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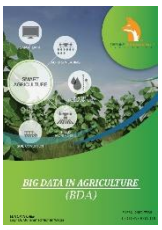

RESEARCH ARTICLE

EFFECT OF DIFFERENT POST-HARVEST TREATMENT ON SHELF-LIFE AND QUALITY OF TOMATO (*SOLANUM LYCOPERSICUM VAR* GAURAV555)

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ABSTRACT

Shelf life and quality of tomato is influenced by fruit senescence, firmness, technology availability as well as farmers' storage practices. Therefore, a lab experiment is conducted to study the effects of different post-harvest treatments on shelf life and quality of tomatoes with seven treatments (1% & 1.5% CaCl2, 0.3% &0.1% GA3, Aloe Vera extract, Guava leaf extract and control) in Completely Randomized Design (CRD) with three replications. Physiological Weight Loss (PWL), Total Soluble Solid, Firmness, Decay, Shelf life and Titrable Acidity were investigated. Data was collected every three days during the fortnight-long observation of tomato post-harvest behaviour during storage. Statistically significant differences were found in between the treatments which were observed through excel and Gen-stat 18th edition. The control showed the greatest rise in PWL percentage (10.617) and 0.3% GA3 acid had the lowest proportion of PWL (8.01). The maximum TSS concentration was recorded in control (0.322) at day 15, while the lowest TSS concentration (0.1333) was recorded in 0.3% GA3 acid. Treatment with 0.3% GA3 showed the minimum decay loss from 9 days to 15 days but the controlled exhibited the maximum decay. Maximum TA was recorded in 0.1% GA3 (0.2518) at 15 days while controlled had the lowest TA (0.1503). The maximum firmness (5.733) was demonstrated by 0.3% GA3 at 15 days while control demonstrated the least (3.467). Thus, from the above results it could be concluded that post-harvest treatment with GA3 (0.3%) has the potential to control decay and prolong the storage life at ambient conditions.

KEYWORDS

Post-harvest, Quality, Shelf life, Tomato, Treatment

1. INTRODUCTION

Tomato (Solanum Lycopersicum) is globally cultivated for its fleshy fruits which is botanically classified as a fruit (berry) but often regarded as a vegetable (Dias et al., 2019; Ayomide et al., 2019). It is the third most significant vegetable in Nepal in terms of area and output after cauliflower and cabbage and is believed to have originated in tropical America. It is edible with red berry-like fruit (Babu et al., 2016). The plant is perennial in its natural habitat and is frequently grown as a seasonal crop in open fields. Tomatoes are an excellent source of vitamins A, C, E and K (Bhowmik et al., 2012). Lycopene, an antioxidant contained in tomatoes, aids in the battle against the development of cancerous cells (Pék et al., 2010). In many countries around, tomato has occupied second rank considering its importance after potato. It comes in first place among canned vegetables. The crop is cultivated in the plains during the winter and in the hills during the summer as an off- season crop. The tomato production in 2021/22 was 422703metric tons in 22911 ha with yield 18.45 metric tons/ha (MoALD, 2023).

In most parts of Nepal, tomatoes are cultivated both in-season and off-season. In Nepal, tomato consumption has been rising in recent years-driving up market demand all year long. The post- harvest loss rate for tomatoes being a perishable vegetable crop is higher than other crops at roughly 22.8% during the marketing campaign. In addition, fungus and bacteria-based post-harvest illnesses account for a sizeable share of post-harvest losses. As it is a climacteric fruit, ripening continue even after harvest, leads to increase in ethylene production (Sammi and Masud, 2007). The beginning of ripening is accompanied by a sharp increase in respiration rate known as respiratory climacteric during which complex substrates undergo oxidative breakdown, ageing and product degradation results. Tomatoes continue to lose water after harvest since they are fleshy fruit. Shelf life is also influenced by whether the stalk is present. It is reported that fruits with stalksexhibited less infection during ripening compare to those without stalks (Sood et al., 2011).

Nepal's tomato productivity is significantly lower compared to other regions of the world. Similar to this, post-harvest losses in tomatoes are also highly significant and account for roughly 22.8% of total losses which further reduces the profit for both farmers and traders. Farmers lose a significant amount of their production each year because tomatoes are perishable. Finding the best post-harvest methods to extend shelf life is essential to reducing post-harvest losses and ultimately motivating the less fortunate farmers to cultivate this crop more extensively and intensively. Therefore, the only other option is to increase the shelf life so they can be shipped to distant markets and made available during the off-season. Tomato transportation can suffer significant losses of up to 25-42% as a result of improper tomato harvesting, handling, and storage (Arah et al., 2015).

After harvest, tomato fruits continue to undergo physiological changes. These changes affect the fruit's quality and shelf life. The type of varietals, the stage of the fruits during harvest, the techniques of harvest, and different endogenous and exogenous factors all play a role in these variations. The quality of tomatoes begins to decline the moment they are

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separated from their natural nutrient source, quality reduction sets in and this is due to a natural process that starts as soon as the biological cycle is interrupted by harvesting (Žnidarčič and Požrl, 2006). In prolong the shelf life of tomatoes, it is essential to slow down deteriorative processes such as regulating the production and effects of ethylene (Ochida et al., 2018).

Postharvest loss is a major challenge hampering tomatoes production in most developing countries (Swetha and Banothu, 2019). There is no much concern given to increase the shelf life of tomato in Nepal. A large amount of tomato is wasted in main season as they are harvested improperly resulting the decreases in shelf life and are transported in the truck without the use of packaging materials that is contributing greater % share in the profit as well as creating environmental pollution too discouraging the farmers to cultivate tomato though it already has virus, nematode problem during its cultivation. While new varieties have been introduced, post-harvest practices and storage arrangements to lengthen the shelf life and maintain quality were not improved to boost tomato production. There is a belief that decreasing post-harvest losses is preferable to expand the area under cultivation because a 10% decrease in post-harvest losses translates into a 10% increase in tomato yield.

Therefore, research into various strategies to prevent ripening and enhance quality is necessary to increase tomato productivity in Nepal.In recent times, Gibberellic acid (GA_3) and calcium chloride ($CaCl_2$) have gained popularity globally for extending the shelf life of perishable fruits like tomato. These chemicals are recognized for their abilities to preserve both the physicochemical and biochemical properties of such products. However, there is limited information available aboutpost-harvest use in Nepal. Therefore, study is needed to examine the impact of GA_3 and $CaCl_2$ on shelf life of tomatoes during storage. Synthetics such as Sodium hypochloride, Sodium metabisulphite, and Calcium chloride have been used to preserve tomato fruits. However, there is growingconcern about the use of synthetics on horticultural crops like tomatoes. Despite this, there has been a limited exploration into the use of plants for preservation which are cheap, readily available and easy to use (Liamngee et al., 2017).

The study seeks to enhance the shelf life and quality of tomatoes through effective post-harvest treatments, examine the physiological changes as influenced by different treatments to extend the tomato shelf life and identify specific physiological factors that lead to the deterioration of tomato quality.

2. Materials and Methodology

The experiment was carried out at the horticulture laboratory of Prithu Technical College, Deukhuri, Dang during the spring season (18th march 2024 to 2nd April 2024) in the laboratory. The area lies within the subtropical agro-ecological belt, between 27.8620 N Latitude and 84.8442 E Longitude with an altitude of 629 masl. The maximum temperature recorded was 29°C and minimum was 26°C.The experiment was conducted in a completely randomized design (CRD) with 7 treatments and each treatment was replicated 3 times. The treatments were:

T1 = 1% $CaCl_2$

T2 = 1.5% $CaCl_2$

T3 = Aloe Vera extract (100 ml per treatment)

T4 = 0.3% GA_3

T5 = 0.1% GA_3

T6 = Guava leaf extract (100 ml per treatment)

T7 = Control

At the beginning, a well-ventilated site was selected, and the experimental site was cleaned. Additionally, tomatoes were washed thoroughly before placing them in each tray. Moreover, the uniform size tomatoes about 850 grams were taken in each tray. Furthermore, those tomatoes were subjected to treatment. Then appropriate treatments were prepared. In addition to it, tomatoes were dipped in Aloe Vera extract, $CaCl_2$ solution and GA_3 for each treatment for 20 minutes. Then tomatoes were sprayed with guava leaf extract for 20 minutes. Finally, data reading was done in three days interval for five times.

2.1 Acquisition of materials

The materials required for the experiment including chemicals and other laboratory equipment were brought from the near market. Furthermore, plant materials like Aloe Vera and guava leaf were collected from the campus periphery. The required amount of tomato, plant materials and plastic trays were brought to the college laboratory. 18 K.G. of Gaurav variety tomatoes were brought from the farm which is located near the college. The uniform size fruits were selected for each treatment and replications to reduce the biasness. The damaged fruits were eliminated. Tomatoes of green peel and uniform size were selected.

2.2 Preparation of Aloe Vera extract

Fully expanded, mature, healthy and fresh leaves of Aloe Vera were collected from the plants using a sharp knife and washed with clean water then with sterilize distilled water. The tapering point of the leaf top and the short sharp spines located along the leaf margins were removed by sharp knife and then the knife was inserted into the mucilage layer beneath the green rind, taking care to avoid the vascular bundles. The top and bottom of the leaves were removed and then the Aloe Vera gel was extracted. After separating AloeVera gel from the outer cortex, this colorless hydro parenchyma was blended to remove fibers and put in clean and sterilize bottles for further use.

2.3 Preparation of guava leaf extract

The guava leaf (20 gm) was boiled at 90°C in 100 ml of distilled water in sterilized flask for 30 min. The mixture was centrifuged at 4000 revolution per minute for ten minutes (Biswas et al., 2013). The supernatant was separated.

2.4 Observation

2.4.1 Physiological Weight Loss

The tomatoes were weighed using a weighing balance and weight loss percentage was calculated by using the following formula (Ghimire et al., 2021):

$$\text{Weight Loss} = \frac{\text{Initial Weight - Next Measurement Weight} * 100}{\text{Initial Weight}}$$

2.4.2 Total Soluble Solid (TSS)

The Total Soluble Solid of the fruit was measured with the help of refractometer. The tomato was crushed, and 2-3 drops of the fruit juice was in placed in the prism of the refractometer and then the reading was observed through the eye piece. The reading was observed in °Brix.

2.4.3 Decay Loss (%)

Spoiled fruit was identified through visual observation, specifically by noting signs of rot. The decay percentage was calculated by dividing the number of decayed fruits by the initial total number of fruits and then multiplying by 100.

2.4.4 Firmness

The firmness of the fruit was measured by Penetrometer. The instrument was applied to the top, middle and bottom section of the fruit and the average of the three readings was used to determine fruit's firmness. The result was expressed in (kg/cm2).

2.4.5 Tritable Acidity

To measure the tritable acidity 50gm of pulp of the fruit was grinded in the mixture where 20ml of water was also added to recover the juice. After filtration, 10ml of the juice was taken in the separate conical flask and the volume was made to 50ml which was titrated against 0.1N NaOH using phenolphthalein as indicator. The endpoint was identified when pink colour appeared. Then the tritable acidity was calculated by using the following formula (Kator et al., 2018):

$$\text{TA} = \frac{\text{ml of NaOH} * \text{Molarity Base} * \text{Equivalent Weight of Acid}}{\text{Volume of Sample in ml} * 10}$$

3. Results and Discussion

3.1 Physiological Weight Loss (PWL)

It was discovered that the PWL of tomatoes differ significantly between treatments. As shown in figure 1, the PWL of fruit increased gradually and continuously as the storage period increased in all treatments. The increase in PWL percentage was found maximum in the fruit kept as a control (10.617%). Minimum PWL percentage was observed in the fruit treated with 0.3% GA_3 acid (8.01%) followed by 0.1% GA_3 acid (8.11%) and Guava leaf extract (9.053%).

It was proposed that vapour-phase diffusion, which is influenced by a gradient of water vapour pressure at various sites, was the principal mechanism of moisture loss from fresh fruit and vegetables (Yaman and Bayoindirli, 2002). Additionally, by adding extra physical barriers between the product and the outside air, water loss can be efficiently minimized. Additionally, during the ripening of fleshy fruit, changes in tissue permeability and cellular compartmentation take place (Devkota et al., 2019). In terms of weight loss, it has been suggested that the reduction in fruit treated with GA may be due to its anti-senescent action (Sudha et al., 2007). As a result, in the current study, the GA3 treatments that reduced tissue permeability and thus reduced the rate of water loss may have resulted in a delay in fruit ripening. On the other-hand the guava leaf extract causes the delay as the extract of guava leaves possesses antioxidant and antibacterial properties which make it a natural preservative. Similar finding was reported by (Devkota et al., 2019).

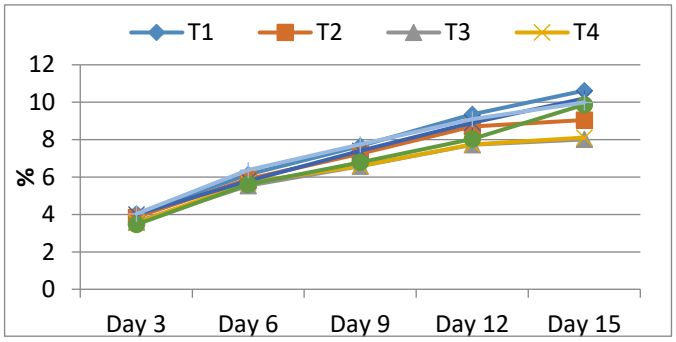

Figure 1: Effect on shelf life extending material on PLW of tomato

3.2 Total Soluble Solid

Different treatments had some significant impact on the TSS content of tomato fruit (Table 1). The TSS content of the fruit was affected by its maturity stage. TSS continued to decline as storage period was prolonged. At day 15 the maximum TSS content found in control tomatoes was (0.322) and the minimum TSS content was found in 0.3% GA_3 acid (0.1333) followed by 1% $CaCl_2$ that is 0.1667 and guava leaf extract (60 ml extract + 240 ml distilled water) that is 0.2.TSS content increased up to 6 days in the current study, followed by a value decrement and storage period extension.

A group researcher made a similar observation in Mango, where TSS content increased linearly up to the sixth day and then began to decline during storage (Islam et al., 2013). TSS increases during storage may be related to the conversion of pectic substances, starch, hemicellulose, or other polysaccharides into soluble sugar, as well as fruit dehydration (Chardonnet et al., 2003). TSS decrement with storage advancement could be due to depleted stored metabolites such as sugar used during the respiration process.

3.3 Decay Loss (%)

Table (1) presents the decay loss, indicating that the loss increased almost significantly as the storage period was extended across all treatments.

The decay loss was observed in control fruit, fruit treated with 0.1% GA_3 acid and Calcium chloride 1.5% after 6 DAYS of storage. As the day increase significant loss in fruit was observed in all treatments that is from 12 DAYS which is shown in the table (1). As a result, from 9 DAYS to 15 DAYS, the tomato treated with 0.3% GA_3 showed the least decay loss followed by 1% calcium chloride and Guava leaf extract, whereas the untreated fruit showed the most decay. The decay loss in the control sample was higher than in the fruit treated with 0.3% GA_3 and 1% $CaCl_2$. The application of calcium chloride reduced decaying loss.

A group researcher identified the change in firmness as an indication of apple cell wall degradaysion and, as a result, a reduction in fruit quality (Chardonnet et al., 2003). According to a study, the loss of firmness caused by cell wall carbohydrate metabolism during storage was associated with increased susceptibility to infection by fungal pathogens (Wang et al., 1993). The chemicals used here may have reduced pathogen susceptibility and slowed decay. Similar finding was reported by (Devkota et al., 2019).

3.4 Tritable Acidity (YA)

The effects of the shelf life extending treatments were found to be non-significant. Table (2) shows that as the storage period extended tritable acidity decreases. At 3 days maximum TA was observed on fruit treated with 0.3% GA_3 (0.3478) followed by 0.1% GA_3 (0.3002) and Aloe Vera extract (0.2988). Similarly, at 15 days maximum TA was observed in 0.1% GA_3 (0.2518) followed by 1% $Cacl_2$ (0.2297) and 0.3% GA_3 (0.2261) whereas the minimum TA was observed in untreated fruit (0.1503).

Changes in TA occur as a result of changes in citric, malic, and ascorbic acids. These acid's concentrations are known to decrease during ripening (Hossain et al., 2020). The decreasing trend in acidity during storage was most likely caused by the use of acid in the tricarboxylic acid cycle during the respiration process. The change in total titratable acids during storage was primarily due to the metabolic activities of living tissues, which cause organic acid depletion (Hossain et al., 2020).

3.5 Firmness

As the storage day advances tomato fruit's firmness shows a significant decreasing pattern. At 3 days after treatment, maximum firmness was shown by 0.3% GA_3 (12.17) followed by 0.1% GA_3 (12.17) and 300 ml guava leaf extract (10.47). As the storage day extended there was gradual decrease in firmness from day 12 to 15. At 15 days maximum firmness was shown by 0.3% GA_3 (5.733) followed by 1% $Cacl_2$ (5.333) and 300ml guava leaf extract (4.430).

The progression of fruit ripening causes a decrease in tomato fruit firmness in all treatments which might may be due to ripening changes initiated by disruptions in cell integration by pectin enzymes, including pectin methylesterase and polygalacturonase (PG) (Safitri et al., 2024). Additionally, it could be the result of the cell walls breaking down, the middle lamella's link weakening as a result of the pectic chemicals being diluted, or the water moving from the skin to the flesh through osmosis during the ripening process (Tagheabady et al., 2024). Fruit softening is caused by a combination of hydrolytic enzymes and fluctuations in hydrostatic pressure within the fruit cells (Tran et al., 2017).

Table 1: Effect of shelf life extending material on Total Soluble Solid and Decay Loss of tomato at Deukhuri, Dang

Treatments	Total Soluble Solid					Decay %		
	Day 3	Day 6	Day 9	Day 12	Day 15	Day 9	Day 12	Day 15
T1	2.5^{a}	2.97^{ab}	1.8^{a}	0.93^{ab}	0.32^{a}	5.56^{a}	22.22^{b}	36.11^{b}
T2	1.93^{a}	3^{b}	1.9^{a}	0.63^{a}	0.2^{a}	0^{a}	5.53^{ab}	22.22^{ab}
T3	2.1^{a}	2.5^{a}	1.63^{a}	0.53^{a}	0.23^{a}	2.77^{a}	16.66^{ab}	30.55^{ab}
T4	2^{a}	2.3^{a}	1.67^{b}	1.5^{a}	0.13^{a}	0^{a}	2.77^{a}	16.66^{a}
T5	2.16^{a}	2.67^{ab}	1.93^{a}	0.47^{a}	0.27^{a}	0^{a}	13.89^{ab}	27.78^{ab}
T6	2.50^{b}	3.17^{ab}	1.4^{a}	0.83^{ab}	0.3^{a}	2.67^{a}	13.88^{ab}	33.33^{ab}
T7	1.9^{a}	2.57^{ab}	1.8^{a}	0.2^{a}	0.17^{a}	0^{a}	8.3^{a}	19.45^{ab}
P-value	0.01	0.001	0.63	0.91	0.93	0.64	0.044	0.026
Grand Mean	2.18	2.59	1.73	0.73	0.22	1.58	11.9	26.6
LSD	0.93	0.91	1.14	0.64	0.34	7.79	11.92	11.92

Table 2: Effect of shelf life extending materials on TA and firmness of tomato at Deukhuri, Dang

Treatments	TA					Firmness				
	Day 3	Day 6	Day 9	Day12	Day15	Day 3	Day 6	Day 9	Day12	Day15
T1	0.21^{a}	0.19^{a}	0.18^{a}	0.17^{a}	0.15^{a}	10.33^{a}	9.13^{a}	7.4^{ab}	6.47^{a}	3.47^{a}
T2	0.29^{a}	0.29^{a}	0.24^{a}	0.23^{a}	0.21^{a}	10.47^{a}	9.5^{a}	8.97^{ab}	6.93^{a}	4.43^{ab}
T3	0.31^{a}	0.28^{a}	0.28^{a}	0.26^{a}	0.25^{a}	12.17^{a}	10.87^{a}	9.37^{b}	7.77^{a}	4.13^{ab}
T4	0.35^{a}	0.32^{a}	0.28^{a}	0.26^{a}	0.23^{a}	12.33^{a}	11.17^{a}	9.23^{b}	7.7^{a}	5.73^{b}
T5	0.29^{a}	0.27^{a}	0.24^{a}	0.23^{a}	0.21^{a}	9.73^{a}	8.83^{a}	7^{a}	5.7^{a}	4.33^{ab}
T6	0.29^{a}	0.27^{a}	0.25^{a}	0.24^{a}	0.18^{a}	9.33^{a}	8.77^{a}	8.1^{ab}	6.6^{a}	4.03^{ab}
T7	0.35^{a}	0.33^{a}	0.27^{a}	0.25^{a}	0.23^{a}	10.7^{a}	9.7^{a}	7.9^{ab}	7.5^{a}	5.33^{b}
P-value	0.24	0.41	0.17	0.745	0.571	0.174	0.071	0.015	0.31	0.007
CV%	23.7	32.5	29.2	33.8	34	13.8	10.7	9.7	16.4	13.7
LSD	0.12	0.154	0.14	0.154	0.115	2.589	1.83	1.403	2	1.08

4. Conclusion

The results clearly showed that GA3 is highly in managing weight loss, decay and changes in composition including TA and TSS in tomato fruit. This chemical can delay the ripening process with minimal quality loss, whereas in the case of control during storage at ambient temperature, there were greater compositional changes with maximum quality loss. Among all tested treatments, GA3 @ 0.3% shows better storage life and maintained quality parameters. Furthermore, it was clearly demonstrated that GA3 has the ability to control decay, extend storage life, and preserve valuable attributes of tomato fruit while retaining nutritional quality. On the basis of our research, we recommended to use post-harvest treatment GA_3 0.3% for optimum shelf life and maintaining the quality of tomato. However, if the $GA_3$is not available then the guava leaf extract can also be used at the farmer levels which have antioxidant that acts as a preservative and is easily available.

Credit Authorship Contribution Statement

All authors had contributed equally in all CrediT role.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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