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Research Article

EFFECT OF POST HARVEST TREATMENTS ON SHELF LIFE AND QUALITY OF BANANA CV. GRAND NAINE

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Abstract- The present study was undertaken at Post Harvest Laboratory, Dr. Y.S.R Horticultural University, Hyderabad during 2014 and 2015 to envisage the effect of different chemicals and growth regulators in post harvest life of banana *cv.* Grand Naine where fruits were subjected to ten treatments with different concentration of GA_3, BA, $CaCl_2$ and Control (without any treatment) and replicated thrice. Fruits are treated in different chemicals/growth regulator delayed colour, texture, pulp to peel ratio and total soluble solids (TSS) content as compared to openly kept control banana. But, fruits treated with GA_3 150ppm (Dipping) recorded significantly lowest PLW (2.52 %) by maintaining significant amount of TSS (119.91° B), Brix-acid ratio (36.88%) and total sugars (16.50%), reducing sugar (7.72%) and non-reducing sugar (8.78%)in longest storage observation (on day 15) with a maximum shelf life up to 20.23 days compared to 9 days only for untreated fruits.

Keywords- Banana, Chemicals, Growth Regulator, Quality, Shelf-life

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Introduction

Banana (*Musa spp.)* is one of the most popular fruit all over the world because of its good calorific, nutritive value and multipurpose use as food. It belongs to the family Musaceae, is one of the most commercial fruit crops grown in tropics and subtropics. It plays a key role in the economy of India and other developing countries. Considering the nutritive values of banana, it is believed to be the "Poor man's apple". Banana is a rich source of carbohydrate, potassium, phosphorus, calcium, magnesium and vitamins like Vit-B. Fruit is free from fat with high calorific value. The low-fat and high sugar bananas are uses as dessert food and staple foods [1]. It is the cheapest fruits among all other fruits in the countries. India is the largest producer of banana (*Musa spp.*) in the world with a production of 28.45 million ton from an area of 802.6 thousand ha and productivity of 37 MT/ha [2]. There are large number of banana varieties grown in India, out of these, cv. Grand Naine is an introduced high yielding variety, the area of indigenous cultivars get shriveled to a great extent [3] and made this new cultivar popular and dominant one for domestic trade in India. Besides the increasing population, the production of banana has also increased for fulfilling the demand of produce. Nowadays, with increase production there is a lack of adequate postharvest storage facilities has posed a great threat to the commercial cultivation of banana. As a result, a huge amount of banana is spoiled every year.

Banana is a climacteric fruit and its biochemical changes are a continuous process after harvest till senescence [4]. Unlike many other fruits, banana is not a seasonal fruit and the availability of fruits in large quantities round the year. The benefits of increased production will not be realized unless it is duly accompanied by advanced storage, packaging and transport techniques. The aim of successful storage of fruits is to minimize the post-harvest losses by adopting proper post-harvest handling practices and a better understanding of the biochemical control of fruit ripening to enhance the shelf life. Ripening of banana can be delayed by the use of chemical like GA_3, Kinetin, BA, Benlate and ethylene absorbent [5]. Application of GA_3 and found that significantly lower physiological weight loss and pulp to peel ratio throughout the storage period[6].These treatments may arrest the growth and spread of micro organism by reducing the shriveling which leads to an increased shelf life and maintain the marketability of the fruit for a certain period [7]. It is necessary to study and understand the shelf life and quality of banana under different chemical treatments. Hence, the study was undertaken with the following objectives: to find out the physical changes of banana due to postharvest treatments and to identify the suitable treatment in extending the shelf life.

Materials and methods

Sample preparation, experimental design and treatments

The present experiment on the effect of post harvest treatments on shelf life and quality of banana cv. Grand Naine was carried out during 2014-15. Mature banana fruits were collected from farmers field located at Peddapur village of Medak district in Telangana, wherein pre-harvest spray schedules for effective control of major pests and diseases were strictly followed during fruit development and maturation until the fruits are harvested. Selected fruits were then sorted and graded by size, colour and weight. The individual hands were surface disinfected with Benomyl fungicide solution (1000 ppm) for 5 min and dried under shade. The hands were randomly divided into different treatment groups. Each treatment group consisted of five uniform hands (15 to 18 fingers per hand). The experiment was designed in completely randomized design (CRD) at Post Harvest laboratory, College of Horticulture, DR. Y.S.R Horticultural University, Rajendranagar, Hyderabad, during the year 2014 and 2015 with following ten treatments [T_1 - Gibberellic acid (Dipping) 100 ppm, T_2 - Gibberellic acid (Dipping) 150 ppm, T_3 - Gibberellic acid (Dipping) 200 ppm, T_4- BA (Dipping) 25ppm, T_5- BA (Dipping) 50 ppm, T_6- BA (Dipping) 100 ppm, T_7-Calcium Chloride (Dipping) 0.5 %, T_8-Calcium Chloride (Dipping) 1%, T_9-Calcium Chloride (Dipping) 1.5%, T_{10}-Control (without any treatment)] replicated thrice. 100, 150 and 200 mg of GA_3 was weighed and dissolved in small amount of ethanol at the slight warm state and made up to one liter with distilled water to get 100, 150 and 200 ppm solution respectively. To prepare 25, 50 and 100 ppm solutions of BA with 25, 50 and 100 mg respectively of BA was weighed and dissolved in small amount of ethanol at the slight warm state and made up to one litre with distilled water. 500, 1000 and 1500 mg of $CaCl_2$ were weighed and dissolved in small amount of ethanol at the slight warm state and made up to one litre with distilled water to get 0.5%, 1% and 1.5% solution respectively.

Data collection and observation

To determine internal and external quality parameters of banana for using two hand sample per treatment, fruit samples were drawn periodically at 3rd, 6th, 9th, 12th and 15th, days of storage. The physiological loss in weight (PLW) was calculated by the following formula:

$$\text{PLW} = \frac{\text{Initial weight of fruit} - \text{final weight of fruit}}{\text{Initial weight of fruit}} \times 100$$

A table top penetrometer was used to record the fruit firmness in kg/cm^2. The peel colour of fruit marked with visual observation and given the colour status of green, greenish yellow, yellow with green tips only, uniform yellow, yellow with small spots, yellow with brown spots and yellow with big black spots[8]**.** Fruit spoilage determined based on a visual symptom of fruit, hardening of the rind, fungal infection and subsequent rotting and percent fruit determined using following formula:

$$\text{Fruit spoilage \%} = \frac{\text{No. of spoiledfruits}}{\text{Total no. of fruits}} \times 100$$

The shelf life of fruit expressed as a mean number of days was assessed by recording the number of days required to make more than 50 percent fruit unfit for consumption and considered as the end of shelf life in that particular treatment.

Determination of bio-chemical properties

The total soluble solid was estimated using Carl-Zeiss hand refractometer and expressed in ^{0}Brix. Titrable acidity was determined by titrating 5 ml of juice against 0.1% NaOH and expressed as apercent value. The Brix-acid ratio was calculated by dividing the Brix with their respective titrable acidity [9]. Total sugars, reducing sugars and Non- reducing sugars were estimated as per the method suggested by [10].

Results and Discussion

Physiological parameters

Physiological loss in weight (%)

The results obtained on the effect of post-harvest treatments on physiological loss in weight of fruits are furnished in [Table-1]. There was a significant increase in PLW throughout the storage period ranging from 3rd day (0.40 - 2.10 %) to 15th day (10.01-15.70 %). Among the treatments, the lowest PLW of 0.40, 1.62, 3.31, 6.51 and 10.01% were observed in T_2 [Gibberellic acid (Dipping) 150 ppm] on 3rd, 6th, 9th, 12th and 15th Days of Storage (DOS) respectively, followed by T_3 [Gibberellic acid (Dipping) 200 ppm]. The highest PLW of 2.10, 5.35 and 8.72% on three stages 3rd, 6th and 9th DOS was observed in T_{10}(control) respectively. The present experimental findings have revealed that lowest PLW was recorded with Gibberellic acid dipping at 150 ppm over the other treatment combinations during the different days of storage. It might be due to effect of GA_3, which might have retained more water against the force of transpiration and also due to reduced rate of respiration and transpiration. The present observation is in conformity with the results reported [11, 12, 8] in banana.

Table-1 *Effect of postharvest treatments on Physiological loss in weight (PLW) and Firmness of banana cv. Grand Naine.*

Treatments	PLW (%)					Firmness (%)				
	3rd day	6th day	9th day	12th day	15th day	3rd day	6th day	9th day	12th day	15th day
T_1	3.35	2.97	2.44	2.15	1.72	1.32	1.61	2.06	2.13	2.92
T_2	3.51	3.22	2.82	2.62	2.52	1.31	1.39	2.02	2.11	2.28
T_3	3.42	3.12	2.62	2.52	2.33	1.32	1.40	2.03	2.12	2.52
T_4	3.05	2.52	2.13	1.62	-	1.31	1.97	2.34	2.80	-
T_5	2.98	2.62	2.24	1.72	-	1.32	1.71	2.18	2.23	-
T_6	2.97	2.53	2.33	1.82	1.22	1.30	1.59	2.06	2.23	3.04
T_7	3.03	2.52	2.15	1.72	-	1.31	1.82	2.27	2.49	-
T_8	3.02	2.51	2.22	1.92	1.42	1.32	1.61	2.08	2.13	3.14
T_9	2.97	2.51	2.19	1.82	-	1.31	1.71	2.09	2.40	-
T_{10}	1.43	0.97	0.53	-	-	1.44	2.13	3.09	-	-
SEm(±)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
CD at 0.05%	0.05	0.03	0.03	0.03	0.04	NS	0.03	0.03	0.03	0.07

* Significant,NS-Non-Significant,–End of shelf life.

T_1 – Gibberellic acid (Dipping) 100 ppm, **T_2** - Gibberellic acid (Dipping) 150 ppm, **T_3** - Gibberellic acid (Dipping) 200 ppm, **T_4**- BA (Dipping) 25ppm, **T_5** - BA (Dipping) 50 ppm, **T_6**- BA (Dipping) 100 ppm,**T_7**-Calcium Chloride (Dipping) 0.5 %, **T_8**-Calcium Chloride (Dipping) 1%, **T_9**-Calcium Chloride (Dipping) 1.5% ,**T_{10}** – Control (without any treatment). Values were compared with respective C.D values.

Firmness (kg/cm^2)

The firmness content [Table-1] of fruit was gradually declined with the proceeding of storage period from 3rd day to 15th day may be due to the break down of pectic substances and cell wall softening. The firmness of stored fruits ranged from 3rd DOS (2.97-3.51 kg/cm^2) to 15th DOS [Days of storage] (1.22-2.52 kg/cm^2). Among the treatments the highest firmness of 3.51, 3.22, 2.82, 2.62 and 2.52 kg/cm^2 were observed in T_2 [Gibberellic acid (Dipping) 150 ppm] on 3rd, 6th, 9th, 12th and 15th DOS respectively followed by T_3[Gibberellic acid (Dipping) 200 ppm]. The lowest firmness of 1.43, 0.97 and 0.53 kg/cm^2 on 3rd, 6th, and 9th day of storage was observed in T_{10} (control) respectively. The fruit firmness was gradually decreased from harvest to ripening and further towards the end of shelf life. The firmness of the fruit was found to reduce with increase in storage period. Gibberellic acid dipping at 150 ppm due to retarded degradation of polymer likes starch, cellulose, and hemicellulose. The results are agreement with those of [12-13] in banana.

Pulp to peel ratio

There was significant ($P \leq 0.05$) variation in pulp to peel ratio of the banana fruits subjected to different postharvest treatments throughout the storage period [Table-2]. The pulp to peel ratio range from 1.30% in 3rd DOS to 3.14% in 15th Days of Storage. For untreated fruits a steady uplift of pulp to peel ratio from 1.44

to 3.09% recorded during 3rd to 9th day; but during same period of storage lowest incensement of (1.31, 1.39, 2.02, 2.11 and 2.28%) recorded in T_2 [Gibberellic acid (Dipping) 150 ppm] during 3rd, 6th, 9th, 12th and 15th DOS (Days of Storage) respectively. Our results are in conformity of the results reported by [14] in banana.

Table -2 *Effect of post-harvest treatments on Pulp to peel ratio and Spoilage of banana cv. Grand Naine.*

Treatments	Pulp to peel ratio (%)					Spoilage (%)				
	3rd day	6th day	9th day	12th day	15th day	3rd day	6th day	9th day	12th day	15th day
T_1	1.32	1.61	2.06	2.13	2.92	0	0	05.33	25.25	43.08
T_2	1.31	1.39	2.02	2.11	2.28	0	0	2.53	11.07	26.17
T_3	1.32	1.40	2.03	2.12	2.52	0	0	2.70	13.91	27.40
T_4	1.31	1.97	2.34	2.80	-	0	5.33	22.78	42.63	60.00
T_5	1.32	1.71	2.18	2.23	-	0	2.53	22.07	40.76	58.30
T_6	1.30	1.59	2.06	2.23	3.04	0	2.70	20.04	40.03	50.00
T_7	1.31	1.82	2.27	2.49	-	0	2.53	13.83	33.21	60.00
T_8	1.32	1.61	2.08	2.13	3.14	0	2.55	11.83	24.64	50.00
T_9	1.31	1.71	2.09	2.40	-	0	2.70	13.83	24.63	54.00
T_{10}	1.44	2.13	3.09	-	-	4.30	25.30	50.00	76.03	-
S.Em(±)	0.01	0.01	0.01	0.01	0.02	0.30	0.44	0.05	0.27	0.16
CD at 0.05%	NS	0.01	0.01	0.01	0.02	0.91	1.32	0.15	0.81	0.48

* Significant, NS- Non-Significant,–End of shelf life.

T_1 – Gibberellic acid (Dipping) 100 ppm, **T_2** - Gibberellic acid (Dipping) 150 ppm, **T_3** - Gibberellic acid (Dipping) 200 ppm, **T_4**- BA (Dipping) 25ppm, **T_5** - BA (Dipping) 50 ppm, **T_6**- BA (Dipping) 100 ppm,**T_7**-Calcium Chloride (Dipping) 0.5 %, **T_8**-Calcium Chloride (Dipping) 1%, **T_9**-Calcium Chloride (Dipping) 1.5% ,**T_{10}** – Control (without any treatment). Values were compared with respective C.D values.

Table- 3 *Effect of post-harvest treatments on Colour and Shelf life of banana cv. Grand Naine*

Treatments	Colour					Shelf life
	3rd day	6th day	9th day	12th day	15th day	Days
T_1	Green	Green	Greenish yellow	Yellow with green tip	Yellow with small spots	17.00
T_2	Green	Green	Green	Greenish yellow	Uniform yellow	20.23
T_3	Green	Green	Green	Yellow with green tip	Uniform yellow	19.23
T_4	Greenish yellow	Yellow with green tip	Uniform yellow	Uniform yellow	-	13.28
T_5	Green	Green	Uniform yellow	Uniform yellow	-	14.28
T_6	Green	Green	Greenish yellow	Uniform yellow	Yellow with small spots	15.31
T_7	Greenish yellow	Yellow with green tip	Greenish yellow	Uniform yellow	-	13.28
T_8	Green	Green	Greenish yellow	Uniform yellow	Yellow with small spots	15.24
T_9	Green	Green	Greenish yellow	Uniform yellow	-	14.25
T_{10}	Greenish yellow	Yellow with green tip	Yellow with small spots	Yellow with black spot	-	9.00
SEm(±)	-	-	-	-	-	0.16
CD at 0.05%	-	-	-	-	-	0.46

* Significant,NS-Non-Significant, **–** End of shelf life.

T_1 – Gibberellic acid (Dipping) 100 ppm, **T_2** - Gibberellic acid (Dipping) 150 ppm, **T_3** - Gibberellic acid (Dipping) 200 ppm, **T_4**- BA (Dipping) 25ppm, **T_5** - BA (Dipping) 50 ppm, **T_6**- BA (Dipping) 100 ppm,**T_7**-Calcium Chloride (Dipping) 0.5 %, **T_8**-Calcium Chloride (Dipping) 1%, **T_9**-Calcium Chloride (Dipping) 1.5% ,**T_{10}** – Control (without any treatment). Values were compared with therespective C.D value.

Spoilage (%)

A progressive increase in the spoilage of fruits was observed with progress in storage period. On the 3rd day of observation, no spoilage was recorded in all the treatments except 4.30 % in T_{10}(control).The perusal data [Table-2] revealed that the highest spoilage was found 25.30, 50.00, 76.03% in T_{10} (control) at 6th, 9th, and 12th DOS respectively followed by T_4 [BA (Dipping) 25ppm]. The lowest spoilage of 2.53, 11.07, 26.17 % were observed in T_2 [Gibberellic acid (Dipping) 150 ppm] on 9th, 12th and 15th Days of Storage (DOS) respectively followed by T_3 [Gibberellic acid (Dipping) 200 ppm]. The rate of spoilage increased with the progressive its increase in ripening and days to storage. Spoilage of fruits was directly related to the rate of respiration of fruits, which leads to deterioration of fruits. [15].

Colour development

Perusal data from [Table-3] revealed that the banana fruits were greenish initially but subsequently on their gradual ripening, they turned greenish yellow with green tips, uniform yellow, yellow with small spots and finally yellow with brown spotting during the storage. The change in colour was much faster in untreated control as compared to treated fruits. The visual spots first appeared in (T_{10}) control on the 9th day. Fruits kept in (T_2) Gibberellic acid dipping 150 ppm were noticed with fewer spots compared with other treatments. On the 15th day of storage fruits kept in T_2 (Gibberellic acid dipping at 150 ppm) maintained the good marketable colour of fruits. Fruits treated with Gibberellic acid dipping at 150 ppm delayed the colour development; this might be due to control in ethylene level and respiratory activity. Similar findings were reported by [6, 11] in banana. Colour development was closely associated with a climacteric peak in all the treatments and in control. The colour development which started prior to the onset of climacteric was completed at the peak climacteric [16].

Shelf life (Days)

The maximum day of shelf life was significantly recorded for total ripening of bananas by Gibberellic acid dipping at 150 ppm (20.23 days) in T_2 treatment followed by (T_3) Gibberellic acid dipping 200 ppm (19.23 days). Minimum shelf life was observed in (T_{10}) control (9 days) of banana fruits showed in [Table-3]. It is evident from the data that Gibberellic acid dipping at 150 ppm recorded the highest shelf life. This may be due to that Gibberellic acid might have controlled the ethylene production as well as enzymatic activity resulting into reduction in the ripening process. Corroborative results were obtained by [4, 6 and 12] in banana.

Biochemical parameters

Total soluble solids (°Brix)

Significant differences were observed in the total soluble content of fruits due to different treatments and data furnished in [Table-4]. The TSS of stored fruits ranged from 3rd DOS (6.52-14.55⁰ Brix) to 15th DOS (19.91-22.12⁰ Brix). Among the treatments, the highest total soluble solids 14.55, 20.08, 16.10°Brix on 3rd, 6th and 9th DOS respectively was observed in T_{10}(control) followed by T_4 treatment [BA (Dipping) 25ppm]. The lowest total soluble solid with 6.52, 7.93, 12.91, 16.93 and 19.91 °Brix on 3rd, 6th, 9th, 12th and 15th DOS was observed in T2 [Gibberellic acid (Dipping) 150 ppm] respectively. The total soluble solids content of the fruits reached a maximum at the ripe stage and started declining towards the end of shelf life. The increase in the Total soluble solids during ripening was due to break down of starch and polysaccharides into sugars. Further due to over ripening/senescence the sugar is degraded to CO_2 because of respiration. Gibberellic acid dipping recorded minimum Total soluble solids it might be due to reduced rate of respiration and delayed ripening [17-18].

Acidity (%)

It is evident from the [Table-4], that the acidity in the fruits was significantly affected by the duration and treatments. The acidity of stored fruits ranged from 3rd DOS (0.74- 1.07%) to 15th DOS (0.49- 0.54%). Acidity was not influenced by treatments on 3rd DOS. The lowest acidity was observed in T_{10} (control) [0.74, 0.51, 0.41%] respectively on 3rd, 6th and 9th DOS followed by (T_4) BA (dipping at 25 ppm) and the highest acidity was recorded in (T_2) Gibberellic acid dipping at 150 ppm with 0.94, 0.74, 0.64 and 0.54% on 6th, 9th, 12th and 15th DOS respectively followed by T_3 treatment. The acidity showed a constant decrease during the storage period. The decline in acidity may be due to utilization of acids in the process of ripening in the presence of reduced supply of sugar as a substrate of respiration which might be due to lower rate of starch degradation during the ripening. A Higher level of acidity in Gibberellic acid dipping treated fruits might be due to less utilization of organic acids in respiration due to controlled ripening. A similar result was obtained by [6].

Table-4 *Effect of post-harvest treatments on TSS, acidity and Brix-acid ratio of banana cv. Grand Naine*

Treatments	TSS (⁰Brix)					Acidity (%)					Brix-acid ratio (%)				
	3rd day	6th day	9th day	12th day	15th day	3rd day	6th day	9th day	12th day	15th day	3rd day	6th day	9th day	12th day	15th day
T_1	6.65	8.43	14.25	18.25	22.12	1.07	0.87	0.71	0.62	0.51	6.21	9.68	20.07	29.43	43.39
T_2	6.52	7.93	12.91	16.93	19.91	1.07	0.94	0.74	0.64	0.54	6.09	8.43	17.45	26.44	36.88
T_3	6.65	8.11	13.08	17.08	20.09	1.07	0.91	0.72	0.62	0.53	6.21	8.91	18.16	27.40	37.46
T_4	7.45	9.55	15.30	22.15	-	1.06	0.75	0.57	0.42	-	7.02	12.73	26.84	52.73	-
T_5	7.15	9.15	15.15	22.14	-	1.06	0.84	0.64	0.53	-	6.74	10.89	23.67	41.47	-
T_6	6.81	8.45	14.26	18.25	22.05	1.07	0.82	0.65	0.57	0.50	6.36	10.31	21.38	31.84	44.10
T_7	7.42	9.49	15.21	22.05	-	1.06	0.81	0.64	0.54	-	7.00	11.71	23.76	40.21	-
T_8	6.82	8.46	14.36	20.12	22.15	1.07	0.82	0.65	0.57	0.49	6.37	10.30	22.09	35.29	45.20
T_9	7.25	9.28	15.10	18.45	-	1.06	0.81	0.63	0.53	-	6.83	11.45	23.96	34.59	-
T_{10}	14.55	20.08	16.10	-	-	0.74	0.51	0.41	-	-	19.66	39.37	39.26	-	-
SEm(±)	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.06	0.17	0.02	0.04	0.53
CD at 0.05%	0.05	0.06	0.07	0.07	0.07	NS	0.02	0.03	0.03	NS	0.18	0.50	0.64	1.22	1.59

NS- Non-Significant, –End of shelf life.

T_1 – Gibberellic acid (Dipping) 100 ppm, **T_2** - Gibberellic acid (Dipping) 150 ppm, **T_3** - Gibberellic acid (Dipping) 200 ppm, **T_4**- BA (Dipping) 25ppm, **T_5** - BA (Dipping) 50 ppm, **T_6**- BA (Dipping) 100 ppm,**T_7**-Calcium Chloride (Dipping) 0.5 %, **T_8**-Calcium Chloride (Dipping) 1%, **T_9**-Calcium Chloride (Dipping) 1.5% ,**T_{10}** – Control (without any treatment). Values were compared with respective C.D values.

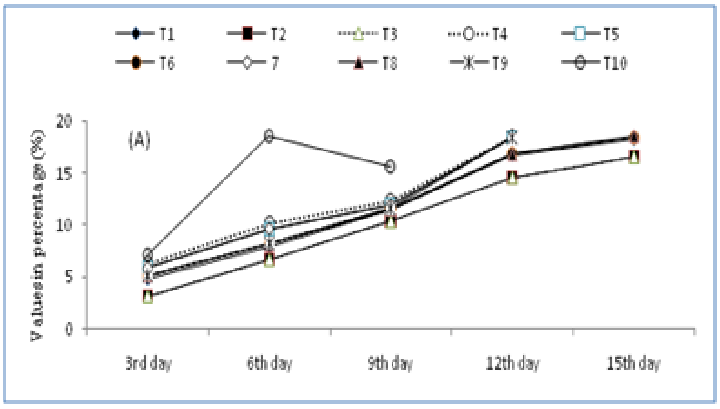
Brix-acid ratio (%)

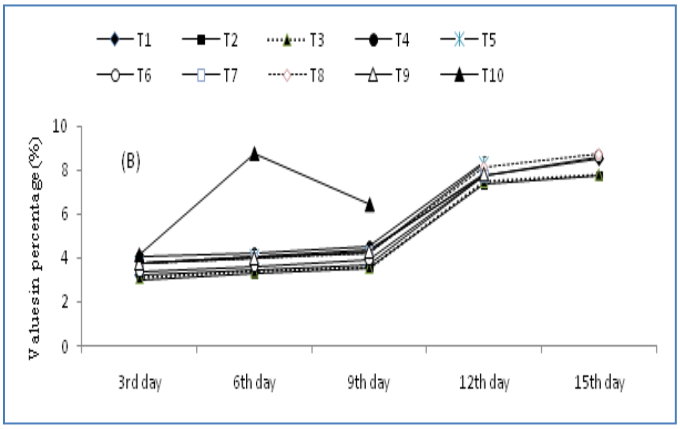
The data on the Brix-acid ratio in banana as influenced by different post-harvest treatments is presented in [Table-4].The Brix-acid ratio of stored fruits ranged from 3rd DOS (6.09-19.66 %) to 15th DOS (36.88-45.20 %). The highest Brix-acid ratio (19.66, 39.37, and 39.26%) was observed in T10 (control) on 3rd, 6th and 9th DOS respectively followed by T_4(BA dipping at 25 ppm). The lowest Brix-acid ratio (6.09, 8.43, 17.45, 26.44 and 36.88%) was observed in T_2 [Gibberellic acid (Dipping) 150 ppm] on 3rd, 6th, 9th, 12th and 15th DOS respectively. Brix-acid of banana fruits increased continuously throughout the storage periods. The lower Brix-acid ratio was recorded in Gibberellic acid dipping. This might be due to retarded ripening in treated fruits [19].

Total sugars (%), reducing sugars (%) and non-reducing sugars (%)

Perusal data in [Fig-1] revealed that the total sugars of stored fruits ranged from 3.12 percent at 3rd DOS to 18.56 percent at 15th DOS. Among the treatments, the highest total sugars of 7.14, 18.55 and 15.63 percent were observed in T_{10} (control) on 3rd, 6th and 9th DOS respectively and on par with the treatment T_4 [BA Dipping at 25ppm]. The lowest total sugar of 3.12, 6.63, 10.63, 14.45 and 16.50 percent was recorded in T_2[Gibberellic acid Dipping at 150 ppm] on 3rd, 6th, 9th and 12th DOS respectively.

The data pertaining to the reducing sugars was presented in [Fig-1], which indicates that there were significant changes in reducing sugars among the treatments. The reducing sugars of stored fruits ranged from 3.02 percent at 3rd DOS to 8.73% at 15th DOS. Among the treatments, the highest reducing sugars of 4.10, 8.74 and 6.41% were observed in T_{10} (control) on 3rd, 6th and 9th DOS respectively and on par with the treatment T_4 [BA (Dipping) 25ppm]. The lowest total sugar of 3.02, 3.29, 3.54, 7.34 and 7.72% was recorded in T_2 [Gibberellic acid (Dipping) 150 ppm] on 3rd, 6th, 9th and 12th DOS respectively. The non-reducing sugars of stored fruits ranged from 0.08 per cent at 3 DOS to 9.83 percent at 15th DOS. Among the treatments, the highest reducing sugars of 3.01, 9.81 and 9.21 per cent were observed in T_{10} (control) on 3rd, 6th, and 9th DOS respectively and on par with the treatment T_4 [BA (Dipping) 25ppm]. The lowest total sugar of 0.08, 3.35, 6.82, 7.11 and 8.78 per cent was recorded in T_2 [Gibberellic acid (Dipping) 150 ppm] on 3rd, 6th, 9th and 12th DOS respectively. It is observed from the data that reducing, total and non-reducing sugar percentage increased up to ripening and the decreased thereafter. The reducing sugar and total sugars were found to be increased up to ripening thereafter showed a decline at the end of shelf life in all the treatments. The initial raise in sugar content may be due to the conversion of starch into sugars, while later the decrease was due to consumption of sugars for respiration during storage. The total sugar of banana fruits was increased upto certain periods of storage and declined thereafter till the end of shelf life. Hence from the result, it is clear that Gibberellic acid dipping recorded lowest total sugar, reducing sugar and non-reducing sugar content. A similar result was reported by [4].





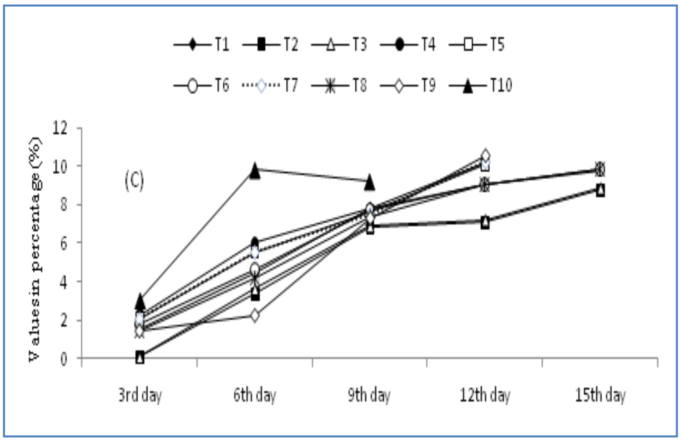


Fig-1 (A, B and C) Effect of active packaging methods on Reducing sugar (%), Non-reducing sugar (%) and Total sugar (%) of banana cv. *Grand Naine.* T_1 – Gibberellic acid (Dipping) 100 ppm, T_2 - Gibberellic acid (Dipping) 150 ppm, T_3 - Gibberellic acid (Dipping) 200 ppm, T_4- BA (Dipping) 25ppm, T_5 - BA (Dipping) 50 ppm, T_6- BA (Dipping) 100 ppm, T_7-Calcium Chloride (Dipping) 0.5 %, T_8-Calcium Chloride (Dipping) 1%, T_9-Calcium Chloride (Dipping) 1.5% ,T_{10} – Control (without any treatment).

Conclusion

From the present study, it is conclude that post-harvest treatment improved post-harvest quality of banana by reducing losses and extended shelf life. Thus, treatment with GA_3 150 ppm (Dipping) had longer shelf life with minimum spoilage of fruits and good quality attributes of fruits.

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Abbreviations: ml: Millilitre; ha: Hectare; MT: Metric tonne; %: Percentage; m^2: metre square; kg : Kilogram; CD: Critical difference; SEm : Standard error mean; et al: and others. Spp.: Species; GA_3: Gibberellic acid; BA: Benzyl adenine; ppm: Parts per million; DOS: Days of Storage.

Conflict of Interest: None declared

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