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PRE-HARVEST APPLICATION OF CHEMICALS AFFECT BIOCHEMICAL CHANGES IN BANANA CV. DWARF CAVENDISH DURING STORAGE

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ABSTRACT

An experiment was laid out to improve the bio-chemical activities of tissue cultured banana cv. Dwarf Cavendish. The results indicated that on 18th day of storage maximum TSS (23.99 °Brix), reducing sugar (10.07 per cent) as well as ascorbic acid (3.78 mg/100 g pulp) were obtained in fruits sprayed with GA_3 (200 ppm). On 18th day of storage the maximum 0.404 per cent acidity was found with GA_3 200 ppm (T_6) while minimum 0.273 per cent was with NAA 100 ppm (T_4). On 15th day, the maximum (81.52) TSS/acid ratio was found with NAA 100 ppm (T_4) which was significantly superior to rest of the treatment while lowest (46.00) TSS/acid ratio was noted under control (T_{12}).

***Key words :** Banana, chemicals, bio-chemical changes.*

Banana (*Musa sp.*) belonging to the family Musaceae is one of the oldest and choicest fruits of world. It is believed to have originated in the hot tropical regions of South-East Asia and India is believed to be one of centres of origin. Area, production and productivity in india are 7.09 lakh hectare, 262.17 lakh tone and 37.0 MT/ha respectively (Indian Horticulture Database, 2009). It is very nourishing fruit and contains nearly all essential nutrients including minerals and vitamins and has several medical properties. It is a rich source of energy and contains as much as 27 percent carbohydrate. The pulp of green fruits of banana is mostly starch which is converted into simple sugars during ripening. India is the largest producer of banana in the world and banana production has surpassed the total production of mango in the country. This fruit occupies an estimated area of 4.64 lakh hectares in India (Chadha, 2001).

Banana is a climacteric fruit which shows rapid increase in respiration after harvesting. The banana fruits are highly perishable and cannot be stored for long after harvest. Under ordinary conditions; fruits keep well for 6-8 days and are spoiled within few days of harvesting due to fast ripening and degradative metabolism. The magnitude of post-harvest losses of banana fruits is estimated to be as high as 30-40 per cent (Salunkhe and Desai, 1984) in India due to prevailing high temperature and humidity. The losses also occur on account of various reasons such as improper handling, poor transportation, inadequate storage facilities, lack of packaging and refrigerated storage condition. Under prevailing ambient condition fruits may become unconsumable very soon and marketability declines very sharp. Due to high tropical atmospheric temperatures, often severe weight losses, stalk rotting and poor marketability of banana bunches during handling and storage have been associating with rapid rate of ripening (Patil and Magar, 1975). Fruits are living entities and biologically active even after harvest. They undergo continuous enzymatic and bio-chemical changes and carry out live processes like transpiration and respiration, which accelerate ripening and deteriorate the quality of the produce and finally make it unconsumable. Proper storage provides an environment, which minimizes the biological activities and the pathological deterioration of fruits. Thus, to preserve freshness of banana fruits for considerable period some inexpensive and convenient storage measures are in need to be adopted. The changes in biochemical parameters and extension of shelf-life is possible by delaying ripening, inhibiting ethylene production, reducing respiration and minimizing oxidative metabolism and activities of various enzymes at prevailing warm ambient condition at which the bulk of fruits is handled in India.

Development of methods for delaying ripening and senescence without adverse effect on quality would therefore be of immense value in maintaining quality parameters of fruits during storage. Extension of shelf-life and improving the quality parameters of fruits at ambient conditions

Table-1 : TSS content of banana fruits during storage under various pre-harvest treatments.

Treatments	Pooled							Mean
	Days in storage							
	0	3	6	9	12	15	18	
T_1-$CaCl_2$ (1%)	1.34	3.76	7.21	14.41	18.13	20.01	18.87	11.96
T_2-$CaCl_2$ (2%)	1.31	3.75	7.01	14.01	18.01	19.73	18.71	11.79
T_3-NAA (50 ppm)	2.69	5.44	11.13	18.83	22.13	23.17	20.11	14.78
T_4-NAA (100 ppm)	2.89	5.96	12.00	18.90	22.33	23.31	19.97	15.05
T_5-GA_3 (100 ppm)	1.40	3.61	7.37	14.01	17.88	19.43	23.93	12.52
T_6-GA_3 (200 ppm)	1.27	3.50	6.73	13.09	17.24	19.31	23.99	12.16
T_7-Ca $(NO_3)_2$ (1%)	1.39	3.82	7.23	14.46	18.22	20.22	19.11	12.06
T_8-Ca $(NO_3)_2$ (2%)	1.36	3.76	7.21	14.30	18.13	19.93	19.01	11.96
T_9-MH (200 ppm)	1.52	4.41	7.78	15.03	19.51	20.06	17.13	12.20
T_{10}-MH (400 ppm)	1.60	4.52	7.67	15.31	19.86	20.61	17.02	12.37
T_{11}-Water Spray	1.65	5.02	9.93	16.62	19.13	21.43	16.13	12.84
T_{12}-Control	1.66	5.09	10.01	16.68	19.68	21.59	15.74	12.92
Mean	1.68	4.38	8.44	15.47	19.18	20.73	19.14	12.72
C.D. at 5%								
Treatments	0.1826							
Days	0.1404							
Treatments x Days	0.4535							

Table-2 : Titratable acidity (%) of banana fruits during storage under various pre harvest treatments.

Treatments	Pooled							Mean
	Days in storage							
	0	3	6	9	12	15	18	
T_1-$CaCl_2$ (1%)	0.246	0.299	0.340	0.366	0.381	0.398	0.388	0.345
T_2-$CaCl_2$ (2%)	0.237	0.289	0.331	0.363	0.377	0.389	0.371	0.337
T_3-NAA (50 ppm)	0.152	0.199	0.237	0.269	0.288	0.297	0.279	0.246
T_4-NAA (100 ppm)	0.145	0.187	0.224	0.255	0.276	0.286	0.273	0.235
T_5-GA_3 (100 ppm)	0.250	0.295	0.334	0.362	0.384	0.395	0.390	0.344
T_6-GA_3 (200 ppm)	0.252	0.303	0.341	0.372	0.391	0.402	0.404	0.352
T_7-Ca $(NO_3)_2$ (1%)	0.240	0.289	0.335	0.364	0.378	0.388	0.373	0.338
T_8-Ca $(NO_3)_2$ (2%)	0.231	0.277	0.320	0.357	0.372	0.381	0.369	0.329
T_9-MH (200 ppm)	0.224	0.286	0.321	0.355	0.372	0.380	0.371	0.330
T_{10}-MH (400 ppm)	0.220	0.272	0.313	0.345	0.366	0.375	0.363	0.322
T_{11}-Water Spray	0.239	0.251	0.297	0.320	0.342	0.355	0.341	0.306
T_{12}-Control	0.254	0.273	0.298	0.326	0.349	0.355	0.343	0.314
Mean	0.224	0.268	0.307	0.338	0.356	0.366	0.355	0.316
C.D. at 5%								
Treatments	0.0009							
Days	0.0009							
Treatments x Days	0.0026							

has successfully been achieved with the use of certain chemicals and growth regulators. Usefulness of chemicals like calcium chloride, calcium nitrate, GA_3, NAA, and MH have been established in various climacteric fruits like banana, mango, sapota etc. These chemicals counteract ethylene production and reduce the rate of respiration leading to lower rate of oxidative metabolism and pectin hydrolysis through declined catalase and PME activities.

MATERIALS AND METHODS

The present investigation was carried out in the Department of Horticulture, Institute of Agricultural Sciences, BHU, Varanasi on tissue cultured banana plants of cultivar Dwarf Cavendish (AAA) during the cropping season of 2008-2009 and 2009-2010. There are twelve treatments namely T_1-$CaCl_2$ (1 %), T_2 -$CaCl_2$ (2 %), T_3-NAA (50 ppm), T_4-NAA (100 ppm), T_5-GA_3 (100 ppm), T_6-GA_3 (200 ppm), T_7-Ca $(NO_3)_2$ (1 %), T_8-Ca $(NO_3)_2$ (2%), T_9-MH (200 ppm), T_{10}-MH (400 ppm), T_{11}-water spray and T_{12}- control (without water spray) under completely randomized design with three replication.

Spraying was done 15 days before harvesting of the fruits. Fruits were stored in bamboo basket at ambient temperature of 28.5 ± 4.5^{0}C and 75-95 per cent relative humidity. The storage was terminated on the day when the fruits exhibited 12-14 per cent loss due to rotting in best treatment.

Total soluble solids (TSS) : The total soluble solids of the fruits were estimated at harvest and during storage with the help of hand refractrometer and value were expressed as ^{o}Brix.

Titratable acidity : The acidity of fruits under different treatments was estimated soon after harvest of the fruits and during storage at three days intervals. For its determination, the method suggested by A.O.A.C. (1975) was followed. Clear homogenized juice extracted from the fruits was titrated against standard sodium hydroxide solution (N/10) using phenolphthalin as an indicator. The acidity of fruits so obtained was expressed in grams of anhydrous citric acid per 100 g of the pulp.

Reducing sugar (per cent) : Reducing sugars were estimated by Lane and Eynon (1923). 5 ml. Each of Fehling's A and B solutions was taken in a conical flask and 10 ml of distilled water was added to it. The juice was than titrated against boiling solutions of Fehling's using methylene blue as an indicator. The appearance of brick red colour determined the end point. The content of reducing sugar in gram per 100 g, of pulp in terms of glucose was worked out.

Ascorbic acid (mg/100 g pulp) : Ascorbic acid content of pulp was determined by titrating freshly extracted juice against 2, 6 – dichlorophenol endophenols dye (A.O.A.C. 1975). For its determination, 20 g pulp was taken and 50 ml of 3.0 per cent meta-phosphoric acid solution was added to it. Aliquot of filtrate was titrated against standard 0.025 per cent 2, 6-dichlorophenol indophenols dye solution. The end point was determined by the appearance of pink colour, which persisted for 15 seconds. It was expressed as milligrams of ascorbic acid per 100 gram of pulp.

Statistical analysis : The data with regards to different characters under study were subjected to statistical analysis as suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Total Soluble Solids (^{0}Brix) : In all the treatments as the days of storage increased the TSS gradually increased significantly upto the 15th day of storage and then it decreased with further increase in the storage period except in GA_3 100 ppm (T_5) and GA_3 200 ppm (T_6) where it increased upto 18th day of storage. It was further noticed that the maximum (23.99 ^{o}Brix) TSS was recorded in GA_3 200 ppm (T_6) which was at par with GA_3 100 ppm (T_5) and significantly minimum (15.74^0 Brix) TSS under control (T_{12}) on the 18th day of storage. However, on 15th day of storage the maximum TSS (23.31^{0}Brix) was obtained with NAA 100 ppm (T_4) which shows statistical equality with NAA 50 ppm (T_3). The TSS content in fruits gradually increased significantly upto 15th day of storage and it declined a little thereafter on 18th day of storage except in the treatment GA_3 (100 and 200 ppm) where it was increased. Similar views were expressed by Ghosh *et al*. (1997b), Sarkar *et al.* (1995) and Firmin (1991) in banana. The increase in TSS may be accounted to the moisture loss, hydrolysis of polysaccharide and conversion of organic acids into sugar. The decrease in TSS on prolonged storage period could be due to greater utilization of reserved sugars in respirating process during prolonged storage. It appears that on complete hydrolysis of starch yielding mono and disaccharide sugars no further formation occurred and subsequently a decline in content of these sugars is predictable as these are the primary substrate of perspiration.

Titratable acidity (per cent) : It is discerned from the two way mean table that in all the treatments the titratable acidity increased steadily up to 15th day of storage and thereafter it declined on the last day i.e., on 18th day of storage except in GA_3 200ppm (T_6). On first day of storage, maximum acidity 0.254 per cent was noted in control (T_{12}) which showed statistical parity with GA_3 200 ppm (T_6) while minimum acidity 0.145 per cent was recorded with NAA 100 ppm (T_4). The observations on 18th day of storage indicated that the

Table-3 : Ascorbic acid (mg/100g pulp) content of banana fruits during storage under various pre-harvest treatments.

Treatments	Pooled							Mean
	Days in storage							
	0	3	6	9	12	15	18	
T_1-$CaCl_2$ (1%)	13.47	12.41	11.33	9.31	6.68	3.01	2.20	8.34
T_2-$CaCl_2$ (2%)	15.82	14.82	13.88	11.81	8.91	4.44	3.04	10.39
T_3-NAA (50 ppm)	12.77	11.71	10.50	8.70	5.93	3.00	2.00	7.80
T_4-NAA (100 ppm)	12.73	11.62	10.42	8.59	5.79	2.50	1.91	7.65
T_5-GA_3 (100 ppm)	14.45	13.43	12.41	10.04	7.90	3.72	2.59	9.22
T_6-GA_3 (200 ppm)	16.16	15.17	14.08	12.01	8.92	4.63	3.78	10.68
T_7-Ca $(NO_3)_2$ (1%)	13.51	13.43	11.31	9.37	6.72	3.02	2.27	8.52
T_8-Ca $(NO_3)_2$ (2%)	15.95	14.87	13.91	11.87	9.03	4.48	3.11	10.46
T_9-MH (200 ppm)	11.52	10.40	9.31	7.40	4.36	2.34	1.85	6.74
T_{10}-MH (400 ppm)	11.19	10.02	9.08	7.32	4.11	2.10	1.70	6.50
T_{11}-Water Spray	10.56	9.89	8.78	7.80	4.01	2.02	1.02	6.29
T_{12}-Control	10.54	9.86	8.76	7.78	3.97	2.00	0.99	6.27
Mean	13.22	12.30	11.14	9.33	6.36	3.10	2.20	8.24
C.D. at 5%								
Treatments	0.1356							
Days	0.1035							
Treatments x Days	0.3524							

Table-4 : Reducing sugar (%) of banana fruits during storage under various pre-harvest treatments.

Treatments	Pooled							Mean
	Days in storage							
	0	3	6	9	12	15	18	
T_1-$CaCl_2$ (1%)	0.54	1.74	3.35	6.57	8.12	9.37	8.00	5.38
T_2-$CaCl_2$ (2%)	0.56	1.85	3.76	6.74	8.46	9.48	7.92	5.54
T_3-NAA (50 ppm)	1.10	2.61	5.03	7.73	9.28	10.14	8.44	6.33
T_4-NAA (100 ppm)	1.19	2.96	5.38	7.81	9.31	10.27	8.38	6.47
T_5-GA_3 (100 ppm)	0.61	1.81	3.59	5.91	7.87	9.50	10.04	5.62
T_6-GA_3 (200 ppm)	0.51	1.72	3.13	5.46	7.80	9.44	10.07	5.44
T_7-Ca $(NO_3)_2$ (1%)	0.55	1.78	3.37	6.55	8.16	9.40	8.01	5.40
T_8-Ca $(NO_3)_2$ (2%)	0.58	1.89	3.78	6.73	8.47	9.51	7.79	5.53
T_9-MH (200 ppm)	0.70	1.72	3.75	7.04	8.38	8.82	7.21	5.37
T_{10}-MH (400 ppm)	0.79	1.71	3.77	7.27	8.39	8.96	7.57	5.49
T_{11}-Water Spray	0.88	2.17	4.06	7.46	9.16	9.99	7.13	5.83
T_{12}-Control	0.90	2.10	4.07	7.52	9.19	10.13	7.03	5.85
Mean	0.75	2.00	3.92	6.90	8.55	9.58	8.13	5.69
C.D. at 5%								
Treatments	0.0756							
Days	0.0582							
Treatments x Days	0.1871							

Table-5 : TSS/Acid ratio of banana fruits during storage under various pre-harvest treatments.

Treatments	Pooled							Mean
	Days in storage							
	0	3	6	9	12	15	18	
T_1-$CaCl_2$ (1%)	5.44	12.56	21.22	39.37	47.57	50.33	48.62	32.16
T_2-$CaCl_2$ (2%)	5.52	12.96	21.21	38.59	47.77	50.79	50.42	32.47
T_3-NAA (50 ppm)	17.70	27.38	46.94	70.00	76.96	78.01	72.08	55.58
T_4-NAA (100 ppm)	19.86	31.93	53.71	74.18	81.12	81.52	73.32	59.38
T_5-GA_3 (100 ppm)	5.62	12.26	22.07	38.79	46.67	49.26	61.47	33.73
T_6-GA_3 (200 ppm)	5.06	11.57	19.76	35.27	44.18	48.12	59.40	31.91
T_7-Ca $(NO_3)_2$ (1%)	5.80	13.24	21.61	39.81	48.25	52.20	51.33	33.18
T_8-Ca $(NO_3)_2$ (2%)	5.90	13.60	22.55	40.06	48.80	52.38	51.59	33.55
T_9-MH (200 ppm)	6.77	15.45	24.22	42.42	52.54	52.88	46.24	34.36
T_{10}-MH (400 ppm)	7.30	16.60	24.49	44.46	54.32	54.99	46.95	35.59
T_{11}-Water Spray	6.93	20.01	33.49	51.92	56.06	60.47	47.40	39.47
T_{12}-Control	6.56	18.65	33.61	51.15	56.40	60.83	46.00	39.03
Mean	8.21	17.18	28.74	47.17	55.05	57.65	54.57	38.37
C.D. at 5%								
Treatments	0.98							
Days	0.75							
Treatments x Days	2.59							

maximum 0.404 per cent acidity was found with GA_3 200 ppm (T_6) while minimum 0.273 per cent was with NAA 100 ppm (T_4). The titratable acidity of banana fruits increased upto 15^{th} day with application of all the chemical under study and thereafter it declined on 18^{th} day of storage except GA_3 (200 ppm) where it was increased. This result can be correlated with the findings of Tomi *et al.* (1970) who had recorded higher acidity in banana fruits with application of GA_3. Rajkumar *et al*. (2005) also noticed that GA_3 100 ppm maintained higher titratable acidity at the end of 9^{th} day of storage of papaya.

Ascorbic Acid (mg/100g pulp) : In all the treatments as the days of storage increased the ascorbic acid content of banana gradually and significantly decreased upto last day of observations. It was further noticed that the maximum (16.16 mg/100 g pulp) ascorbic acid content was recorded on initial day of storage with GA_3 200 ppm (T_6) while minimum (10.54 mg/100 g pulp) was noted control (T_{12}) which was at par with application of water spray (T_{11}). On the 18^{th} day of storage the significantly maximum (3.78 mg/100 g pulp) ascorbic acid content was obtained in fruits treated with GA_3 200 ppm (T_6) followed by Ca $(NO_3)_2$ 2 per cent (T_8) and $CaCl_2$ 2 per cent (T_2) whereas minimum (0.99 mg/100 g pulp) value was estimated in fruits under control (T_{12}) followed by water spray (T_{11}). The ascorbic acid content of fruits declined gradually with the enhancement of storage period. Similar results were obtained by Emerald and Sreenarayanan (1999) and Sarkar *et al*. (1995) in banana.

Reducing Sugar (per cent) : It is evident from the two way mean table that the content of reducing sugar in banana fruits increased steadily up to the 18^{th} day under GA_3 100 & 200 ppm (T_5 & T_6) treated fruits, whereas in others it declined after the 15^{th} day. On the 1^{st} day of observation the maximum of 1.19 per cent was in fruits treated with NAA 100 ppm (T_4) which was at par with NAA 50 ppm (T_3) while minimum of 0.51 per cent was recorded with GA_3 200 ppm (T_6). Similar trend was noted upto 15^{th} day of storage. On 15^{th} day of storage, the maximum of 10.27 per cent was recorded with NAA 100 ppm (T_4) and it was at par with NAA 50 ppm (T_3) and control (T_{12}). The minimum of 8.82 per cent was recorded with MH 200 ppm (T_9) which was at par with MH 400 ppm (T_{10}). The observations on 18^{th} day of storage indicated that the maximum of 10.07 per cent was noted with GA_3 200 ppm (T_6) which was at par with GA_3 100 ppm (T_5) and minimum of 7.03 per cent was recorded in control (T_{12}). The reducing sugar of fruits had increasing trend in all treatments after each interval during storage with varying degrees. After attaining peak it declined significantly on 18^{th} day of storage. On termination of trial maximum content of reducing sugar was recorded in fruits treated with GA_3 followed by NAA. These changes are very much related to TSS content. Hydrolysis of starch yielding mono and disaccharides is one of the reasons for increase in level of this sugar. The higher level of reducing sugar under the influence of these applied chemicals was probably due to reduced rate of catabolic activities and less utilization of this sugar in respiration. These results are in close proximity with those obtained by Chandramonti *et al.* (1991) and Sarkar *et al* (1995) in banana.

TSS/Acid ratio : TSS/acid ratio of fruits enhanced gradually upto 15th day in all the treatment except with GA_3 100 ppm which gave continuous rise upto last day of storage but it gave lower value of TSS/acid ratio as compare to NAA 100 ppm (T_4) on that day of storage. On 3rd day, the maximum (31.93) TSS/ acid ratio was noted with pre harvest spray of NAA 100 ppm (T_4) and minimum (11.57) under GA_3 200 ppm. On 15th day, the maximum (81.52) TSS/acid ratio was found with NAA 100 ppm (T_4) which was significantly superior to rest of the treatment. At last, the application of NAA 100 ppm (T_4) significantly decreased the TSS/acid ratio in fruits but it was significantly highest (73.32) as compared to rest of the treatments. The lowest (46.00) TSS/acid ratio was noted under control (T_{12}). Similar results were obtained by Emerald and Sreenarayanan (1999) and Sarkar *et al*. (1995) in banana.

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