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# Effect of antioxidants on chilling injury and storage life of guava cv. Allahabad safeda

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**Abstract**
An experiment was done to decrease the chilling injury and increase the shelf life of guava by antioxidants. In this study fruits were dipped in 50,100 ppm benzyl adenine, 0.1,1 µM methyl jasmonate, 500, 750 ppm thiabenzadole and 4,6 mmol oxaloacitic acid observed the chilling injury and storage life of guava cv.Allahabad safeda stored at 6+1 $^{0}$C.This experiment was conducted at fruit research station, Sangareddy, Medak district, Telangana. The experiment was done by using completely randomized design with factorial concept with three replications per treatment. Guava fruits cv. Allahabad safesda were dipped in antioxidants and stored at 6+1$^{0}$C. Fruits dipped in 50ppm benzyl adenine significantly recorded lowest PLW. Significantly highest fruit firmness and organoleptic evaluation were recorded with fruits dipped in 50 ppm benzyl adenine. Significantly lowest chilling injury and electrolyte leakage was recorded in fruits dipped in 50ppm benzyl adenine and corresponding increase the shelf life of upto 26.63 days. The fruits kept under control recorded a shelf life of 20.05 days only. Titratable acidity was significantly lowest in fruits dipped with 50ppm benzyl adenine. Fruits dipped in 50ppm benzyl adenine recorded significantly highest TSS, Brix-acid ratio and ascorbic acid.

**Keywords:** guava, benzyl adenine, methyl jasmonate, thiabendazol and oxalixc acid, chilling injury

## Introduction
There is a great demand of guava fruits in both domestic and international markets for fresh and processing purposes. India by far, is the world largest producer of guava, while the fruits are consumed mostly within the country itself. Guava fruit is best relished when perfectly ripened and freshly plucked from the tree. It emits sweet aroma and is pleasantly sweet and refreshingly acidic flavour. It is wholly edible along with skin which is papery thin and almost merges with the pulp. Guava being a climatric fruit exhibits a rise in respiration and ethylene production during ripening, and is highly perishable in nature (Singh and Pal, 2008) [16], Being a highly perishable fruit, undergoes rapid postharvest ripening in a few days under ambient conditions.

The shelf life of guava can be increased by various methods like MAP, low temperature and antioxidants treatments. When fruits are stored at low temperature below or up to like 5$^{0}$C, leads to the development of chilling injury symptoms (Roberto *et al*, 1990) [14]. In chilling injury, the free radicals are increased and the fruit senescence rapidly without proper ripening. Under this situation, dipping the fruit in antioxidants was found to ameliorate/reduce the chilling injury of the fruit when stored at low temperature (Tiehua *et al.*, 2010) [20]. Antioxidants help in extending the shelf life of fruits. These are the compounds which prevent the free radical formation and cell membrane disintegration which occurs by lipoxy genase and lipid peroxidation reactions. These compounds could extend the shelf life of fruits by minimizing the onset of ripening and ethylene production which is mediated by lipid peroxidation reactions. Various commercial antioxidants are being used in post-harvest sectors as well as in food industries, like benzyl adenine, oxalic acid, methyl jasmonate and thiabendazole etc. These antioxidants will prevent or delay the formation of free radicals and different degenerative pathways like lipoxygenase reactions which would enhance the production of ethylene that may lead to the ripening (Sukumar Reddy, 2009) [19]. Keeping into holistic view of constraints and industry demand, the present investigation was undertaken.

## Material and Methods
The experiment was carried out during 2013-14 at Fruit Research Station, Sangareddy, Medak.

The experiment consists of nine treatments in three replications with forty five units per replication was laid out in completely randomised design with factorial concept. Dipping time of fruits is five minutes and temperature of 6±1$^0$ C was maintained during storage. Each treatment was evaluated at five days interval. Data recorded was subjected to statistical analysis as outlined by Panse and Sukhatme (1985) [12].

## Results and Discussion

### 1. Physiological loss in weight (%)

Lowest (2.75) PLW was recorded in benzyl adenine 50 ppm. The PLW increased from 5$^{th}$ day (1.39) to 25$^{th}$ day (5.47). The increase was more pronounced from 15$^{th}$ day (3.28) to 20$^{th}$ day (4.49). Among all interactions, the highest PLW was recorded with the fruits kept under control on all intervals of storage.The lowest PLW was recorded with the fruits treated with benzyl adenine 50 ppm on all the intervals of storage (table 1). The results obtained in the present investigation are in close conformity with those of Bhardwaj *et al*. (2005) [5] in mandarin cv. Nagpur Santra in which plant growth regulators like benzyl adenine acted as an anti-senescent and arrested the metabolic break down deterioration caused by various biochemical activities in the fruits.

**Table 1:** Effect of postharvest application of antioxidants physiological loss in weight (%) during storage of guava. Allahabad safeda 6 ± 1º C.

| Treatment | Days after harvest | | | | | Mean |
|---|---|---|---|---|---|---|
| | 5 | 10 | 15 | 20 | 25 | |
| $T_1$ - BA 50 ppm | 1.00 | 1.52 | 2.15 | 3.66 | 4.25 | 2.51$^h$ |
| $T_2$- BA 100 ppm | 1.15 | 2.60 | 3.61 | 4.20 | 5.35 | 3.38$^{cd}$ |
| $T_3$- MJ 0.1µM | 1.00 | 1.60 | 2.50 | 3.91 | 4.50 | 2.70$^g$ |
| $T_4$ - MJ 1 µM | 1.16 | 2.63 | 3.62 | 4.24 | 5.36 | 3.49$^b$ |
| $T_5$- TBZ 500 ppm | 1.00 | 1.72 | 2.86 | 4.15 | 5.20 | 2.98$^f$ |
| $T_6$ –TBZ 750 ppm | 1.10 | 2.65 | 3.63 | 4.30 | 5.41 | 3.41$^c$ |
| $T_7$- OA 4 mmol | 1.15 | 2.58 | 3.60 | 4.20 | 5.30 | 3.36$^d$ |
| $T_8$-OA 6 mmol | 1.10 | 2.35 | 3.40 | 4.15 | 5.11 | 3.22$^e$ |
| $T_9$- control | 1.20 | 2.95 | 3.98 | 4.80 | 5.92 | 3.77$^a$ |
| Mean | 1.09$^e$ | 2.28$^d$ | 3.25$^c$ | 4.17$^b$ | 5.15$^a$ | |
| | F –test | | | S. Em ± | | CD at 5% |
| Treatments | ** | | | 0.012 | | 0.035 |
| Days | ** | | | 0.009 | | 0.026 |
| Treatments × Days | ** | | | 0.028 | | 0.078 |

### 2. Fruit Firmness (kg.cm$^{-2}$)

Data presented in table 2 reveal that treated fruits differed significantly with highest fruit firmness (5.02) in benzyl adenine 50 ppm. The lowest (3.52) fruit firmness was recorded in control.There were significant differences in fruit firmness among different days of storage period. The fruit firmness decreased from 5$^{st}$ day (7.16) to 25$^{th}$ day (2.19). The decrease was more pronounced from 5$^{st}$ day (7.16) to 10$^{th}$ day (5.34). As the storage period increased, the firmness decreased irrespective of treatments. Among all treatments, fruits treated with benzyl adenine 50 ppm recorded significantly highest firmness than any other treatment throughout the storage period. On 5$^{st}$ day to 25$^{th}$ day, lowest fruit firmness was recorded in control. Similar results were also reported in guava by Wills *et al.* (1983). This may be attributed to the retarded nature of ripening as a result of antioxidant treatment (Jayachandran *et al.*, 2007) [9].

**Table 2:** Effect of postharvest application of antioxidants on fruit firmness (kg.cm$^{-2}$) during storage of guava cv. Allahabad safeda at 6 ± 1ºC

| Treatment | Days after harvest | | | | | Mean |
|---|---|---|---|---|---|---|
| | 5 | 10 | 15 | 20 | 25 | |
| $T_1$ - BA 50 ppm | 7.60 | 6.10 | 5 | 3.65 | 2.75 | 5.02$^a$ |
| $T_2$- BA 100 ppm | 7.05 | 5.10 | 4.15 | 3.20 | 2.17 | 4.33$^f$ |
| $T_3$- MJ 0.1µM | 7.50 | 5.84 | 4.65 | 3.52 | 2.64 | 4.83$^b$ |
| $T_4$ - MJ 1µ M | 7.10 | 5.15 | 4.20 | 3.30 | 2.19 | 4.39$^e$ |
| $T_5$- TBZ 500 ppm | 7.30 | 5.65 | 4.45 | 3.35 | 2.42 | 4.63$^c$ |
| $T_6$ –TBZ 750 ppm | 7.03 | 5.05 | 4.10 | 3.10 | 2.15 | 4.28$^g$ |
| $T_7$- OA 4 mmol | 6.98 | 5.02 | 4.05 | 3.05 | 2.10 | 4.24$^g$ |
| $T_8$-OA 6 mmol | 7.25 | 5.50 | 4.35 | 3.20 | 2.30 | 4.52$^d$ |
| $T_9$- control | 6.72 | 4.65 | 3.10 | 2.15 | 1.00 | 3.52$^h$ |
| Mean | 7.16$^a$ | 5.34$^b$ | 4.22$^c$ | 3.17$^d$ | 2.19$^e$ | |
| | F –test | | | S. Em ± | | CD at 5% |
| Treatments | ** | | | 0.013 | | 0.036 |
| Days | ** | | | 0.009 | | 0.027 |
| Treatments × Days | ** | | | 0.028 | | 0.08 |

### 3. Chilling Injury (skin scald)

The lowest (2.51) chilling injury was recorded in fruits treated with benzyl adenine 50 ppm stored at 6 ± 1º C. The chilling injury increased from 5$^{th}$ day (1.09) to 25$^{th}$ day (5.15). Among the treatments, chilling injury increased irrespective of treatments. However, on 1$^{st}$ day no treatment has recorded the chilling injury. On 5$^{th}$ day to 25$^{th}$ day, highest chilling injury was recorded with the fruits kept under control. While, no chilling injury was recorded with benzyl adenine 50 ppm on 5$^{th}$ day which was on par with 0.1µM methyl jasmonate and thiabendazole 500 ppm (table 3). Lowest chilling injury from 10$^{th}$ to 25$^{th}$ day was recorded with benzyl adenine 50 ppm which may be attributed to retarded nature of ripening as a result of antioxidant treatment (Jayachandran *et al.*, 2007) [9]. These antioxidants will scavenge the reactive oxygen species (ROS) and reduces the chilling injury during cold storage (Tiehua *et al.*, 2010) [20].

**Table 3:** Effect of postharvest application of antioxidants on chilling injury (Skin scald) during storage of guava cv. Allahabad safeda at 6 ± 1º C.

| Treatment | Days after harvest | | | | | Mean |
|---|---|---|---|---|---|---|
| | 5 | 10 | 15 | 20 | 25 | |
| $T_1$ – BA 50 ppm | 1.10 | 1.75 | 2.55 | 3.66 | 4.76 | $2.76^h$ |
| $T_2$- BA 100 ppm | 1.20 | 1.95 | 3.10 | 4.20 | 5.10 | $3.11^f$ |
| $T_3$- MJ 0.1µM | 1.15 | 1.90 | 2.93 | 3.95 | 4.98 | $2.98^g$ |
| $T_4$ - MJ 1 µM | 1.25 | 1.96 | 3.20 | 4.35 | 5.25 | $3.20^e$ |
| $T_5$- TBZ 500 ppm | 1.30 | 2.01 | 3.25 | 4.50 | 5.45 | $3.30^d$ |
| $T_6$ –TBZ 750 ppm | 1.40 | 2.10 | 3.30 | 4.70 | 5.66 | $3.43^c$ |
| $T_7$- OA 4mmol | 1.50 | 2.30 | 3.35 | 4.80 | 5.75 | $3.54^b$ |
| $T_8$-OA 6mmol | 1.32 | 2.05 | 3.30 | 4.55 | 5.50 | $3.34^d$ |
| $T_9$- control | 2.31 | 3.45 | 4.57 | 5.69 | 6.82 | $4.57^a$ |
| Mean | $1.39^e$ | $2.16^d$ | $3.28^c$ | $4.49^b$ | $5.47^a$ | |
| | F –test | | | S. Em ± | | CD at 5% |
| Treatments | ** | | | 0.013 | | 0.036 |
| Days | ** | | | 0.009 | | 0.027 |
| Treatments × Days | ** | | | 0.029 | | 0.08 |

### 4. Electrolyte leakage (%)

The effect of antioxidants on electrolyte leakage of guava cv. Allahabad safeda stored at 6 ± 1º C was presented in the Table 4. The lowest (6.66) electrolyte leakage was recorded in the fruits treated with benzyl adenine 50 ppm. The electrolyte leakage increased from 1st day (4.37) to 25th day (9.88). The interaction effect on electrolyte leakage among different treatments and storage period was non-significant in the fruits treated with 100ppm benzyl adenine, 1µM methyl jasmonate and thiabendazole 750ppm. Among all treatments the electrolyte leakage increased irrespective of treatments. However, on 1st day to 25th day storage, the highest electrolyte leakage was recorded with fruits kept under control. Lowest electrolyte leakage was recorded with benzyl adenine 50 ppm on all intervals of storage. These antioxidants will scavenge the reactive oxygen species (ROS) and reduces the chilling injury during cold storage (Tiehua *et al.* 2010) [20] and simultaneously reduces electrolyte leakage. In all the treatments, the electrolyte leakage increases with the increase in storage period. This is due to the fact that, increase in membrane permeability and leakage of electrolytes (Chauhan *et al.* 2006, Chanikan *et al.*, 2012) [6].

**Table 4:** Effect of postharvest application of antioxidants on electrolyte leakage (%) during storage of guava cv. Allahabad safeda at 6 ± 1ºC.

| Treatments | Days after harvest | | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 | 25 | |
| $T_1$ - BA 50 ppm | 4.10 | 5.05 | 6.15 | 7.45 | 8.18 | 9.16 | $6.66^f$ |
| $T_2$- BA 100 ppm | 4.40 | 5.48 | 6.78 | 7.89 | 8.50 | 9.60 | $7.10^b$ |
| $T_3$- MJ 0.1µM | 4.05 | 5.10 | 6.24 | 7.52 | 8.28 | 9.20 | $6.73^e$ |
| $T_4$ - MJ 1µ M | 4.41 | 5.50 | 6.80 | 7.85 | 8.46 | 9.55 | $7.09^b$ |
| $T_5$- TBZ 500 ppm | 4.10 | 5.20 | 6.398 | 7.58 | 8.36 | 9.35 | $6.82^d$ |
| $T_6$ –TBZ 750 ppm | 4.43 | 5.51 | 6.79 | 7.90 | 8.52 | 9.62 | $7.12^b$ |
| $T_7$- OA 4 mmol | 4.42 | 5.50 | 6.78 | 7.89 | 8.51 | 9.61 | $7.11^b$ |
| $T_8$-OA 6 mmol | 4.15 | 5.26 | 6.48 | 7.69 | 8.42 | 9.40 | $6.90^c$ |
| $T_9$- control | 4.48 | 6.30 | 8.15 | 10.31 | 12.05 | 13.43 | $9.12^a$ |
| Mean | $4.37^f$ | $5.43^e$ | $6.72^d$ | $8^c$ | $8.80^b$ | $9.88^a$ | |
| | F -test | | S.Em ± | | CD at 5 % | | |
| Treatments | ** | | 0.011 | | 0.030 | | |
| Days | ** | | 0.009 | | 0.030 | | |
| Treatments × Days | ** | | 0.030 | | 0.080 | | |

### 5. Ripening (in days)

The highest (19.33) days taken to ripening was recorded with benzyl adenine 50 ppm. The lowest (8.75) days taken to ripening was recorded with fruits kept under control (table 5). The retardation of fruit ripening might be due to the scavenging action of antioxidants on free radicals resulting the lower catalase activity and ethylene synthesis. Similar results were reported by Bhagwan (1994) [4] on banana, Rao and Chundawat (1982) [13] on sapota and Vanajalatha (2001) on mango.

**Table 5:** Effect of postharvest application of antioxidants on ripening (in days) during storage of guava cv. Allahabad safeda at 6 ± 1º C

| Treatments | Ripening (Days) |
|---|---|
| $T_1$ - BA 50 ppm | $19.33^a$ |
| $T_2$- BA 100 ppm | $15.10^c$ |
| $T_3$- MJ 0.1µM | $17.48^b$ |
| $T_4$ - MJ 1 µM | $15.25^c$ |
| $T_5$- TBZ 500 ppm | $13.65^d$ |

| | |
|---|---|
| $T_6$ –TBZ 750 ppm | 11.10[e] |
| $T_7$- OA 4 mmol | 11.12[e] |
| $T_8$-OA 6 mmol | 13.52[d] |
| $T_9$- control | 8.75[f] |
| Mean | 12.9[4] |
| F-test | ** |
| S. Em ± | 0.289 |
| CD at 5% Level | 0.869 |

**6. Shelf life (in days)**

As presented in table 6 the treated fruits differed significantly with highest shelf life (26.63) in fruits treated with benzyl adenine 50 ppm. The lowest (20.05) shelf life was recorded in fruits kept under control. The shelf life in methyl jasmonate 1µM (24.20), thiabendazole 500 ppm (23.68) and oxalic acid 6 mmol (23.48) were at on par. Among antioxidant treatments, it was observed that the benzyl adenine 50 ppm recorded the highest shelf life of 26.63 days. (Table 6). Similar results were reported in guava fruits (Jayachandran *et al.* 2007) [9], mango fruits (Ahmed, 1998) [1] and tomato fruits stored at 4°C or 10°C which stored up to 28 days (Yahia *et al.*, 2010) [23].

**Table 6:** Effect of post-harvest application of antioxidants on shelf life (in days) during storage of guava cv. Allahabad safeda at 6 ± 1º C.

| Treatments | Shelf life(Days) |
|---|---|
| $T_1$ - BA 50 ppm | 26.63[a] |
| $T_2$- BA 100 ppm | 24.10[c] |
| $T_3$- MJ 0.1µM | 25.42[b] |
| $T_4$ - MJ 1 µM | 24.20[c] |
| $T_5$- TBZ 500 ppm | 23.68[c] |
| $T_6$ –TBZ 750 ppm | 22.35[d] |
| $T_7$- OA 4 mmol | 22.23[d] |
| $T_8$-OA 6 mmol | 23.48[c] |
| $T_9$- control | 20.05[e] |
| Mean | 23.57 |
| F-test | ** |
| S.Em ± | 0.86 |
| CD at 5% Level | 0.29 |

**7. Organoleptic evaluation**

Highest organoleptic evaluation (6.91) in fruits treated with benzyl adenine 50 ppm. The lowest (5.81) organoleptic evaluation was recorded in fruits kept under control. The organoleptic evaluation increased from 1th day (4.17) to 20th day (8.14) and then decreased from 20th day (8.14) to 25th day (4.76). On 1st day of storage, all the treatments recorded the lowest organoleptic evaluation over all intervals of storage (table 7). The highest organoleptic evaluation was recorded in the fruits treated with benzyl adenine 50 ppm on all intervals of storage. The lowest organoleptic evaluation was recorded in the fruits kept under control on all intervals of storage. This increase in organoleptic score is due to the retarted ripening and softening of fruits and also due to increase or maintaining the firmness of fruits by cohesive effect on tissue firmness there by restring of microbes. Similar results were reported by Padmalatha (1993) [11] in grapes, Singh *et al.* (1981) [17] in guava and Jayachandran (2000) [8] in guava.

**Table 7:** Effect of postharvest application of antioxidants on organoleptic evaluation (score) during storage of guava cv. Allahabad safeda at 6 ± 1º C.

| Treatments | Days after harvest | | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 | 25 | |
| $T_1$ - BA 50 ppm | 4.30 | 6.85 | 7.93 | 8.10 | 8.54 | 5.78 | 6.91[a] |
| $T_2$- BA 100 ppm | 4.10 | 6.20 | 6.95 | 7.60 | 8.10 | 4.90 | 6.34[e] |
| $T_3$- MJ 0.1µM | 4.20 | 6.70 | 7.85 | 8.05 | 8.30 | 5.17 | 6.71[b] |
| $T_4$ - MJ 1 µM | 4.15 | 6.10 | 7.05 | 7.70 | 8.15 | 4.80 | 6.32[ef] |
| $T_5$- TBZ 500 ppm | 4.24 | 6.55 | 7.78 | 8 | 8.20 | 5.05 | 6.63[c] |
| $T_6$ –TBZ 750 ppm | 4.10 | 6.20 | 6.97 | 7.80 | 8.15 | 4.77 | 6.33[ef] |
| $T_7$- OA 4 mmol | 4.18 | 6.10 | 6.78 | 7.65 | 8 | 4.20 | 6.15[g] |
| $T_8$-OA 6 mmol | 4.25 | 6.40 | 7.64 | 8.05 | 8.15 | 4.80 | 6.54[d] |
| $T_9$- control | 4.05 | 5.62 | 6.75 | 7.28 | 7.40 | 2.10 | 5.81[h] |
| Mean | 4.17[f] | 6.30[d] | 7.30[c] | 7.80[b] | 8.14[a] | 4.76[e] | |
| | F -test | | S.Em ± | | CD at 5 % | | |
| Treatments | ** | | 0.011 | | 0.033 | | |
| Days | ** | | 0.009 | | 0.027 | | |
| Treatments × Days | ** | | 0.029 | | 0.081 | | |

**8. Total Soluble Solids (º Brix)**

The results presented in table 8 treated fruits differed significantly with highest (11.38) total soluble solids in fruits treated with benzyl adenine 50 ppm. The lowest (10.98) total soluble solids was recorded in fruits kept under control. The total soluble solids increased from 1th day (9.76) to 20th day (12.17) and then decreased from 20th day (12.17) to 25th day (11.64). The interaction effect on total soluble solids among different treatments and storage period was non-significant except fruits treated with benzyl adenine 50 ppm and 0.1µM methyl jasmonate. However, the total soluble solids increased from 1st day to 20th day, thereafter decreased significantly to reach a minimum on 25th day. On the 1st day, the highest total soluble solids were recorded with benzyl adenine 50 ppm and similar pattern was recorded on 10th, 15th and 20th day of storage. On 25th day highest total soluble solids were recorded with benzyl adenine 50 ppm. Lowest total soluble solids were recorded in fruits kept under control in all intervals of storage. Similar results were reported with guava fruit by Jayachandran (2000) [8], Jayachandran *et al.* (2007) [9]. The TSS increased may be attributed to the conversion of starch and other polysaccharides into soluble forms of sugars (Satyan *et al.* 1992) [15] indicating that the ripening process has started. Bhardwaj *et al.* (2005) [5] reported that the mandarin fruits cv. Nagpur Santra when treated with benzyl adenine 50 and 100 ppm resulted highest TSS in 50 ppm benzyl adenine.

**Table 8:** Effect of postharvest application antioxidants on total soluble solids ($^0$Brix) during storage of guava cv. Allahabad safeda at 6 ± 1º C.

| Treatments | Days after harvest | | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 | 25 | |
| $T_1$ - BA 50 ppm | 9.80 | 10.65 | 11.50 | 11.90 | 12.43 | 11.98 | $11.38^a$ |
| $T_2$- BA 100 ppm | 9.76 | 10.40 | 11.28 | 11.73 | 12.10 | 11.77 | $11.17^d$ |
| $T_3$- MJ 0.1µM | 9.76 | 10.60 | 11.42 | 11.87 | 12.30 | 11.95 | $11.31^b$ |
| $T_4$ - MJ 1µM | 9.72 | 10.38 | 11.28 | 11.73 | 12.11 | 11.75 | $11.16^d$ |
| $T_5$- TBZ 500 ppm | 9.75 | 10.55 | 11.40 | 11.80 | 12.20 | 11.83 | $11.26^c$ |
| $T_6$ –TBZ 750 ppm | 9.76 | 10.35 | 11.26 | 11.70 | 12.10 | 11.74 | $11.15^d$ |
| $T_7$- OA 4 mmol | 9.74 | 10.34 | 11.25 | 11.71 | 12.08 | 11.73 | $11.14^d$ |
| $T_8$-OA 6 mmol | 9.78 | 10.50 | 11.35 | 11.76 | 12.15 | 11.79 | $11.22^c$ |
| $T_9$- control | 9.77 | 10.70 | 11.30 | 11.88 | 12.05 | 10.25 | $10.98^e$ |
| Mean | $9.76^f$ | $10.50^e$ | $11.34^d$ | $11.79^b$ | $12.17^a$ | $11.64^c$ | |
| | F –test | | S.Em ± | | CD at 5 % | | |
| Treatments | ** | | 0.012 | | 0.033 | | |
| Days | ** | | 0.010 | | 0.027 | | |
| Treatments × Days | ** | | 0.029 | | 0.081 | | |

**9. Titratable Acidity (%)**

The treated fruits differed significantly with highest (0.31) titratable acidity in control which was on par with fruits treated with oxalic acid 4mmol (0.30). The lowest (0.25) titratable acidity was recorded in fruits treated with benzyl adenine 50 ppm (table 9). There were significant differences in titrable acidity among different days with significant decrease from 1st day (0.47) to 25th day (0.14). The decrease was more pronounced from 1st day (0.47) to 5th day (0.37). Among all treatments, on 1st day, highest titratable acidity was recorded with thiabendazole 750 ppm. On 5th day and 10th day, highest titratable acidity was recorded in control. On 15th day and 20th day, highest titratable acidity was recorded with control which was on par with oxalic acid 4 mmol. On 25th day, highest titratable acidity was recorded in control. Lowest levels of titrable acidity were recorded with benzyl adenine 50 ppm on 1st day of storage. On 5th day and 10th day, lowest titratable acidity was recorded with benzyl adenine 50 ppm which was on par with thiabendazole 500 ppm. On 15th day, lowest titratable acidity was recorded with benzyl adenine 50 ppm which was on par with oxalic acid 6 mmol. On 20th and 25th days, lowest titrable acidity was recorded with benzyl adenine 50 ppm. This could be attributed to the conversion of acids, into sugar (Pool *et al.* 1972) and utilization of organic acid during respiration (Srivastava *et al.* 1961). Similar decrease in acidity content of sapota fruits with increase in storage period and utilization of organic acid during respiration (Kumbhar and Desai, 1986) [10].

**Table 9:** Effect of postharvest application of antioxidants on titratable acidity (%) during storage of guava cv. Allahabad safeda at 6 ± 1º C.

| Treatments | Days after harvest | | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 | 25 | |
| $T_1$ - BA 50 ppm | 0.43 | 0.33 | 0.25 | 0.20 | 0.17 | 0.13 | $0.25^d$ |
| $T_2$- BA 100 ppm | 0.48 | 0.39 | 0.29 | 0.24 | 0.19 | 0.16 | $0.29^b$ |
| $T_3$- MJ 0.1µM | 0.44 | 0.35 | 0.26 | 0.22 | 0.18 | 0.14 | $0.27^c$ |
| $T_4$ - MJ 1 µM | 0.49 | 0.39 | 0.29 | 0.22 | 0.18 | 0.14 | $0.29^b$ |
| $T_5$- TBZ 500 ppm | 0.46 | 0.33 | 0.25 | 0.21 | 0.19 | 0.15 | $0.27^c$ |
| $T_6$ –TBZ 750 ppm | 0.50 | 0.40 | 0.31 | 0.24 | 0.18 | 0.13 | $0.29^b$ |
| $T_7$- OA 4 mmol | 0.49 | 0.40 | 0.30 | 0.25 | 0.20 | 0.14 | $0.30^a$ |
| $T_8$-OA 6 mmol | 0.48 | 0.39 | 0.26 | 0.20 | 0.18 | 0.14 | $0.28^c$ |
| $T_9$- control | 0.48 | 0.41 | 0.33 | 0.25 | 0.20 | 0.17 | $0.31^a$ |
| Mean | $0.47^a$ | $0.37^b$ | $0.28^c$ | $0.23^d$ | $0.19^e$ | $0.14^f$ | |
| | F -test | | S.Em ± | | CD at 5 % | | |
| Treatments | ** | | 0.002 | | 0.006 | | |
| Days | ** | | 0.001 | | 0.005 | | |
| Treatments × Days | ** | | 0.005 | | 0.016 | | |

**10. Brix-Acid ratio**

Highest (52.47) brix-acid ratio in fruits treated with benzyl adenine 50 ppm (table 10). The lowest (41.68) brix-acid ratio was recorded in the control. The brix-acid ratio increased from 1st day (20.72) to 25th day (81.38). The increase was more pronounced from 20th day (64.56) to 25th day (81.38). Highest brix-acid ratio was recorded in fruits treated with benzyl adenine 50 ppm on all intervals except on 20th day of storage where on 20th day it was recorded with 0.1µM methyl jasmonate. While, the lowest brix-acid ratio was recorded on 1st day (19.84) in fruits treated with methyl jasmonate 1µM. On 5th day, lowest (19.88) brix-acid ratio was recorded with oxalic acid 4 mmol. On 10th day (34.24) and 25th day (61.47), lowest brix-acid ratio was recorded in the control. On 15th day lowest (46.84) brix-acid ratio was recorded with oxalic acid 4 mmol. On 20th day lowest (60.25) brix-acd ratio was recorded in the control. Similar results were reported by Jayachandran *et al*. (2007) [9] in guava fruits. All the treatments recorded the increased brix-acid ratio with the increase in storage period except benzyl adenine 50 ppm where it increased up to 20th day and then decreased at the end of storage period which may be attributed to decrease in TSS comprised mostly of sugars, which are subjected to degradation during respiration (Amerine and Cruess, 1960) [2].

**Table 10:** Effect of postharvest application of antioxidants on brix-acid ratio during storage of guava cv. Allahabad Safeda at 6 ± 1º C.

| Treatments | Days after harvest | | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 | 25 | |
| $T_1$ - BA 50 ppm | 22.79 | 32.27 | 46 | 59.50 | 62.15 | 92.15 | 52.47$^a$ |
| $T_2$- BA 100 ppm | 20.33 | 26.66 | 38.89 | 48.87 | 63.68 | 73.56 | 45.33$^d$ |
| $T_3$- MJ 0.1µM | 22.18 | 30.28 | 43.92 | 53.95 | 68.33 | 85.35 | 50.67$^b$ |
| $T_4$ - MJ 1µ M | 19.84 | 26.61 | 38.89 | 53.31 | 67.27 | 83.92 | 48.31$^c$ |
| $T_5$- TBZ 500 ppm | 21.20 | 31.96 | 45.6 | 56.19 | 64.21 | 78.86 | 49.68$^b$ |
| $T_6$ –TBZ 750 ppm | 19.52 | 25.87 | 36.32 | 48.75 | 67.22 | 90.30 | 48.00$^c$ |
| $T_7$- OA 4 mmol | 19.88 | 25.85 | 37.5 | 46.84 | 60.4 | 83.78 | 45.71$^d$ |
| $T_8$-OA 6 mmol | 20.38 | 26.92 | 43.65 | 58.8 | 67.5 | 84.21 | 50.24$^b$ |
| $T_9$- control | 20.35 | 26.10 | 34.24 | 47.52 | 60.25 | 61.47 | 41.68$^e$ |
| Mean | 20.72$^a$ | 28.06$^b$ | 40.71$^c$ | 52.64$^d$ | 64.56$^e$ | 81.38$^f$ | |
| | F -test | | S.Em ± | | CD at 5 % | | |
| Treatments | ** | | 0.47 | | 1.32 | | |
| Days | ** | | 0.39 | | 1.08 | | |
| Treatments × Days | ** | | 1.15 | | 3.24 | | |

**11. Ascorbic acid (mg/100g)**

Results in table 11 reveal that highest (195.71) levels of ascorbic acid in the fruits treated with benzyl adenine 50 ppm. The lowest (172.5) levels were recorded in the fruits kept under control.The ascorbic acid increased from 1st day (157.34) to 20th day (211.94) and there after decreased from 20th day (211.94) to 25th day (176.51). With any given treatment, the ascorbic acid increased significantly from 1st day to 20th day, thereafter decreased significantly to reach a minimum on 25th day. However, highest ascorbic acid content was recorded with benzyl adenine 50 ppm on 1st day to 25th days of storage. On 1st day of storage, lowest ascorbic acid content was recorded with thiabendazol 750 ppm which was on par with oxalic acid 4 mmol. On 5th day to 25th days, control recorded lowest ascorbic acid. These findings are in agreement with the results of Chaudhary and Farooqui (1969) and Tripathi (1989). Similar results were reported in guava Bhagwan and Reddy (1998) [3] in tomato. The decline in ascorbic acid during storage may be attributed to conversion of ascorbic acid into dehydroascorbic acid (Gustafson and Cooke, 1952) [7].

**Table 11:** Effect of postharvest application of antioxidants on ascorbic acid (mg 100 $g^{-1}$) during storage of guava cv. Allahabad safeda at 6 ± 1º C.

| Treatments | Days after harvest | | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 | 25 | |
| $T_1$ - BA 50 ppm | 164.10 | 178.10 | 196.30 | 211.40 | 235.61 | 192.01 | 195.71$^a$ |
| $T_2$- BA 100 ppm | 156.30 | 170.15 | 184.20 | 193.45 | 208.30 | 174.10 | 181.08$^f$ |
| $T_3$- MJ 0.1µM | 160.60 | 176.25 | 194.10 | 208.10 | 220.25 | 182.10 | 190.23$^b$ |
| $T_4$ - MJ 1µ M | 155.80 | 170.10 | 185.54 | 194.60 | 208.45 | 175.20 | 181.62$^e$ |
| $T_5$- TBZ 500 ppm | 161.40 | 175.15 | 187.80 | 201.10 | 213.75 | 180.10 | 186.55$^c$ |
| $T_6$ –TBZ 750 ppm | 154.20 | 170.05 | 183.20 | 194.48 | 207.62 | 173.40 | 180.49$^f$ |
| $T_7$- OA 4 mmol | 154.65 | 172.85 | 183.48 | 194.60 | 208.20 | 173.45 | 181.20$^e$ |
| $T_8$-OA 6 mmol | 160.30 | 172.85 | 185.75 | 199.40 | 210.10 | 175.10 | 183.92$^d$ |
| $T_9$- control | 155.80 | 162.20 | 173.30 | 185.40 | 195.20 | 163.10 | 172.5$^g$ |
| Mean | 157.34$^f$ | 171.97$^e$ | 185.96$^c$ | 198.86$^b$ | 211.94$^a$ | 176.51$^d$ | |
| | F -test | | S.Em ± | | CD at 5 % | | |
| Treatments | ** | | 0.53 | | 1.48 | | |
| Days | ** | | 0.43 | | 1.21 | | |
| Treatments × Days | ** | | 1.29 | | 3.62 | | |

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