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RESEARCH ARTICLE

Effect of gibberellic acid on postharvest shelf-life and quality of tomato

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ABSTRACT

Tomato is one of the universally grown and widely consumed vegetable with high nutritive and commercial value. High perishable nature of tomato leads to huge post-harvest losses and thus practices to extend its shelf-life is must. Therefore, this research was carried out to study the effect of Gibberellic Acid (GA3) on the post-harvest shelf-life and quality of tomato. The research was conducted in the horticulture laboratory of IAAS, Lamjung Campus with four treatments viz. 0.05% (T1), 0.1% (T2), 0.3% (T3) GA3 and control (T4) in Completely Randomized Design with six replications. Tomato fruits (var. Dalila) were harvested at the breaker stage in January, 2018. Fruits were kept on trays at room temperature of around 20◦C after dipping on different GA3 concentrations for 15minutes with. Quality and quantity parameters that serve as indicators of ripening stages viz. physiological weight loss, color, decay percentage, total soluble solids and titrable acidity and shelf life were studied. Results showed that GA3 has significant effect on study parameters. Among different GA3 concentrations, treatment with 0.1% GA3 was found to be best with significantly lower weight loss (2.429%), significantly lower total soluble solid (5.3166) and significantly higher titrable acidity (0.849%). Longer shelf-life (96.33days) was observed in 0.1% compared to 0.3% (85.667 days) and 0.05% (83 days).Significantly higher weight loss (5.578%) and lower titrable acidity (0.647%) was observed in control. T2 was found best for post-harvest treatment of tomato. However, its impact on other nutritional aspect and health must be further investigated before application.

Keywords: Physiological Weight Loss, Shelf-Life, Titrable acidity, Total Soluble Solids

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INTRODUCTION

Tomato (*Solanum lycoperscion*) is one of the most universally known and widely consumable vegetables in the world (Moniruzzaman et. al., 2013). Tomato is the second most widely grown vegetable crop after potato (Hanson et. al., 2001).In Nepal, tomato is the third most important vegetable after cauliflower and cabbage in terms of area and production (Thapa et al., 2016). It is cultivated in about 20,000 hectares (ha) in Nepal and around 0.3 million metric tons tomato is produced annually in the country (MoAD, 2014).

Tomato has high commercial and dietary value. There are various uses of tomato in fresh and processed forms. It is used in preserved products like ketch-up, sauce, chutney, soup, paste, puree, etc. Tomato is highly nutritious and has potential health benefits. It is the major source of carotenoids (especially lycopene), phenolic, vitamin C and small amounts of vitamin E in daily diets (Khachik et. al., 2002). Different epidemiological studies showed that tomatoes and tomato products have a

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protective effect against prostate cancer and cardiovascular disease (Barber et. al., 2002). Tomatoes are the major source of antioxidants (Sgherri et al., 2008: Jaramillo et.al., 2007: Gupta et. al., 2011).

However, due to highly perishable nature of tomato, it faces several problems in its transportation, storage and marketing (Ben, 1986). Inappropriate information on postharvest treatments, packaging, temperature etc. has led fruits to lose their quality as well as substantial postharvest loss (Nirupama et al 2010). A loss of 20-50% between harvesting, transportation and consumption of fresh tomatoes has been reported in the tropical countries (Kader et al., 1992: Aworth et al., 1981). Therefore an effective technique or appropriate treatment that helps to extend the self-life of harvested tomatoes and preserve its quality is utmost necessary.

In the view of above reports, present investigation was done to study the effect of Gibberellic Acid (GA3) on post-harvest shelf-life and quality of tomato. GA3 has antagonistic effect against ethylene acton. It can block the continuously forming ethylene receptor sites on the plant cells (Duguma, 2014).

MATERIALS AND METHODS

Collection of Sample

Tomato fruits (variety: Dalila) were selected randomly from the local farm situated near Lamjung Campus. Fruits of single tunnel were collected for experiment. Mottled, bruised, diseased and damaged fruits were excluded in the collection process. Harvested fruits were at breaker stage and were handpicked during the daytime in 2074/10/03.

Treatments and Experimental Design

The experiment was conducted as Completely Randomized Block Design (CRBD) with four different treatments having six replications. Of the collected tomato samples, tomato fruits with peduncle, no bruises or damage were selected for treatments with 0.05%, 0.1%, 0.3% GA3 and controlled condition (no GA3). In each replication there were 400±20gm fruits for non-destructive analysis and ten extra fruits were kept in each replication for destructive analysis. The sampled tomatoes were washed with distilled water and spread on the clean slab for drying water. After leaving tomatoes in such condition for few hours, the washed tomatoes were then dipped in GA3 solution with different concentration for 15 minutes. Some tomatoes were dipped in GA3 solution of concentration 0.05%, 0.1% and 0.3% while others were washed with distilled water only. The treated tomatoes were kept in plastic trays and stored for experimentation in laboratory with the average temperature of 19.39◦C and relative humidity of 59.89%.Stored tomato fruits were subjected for following physiochemical analyses:

Physiological weight loss (%)

In order to determine the physiological Weight loss, fruits were weighed before the application of treatments and at 14 days interval after application of treatment with different GA3 concentrations. The recorded weight of previous day served as the initial weight and weight after 14 days served as the final weight. Fruits were weighed using electronic digital balance (Danwer SC, error=10mg).The physiological weight loss was determined by following formula and expressed as percentage.

$$\text{Weight loss (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Color development

Color development was observed at 14days interval until all the fruits of different treatments turned red. Tomatoes were at breaker stage at the time of harvesting. Tomatoes from different treatments were compared with the chart showing different stages of color development for accessing color development of the fruits under different treatments.

Number of days to decay

For determining decay percentage, total number of fruits in each treatment and replications were recorded. Decayed fruits were counted at the interval of 14 days. The number of days on which decay of first tomato fruit, half tomato fruits(50%) and full fruits(100%) from each treatment to were noted and analyzed.

Shelf-life

Tomatoes from each treatment were observed until all the fruits decayed for determining shelf-life.

Total Soluble Solids (^{o}Brix)

The Total Soluble Solid (◦ Brix) was measured using a hand held refractometer (Model: Erma Japan) with range of 0 to 32 degree Brix. Tomato juice was squeezed out from sample fruit of each replication in order to determine TSS. One to two drops of extracted juice was placed on the prism of refractometer and reading was taken by observing it in bright light.

Titrable Acidity (%)

Titrable acidity was determined by a standard titrimetric method. For this, NaOH solution of 0.1 normality was prepared and filled in burette. Tomato juice was extracted in beaker by squeezing tomato. In presence of phenolphthalein as an indicator, the mixture was titrated by adding the prepared NaOH until the break of light pink color was observed for 30seconds.Titrable acidity was calculated by following formula and expressed as percentage of citric acid.

$$TA\ (\%) = \frac{NB \times VB \times \text{Meq. Of acid} \times d.f \times 100}{\text{Volume of sample}}$$

Where, NB = Normality of Base (NaOH)

VB = Volume of Base

Meq = Miliequivalent weight of prominent acid; citric acid= 0.067

d.f = dilution factor

RESULTS AND DISCUSSION

Effect on weight loss (%)

There was gradual decrease in weight of fruits during the entire period of storage. The effect of different concentrations of GA3 showed the highly significant difference in the weight loss. After 14days of storage, significantly higher weight loss (1.563%) percentage was found in control whereas lowest (1.377%) was observed in 0.1% GA3. The weight loss percentage of 0.05% GA3 was statistically at par with 0.3%. Similar result was seen in 28DAS, 42DAS, 56DAS and 70DAS. According to Bhowmik and Pan

(1992), transpiration and respiration are the two main processes that cause weight loss of fresh produce. Transpiration is the process in which water loss occurs due to the difference in the vapor pressure of water in the atmosphere and the transpiring surface. During respiration carbon atoms are lost in the form of carbon-dioxide molecule produced by absorbed oxygen molecule and released from the fruit into the atmosphere (Bhowmik and Pan, 1992). Sudha et al. (2007) found that the reduction of weight loss in the fruits treated with GA3 might be due to the anti-senescent action. According to Wills et al, (1998) GA3 treatment causes the decrease in tissue permeability resulting into reduced water loss and thereby decreasing weight loss. The similar results were reported by Senjaliya et al. (2015), Nirupama et al. (2010) and Duguma (2014) in tomato.

Table.1: Effect of different treatment on weight loss at 14, 28, 42, 56 and 70 days after storage (DAS) at IAAS, Lamjung Campus, 2018.

TREATMENTS	14DAS WL%	28DAS WL%	42DAS WL%	56DAS WL%	70DAS WL%
T1	1.563b	1.483b	1.815a	1.943b	3.583b
T2	1.377c	1.166d	1.573b	1.754c	2.429d
T3	1.517b	1.374c	1.614b	1.840bc	2.948c
T4	1.909a	1.864a	1.931a	2.544a	5.578a
LSD	0.065	0.109	0.117	0.145	0.325
Level of significance	**	**	**	**	**
CV%	3.4	6.153	5.640	5.87	7.32

Values within same column with a common alphabet do not differ as a statistical significance of *= $p<0.05$; **= $p<0.01$ in Duncan's Test

Table.2: Effect of different treatment on color development at 14, 28, 42, 56 and 70 days after storage (DAS) at IAAS, Lamjung Campus, 2018.

TREATMENTS	14 DAS	28 DAS	42 DAS	56 DAS	70 DAS
T1(0.05% GA3)	Pink	Light red	Red	Red	Red
T2 (0.1% GA3)	Pink	Light red	Light red	Light red	Red
T3 (0.3% GA3)	Pink	Light red	Light red	Red	Red
T4 (Control)	Light red	Red	Red	Red	Red

Effect on color development

The development of color was found to be slow in treatment with 0.1% GA3 concentration whereas it was rapid in the control treatment. Control treatment developed red color on 28th DAS whereas red color of fruits was observed on 70th DAS in 0.1%GA3. The change in color of tomato fruit is due to the transformation of chloroplast into chromoplast as well as from the degradation of chlorophyll and accumulation of pigments like carotenes and lycopene which is responsible for the orange, red color of fruit (Gray et al., 1992). Destruction of chlorophyll in the tomato fruits is accelerated by endogenous ethylene (Glick, 2004). The delayed color development of fruits treated with Gibberellic acid is due to the antagonistic effect of GA3 on ethylene and to their ability to neutralize the stimulation of chlorophyll destruction caused by ethylene (Gonzalez et al., 2001). Gibberellic acid has higher affinity for ethylene receptor sites than ethylene; therefore it combines with ethylene receptor sites and inhibits the ethylene action (Duguma, 2014).

Number of days to decay

There was highly significant difference among the treatments in number of days to decay. Early decay of first fruit was observed from control treatment (27.667 days) followed by 0.05% GA3 (43.00 days) which was at par with 0.3% GA3 (43.667 days). Delayed decay of was observed in 0.1%GA3 (50.33days).Fifty percentage decay of fruits in treatment T2 (0.1% GA3) was observed on 77.66th day which was statistically at par with treatment 0.3% GA3 (75 days) and 0.05% (72.33 days). Half decay of fruits in control was observed on 49.00 days. Full decay of fruits was observed on 96.33 days (0.1% GA3), 85.66 days (0.3% GA3), 65.66 days (0.05% GA3) and 65.66 days (control).Similar findings were reported by Nirupama et al., (2010) and Choudhary (2014) in tomato. The natural resistance of vegetables to pathogen decline along with their ageing which leads them to decay. Tomato fruits treated with GA3 exhibited reduced decay in early days due to anti-senescent and anti-respirant nature of GA3 which prevented the cellular disintegration and increased resistance of fruits (Rokaya et al., 2016).According to Hidalgo et al., (2005) GA3 reduced the decrease in antifungal compounds rind which prevented fruit from fungal decay.

Table.3: Effect of different treatment on number of days to decay and shelf-life of tomato fruits at IAAS, Lamjung Campus, 2018

TREATMENTS	Days to 1st decay	Days to half decay (50%)	Days to full decay (100%)	Shelf-life (Days)
T1 (0.05%0	43.000b	72.333a	83.000b	83.00
T2 (0.1%)	50.333a	77.667a	96.333a	96.33
T3 (0.3%0	43.667b	75.000a	85.667b	85.66
T4 (control)	27.667c	49.000b	65.667c	65.67
LSD	4.506	5.180	4.570	
Level of significance	**	**	**	
CV%	9.089	6.279	4.590	

Values within same column with a common alphabet do not differ as a statistical significance of *= p<0.05; **=p<0.01 in Duncan's Test.

Shelf-life

Among various treatments of GA3, tomato fruits treated with 0.1% GA3 recorded significantly longer shelf-life of 96.33days under ambient storage condition followed by 0.3%GA3 (85.66 days) and 0.055 GA3 (83.0 days). Shorter shelf-life of 65.67 days was observed in control treatment. The delayed conversion of starch to sugar thereby reducing the peroxidase activity and ethylene production may be the contributing factor for extended shelf-life of GA3 treated tomatoes.

Effect on Total Soluble Solids (◦Brix)

The TSS of tomato increased in all the treatments during the storage when studied up to a period of thirty days. The increment in TSS was observed to be highest in control treatment. TSS of control at 6DAS was 4.65 ◦Brix which increased to 6.55◦Brix at 30DAS. The increase in TSS was found to be least in treatment with 0.1% GA3 treatment. TSS increased from 3.88◦Brix (6DAS) to 5.65◦Brix (30 DAS).Treatments with 0.05% GA3 and 0.3%GA3 concentrations were statistically similar. TSS increased from 4.25◦Brix (6DAS) to 5.40◦Brix (30DAS) in treatment with 0.3% GA3 concentration and from 4.30◦Brix (6 DAS) to 5.65◦Brix

(30DAS) in treatment with 0.05% GA3. The increase in TSS of the fruits is due to the conversion of starch and other polysaccharides to soluble forms of sugar (Mukherjee and Dutta, 1967).The reduction in value of TSS in the fruits treated with GA3 is due to the slowed respiration and metabolic activity which delays the ripening progression (Neeta, 2010). Slower respiration rate of the treated fruits slows down the production of ethylene and use of metabolites resulting in reduced TSS value (Duguma, 2014).

Table.4: Effect of different treatment on Total Soluble Solids (TSS) at 6, 12, 18, 24 and 30 days after storage (DAS) at IAAS, Lamjung Campus, 2018.

TREATMENTS	**6DAS TSS**	**12DAS TSS**	**18DAS TSS**	**24DAS TSS**	**30DAS TSS**
T1 (0.05%)	4.300b	4.567b	4.933b	5.215b	5.650b
T2 (0.1%)	3.88c	4.100c	4.550c	4.817c	5.3166c
T3 (0.3%)	4.250b	4.500b	4.817b	5.067b	5.533b
T4 (control)	4.650a	4.917a	5.433a	6.167a	6.550a
LSD	0.252	0.171	0.196	0.171	0.189
Level of significance	**	**	**	**	**
CV%	4.906	3.136	3.298	2.673	2.721

Values within same column with a common alphabet do not differ as a statistical significance of *= p<0.05; **=p<0.01 in Duncan's Test

Table.5: Effect of different treatments on Titrable Acidity (TA) at 6, 12, 18, 24 and 30 days after storage (DAS) at IAAS, Lamjung Campus, 2018.

TREATMENTS	**6DAS TA%**	**12DAS TA%**	**18DAS TA%**	**24DAS TA%**	**30DAS TA%**
T1 (0.05%GA3)	1.197b	1.122b	0.945b	0.0813b	0.714c
T2 (0.1% GA3)	1.273a	1.191a	1.037a	0.953a	0.849a
T3 (0.3% GA3)	1.197b	1.146b	0.975b	0.843b	0.776b
T4 (control)	1.051c	0.963c	0.891c	0.730c	0.647d
LSD	0.057	0.037	0.425	0.064	0.048
Level of significance	**	**	**	**	**
CV%	4.038	2.803	3.685	6.370	5.325

Values within same column with a common alphabet do not differ as a statistical significance of *= p<0.05; **=p<0.01 in Duncan's Test

These findings are in conformity with those of Khumbar and Desai (1986) in sapota. Patil and Hulamani (1998) also reported the lowest TSS in banana fruits treated with GA3 at the end of storage. Similar findings were also made by Ahmed and Tingwa (1995) in banana fruit. This indicates that GA3 application delays fruit softening process and starch degradation.

Effect on Titrable Acidity (%)

The titrable acidity of the tomato decreased in all the treatments with the increasing period of storage. At 6DAS the effect of different showed highly significant difference in TA. The highest TA was observed in 0.1% GA3 (1.273%) followed by 0.3% GA3 (1.197%) which was statistically at par with 0.05% GA3 (1.051%). Lowest TA was retained in control treatment (1.051%). At 12DAS, 18DAS and 24DAS similar trend as in day 6 was observed. At 30DAS the TA of 0.1% GA3 was 0.849% and that of 0.3% GA3, 0.05% GA3 and control treatment was 0.776%, 0.714% and 0.647% respectively. The decrease in titrable acidity of the fruits during storage may be due to the utilization of organic acids in various bio-degradable reactions (Zomo et al., 2014). According to Mattoo et al (1975) the reduction in of TA is attributed to the disappearance of malic acid first, followed by citric acid during the process of ripening.

The higher value of TA in tomato fruits treated with GA3 is due to the reduced respiration which effects the utilization of organic acids that delays ripening and restricts starch degradation. Duguma (2014), Senjaliya (2015) and Nirupama (2010) also found out that higher acidity was retained in the tomato fruits treated with GA3 compared to control.

CONCLUSION

The obtained results indicate that application of gibberellic acid prevented the excessive change in measured parameters and delayed fruit ripening when compared to control treatment. The shelf-life of tomato fruit treated with optimum dose of GA3 could be extended up to 30days without excessive quality deterioration. Among different concentrations of gibberellic acid, 0.1% was found best for reducing post-harvest losses and extending shelf-life for maximum days. Thus it can be concluded that post-harvest application of gibberellic acid is effective to prevent rapid post-harvest loss and extend the shelf-life of tomato fruits.

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