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RESPONSE OF CHEMICALS AND PACKAGES ON SHELF-LIFE AND BIO-CHEMICAL ACTIVITIES OF TISSUE CULTURED BANANA CV. DWARF CAVENDISH

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ABSTRACT

An experiment was conducted to study the effect of various packages and chemicals on shelf- life and bio-chemical activities of tissue cultured banana cv. Dwarf Cavendish. The results indicated that on 18th day of storage minimum PLW (8.44%) and maximum TSS (22.32^{0}Brix), total sugar (19.99%) as well as ascorbic acid (2.91 mg/ 100g pulp) were obtained in fruits packaged under $KMnO_4$ (1000 ppm) + sealed polyethylene bag. The lowest spoilage (35.09%) was recorded with bavistin (500 ppm) + ventilated polyethylene bag followed by $KMnO_4$ (1000) + sealed polyethylene bag and $Ca(NO_3)_2$ 1% + ventilated polyethylene bag and remaining treatments did not produce any marketable fruits during 18th day of storage whereas fruits stored under $Ca(NO_3)$ 1% + ventilated polyethylene bag and $KMnO_4$ (1000 ppm) + sealed polyethylene bag were found to retain slightly higher level of titratable acidity but failed to touch the level of significance.

Key words : *Banana, chemicals, packages, shelf-life, bio-chemical activities.*

Banana (*Musa sp.*) is one of the most important fruit crops grown in India due to prolific and highly remunerative. It is very nourishing fruit and contains nearly all essential nutrients including minerals and vitamins. It is a climacteric fruit which shows rapid increase in respiration after harvest and cannot be stored for long at ambient condition due to fast ripening and degradative metabolism. Also, higher temperature and relative humidity prevailing in the country during main harvesting season of the fresh fruits are very conducive to microbial and fungal activities.

Fruits are living entities and biologically active even after harvest. They undergo continuous enzymatic and biochemical changes and carry out live process like transportation and respiration, which accelerate ripening and deteriorate quality of the produce and finally make it inconsumable. The use of fungicides like bavistin or chemicals like Ca $(NO_3)_2$ and $KMnO_4$ in combination with different packaging materials has shown promising results in increasing shelf-life and quality of fruits. In order to prevent the glut in the market and to curtail the post-harvest losses, storage of fruits is necessary. This study was therefore; under taken to investigate the storage behaviour of tissue cultured banana cv. Dwarf Cavendish.

MATERIALS AND METHODS

The investigation was carried out in the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi on tissue cultured banana fruits during the cropping season 2008-10. The fruits were taken from plants grown at this place. The planting materials were procured from M/S A.G.Biotech, Hyderabad and supplied by M/S Ashoka International Society, Patna (Bihar). The fruits from upper five hands of bunch were selected for storage having 10 fingers in each hands and one hand was considered as one experimental unit. The selected fruits were washed in tap water, air dried and dipped in bavistin (500 ppm) and $Ca(NO_3)_2$ 1 per cent for five minutes while $KMnO_4$ (1000 ppm) was soaked in paper shaving and fruits were stored under respective treatments in two lots. One lots for recording PLW and spoilage loss and other for bio-chemical analysis. The treatments comprised of T_1- Ventilated polyethylene bag (6% vent), T_2- $Ca(NO_3)_2$1% + Ventilated polyethylene bag (6% vent), T_3– Bavistin (500 ppm) + Ventilated polyethylene bag (6% vent), T_4- $KMnO_4$ (1000 ppm) + sealed polyethylene bag, T_5- Newspaper shavings + corrugated fibre box (CFB), T_6 -Newspaper shavings + card board box, T_7-Newspaper shavings (covering)+bamboo basket,

T_8–Banana dried leaves (covering) + Bamboo basket, T_9- Bamboo dried leaves (covering) + Bamboo basket, T_{10}– Gunny bag (covering) + Bamboo basket and T_{11}– Control (open bamboo basket). The treatments were replicated thrice under completely randomised design (CRD) with factorial approach. The observations were recorded from fresh fruit at an interval of 3 days up to 18th day of storage. The titratable acidity and ascorbic acid were determined by following standard procedures (AOAC.1975). The total sugars was estimated as per the method outlined (Lane and Eynon. 1923) and TSS was recorded with hand refractometer. The yardstick for determining the shelf-life of the fruits under different treatments has been fixed till 12 per cent spoilage during storage.

RESULTS AND DISCUSSION

The study indicated that PLW (%) increased significantly with prolongation of storage from 3rd day (3.4%) to 18th day (19.99%) and increase was much more drastic in fruits kept under control (T_{11}) than those in different packaging materials (Table-2). Among different packages, PLW was much less (4.35%) in fruits packaged under $KMnO_4$ (1000) + sealed polyethylene bag (T_4) followed by Ca $(NO_3)_2$ 1% + ventilated polyethylene bag (T_2) whereas, maximum (14.88%) was recorded in control (T_{11}). On 18th day of storage the minimum PLW (8.44%) was found with $KMnO_4$ (1000 ppm) + sealed polyethylene bag (T_4) while maximum (28.59%) was under control. The next effective treatments in reducing PLW of fruits was Ca $(NO_3)_2$ 1% + ventilated polyethylene bag (T_2) giving the PLW of 10.44 per cent. These results are in agreement with the findings of (Scott *et al.,*1970; Rao and Rao,1979) in banana and (Chauhan *et al*., 1987) in mango. Fruits packaged in polyethylene bag + $KMnO_4$ soaked paper showed lower PLW, possible due to reduced rate of respiration and slower release of moisture. Sandooja *et al.* (1986) opined that $KMnO_4$ reduces rate of various biological process. The reduction in weight loss with application of Ca $(NO_3)_2$ could be attributed to reduced rate of respiration and inhibition in cellular disintegration by maintaining protein and nucleic acid synthesis. Also, ventilated polyethylene bags acted as a barrier for the smooth passage or diffusion of moisture and gases to the atmosphere.

The spoilage of fruits was started from 6th day of storage and increased significantly with the advancement of storage period, irrespective of treatments (Table-3). The minimum spoilage (5.30%) was observed on 6th day and all the fruits were spoiled on concluding day (18th day) of experiment. The packaging materials also affected significantly the spoilage loss. The lowest spoilage (7.65%) was recorded with bavistin (500 ppm) + ventilated polyethylene bag (T_3) which was at par with $KMnO_4$ (1000 ppm) + sealed polyethylene bag (T_4) while, maximum (32.67%) was recorded under control (T_{11}). On 15thday of storage, minimum spoilage (11.86%) was obtained with bavistin (500 ppm) + ventilated polyethylene bag (T_3) which showed parity with $KMnO_4$ (1000 ppm) + sealed polyethylene bag (T_4) while, rest of the treatments produced more than 50 per cent spoilage except $Ca(NO_3)_2$ 1% + ventilated polyethylene bag (T_2) having 19.91 per cent spoilage. On concluding day of storage (18thday), spoilage was recorded significantly minimum (35.09%) in fruits packaged with bavistin (500 ppm) + ventilated polyethylene bag (T_3) followed by $KMnO_4$ (1000 ppm) + sealed polyethylene bag (T_4) and $Ca(NO_3)_2$1% + ventilated polyethylene bag (T_2) producing the spoilage loss of 47.18 and 60.11 per cent respectively and remaining treatments failed to produce any marketable fruits. The fruits stored under control were exposed to pathogens of the surrounding atmosphere, which easily invaded and multiplied with time resulting in increased rotting. Bavistin (500 ppm) + ventilated polyethylene bag showed least decay probably might be due to bavistin inhibited the growth of pathogens and checked biochemical changes in fruits. $KMnO_4$reduced spoilage loss, probably by minimising ethylene accumulation inside the bag, inhibiting membrane permeability and retarding process. It was also due to its antimicrobial action and thus extended shelf-life of banana fruits. These results are in conformity with the findings of Emerald and Sreenarayanan (1999),Scottand Robert (1996) in banana, Siddiqui *et al.,*(1999) in ber and Rathore *et al.,*(2009) in mango.

Regardless of treatments from initial day (1.71%) to 15th day (21.32%) and thereafter, it declined. The packaging materials also influenced the TSS content of fruits. The maximum TSS (16.66%) was obtained in fruits packaged with gunny bag+bamboo basket (T_{10}) which showed statistical equality with bamboo dried leaves + bamboo basket (T_9) while minimum (13.64%) was under $KMnO_4$ (1000ppm)+sealed polyethylene bag (T_4). All the treatment combinations exhibited

Table-1 : Physiological Loss in Weight (%) of banana fruits during storage under various packages.

Treatments	Pooled Days in storage							Mean
	0	3	6	9	12	15	18	
T_1	0.00	2.60	3.34	4.06	7.48	11.58	15.14	7.36
		(9.27)	(10.52)	(11.61)	(15.86)	(19.88)	(22.89)	(15.01)
T_2	0.00	2.01	2.51	2.95	5.03	7.64	10.24	5.06
		(8.15)	(9.11)	(9.88)	(12.95)	(16.03)	(18.65)	(12.46)
T_3	0.00	2.11	2.52	3.03	5.83	8.42	11.05	5.49
		(8.34)	(9.13)	(10.01)	(13.96)	(16.86)	(19.41)	(12.95)
T_4	0.00	1.84	2.15	2.48	4.63	6.58	8.44	4.35
		(7.78)	(8.43)	(9.05)	(12.41)	(14.86)	(16.88)	(11.57)
T_5	0.00	3.34	4.67	6.06	10.09	18.10	23.92	11.03
		(10.53)	(12.47)	(14.24)	(18.51)	(25.17)	(29.27)	(18.36)
T_6	0.00	3.84	5.03	6.25	12.33	8.58	24.84	10.14
		(11.30)	(12.95)	(14.46)	(20.55)	(17.03)	(29.88)	(17.70)
T_7	0.00	4.52	5.94	7.37	14.05	19.24	26.43	12.92
		(12.26)	(14.09)	(15.74)	(22.01)	(26.00)	(30.93)	(20.17)
T_8	0.00	3.12	4.56	5.94	11.10	16.22	21.34	10.38
		(10.16)	(12.32)	(14.09)	(19.45)	(23.74)	(27.51)	(17.88)
T_9	0.00	3.03	4.45	5.86	10.66	15.57	20.41	10.00
		(10.01)	(12.17)	(14.00)	(19.05)	(23.23)	(26.85)	(17.55)
T_{10}	0.00	5.04	6.74	8.44	14.57	19.35	27.27	13.57
		(12.96)	(15.04)	(16.88)	(22.43)	(26.09)	(31.47)	(20.81)
T_{11}	0.00	5.96	7.64	10.65	16.14	20.29	28.59	14.88
		(14.12)	(16.03)	(19.03)	(23.67)	(26.76)	(32.32)	(21.99)
Mean		3.40	4.50	5.73	10.17	13.78	19.79	9.56
		(10.44)	(12.02)	(13.55)	(18.26)	(21.42)	(26.01)	(16.95)

(Angular transformed values are presented in parenthesis)

*The mean values were calculated from 3rd to 18th days.

C.D. at 5%

Treatments	0.31
Days	0.23
Treatments x Days	0.71

gradual increase in TSS as the days of storage increased upto 15th day and then it decreased on 18th day except in fruits stored under $KMnO_4$ (1000ppm) + sealed polyethylene bag (T_4) which showed increasing trend upto 18th day of storage. On 15th day of storage, the maximum TSS (23.34%) was recorded under gunny bag+bamboo basket (T_{10}) which was at par with bamboo dried leaves + bamboo basket (T_4) and newspaper shavings + card board box (T_6) whereas, minimum (19.12%) was noted with $KMnO_4$ (1000ppm) + sealed polyethylene bag (T_4). On 18th day of experiment, maximum TSS (22.32%) was obtained with $KMnO_4$ (1000ppm) + sealed polyethylene bag (T_4) and proved its superiority over remaining treatments and lowest TSS (15.12%) was noted under control (T_{11}). According to Stahl and Compbell (1936) the conversion of cell wall materials such as pectin and hemicellulosein reducing substances during storage are responsible for increasing TSS. High TSS in fruits under $KMnO_4$ (1000ppm) + sealed polyethylene bag might be associated with the transformation of pectin substances starch or other, polysaccharide into soluble sugars and delayed ripening. Similar results with $KMnO_4$ were also obtained by Chauhan *et al.,* (1987) and Emerald and Srenarayanan (1999) in mango.

The data recorded on different days revealed that there was gradual enhancement in total sugar from first day 1.42 per cent to 15th day 19.38 per centand thereafter it declined to 17.56 per cent on last day of storage (Table -5). The packaging materials significantly influenced the total sugar content in fruits. The maximum (15.33%) total sugar was obtained with

Table-2 : Spoilage loss (%) of banana fruits during storage under various packages.

Treatments	Pooled Days in storage							Mean
	0	3	6	9	12	15	18	
T_1	0.00	0.00	5.10	11.09	43.16	60.03	100.00	43.87
			(13.04)	(19.44)	(41.06)	(50.79)	(90.00)	(42.87)
T_2	0.00	0.00	3.13	5.93	11.89	19.91	60.11	20.19
			(10.18)	(14.08)	(20.16)	(26.49)	(50.84)	(24.35)
T_3	0.00	0.00	2.36	5.25	11.11	11.89	35.09	13.14
			(8.82)	(13.24)	(19.46)	(20.17)	(36.32)	(19.60)
T_4	0.00	0.00	2.84	5.87	11.47	12.00	47.18	15.87
			(9.70)	(14.01)	(19.79)	(20.26)	(43.38)	(21.43)
T_5	0.00	0.00	6.33	11.47	35.31	70.03	100.00	44.63
			(14.57)	(19.79)	(36.45)	(56.84)	(90.00)	(43.53)
T_6	0.00	0.00	6.45	11.66	37.11	71.34	100.00	45.31
			(14.71)	(19.96)	(37.52)	(57.67)	(90.00)	(43.97)
T_7	0.00	0.00	6.59	11.69	38.32	72.04	100.00	45.73
			(14.87)	(19.99)	(38.24)	(58.12)	(90.00)	(44.25)
T_8	0.00	0.00	6.01	11.31	33.46	66.62	100.00	43.38
			(14.19)	(19.65)	(35.33)	(54.73)	(90.00)	(42.78)
T_9	0.00	0.00	6.12	11.44	34.12	67.32	100.00	43.80
			(14.32)	(19.76)	(35.73)	(55.16)	(90.00)	(42.99)
T_{10}	0.00	0.00	6.65	11.89	38.46	72.05	100.00	45.81
			(14.93)	(20.16)	(38.32)	(58.13)	(90.00)	(44.31)
T_{11}	0.00	0.00	6.77	11.99	38.97	72.97	100.00	46.14
			(15.07)	(20.25)	(38.62)	(58.72)	(90.00)	(44.53)
Mean			5.30	9.96	30.31	54.20	85.67	37.09
			(13.13)	(18.21)	(32.79)	(47.01)	(77.32)	(37.69)

(Angular transformed values are presented in parenthesis)

*The mean values were calculated from 6^{th} to 18^{th} days.

C.D. at 5%

Treatments	0.64
Days	0.44
Treatments x Days	1.35

fruits packaged in gunny bag+bamboo basket (T_{10}) which was at par with bamboo dried leaves+bamboo basket while minimum (13.67%) was obtained in ventilated polyethylene bag (T_1). The total sugars increased steadily up to 18^{th} day under $KMnO_4$ (1000ppm)+sealed polyethylene bag (T_4) whereas in remaining packages it declined after 15^{th} day of storage. The observation on 18^{th} day indicated that the highest (19.99%) value of total sugar with $KMnO_4$ (1000ppm)+sealed polyethylene bag (T_4) and minimum (15.45%) in fruits under control (T_{11}). The possible reason for increase in sugars might be due to slow conversion of starch and polysaccharides into soluble sugars. The reduced rate of respiration and slow conversion of starch and polysaccharides for longer duration might be the cause of the highest level of sugars at termination of storage in the fruits packaged under $KMnO_4$ (1000ppm) + sealed polyethylene bag. These results able in agreement with the findings of Awan and Ndubizu (1987) and Emeraled and Sreenarayana (5) in banana and Dutta *et al.,* (1991) in guava and Rathore *et al.,* (2009)in mango.

The increasing periods of storage brought about corresponding decrease in ascorbic acid and the lowest (177mg/100g pulp) was on 18^{th} day of storage (Table-6). The treatment $KMnO_4$ (1000ppm)+sealed polyethylene bag (T_4) proved the best in recording the highest (6.58mg/100g pulp) ascorbic acid of allowed by $Ca(NO_3)_2$ 1%+ventilated polyethylene bag (T_2) giving

Table-3 : TSS (0Brix) content of banana fruits during storage under various packages.

Treatments	Pooled Days in storage							Mean
	0	3	6	9	12	15	18	
T_1	1.71	4.75	8.01	13.94	18.02	20.51	19.01	14.04
T_2	1.71	4.51	7.97	13.86	17.97	20.12	18.91	13.89
T_3	1.71	5.01	8.52	15.01	19.15	20.60	18.01	14.38
T_4	1.71	4.03	7.46	12.03	16.92	19.12	22.32	13.64
T_5	1.71	5.20	8.80	15.15	19.17	20.88	17.95	14.52
T_6	1.71	5.73	10.44	16.85	20.16	22.70	19.66	15.92
T_7	1.71	5.46	10.01	16.48	20.02	22.23	19.22	15.57
T_8	1.71	5.24	9.24	15.93	19.86	21.12	18.13	14.92
T_9	1.71	6.01	10.52	17.01	20.90	23.01	20.19	16.27
T_{10}	1.71	6.23	11.02	17.43	21.45	23.34	20.50	16.66
T_{11}	1.71	5.12	9.03	15.73	19.64	20.88	15.12	14.25
Mean	1.71	5.21	9.18	15.40	19.39	21.32	19.00	14.91

*The mean values were calculated from 3rd to 18th days.

C.D. at 5%	
Treatments	0.31
Days	0.23
Treatments x Days	0.70

Table-4 : Total sugar (%) of banana fruits during storage under various packages.

Treatments	Pooled Days in storage							Mean
	0	3	6	9	12	15	18	
T_1	1.42	3.81	7.21	13.44	17.53	16.12	17.92	12.67
T_2	1.42	3.65	7.11	13.06	17.07	19.02	17.99	12.98
T_3	1.42	4.00	8.03	14.74	18.13	19.41	18.13	13.74
T_4	1.42	3.51	6.00	12.94	16.07	18.18	19.99	12.78
T_5	1.42	4.20	8.25	14.92	18.24	19.67	16.12	13.56
T_6	1.42	5.23	10.01	15.90	19.02	20.42	16.05	14.43
T_7	1.42	4.90	6.60	15.51	18.88	19.99	17.98	13.97
T_8	1.42	4.45	8.64	15.08	18.45	19.99	17.12	13.95
T_9	1.42	5.80	10.10	16.05	19.99	20.21	18.14	15.05
T_{10}	1.42	5.91	10.71	16.66	20.05	20.31	18.33	15.33
T_{11}	1.42	4.02	8.03	15.01	18.35	19.89	15.45	13.46
Mean	1.42	4.50	8.24	14.84	18.34	19.38	17.56	13.81

*The mean values were calculated from 3rd to 18th days.

C.D. at 5%	
Treatments	0.70
Days	0.58
Treatments x Days	1.61

the ascorbic acid of (6.45 mg/100g pulp). A gradual fall in content of ascorbic acid was noted with prolon at 5% ation of storage period, irrespective of treatments. On 18th day of storage the fruits exhibited the highest value of ascorbic acid (2.91mg/100g pulp) when packaged under $KMnO_4$(1000ppm)+sealed polyethylene bag (T_4) and least value (1.03 mg/100g pulp) was under control (T_{11}). This could be due to greater accumulation of carbon dioxide in the bag which probably reduced the rate of oxidation of ascorbic acid. It may also be due to the retardation in accumulation of ethylene which is known to cause the distraction of ascorbic acid (Isherwood and Mapson,1962). This finding gets supports with the results of Awan and Nalubizu (1987) and Emerald and Sreenaragana (1999) in banana.

The maximum acidity (0.33%) was recorded on 12th and 15th day of storage and declined thereafter

Table-5 : Ascorbic acid (mg/100g pulp) content of banana fruits during storage under various packages.

Treatments	Pooled Days in storage							Mean
	0	3	6	9	12	15	18	
T_1	10.57	9.23	8.61	5.61	5.33	4.29	1.84	5.82
T_2	10.57	9.35	8.70	7.70	5.54	4.82	2.60	6.45
T_3	10.57	9.01	8.55	7.61	5.45	4.43	2.01	6.18
T_4	10.57	9.42	8.75	7.90	5.67	4.88	2.91	6.58
T_5	10.57	8.99	7.91	6.98	4.90	3.90	1.76	5.74
T_6	10.57	7.53	6.89	5.92	3.88	3.04	1.45	4.78
T_7	10.57	8.78	7.73	6.73	4.48	3.54	1.54	5.46
T_8	10.57	8.83	7.84	6.89	4.79	3.87	1.64	5.64
T_9	10.57	7.91	6.80	5.87	3.86	2.74	1.37	4.76
T_{10}	10.57	7.87	6.61	5.75	3.70	2.67	1.32	4.65
T_{11}	10.57	7.35	5.81	4.70	3.02	2.04	1.03	3.99
Mean	10.57	8.57	7.65	6.51	4.60	3.65	1.77	5.46
*The mean values were calculated from 3rd to 18th days.								
C.D. at 5%								
Treatments	0.0745							
Days	0.0556							
Treatments x Days	0.1709							

estimating 0.316% on last day of storage also obtained progressive increase in acidity of aonla fruits during storage. The fruits packaged under $Ca(NO_3)_2$ 1% + ventilated polyethylene bag (T_2) and $KMnO_4$ (1000ppm) + sealed polyethylene bag (T_4) were found to retain slightly higher level of acidity on 18th day but failed to touch the level of significance which indicated that different storage periods did not influence the packaging materials behaviour and vice - versa.

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