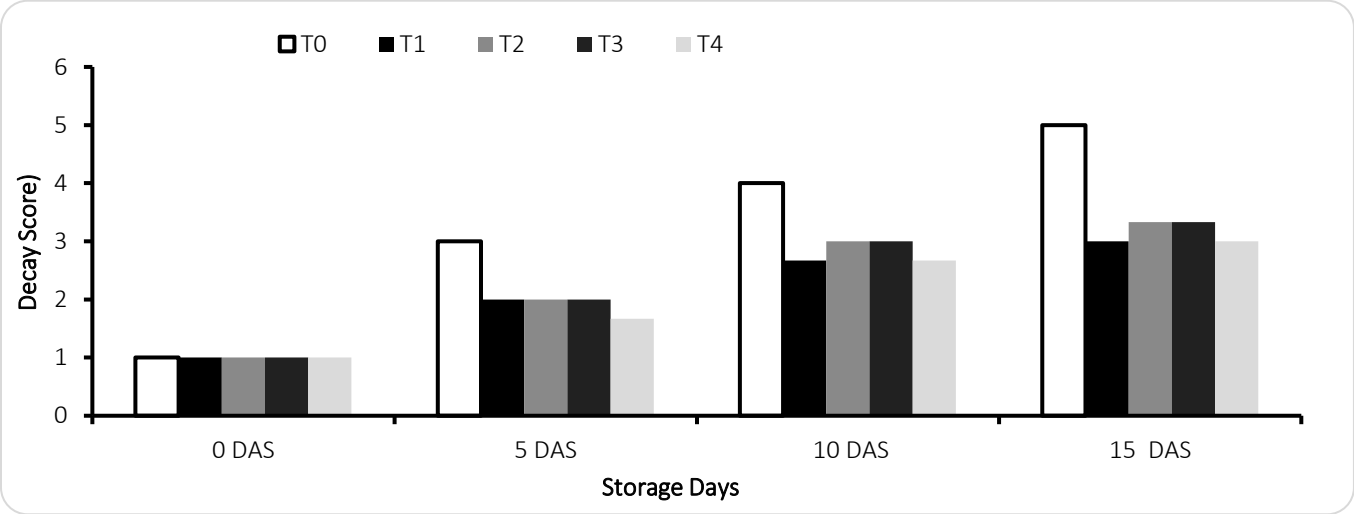

Figure 3. Postharvest management of guava by using different coating materials on fruit decay Score) of the guava fruit. T0 = Control, T1 = 0.5% potato starch, T2 = 0.5% sodium nitroprusside, T3 = 0.5% potato starch + 0.5% sodium nitroprusside and T2 =0.25% potato starch + 0.25% sodium nitroprusside. Vertical bars represent the average standard deviation3 repetitions, n = 24 fruits per treatment).

Disease incidence Score

The results regarding disease incidence revealed that the effect of treatments and interaction between treatments and storage days on disease incidence in the 'Guava' fruit was highly significant. However, the results regarding storage days were significant Annexure 4).The results unveiled that there was no disease incidence on the pre-storage day. It was observed that during the first 5 days, there were no disease symptoms in all treatments, however, T_0 started to show disease symptoms after 5 days of storage. As the storage period progressed, the disease incidence gradually increased for T_0. After 15 days of storage, a swift increase in disease symptoms was noticed in all treatments. The maximum fruit disease incidence score5 score) was noted in the T_0control treatment) as compared toT_4) 0.25% potato starch + 0.25% sodium nitroprusside treated fruits which showed less score of disease incidence3.67 score).

The physiological changes and senescence process are the cause of fruits' susceptibility to diseases during postharvest storage(Embaby *et al.*, 2012). Generally, sodium nitroprusside lessens chilling injury, controls diseases induce pathogenic resistance, and alleviate physiological disorders during storage(Alam *et al.*, 2019).So, the best results were found in the fruits ofT_4) 0.25% potato starch + 0.25% sodium nitroprusside treated fruits.

Annexure 4.Analysis of variance table for diseases incidence.

Source	DF	SS	MS	F	P
Treatment	4	1.7667	0.44167	3.79	0.0106*
Storage Days	3	10.7333	3.57778	30.67	0.0000**
Storage Days X Treatment	12	6.7667	0.56389	4.83	0.0001**
Error	40	4.6667	0.11667		
Total	59	23.9333			

Grand Mean = 1.3667, CV = 24.99, ** = highly significant at $P \leq 0.001$ and * = significant at $P \leq 0.05$.

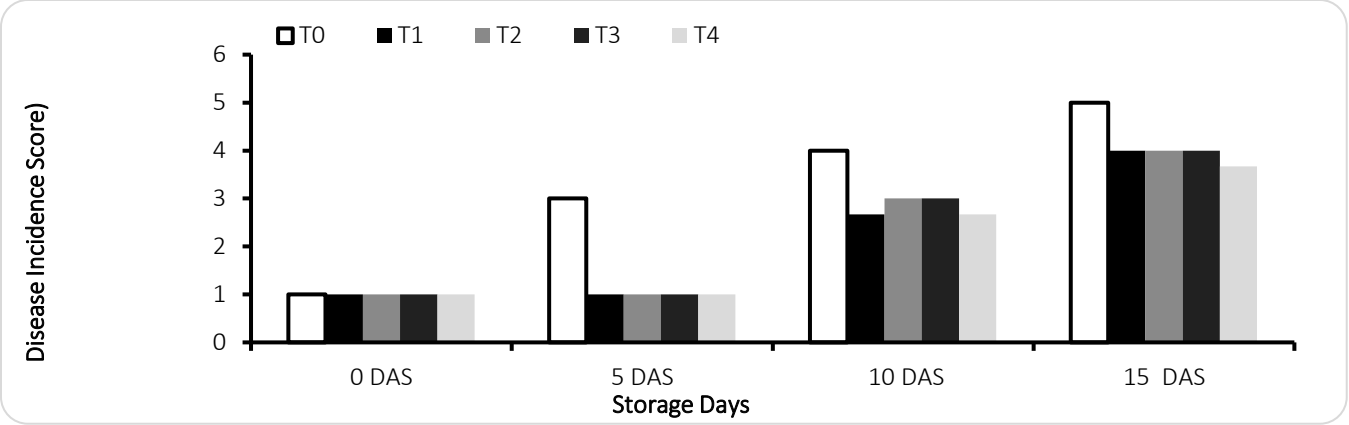

Figure 4. Postharvest management of guava by using different coating materials on disease incidences Score) of the guava fruit. T0 = Control, T1 = 0.5% potato starch, T2 = 0.5% sodium nitroprusside, T3 = 0.5% potato starch + 0.5% sodium nitroprusside and T2 =0.25% potato starch + 0.25% sodium nitroprusside. Vertical bars represent the average standard deviation3 repetitions, n = 24 fruits per treatment).

Marketability index%)

The data concerning the fruit marketability index%) of the 'Guava' fruit is Statistical analysis at the 5% level of significance revealed extremely significant findings for the storage duration, however, showed significant results for treatments and combined effect of treatments and storage days Annexure 5). The maximum fruit marketability index%) of guava75%) was recorded in fruits of $T_1$0.5% potato starch) as compared to the fruits of other treatments at the end of the storage period. Fruits of T_0Control) showed the lowest43.33%) a percentage of the fruit marketability index.

The marketability index of guava gradually reduced with the advancement in the storage period. However, potato starch and sodium nitroprusside-coated guava fruits displayed and maintain more marketability index during storage as compared to uncoated fruits. The findings of (Gurjar *et al.*, 2018), who investigated the effect of postharvest sodium nitroprusside treatments on the quality and marketability of guava fruits, confirm the conclusions of this research. As a consequence, the greatest findings were discovered in T1 fruits0.5% potato starch).

Visual quality score)

The results about the effect of potato starch and sodium nitroprusside coating on the visual quality score) of guava fruit showed significant results. The statistical analysis of visual quality findings revealed highly significant differences between storage duration and treatments; moreover, the interaction between treatments and storage days revealed significant differences Annexure 6). The highest score between 4 and 6 Score) of visual quality was recorded in fruits treated with different concentrations of potato starch and sodium nitroprusside. However, the lowest score of visual quality was recorded in control fruits3 Score). Results are in line with the results of (Khorram *et al.*, 2017) who studied the postharvest coatings on fruit quality antioxidant metabolism in Kinnow. The fact is that edible coatings act as barriers and hinder stomata and guard cells. The steady incline in these fruit quality attributes with the progression of the storage period is due to increased metabolic processes like transpiration and respiration(Mathew, 2010). So, the best results were found in fruits of $T_2$0.5% sodium nitroprusside), $T_3$0.5% potato starch + 0.5% sodium nitroprusside) and $T_4$0.25% potato starch + 0.25% sodium nitroprusside).

Annexure 5.Analysis of variance table for marketability index.

Source	DF	SS	MS	F	P
Treatment	4	800.15	200.038	4.00	0.0080*
Storage Days	3	2720.80	906.933	18.12	0.0000**
Storage Days X Treatment	12	1272.65	106.054	2.12	0.0377*
Error	40	2001.58	50.039		
Total	59	6795.18			

Grand Mean = 92.518CV = 7.65** = highly significant at $P \leq 0.001$ and * = significant at $P \leq 0.05$.

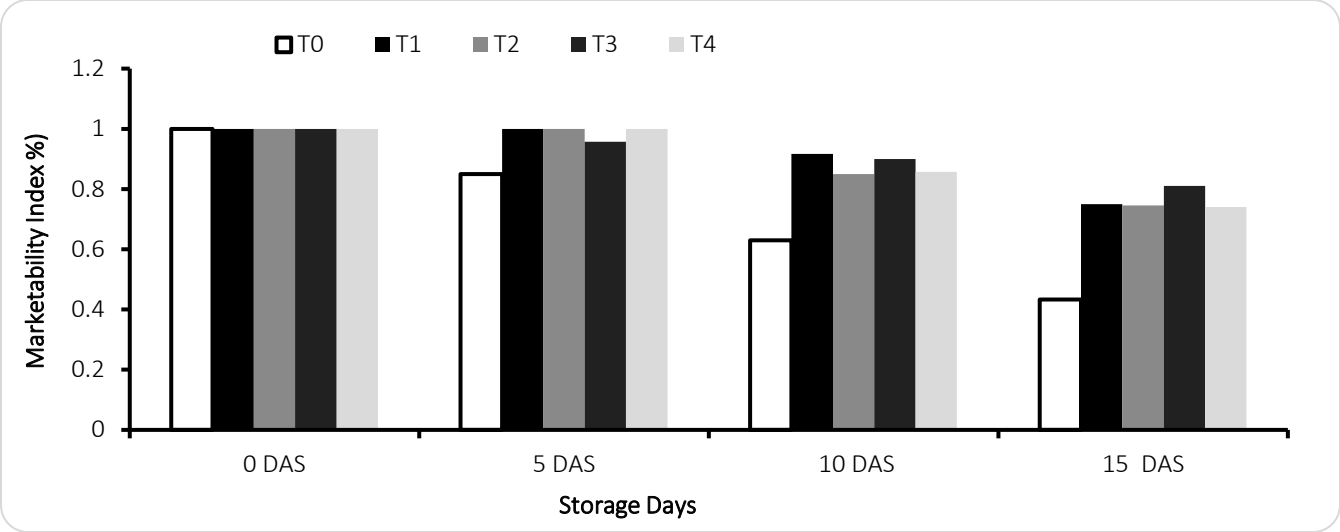

Figure 5. Postharvest management of guava by using different coating materials on fruit marketability index%) of the guava fruit. T0 = Control, T1 = 0.5% potato starch, T2 = 0.5% sodium nitroprusside, T3 = 0.5% potato starch + 0.5% sodium nitroprusside and T2 =0.25% potato starch + 0.25% sodium nitroprusside. Vertical bars represent the average standard deviation3 repetitions, n = 24 fruits per treatment).

Annexure 6.Analysis of variance table for visual quality.

Source	DF	SS	MS	F	P
Treatment	4	7.067	1.7667	5.30	0.0010**
Storage Days	3	113.800	37.9333	113.80	0.0000**
Storage Days X Treatment	12	10.533	0.8778	2.63	0.0108*
Error	40	13.333	0.3333		
Total	59	144.733			

Grand Mean = 7.7667, CV = 7.43, ** = highly significant at $P \leq 0.001$ and * = significant at $P \leq 0.05$.

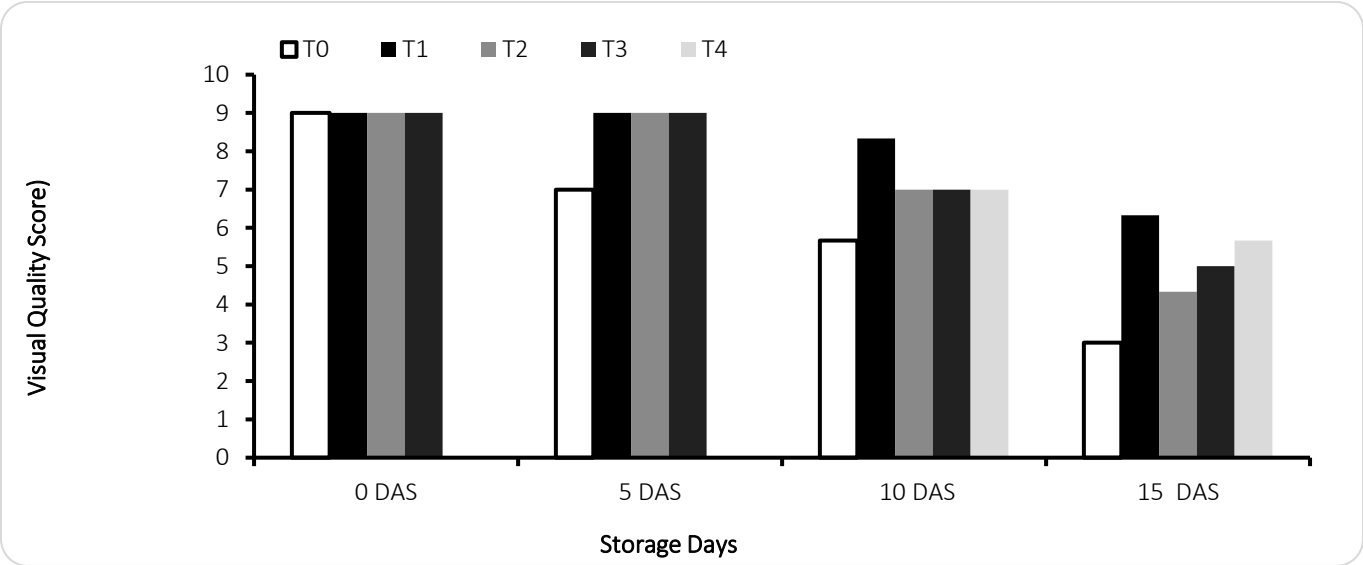

Figure 6. Postharvest management of guava by using different coating materials on fruit visual quality Score) of the guava fruit. T0 = Control, T1 = 0.5% potato starch, T2 = 0.5% sodium nitroprusside, T3 = 0.5% potato starch + 0.5% sodium nitroprusside and T2 =0.25% potato starch + 0.25% sodium nitroprusside. Vertical bars represent the average standard deviation3 repetitions, n = 24 fruits per treatment).

Biochemical Fruit quality traits

Total soluble solids °Brix

TSS observations were very significant for treatments, storage days and interactions between treatments and storage days, according to the findings Annexure 8). The greatest statistically assessed mean of TSS was seen6.83 °Brix) on the pre-storage day, while the minimum TSS mean value4.83 °Brix) was observed in T1 = 0.5 percent potato starch fruits on the 15th day of storage. Fig 4.13). However, higher TSS was observed in fruits of T_4= 0.25% potato starch + 0.25% sodium nitroprusside5.97 °Brix)as compared to untreated fruits of T_0 = control treatment5.57 °Brix).

Total soluble solids content, which continues to increase with the ripening of guava fruit is a crucial indicator in assessing the quality of guava fruit(Rueda, 2005). In our investigation, the total soluble solids of guava fruit began to rise as storage time progressed. The evaporation of active compounds present in coatings might be responsible for the decline in titratable acidity and the combination of various edible coatings provide a greater extent and retain a higher amount of titratable acidity and soluble solid contents(Yadav *et al.*, 2022).As a consequence, the greatest results were discovered in T4 fruits0.25% potato starch + 0.25% sodium nitroprusside).

Annexure 8.Analysis of variance table for TSS.

Source	DF	SS	MS	F	P
Treatment	4	50.6828	12.6707	16038.9	0.0000**
Storage Days	3	6.2818	2.0939	2650.53	0.0000**
Storage Days X Treatment	12	19.4258	1.6188	2049.14	0.0000**
Error	40	0.0316	0.0008		
Total	59	76.4220			

Grand Mean = 8.8663, CV = 0.32 and** = highly significant at $P \leq 0.001$.

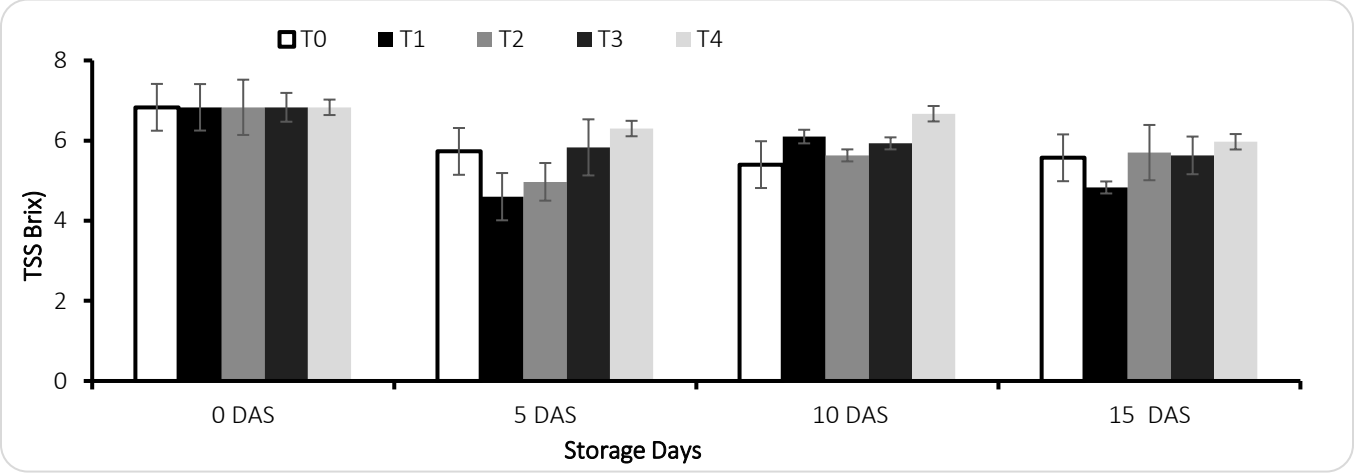

Figure 7. Postharvest management of guava by using different coating materials on TSSBrix) of the guava fruit. T_0 = Control, T_1 = 0.5% potato starch, T_2 = 0.5% sodium nitroprusside, T_3 = 0.5% potato starch + 0.5% sodium nitroprusside and T_2 = 0.25% potato starch + 0.25% sodium nitroprusside. Vertical bars represent the average standard deviation3 repetitions, n = 24 fruits per treatment).

Titratable acidity TA %)

During ambient storage, guava demonstrated substantial diversity in terms of storage days, treatments, and interaction between treatments and storage days Annexure 9). Pre-storage day revealed the titratable acidity0.5 %) of all treatments. An increased trend was seen during the storage period after 15 days of storage. The highest value TA0.82%) was found in T_0 the control treatment followed by the0.63 %) in the fruits of treatment $T_1$0.5% potato starch). The minimum values0.52 %) was recorded in the fruits of $T_2$0.5% sodium nitroprusside). Therefore, the finest results were

discovered in the fruits of T20.5 % sodium nitroprusside).

The largest drop in TA during storage indicates senescence. On fruit surfaces, edible coatings create a thin layer that slows gas exchange and respiration. Our results paralleled those of (Yadav *et al.*, 2022), in which pear fruit exhibited a similar trend in terms of soluble solid content and titratable acidity retention after the application of sodium-based coatings for quality preservation and shelf-life enhancement of pear fruit.

Annexure 9. Analysis of variance table for TA.

Source	DF	SS	MS	F	P
Treatment	4	0.07497	0.01874	1606.57	0.0000**
Storage Days	3	0.17495	0.05832	4998.62	0.0000**
Storage Days X Treatment	12	0.86511	0.07209	6179.33	0.0000**
Error	40	0.00047	0.00001		
Total	59	1.11550			

Grand Mean = 0.5548, CV = 0.62 and ** = highly significant at $P \leq 0.001$.

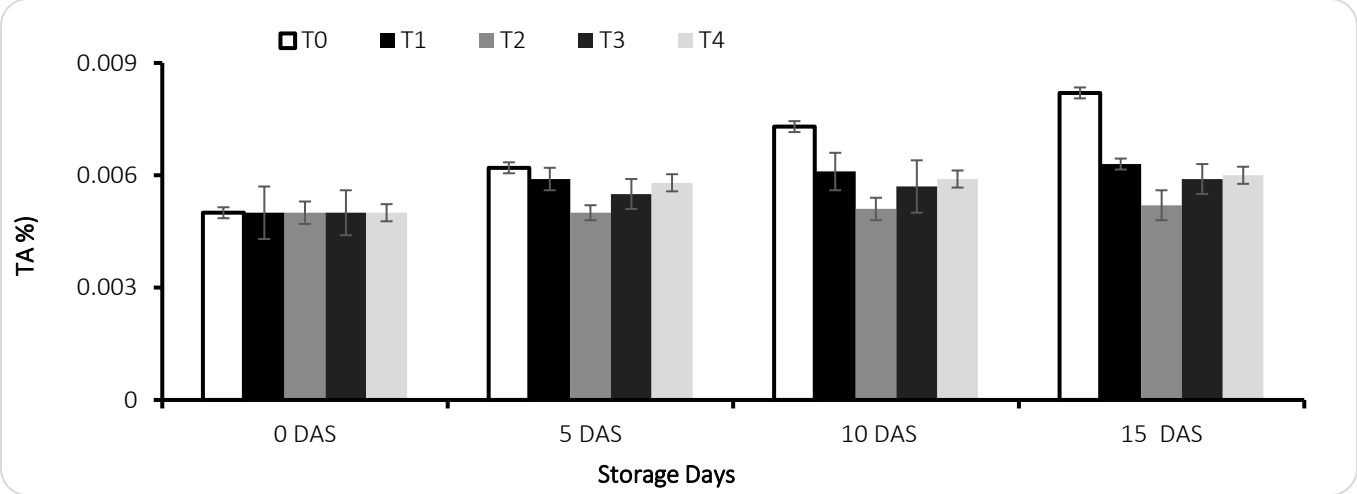

Figure 8. Postharvest management of guava by using different coating materials on TA%) of the guava fruit. T0 = Control, T1 = 0.5% potato starch, T2 = 0.5% sodium nitroprusside, T3 = 0.5% potato starch + 0.5% sodium nitroprusside and T2 =0.25% potato starch + 0.25% sodium nitroprusside. Vertical bars represent the average standard deviation3 repetitions, n = 24 fruits per treatment).

CONCLUSIONS

It is concluded that the various potato starch and sodium nitroprusside treatments had positive impacts on the qualitative characteristics of guava fruit. However, the use of edible coatings containing 0.25 % potato starch + 0.25 % sodium nitroprusside, 0.5 % sodium nitroprusside, and 0.5 % potato starch + 0.5 % sodium nitroprusside is more advantageous than the use of other coatings. By producing a semipermeable layer on the surface of the fruit, this coating reduces the respiration rate and maintains the interior environment of the fruit, so preserving the postharvest quality of the fruit.

REFERENCES

Aghdam, M. S., Z. Luo, A. Jannatizadeh, M. Sheikh-Assadi, Y. Sharafi, B. Farmani, J. R. Fard and F. Razavi. 2019. Employing exogenous melatonin applying confers chilling tolerance in tomato fruits by upregulating ZAT2/6/12 giving rise to promoting endogenous polyamines, proline, and nitric oxide accumulation by triggering arginine pathway activity. Food Chemistry, 275: 549-556.

Ainsworth, E. A. and K. M. Gillespie. 2007. Estimation of total phenolic content and other oxidation substrates in plant tissues using Folin–Ciocalteu reagent. Nature protocols, 2: 875-877.

Alam, K., M. Alam, M. Islam, R. Momotaz, M. Arifunnahar,

M. Humauan, D. Sarkar, S. Das and S. Banu. 2019. First report of Nalanthamala psidii causing wilt disease of guava in Bangladesh. Plant Dis, 103: 1042.

Alam, M. M., A. F. Saleem, A. S. Shaikh, O. Munir and M. Qadir. 2014. Neonatal sepsis following prolonged rupture of membranes in a tertiary care hospital in Karachi, Pakistan. The Journal of Infection in Developing Countries, 8: 067-073.

Asgher, M., T. S. Per, A. Masood, M. Fatma, L. Freschi, F. J. Corpas and N. A. Khan. 2017. Nitric oxide signaling and its crosstalk with other plant growth regulators in plant responses to abiotic stress. Environmental Science and Pollution Research, 24: 2273-2285.

Azzolini, M., A. P. Jacomino, I. U. Bron, R. A. Kluge and M. A. Schiavinato. 2005. Ripening of" Pedro Sato" guava: study on its climacteric or non-climacteric nature. Brazilian Journal of Plant Physiology, 17: 299-306.

Bodanapu, R., S. K. Gupta, P. O. Basha, K. Sakthivel, Y. Sreelakshmi and R. Sharma. 2016. Nitric oxide overproduction in tomato shr mutant shifts metabolic profiles and suppresses fruit growth and ripening. Frontiers in Plant Science, 7: 1714.

Chauhan, O., C. Nanjappa, N. Ashok, N. Ravi, N. Roopa and P. Raju. 2015. Shellac and Aloe vera gel based surface coating for shelf life extension of tomatoes. Journal of food science and technology, 52: 1200-1205.

Cho, E., T. Yokozawa, D. Rhyu, S. Kim, N. Shibahara and J. Park. 2003. Study on the inhibitory effects of Korean medicinal plants and their main compounds on the 1, 1-diphenyl-2-picrylhydrazyl radical. Phytomedicine, 10: 544-551.

Domingos, P., A. M. Prado, A. Wong, C. Gehring and J. A. Feijo. 2015. Nitric oxide: a multitasked signaling gas in plants. Molecular plant, 8: 506-520.

Embaby, E., L. Hagagg and M. Abdel-Galil. 2012. Decay of some fresh and dry fruit quality contaminated by some mold fungi. Journal of Applied Sciences Research: 3083-3091.

Fatemi, H. and L. Dube. 2013. Effect of Csr attributes of food products on taste evaluation, mediation role of naturalness. ACR North American Advances.

Fekry, O. M. 2018. Effect of edible coating chitosan and calcium gluconate on maintaining fruit quality and marketability of Guava (Psidium guajava) fruits during storage. Middle East Journal of Applied Sciences, 8: 1046-1060.

Guo, K., T. Liu, A. Xu, L. Zhang, X. Bian and C. Wei. 2019. Structural and functional properties of starches from root tubers of white, yellow, and purple sweet potatoes. Food Hydrocolloids, 89: 829-836.

Gurjar, P., B. Killadi, J. Lenka and D. Shukla. 2018. Effect of gum arabic coatings on physico-chemical and sensory qualities of guava (Psidium guajava L.) cv. Shweta. International Journal of Current Microbiology and Applied Sciences, 7: 3769-3775.

Hassan, B., S. A. S. Chatha, A. I. Hussain, K. M. Zia and N. Akhtar. 2018. Recent advances on polysaccharides, lipids and protein based edible films and coatings: A review. International journal of biological macromolecules, 109: 1095-1107.

Hassimotto, N. M. A., M. I. Genovese and F. M. Lajolo. 2005. Antioxidant activity of dietary fruits, vegetables, and commercial frozen fruit pulps. Journal of Agricultural and Food Chemistry, 53: 2928-2935.

Hortwitz, W. 1960. Official and tentative methods of analysis. Association of the Official Agriculture Chemist, Washington, DC, 9: 320-341.

Kader, A. A. 2002. Quality parameters of fresh-cut fruit and vegetable products. Fresh-cut fruits and vegetables. Science, technology and market: 11-20.

Kamath, J., N. Rahul, C. A. Kumar and S. M. Lakshmi. 2008. Psidium guajava L: A review. International Journal of Green Pharmacy (IJGP), 2.

Khorram, F., A. Ramezanian and S. M. H. Hosseini. 2017. Effect of different edible coatings on postharvest quality of 'Kinnow'mandarin. Journal of Food Measurement and Characterization, 11: 1827-1833.

Khushk, A. M., A. Memon and M. I. Lashari. 2009. Factors affecting guava production in Pakistan. Journal of Agricultural Research (03681157), 47.

Liu, C., H. Yao, S. J. Chapman, J. Su and C. Wang. 2020. Changes in gut bacterial communities and the incidence of antibiotic resistance genes during degradation of antibiotics by black soldier fly larvae. Environment International, 142: 105834.

Malik, M. 1993. Challenges for the Year 2000 in the Field of Horticulture. Proc. First International Horticulture Seminar. January. p. 9-11.

Maqbool, M., A. Ali, S. Ramachandran, D. R. Smith and P.

G. Alderson. 2010. Control of postharvest anthracnose of banana using a new edible composite coating. Crop Protection, 29: 1136-1141.

Mathew, S. 2010. The prevalence of fungi on the post harvested guava (Psidium guajava L.) in Aksum. International Journal of Pharmaceutical Sciences and Research, 1: 145.

Nasef, I. N. 2018. Short hot water as safe treatment induces chilling tolerance and antioxidant enzymes, prevents decay and maintains quality of cold-stored cucumbers. Postharvest Biology and Technology, 138: 1-10.

Orfanidou, M. A., A. Lafioniatis, A. Trevlopoulou, N. Touzlatzi and N. Pitsikas. 2017. Acute and repeated exposure with the nitric oxide (NO) donor sodium nitroprusside (SNP) differentially modulate responses in a rat model of anxiety. Nitric Oxide, 69: 56-60.

Reddy, A. R., K. Chaitanya, P. Jutur and K. Sumithra. 2004. Differential antioxidative responses to water stress among five mulberry (Morus alba L.) cultivars. Environmental and experimental botany, 52: 33-42.

Rueda, F. d. M. N. 2005. Guava (Psidium guajava L.) fruit phytochemicals, antioxidant properties and overall quality as influenced by postharvest treatments. (Unpublished) thesis, University of Florida Gainesville.

Saengnil, K., K. Lueangprasert and J. Uthaibutra. 2006. Control of enzymatic browning of harvested 'Hong Huay'litchi fruit with hot water and oxalic acid dips. ScienceAsia, 32: 345.

Sapper, M. and A. Chiralt. 2018. Starch-based coatings for preservation of fruits and vegetables. Coatings, 8: 152.

Silip, J., R. Yung, K. Lim, M. Mohamad and S. Hamdan. 2014. Postharvest life of guava fruit under selected postharvest handling practices. Proc. Int. Conf. Plant Physiology. p. 152-158.

Steinhaus, M., D. Sinuco, J. Polster, C. Osorio and P. Schieberle. 2008. Characterization of the aroma-active compounds in pink guava (Psidium guajava, L.) by application of the aroma extract dilution analysis. Journal of agricultural and food chemistry, 56: 4120-4127.

Wang, A., R. Li, L. Ren, X. Gao, Y. Zhang, Z. Ma, D. Ma and Y. Luo. 2018. A comparative metabolomics study of flavonoids in sweet potato with different flesh colors (Ipomoea batatas (L.) Lam). Food chemistry, 260: 124-134.

Yadav, A., N. Kumar, A. Upadhyay, O. A. Fawole, M. K. Mahawar, K. Jalgaonkar, D. Chandran, S. Rajalingam, G. Zengin and M. Kumar. 2022. Recent advances in novel packaging technologies for shelf-life extension of guava fruits for retaining health benefits for longer duration. Plants, 11: 547.

Yun, Z., H. Qu, H. Wang, F. Zhu, Z. Zhang, X. Duan, B. Yang, Y. Cheng and Y. Jiang. 2016. Comparative transcriptome and metabolome provides new insights into the regulatory mechanisms of accelerated senescence in litchi fruit after cold storage. Scientific Reports, 6: 1-16.

Zahedyan, A., A. A. Jahromi, A. Zakerin, V. Abdossi and A. M. Torkashvand. 2022. Nitroxin bio-fertilizer improves growth parameters, physiological and biochemical attributes of cantaloupe (Cucumis melo L.) under water stress conditions. Journal of the Saudi Society of Agricultural Sciences, 21: 8-20.