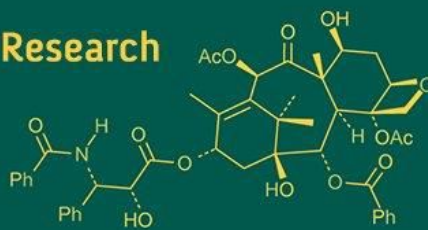


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Studies on post-harvest application of chemicals and packaging materials on ripening and shelf-life of banana (*Musa paradisiaca* L.) cv. Grand Naine

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Abstract

The present investigation, entitled “Studies on post-harvest application of chemicals and packaging materials on ripening and shelf-life of banana (*Musa paradisiaca* L.) cv. Grand Naine”, was conducted during 2024-2025 at the Processing Laboratory, Department of Fruit Science, Pt. K.L.S. College of Horticulture and Research Station, Rajnandgaon, Mahatma Gandhi Udyanikee Evam Vanikee Vishwavidyalaya, Durg (C.G.). The study revealed that the physico-chemical and sensory attributes of banana were significantly influenced by post-harvest treatments. Among the treatments, T₈ [CaCl₂ (5%) + Polyethylene bag (LDPE 200 gauge)] recorded the highest values for total soluble solids (21.65 °Brix) and ascorbic acid (4.15 mg/100 g pulp), while the lowest acidity (0.52%) was observed under the same treatment. In terms of sensory evaluation, T₈ also received the highest scores for appearance (8.75), flavour (8.92) and taste (8.92). Thus, treatment T₈ proved superior in maintaining quality and extending shelf-life of banana up to 20 days after storage under ambient conditions.

Keywords: Ascorbic acid, polyethylene, physico-chemical, sensory evolution TSS

Introduction

Banana (*Musa* sp., family Musaceae) is among the world's most important tropical fruit crops, valued for its nutritional richness, affordability, and cultural significance. India leads global production, contributing nearly 30%, with Chhattisgarh being a major producing state. The cultivar Grand Naine has gained prominence for its high yield, early maturity, and export potential. However, as a climacteric fruit, banana is highly perishable with a short shelf life, often resulting in post-harvest losses of 30-40% due to rapid ripening, mechanical damage, and inadequate storage and handling.

To mitigate these challenges, various post-harvest treatments have been explored. Growth regulators such as salicylic acid, gibberellins, and 1-methylcyclopropane effectively delay ripening by suppressing key enzyme activities, while calcium salts and antioxidants maintain firmness, reduce respiration, and minimize disease incidence. Inorganic salts including sodium bicarbonate, calcium chloride, and potassium bicarbonate—recognized as safe (GRAS)—also enhance storability and act as safe alternatives to toxic fungicides. Conversely, artificial ripening agents like calcium carbide, ethephon, and ethylene glycol, though commonly used, pose health hazards and require strict regulation (Deliopoulos *et al.*, 2010) [5].

Packaging further contributes to shelf-life extension by reducing physiological weight loss, maintaining fruit quality, and preventing microbial decay. Despite these interventions, bananas remain highly vulnerable to deterioration under ambient conditions, highlighting the need for low-cost, safe, and efficient post-harvest strategies (Bhatia *et al.* 2013) [3].

Materials and Methods

The Experiment was carried out during the year 2024-25 at The Horticulture Processing Laboratory, Pt. K.L.S. College of Horticulture and Research Station, Rajnandgaon (C.G.). The experimental material consisted of two packaging materials and two chemicals, applied either singly or in combination, forming a total of 12 treatments including control.

The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Freshly harvested banana fruits were procured from The Research Farm of Precision Farming Development Centre (PFDC), Indira Gandhi Krishi Vishwavidyalaya, Raipur Chhattisgarh. Fruits were stored under ambient conditions for up to 20 days, and data were recorded at 4-day intervals for physico-chemical and sensory parameters.

Treatment Details

- T₀ Control (Without chemicals and packaging)
 T₁ CaCl₂ (3%)
 T₂ CaCl₂ (5%)
 T₃ NaHCO₃ (0.4%)
 T₄ Polyethylene bag (LDPE 200 gauge)
 T₅ Newspaper
 T₆ CaCl₂ (3%) + Polyethylene bag (LDPE 200 gauge)
 T₇ CaCl₂ (3%) + Newspaper
 T₈ CaCl₂ (5%) + Polyethylene bag (LDPE 200 gauge)
 T₉ CaCl₂ (5%) + Newspaper
 T₁₀ NaHCO₃ (0.4%) + Polyethylene bag (LDPE 200 gauge)
 T₁₁ NaHCO₃ (0.4%) + Newspaper

Results and Discussion

Chemical parameters

The chemical composition of banana fruits was evaluated in terms of total soluble solids (TSS), titratable acidity, ascorbic acid, total sugars, reducing sugars, and non-reducing sugars. TSS increased progressively during

storage, with the highest value (21.65 °Brix) observed under treatment T₈ [CaCl₂ (5%) + polyethylene bag (LDPE, 200 gauge)], followed by T₆ [CaCl₂ (3%) + polyethylene bag] (21.04 °Brix), while the lowest (11.16 °Brix) was recorded in the control (T₀). Titratable acidity decreased significantly with storage duration, reaching the lowest level (0.52%) in T₈, whereas the highest value (1.01%) was recorded in T₀. Ascorbic acid content declined over time, with T₈ (4.15 mg/100 g pulp) and T₆ (4.12 mg/100 g pulp) retaining maximum levels, while the lowest (3.44 mg/100 g pulp) was observed in T₁₁ [NaHCO₃ (0.4%) + newspaper]; fruits in control were discarded due to spoilage. Overall, treatment T₈ [CaCl₂ (5%) + polyethylene bag (LDPE, 200 gauge)] consistently maintained superior chemical quality attributes compared to other treatments.

The progressive increase in TSS during storage reflects starch hydrolysis and ripening metabolism in bananas (Hailu *et al.*, 2013) [6]. Among treatments, CaCl₂ (5%) + LDPE (T₈) consistently maintained the highest values, followed by T₆, confirming the role of calcium in delaying senescence and polyethylene packaging in reducing moisture loss (Chandrakar *et al.*, 2022) [4]. Titratable acidity and ascorbic acid declined with storage, but CaCl₂-treated fruits retained higher levels than control, in line with earlier reports that calcium slows acid degradation and vitamin C loss. The rapid deterioration in untreated fruits (T₀) highlights the necessity of integrated post-harvest treatments for sustaining chemical quality and extending shelf life.

Table 1: Effect of different post-harvest chemicals and packaging materials on total soluble solids of banana cv. Grand Naine during storage

Notations	Treatments	Total soluble solids (°Brix)						
		0 Day	4 DAS	8 DAS	12 DAS	16 DAS	20 DAS	Mean
T ₀	Control (Without chemicals and packaging)	10.80	10.86	10.89	10.93	11.08	12.05	11.16
T ₁	CaCl ₂ (3%)	10.92	12.15	13.53	17.32	18.08	19.57	16.13
T ₂	CaCl ₂ (5%)	10.91	11.25	13.07	16.13	19.18	19.26	15.78
T ₃	NaHCO ₃ (0.4%)	10.94	14.34	17.16	19.51	21.78	24.20	19.40
T ₄	Polyethylene bag (LDPE 200 gauge)	10.81	11.26	12.23	13.70	13.48	14.07	12.95
T ₅	Newspaper	10.86	11.05	12.00	13.90	14.70	15.93	13.52
T ₆	CaCl ₂ (3%) + Polyethylene bag (LDPE 200 gauge)	10.96	14.86	20.07	21.34	23.51	25.43	21.04
T ₇	CaCl ₂ (3%) + Newspaper	10.89	11.09	12.52	14.22	17.23	20.31	15.07
T ₈	CaCl ₂ (5%) + Polyethylene bag (LDPE 200 gauge)	10.97	15.15	20.29	22.23	24.24	26.35	21.65
T ₉	CaCl ₂ (5%) + Newspaper	10.87	11.14	12.06	13.50	15.25	15.03	13.40
T ₁₀	NaHCO ₃ (0.4%) + Polyethylene bag (LDPE 200 gauge)	10.83	10.96	11.83	12.50	13.32	14.44	12.61
T ₁₁	NaHCO ₃ (0.4%) + Newspaper	10.77	10.83	11.11	12.27	12.72	13.28	12.04
	SE (m)±	0.010	0.127	0.126	0.182	0.104	0.016	
	C.D. at 5%	0.028	0.371	0.367	0.533	0.305	0.048	

Table 2: Effect of different post-harvest chemicals and packaging materials on Titrable acidity (%) of banana cv. Grand Naine during storage

Notations	Treatments	Titrable acidity (%)						
		0 Day	4 DAS	8 DAS	12 DAS	16 DAS	20 DAS	Mean
T ₀	Control (Without chemicals and packaging)	1.06	1.04	1.02	1.01	0.99	0.96	1.01
T ₁	CaCl ₂ (3%)	1.03	0.84	0.62	0.58	0.51	0.42	0.59
T ₂	CaCl ₂ (5%)	1.04	0.91	0.90	0.83	0.78	0.72	0.83
T ₃	NaHCO ₃ (0.4%)	1.03	0.78	0.73	0.68	0.65	0.63	0.69
T ₄	Polyethylene bag (LDPE 200 gauge)	1.07	1.05	0.98	0.95	0.77	0.00	0.75
T ₅	Newspaper	1.02	0.88	0.93	0.90	0.80	0.00	0.70
T ₆	CaCl ₂ (3%) + Polyethylene bag (LDPE 200 gauge)	1.02	0.72	0.62	0.55	0.47	0.35	0.54
T ₇	CaCl ₂ (3%) + Newspaper	1.01	0.91	0.89	0.77	0.68	0.60	0.77
T ₈	CaCl ₂ (5%) + Polyethylene bag (LDPE 200 gauge)	1.03	0.70	0.60	0.52	0.44	0.34	0.52
T ₉	CaCl ₂ (5%) + Newspaper	1.01	0.96	0.90	0.78	0.63	0.60	0.77
T ₁₀	NaHCO ₃ (0.4%) + Polyethylene bag (LDPE 200 gauge)	1.05	1.01	0.91	0.77	0.65	0.53	0.77
T ₁₁	NaHCO ₃ (0.4%) + Newspaper	1.09	1.04	0.99	0.83	0.76	0.67	0.86
	SE (m)±	0.010	0.009	0.009	0.008	0.007	0.009	
	C.D. at 5%	0.028	0.025	0.027	0.023	0.021	0.028	

Table 3: Effect of different post-harvest chemicals and packaging materials on Ascorbic acid of banana *cv.* Grand Naine during storage

Notations	Treatments	Ascorbic acid (mg/100 g pulp)						
		0 Day	4 DAS	8 DAS	12 DAS	16 DAS	20 DAS	Mean
T ₀	Control (Without chemicals and packaging)	4.20	3.44	3.42	3.39	3.40	0.00	2.73
T ₁	CaCl ₂ (3%)	4.25	4.14	4.08	3.93	3.89	3.86	3.98
T ₂	CaCl ₂ (5%)	4.22	4.07	4.06	3.90	3.85	3.82	3.94
T ₃	NaHCO ₃ (0.4%)	4.26	4.19	4.11	3.94	3.94	3.94	4.02
T ₄	Polyethylene bag (LDPE 200 gauge)	4.22	3.64	3.61	3.59	3.52	0.00	2.87
T ₅	Newspaper	4.18	3.51	3.49	3.46	3.41	0.00	2.77
T ₆	CaCl ₂ (3%) + Polyethylene bag (LDPE 200 gauge)	4.42	4.35	4.19	4.07	4.01	4.00	4.12
T ₇	CaCl ₂ (3%) + Newspaper	4.13	4.01	3.91	3.83	3.74	3.77	3.85
T ₈	CaCl ₂ (5%) + Polyethylene bag (LDPE 200 gauge)	4.47	4.38	4.21	4.10	4.03	4.01	4.15
T ₉	CaCl ₂ (5%) + Newspaper	4.01	3.87	3.72	3.55	3.67	3.61	3.68
T ₁₀	NaHCO ₃ (0.4%) + Polyethylene bag (LDPE 200 gauge)	4.35	3.68	3.63	3.41	3.61	3.59	3.58
T ₁₁	NaHCO ₃ (0.4%) + Newspaper	4.32	3.71	3.55	3.38	3.30	3.28	3.44
	SE (m)±	0.044	0.057	0.041	0.033	0.023	0.029	
	C.D. at 5%	0.129	0.166	0.118	0.097	0.068	0.084	

Sensory parameters

Sensory attributes of banana fruits, namely appearance, flavor, taste, colour, and overall acceptability, declined progressively with storage duration. At 20 days after storage, treatment T₈ (CaCl₂ 5% + Polyethylene bag, LDPE 200 gauge) consistently recorded the highest scores for appearance (8.75), flavor (8.92), taste (8.92). This was closely followed by T₆ (CaCl₂ 3% + Polyethylene bag, LDPE 200 gauge), while the lowest scores for all parameters were observed under control (T₀), with values 5.74, 6.47 and 6.60 respectively. (Table 4 to Table 6). Sensory attributes of

banana fruits declined progressively during storage, consistent with the ripening and senescence of climacteric fruits. Among the treatments, CaCl₂ (5%) + LDPE (T₈) maintained the highest scores for appearance, flavour, taste, colour, and overall acceptability, followed by CaCl₂ (3%) + LDPE (T₆). The effectiveness of calcium in preserving sensory quality is attributed to its role in strengthening cell walls, delaying softening, reducing respiration, and minimizing enzymatic browning, while polyethylene packaging reduced moisture loss and shrivelling.

Table 4: Effect of different post-harvest chemicals and packaging materials on appearance of banana *cv.* Grand Naine during storage.

Notations	Treatments	Appearance						
		0 Day	4 DAS	8 DAS	12 DAS	16 DAS	20 DAS	Mean
T ₀	Control (Without chemicals and packaging)	6.03	6.10	5.75	5.35	5.17	4.97	5.47
T ₁	CaCl ₂ (3%)	6.06	7.16	6.43	5.70	5.36	5.08	5.95
T ₂	CaCl ₂ (5%)	6.23	7.99	6.52	6.24	6.06	5.98	6.56
T ₃	NaHCO ₃ (0.4%)	6.90	8.80	8.72	8.64	8.61	8.54	8.66
T ₄	Polyethylene bag (LDPE 200 gauge)	6.69	8.68	8.60	8.52	8.48	8.43	8.54
T ₅	Newspaper	6.43	8.35	8.32	8.32	8.25	8.06	8.26
T ₆	CaCl ₂ (3%) + Polyethylene bag (LDPE 200 gauge)	6.51	8.85	8.79	8.71	8.67	8.59	8.72
T ₇	CaCl ₂ (3%) + Newspaper	6.15	8.83	8.76	8.69	8.65	8.56	8.70
T ₈	CaCl ₂ (5%) + Polyethylene bag (LDPE 200 gauge)	6.49	8.87	8.81	8.77	8.69	8.62	8.75
T ₉	CaCl ₂ (5%) + Newspaper	6.94	8.82	8.75	8.67	8.64	8.57	8.69
T ₁₀	NaHCO ₃ (0.4%) + Polyethylene bag (LDPE 200 gauge)	6.85	8.76	8.69	8.60	8.57	8.50	8.62
T ₁₁	NaHCO ₃ (0.4%) + Newspaper	6.76	8.73	8.65	8.56	8.53	8.47	8.59
	SE (m)±	0.021	0.069	0.056	0.053	0.027	0.032	
	C.D. at 5%	0.061	0.203	0.162	0.155	0.078	0.092	

Table 5: Effect of different post-harvest chemicals and packaging materials on flavor of banana *cv.* Grand Naine during storage.

Notations	Treatments	Flavor						
		0 Day	4 DAS	8 DAS	12 DAS	16 DAS	20 DAS	Mean
T ₀	Control (Without chemicals and packaging)	5.57	6.87	6.74	6.47	6.25	6.01	6.47
T ₁	CaCl ₂ (3%)	5.59	7.82	7.57	7.16	7.09	7.05	7.34
T ₂	CaCl ₂ (5%)	5.63	8.37	8.17	8.09	7.88	7.82	8.07
T ₃	NaHCO ₃ (0.4%)	5.62	8.51	8.45	8.29	8.14	8.06	8.29
T ₄	Polyethylene bag (LDPE 200 gauge)	5.61	7.65	7.52	7.48	7.46	7.40	7.50
T ₅	Newspaper	5.59	7.31	7.17	6.90	6.73	6.43	6.91
T ₆	CaCl ₂ (3%) + Polyethylene bag (LDPE 200 gauge)	5.75	8.92	8.90	8.84	8.82	8.76	8.85
T ₇	CaCl ₂ (3%) + Newspaper	5.72	8.80	8.75	8.62	8.54	8.23	8.59
T ₈	CaCl ₂ (5%) + Polyethylene bag (LDPE 200 gauge)	5.81	8.98	8.96	8.91	8.88	8.85	8.92
T ₉	CaCl ₂ (5%) + Newspaper	5.72	8.82	8.81	8.78	8.75	8.71	8.77
T ₁₀	NaHCO ₃ (0.4%) + Polyethylene bag (LDPE 200 gauge)	5.69	8.72	8.62	8.56	8.54	8.51	8.59
T ₁₁	NaHCO ₃ (0.4%) + Newspaper	5.66	8.59	8.44	8.35	8.07	7.89	8.26
	SE (m)±	0.015	0.012	0.020	0.033	0.028	0.021	
	C.D. at 5%	0.043	0.035	0.058	0.096	0.082	0.060	

Table 6: Effect of different post-harvest chemicals and packaging materials on taste of banana cv. Grand Naine during storage.

Notations	Treatments	Taste						
		0 Day	4 DAS	8 DAS	12 DAS	16 DAS	20 DAS	Mean
T ₀	Control (Without chemicals and packaging)	4.07	6.92	6.83	6.61	6.39	6.24	6.60
T ₁	CaCl ₂ (3%)	4.19	7.87	7.75	7.41	7.36	7.26	7.52
T ₂	CaCl ₂ (5%)	4.35	8.44	8.31	8.18	7.99	7.90	8.16
T ₃	NaHCO ₃ (0.4%)	4.41	8.57	8.49	8.36	8.24	8.18	8.37
T ₄	Polyethylene bag (LDPE 200 gauge)	4.14	7.70	7.57	7.51	7.44	7.42	7.53
T ₅	Newspaper	4.07	7.41	7.27	7.08	6.87	6.55	7.03
T ₆	CaCl ₂ (3%) + Polyethylene bag (LDPE 200 gauge)	4.95	8.94	8.89	8.85	8.82	8.78	8.86
T ₇	CaCl ₂ (3%) + Newspaper	4.75	8.81	8.77	8.66	8.65	8.46	8.67
T ₈	CaCl ₂ (5%) + Polyethylene bag (LDPE 200 gauge)	4.95	9.00	8.97	8.94	8.86	8.81	8.92
T ₉	CaCl ₂ (5%) + Newspaper	4.83	8.85	8.83	8.80	8.77	8.73	8.79
T ₁₀	NaHCO ₃ (0.4%) + Polyethylene bag (LDPE 200 gauge)	4.64	8.78	8.72	8.65	8.60	8.54	8.66
T ₁₁	NaHCO ₃ (0.4%) + Newspaper	4.55	8.67	8.50	8.43	8.32	8.02	8.39
	SE (m)±	0.021	0.016	0.039	0.039	0.046	0.048	
	C.D. at 5%	0.061	0.047	0.115	0.113	0.136	0.140	

Conclusion

The study revealed that post-harvest application of CaCl₂ (5%) combined with polyethylene packaging (LDPE, 200 gauge) was most effective in maintaining both chemical and sensory quality of banana fruits during storage. This treatment consistently recorded higher TSS, and ascorbic acid, along with superior scores for appearance, flavour and taste, while reducing acidity and spoilage. In contrast, untreated fruits deteriorated rapidly. Thus, CaCl₂ with LDPE packaging can be recommended as a practical strategy to extend shelf life and enhance marketability of bananas under ambient conditions.

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