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Effect of gibberellic acid and chitosan on physio-chemical properties and shelf life of banana (*musa paradisiaca*) cv. g-9

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Abstract
The GA_3 and Chitosan Coated Banana were evaluated for their physico-chemical properties during storage. Treatments were T_0: Control, T_1: Chitosan 1%, T_2: Chitosan 1.5%, T_3: Chitosan 2%, T_4: Chitosan 2.5%, T_5: GA_3 100 ppm, T_6: GA_3 150 ppm, T_7: GA_3 200 ppm and T_8: GA_3 250 ppm. On the basis of evaluation of GA_3 and Chitosan coated banana, T_7 found maximum (0.051g) mean fruit weight, (6.02%) loss in weight, (13.367 ^{0}Brix) TSS, (1.373 mg/100g) Vitamin C, (76.507%) Moisture and minimum (0.197%) Acidity, where as maximum (7.00 days) green life, (17.70%) Total sugar was found in T_8 and maximum (15.33 days) yellow life was found in T_6 after 18 days of coatings whereas minimum was found with T_0 (Control) in all the parameters on 9th day of coatings, In terms of Economics Maximum Net income (Rs. 46.75) and benefit cost ratio (1.95:1) was recorded in T_8 followed by T_7 with (39.75 Rs. Net Return and 1.92:1 Benefit Cost Ratio) and the minimum (Net Return – Rs. 1.25 and Benefit cost ratio – 1.01:1) was found in T_3. T_7 was found significantly superior to all other treatments in most of the parameters followed by T_8 GA_3 and Chitosan coated Banana during storage.

Keywords: Banana, chitosan, ga_3, coatings, shelf life

Introduction
The banana is characterized as a flavorful and nutritive fruit, being an excellent source of carbohydrates, fiber, potassium and vitamins (Osman *et al.*, 2008) [5]. Quality is an important factor in the marketing of banana, especially when intended for fresh consumption. Banana physical and chemical characteristics are influenced by several factors, such as edapho-climatic conditions, fertilization, cultivar and planting and harvest time, however, to analyze them, assessing the quality of marketed fruits and whether these are within the standards required by consumers, is important that the most important attributes of the fruits, according to the consumer preferences at purchasing banana, are the flavor, shelf life and appearance (length, diameter and color). Therefore, studies on physical and chemical parameters related to fruit quality, such as length, diameter, weight, pulp and peel color, pulp firmness, soluble solids and titratable acidity, seeking to maintain the desirable characteristics required by market standards, is very important (Pathak *et al.*, 1999)

Banana is a quite popular tropical fruit, especially in commercial local trade. It contains a lot of nutrients and minerals which are very beneficial for health. Its vitamin C content which is regarded as a familiar antioxidant is relatively high of up to 15%. Bananas are usually harvested before fully mature for domestic consumption. Usually bananas are stored at room temperature. During storage, banana fruit is easily deteriorated due to the quick ripening process**.** (Marriott *et al.*, 1980) [4].

Edible coatings are traditionally used to improve food conservation and appearance due to their environmentally friendly nature. They are obtained from both animal and vegetable or plant agricultural products. The type and concentration of edible components have important effects on the quality characteristics of coated fruits such as weight loss, pH, firmness, colour, reducing sugars, total sugars and Non-reducing sugars**.**

Recently, there have been many researches on edible coatings and films to diminish crop losses and maintain the quality of fresh fruit for a longer period. Edible coating is one of the methods of extending postharvest shelf-life. Many edible coating techniques to extend the shelf life and prolong freshness of fruits have been developed using polyethylene wax emulsion, bee wax, carnauba, candelilla, chitosan, and paraffin It has been observed that during refrigerated shipment of banana, changes in chamber temperature owing to variation in

power supplies and cooling equipments efficiency lead to chilling damage and fruit losses. Hence, in order to reduce fruit losses information on the effect of storage temperature is crucial, especially when a new banana variety is to be transported over long distances. Studies were, therefore, carried out on the control of post-harvest losses by extending shelf life with the help of plant growth regulators and temperature conditions**.** (Lozel S., 2010) [3].

Materials and Methods

The Experimental was conducted in Completely Randomized Design (CRD) with 9 treatments and 3 replications in the Post-Harvest Laboratory of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad during the year 2017 - 2018.

Total number of treatments were nine *viz.* T_0: Control, T_1: Chitosan 1%, T_2: Chitosan 1.5%, T_3: Chitosan 2%, T_4: Chitosan 2.5%, T_5: GA_3 100 ppm, T_6: GA_3 150 ppm, T_7: GA_3 200 ppm and T_8: GA_3 250 ppm. to estimation the shelf life of Banana, has stored for 18 days under ambient temperature.

Fruit selection

Banana were purchased from fruit market, of Allahabad on 02nd November, 2017 and stored in the Post-Harvest Laboratory of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad at room temperature. On 03rd November, 2017 Coatings was started.

Results and Discussion

The results of the experiment are summarized below,

1. In terms of mean fruit weight the treatment T_7 (GA_3 @ 200 ppm) found maximum (0.051g) mean fruit weight after 18 days of coatings followed by T_6 (GA_3 @ 150 ppm) with (0.042 g) mean fruit weight after 18 days of coatings, where as minimum Mean fruit weight (0.061 g) was found with treatment T_0 (Control) after 9 days of coatings, after 9th days storage the fruits get fully spoiled and found not fit for consumption. Similar findings were also reported by Kaur and Kaur (2017) [1] With Treatment of Hot water + Ethrel 600 ppm.
2. The treatment T_8 (GA_3 @ 250 ppm) found maximum (7.00 days) green life after 18 days of coatings followed by T_6 (GA_3 @ 150 ppm) (6.00 days) after 18 days of coatings, where as minimum Green life (4.00 days) was found with treatment T_0 (Control) after 9 days of coatings, after 9th days storage it becomes fully yellow in colour. Similar findings were also reported by Kaur and Kaur (2017) [1] with Treatment of Hot water + Ethrel 600 ppm.
3. The treatment T_6 (GA_3 @ 150 ppm) found maximum (15.33 days) yellow life after 18 days of coatings followed by T_7 (GA_3 @ 200 ppm) (14.16 days) after 18 days of coatings, where as minimum Green life days (6.00 days) was found with treatment T_0 (Control) on 9th days of coatings, after 9th days storage it is fully spoiled and found not fit for consumption. Similar findings were also reported by Kaur and Kaur (2017) [1] With treatment of Hot water + Ethrel 600 ppm.
4. The treatment T_7 (GA_3 @ 200 ppm) found maximum (6.02%) loss in weight after 18 days of coatings followed by T_8 (GA_3 @ 250 ppm) (4.90%) after 18 days of coatings, where as minimum weight loss (3.617%) was found with treatment T_0 (Control) after 9 days of coatings, after 9th days storage it becomes fully spoiled and found not fit for consumption. Similar findings were also reported by Kaur and Kaur (2017) [1] with Treatment of Hot water + Ethrel 600 ppm.
5. The treatment T_7 (GA_3 @ 200 ppm) found maximum (13.367 ^{0}Brix) TSS after 18 days of coatings closely followed by Treatment T_8 (GA_3 @ 250 ppm) and Treatment T_6 (GA_3 @ 150 ppm) with (13.267 ^{0}Brix) and (13.133 ^{0}Brix) respectively after 18 days of coatings, where as minimum TSS ^{0}Brix (12.717) was found with treatment T_0 (Control) after 9 days of coatings, after 9th days storage it becomes fully spoiled and found not fit for consumption. Similar findings were also reported by Kaur and Kaur (2017) [1] with Treatment of Hot water + Ethrel 600 ppm.
6. The treatment T_8 (GA_3 @ 250 ppm) found maximum (17.70%) Total sugar after 18 days of coatings closely followed by Treatment T_7 (GA_3 @ 200 ppm) and Treatment T_6 (GA_3 @ 150 ppm) with (17.50%) and (17.467%) respectively after 18 days of coatings, where as minimum Total Sugar percent (16.433%) was found with treatment T_0 (Control) after 9 days of coatings, after 9th days storage it becomes fully spoiled and found not fit for consumption. Similar findings were also reported by Kaur and Kaur (2017) [1] with treatment of Hot water + Ethrel 600 ppm.
7. The treatment T_7 (GA_3 @ 200 ppm) found maximum (1.373 g) Vitamin C after 18 days of coatings closely followed by Treatment T_8 (GA_3 @ 250 ppm) and Treatment T_6 (GA_3 @ 150 ppm) with (1.307) and (1.303) g respectively after 18 days of coatings, where as minimum Vitamin C (mg/100g) (1.267 g) was found with treatment T_0 (Control) after 9 days of coatings, after 9th days storage it becomes fully spoiled and found not fit for consumption. Similar findings were also reported by Kaur and Kaur (2017) [1]. With Treatment of Hot water + Ethrel 600 ppm.
8. The treatment T_7 (GA_3 @ 200 ppm) found minimum (0.197%) Acidity after 18 days of coatings followed by Treatment T_6 (GA_3 @ 150 ppm) and Treatment T_8 (GA_3 @ 250 ppm) with (0.253%) both, after 18 days of coatings, where as maximum Acidity percent (0.407%) was found with treatment T_0 (Control) after 9 days of coatings, after 9th days storage it becomes fully spoiled and found not fit for consumption. Similar findings were also reported by Kaur and Kaur (2017) [1] with Treatment of Hot water + Ethrel 600 ppm.
9. The treatment T_7 (GA_3 @ 200 ppm) found maximum (76.507%) Moisture after 18 days of coatings followed by Treatment T_8 (GA_3 @ 250 ppm) and Treatment T_6 (GA_3 @ 150 ppm) with (75.783%) and (74.953%) respectively after 18 days of coatings, where as minimum Moisture content of pulp percent (71.777%) was found with treatment T_0 (Control) after 9 days of coatings, after 9th days storage it becomes fully spoiled and found not fit for consumption. Similar findings were also reported by Kaur and Kaur (2017) [1]. With Treatment of Hot water + Ethrel 600 ppm.
10. Based on the calculations data shows that the Maximum Net income (Rs. 46.75) and benefit cost ratio (1.95:1) was recorded with treatment T_8 (GA_3 @ 250 ppm), followed by treatment T_7 (GA_3 @ 200 ppm) with (39.75 Rs. Net Return and 1.92:1 Benefit Cost Ratio) and the minimum (Net Return – Rs. 1.25 and Benefit cost ratio – 1.01:1) was found in treatment T_3 (Chitosan @ 2%).
11. Treatment T_8 (GA_3 @ 250 ppm) was found significantly superior to all other treatments in terms of economic returns of GA_3 and Chitosan coated Banana during storage.

Table 1: Effect of gibberellic acid and chitosan on mean fruit weight, green life (days) and yellow life days of banana (*Musa paradisiaca*) cv. G-9:

Treatment	Mean fruit weight (g)						Green life (days)						Yellow life (days)					
	3 DAC	6 DAC	9 DAC	12 DAC	15 DAC	18 DAC	3 DAC	6 DAC	9 DAC	12 DAC	15 DAC	18 DAC	3 DAC	6 DAC	9 DAC	12 DAC	15 DAC	18 DAC
T_0	0.11	0.11	0.06	0.00	0.00	0.00	3.00	4.00	4.00	0.00	0.00	0.00	0.00	2.00	6.00	0.00	0.00	0.00
T_1	0.12	0.09	0.06	0.05	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	2.00	5.00	9.00	12.00	0.00	0.00
T_2	0.11	0.08	0.05	0.04	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	2.00	5.00	8.66	11.50	0.00	0.00
T_3	0.11	0.09	0.06	0.04	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	2.00	5.00	8.60	11.66	0.00	0.00
T_4	0.12	0.10	0.07	0.04	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	2.00	5.00	8.80	12.00	0.00	0.00
T_5	0.14	0.12	0.10	0.08	0.06	0.00	3.00	5.00	5.00	5.00	5.00	0.00	0.00	1.00	4.93	7.00	11.66	0.00
T_6	0.13	0.11	0.10	0.08	0.06	0.04	3.00	5.00	5.00	5.00	5.00	5.33	0.00	1.00	5.33	6.66	12.00	15.33
T_7	0.14	0.12	0.11	0.09	0.07	0.05	3.00	5.00	6.00	6.00	6.00	6.00	0.00	1.00	4.00	6.00	11.33	14.16
T_8	0.12	0.11	0.10	0.09	0.06	0.04	3.00	5.00	7.00	7.00	7.00	7.00	0.00	1.00	3.33	5.33	10.00	13.03
F-test	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
SE(d)	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.80	0.62	0.52	0.40	0.76	0.25	0.50	0.61	0.77	0.44	0.77
C.D.	0.00	0.00	0.00	0.00	0.00	0.00	0.64	1.71	1.32	1.11	0.85	1.07	0.54	1.05	1.31	1.63	0.94	1.63

Table 2: Effect of gibberellic acid and chitosan on weight loss percent, TSS ^{O}brix and total Sugar (%) of banana (*Musa paradisiaca*) cv. G-9:

Treatment	Weight loss percent						TSS ^{O}Brix						Total Sugar (%)					
	3 DAC	6 DAC	9 DAC	12 DAC	15 DAC	18 DAC	3 DAC	6 DAC	9 DAC	12 DAC	15 DAC	18 DAC	3 DAC	6 DAC	9 DAC	12 DAC	15 DAC	18 DAC
T_0	1.58	2.21	3.61	0.0	0.00	0.00	7.03	10.03	12.71	0.00	0.00	0.00	13.20	14.20	16.43	0.00	0.00	0.00
T_1	1.65	2.33	2.88	3.73	0.00	0.00	6.93	8.05	10.55	13.57	0.00	0.00	13.33	14.46	16.40	17.03	0.00	0.00
T_2	1.33	2.77	3.23	3.80	0.00	0.00	7.80	9.40	12.32	13.77	0.00	0.00	13.26	14.30	16.26	16.80	0.00	0.00
T_3	1.78	2.87	3.13	3.97	0.00	0.00	7.50	9.14	11.67	12.70	0.00	0.00	13.36	14.30	16.26	17.13	0.00	0.00
T_4	1.61	2.68	3.38	3.83	0.00	0.00	9.33	11.10	12.10	13.76	0.00	0.00	12.93	13.40	16.06	17.06	0.00	0.00
T_5	2.06	2.48	2.90	3.47	3.90	0.00	7.00	8.27	9.56	10.36	12.47	0.00	12.60	13.26	15.16	15.93	17.17	0.00
T_6	1.76	2.55	3.01	3.60	4.03	4.76	6.80	7.97	8.96	9.51	11.73	13.13	12.26	13.23	15.06	15.66	17.00	17.46
T_7	1.39	2.90	4.06	4.73	5.10	6.02	7.06	8.30	9.80	10.68	12.60	13.37	12.40	13.50	14.26	15.86	16.53	17.50
T_8	1.51	2.13	2.94	3.63	4.20	4.90	6.73	8.20	9.50	10.63	11.93	13.27	12.06	13.20	14.16	15.93	17.04	17.70
F-test	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
SE(d)	0.22	0.38	0.28	0.50	0.14	0.16	0.43	0.20	0.27	0.25	0.31	0.22	0.31	0.31	0.44	0.49	0.21	0.23
C.D.	N/A	N/A	0.60	0.28	0.31	0.35	0.92	0.43	0.58	0.53	0.71	0.47	0.66	0.67	0.94	1.04	0.44	0.49

Table 3: Effect of gibberellic acid and chitosan on vitamin C (MG/100 g), acidity (%), moisture Content (%) and benefit Ccost ratio of banana (*Musa paradisiaca*) cv. G-9:

Treatment	Vitamin C (mg/100 g)						Acidity (%)						Moisture content%						Benefit cost ratio (Rs.)
	3 DAC	6 DAC	9 DAC	12 DAC	15 DAC	18 DAC	3 DAC	6 DAC	9 DAC	12 DAC	15 DAC	18 DAC	3 DAC	6 DAC	9 DAC	12 DAC	15 DAC	18 DAC	
T_0	0.30	0.80	1.26	0.00	0.00	0.00	0.48	0.45	0.40	0.00	0.00	0.00	70.69	71.04	71.77	0.00	0.00	0.00	1.33:1
T_1	0.30	0.50	0.78	1.36	0.00	0.00	0.4	0.430	0.41	0.37	0.00	0.00	71.59	72.00	72.73	73.17	0.00	0.00	1.14:1
T_2	0.30	0.56	0.89	1.30	0.00	0.00	0.47	0.453	0.41	0.37	0.00	0.00	71.90	72.15	73.27	73.77	0.00	0.00	1.04:1
T_3	0.20	0.60	0.73	1.53	0.00	0.00	0.3	0.450	0.43	0.30	0.00	0.00	70.54	70.78	71.20	72.14	0.00	0.00	1.01:1
T_4	0.20	0.66	0.83	1.59	0.00	0.00	0.67	0.437	0.39	0.37	0.00	0.00	71.62	71.99	72.50	73.30	0.00	0.00	1.05:1
T_5	0.30	0.41	0.64	0.81	1.50	0.00	0.17	0.387	0.35	0.33	0.28	0.00	72.76	72.93	73.47	74.05	75.12	0.00	1.52:1
T_6	0.30	0.49	0.70	0.82	1.17	1.3	0.03	0.383	0.35	0.30	0.29	0.25	73.19	73.61	74.40	74.82	74.95	74.95	1.84:1
T_7	0.30	0.41	0.61	0.90	1.17	1.37	0.50	0.313	0.27	0.25	0.22	0.19	73.95	74.29	74.82	75.34	75.53	76.50	1.92:1
T_8	0.30	0.42	0.62	0.81	1.13	1.30	0.90	0.370	0.34	0.30	0.28	0.25	73.40	73.84	74.21	74.87	75.09	75.78	1.95:1
F-test	NS	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
SE(d)	0.05	0.06	0.05	0.05	0.08	0.03	0.02	0.019	0.02	0.01	0.01	0.10	0.73	0.22	0.45	0.60	0.35	0.27	
C.D.	N/A	0.12	0.11	0.12	0.08	0.06	0.04	0.040	0.04	0.03	0.02	0.02	1.54	0.47	0.95	1.26	0.75	0.57	

Conclusion

On the basis of present experimental findings it is concluded that T_7 (GA_3 @ 200 ppm) found maximum (0.051g) mean fruit weight, (6.02%) loss in weight, (13.367 ^{0}Brix) TSS, (1.373 g) Vitamin C, (76.507%) Moisture and minimum (0.197%) Acidity, where as maximum (7.00 days) green life, (17.70%) Total sugar was found in T_8 (GA_3 @ 250 ppm) and maximum (15.33 days) yellow life was found in T_6 (GA_3 @ 150 ppm), after 18 days of coatings whereas minimum was found with T_0 (Control) in all the parameters on 9th days of coatings, In terms of Economics Maximum Net income (Rs. 46.75) and benefit cost ratio (1.95:1) was recorded in T_8 (GA_3 @ 250 ppm), followed by T_7 (GA_3 @ 200 ppm) with (39.75 Rs. Net Return and 1.92:1 Benefit Cost Ratio) and the minimum (Net Return – Rs. 1.25 and Benefit cost ratio – 1.01:1) was found in T_3 (Chitosan @ 2%). T_7 (GA_3 @ 200 ppm) was found significantly superior to all other in most of the parameters followed by T_8 (GA_3 @ 250 ppm) GA_3 and Chitosan coated Banana during storage.

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"Research is to see what everybody else has seen, and to think what nobody else has thought"

- Albert Szent-Syorgyi

(Hungarian Biochemist, 1937 Nobel Prize for Medicine, 1893-1986.

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