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A Nithya Devi
Horticultural College and Research Institute for Women, Tiruchirappalli, Tamil Nadu, India

T Arumugam
Horticultural College and Research Institute, Periyakulam, Tamil Nadu, India

K Kumanan
Vegetable Research Station, Palur, Tamil Nadu, India

Corresponding Author:
A Nithya Devi
Horticultural College and Research Institute for Women, Tiruchirappalli, Tamil Nadu, India

Effect of various post-harvest treatments on banana cv. Rasthali

A Nithya Devi, T Arumugam and K Kumanan

Abstract
India is the largest producer of banana in the world. Lack of proper post harvest handling techniques and infrastructural facilities poses a hurdle for export. A study was therefore conducted with the objective to explore the effect of waxing and fungicides (*Trichoderma harzianum* and Benomyl) on shelf life, quality characters and disease incidence in banana cv. Rasthali. Edible waxes can enhance or even replace many of the costliest post-harvest techniques. Rasthali was selected for the present investigation for its uniqueness in quality and potential for export. The effect of skin coating with wax combined with fungicides on the physiochemical changes and ripening of banana cv. Rasthali at ambient condition was studied. The green life and quality can be extended by treating the fruits with eco friendly bio fungicide (*Trichoderma harzianum*) along with 8% wax coating. This treatment combination registered the maximum total sugars (23.60%) and acidity (0.43%) with longest shelf life of 17.50 days.

Keywords: Banana, wax, bio fungicide, post-harvest treatments, shelf life, quality parameters

Introduction
Research efforts have helped to increase the production of banana but the purpose of obtaining maximum profits will not be served unless the increase in production is supplemented with similar efforts to minimize post-harvest losses and to extend their shelf life. The post harvest losses can be minimized through checking the rate of respiration and transpiration, microbial infection and protecting membranes from degradation. The foresaid objectives can be achieved to some extent by the use of wax emulsion coating, storage at low temperature and using fungicides. Edible coatings can create a modified atmosphere and wax coating actively involved in reduction of water loss, retardation of ripening, reduction of chilling and mechanical injury, reduced decay, and added shine or gloss to the coated commodity. Fungicides are a primary means of controlling post-harvest diseases. But they have come under special scrutiny as posing potential oncogenic risks as per the report of US National Academy of Sciences (7).
Antagonistic microorganisms were recently developed as living fungicides for the control of post harvest diseases. Keeping the above in view, the present study was undertaken to investigate the efficiency of different post harvest treatments in enhancing the shelf life and quality of banana cv. Rasthali.

Material and Methods
Investigations on post harvest treatments and storage of banana cv. Rasthali (syn. Silk – AAB) were undertaken at the Post harvest Laboratory, Horticultural College and Research Institute, TNAU, Coimbatore. An experiment with 12 treatments having 3 replications was laid out in FCRD under ambient condition. The temperature and relative humidity inside the laboratory during the experimental period were monitored daily using a digital temperature and RH meter. Fruits used in the study were collected from the banana wholesale market, Coimbatore. In all the experiments, uniform sized mature fruits free from bruises or blemishes were used. Wax formulation was prepared using edible waxes like carnauba wax and bees wax using emulsifiers and stabilizers as per the CFTRI recommendation.
The fruits from the bunch were dehanded and the second, third and fourth hands were used in the experiments. The hands were first washed in cold water (15 °C) to remove latex strains, soil particles, and floral remnants and also to remove field heat from the fruits. Chlorine in the form of sodium hypochlorite solution (150 ppm) was added during hydro cooling as a disinfectant.

1. Fungicide: F_1-Without fungicide, F_2-Bio fungicide, F_3-Chemical fungicide
2. Waxing: W_1 -Without waxing, W_2 -Wax-4%, W_3 -Wax-8%, W_4 -Wax-12%

Chemical fungicide - Benomyl (0.1%)
Bio fungicide - *Trichoderma harzianum* @ 20 ml/Kg of fruits

After precooling the weighed fruits were treated with fungicide. Pre cooled fruits were dipped in Benomyl (0.1%) for 2 minutes. Fruits were sprayed with the culture filtrate of *Trichoderma harzianum* (20ml/Kg of fruits). *Trichoderma* culture was filtered through Whatmann filter paper. The filtrate was used in the treatments. The treated fruits were dipped in wax at 4, 8 and 12 per cent concentrations for 30-60 seconds. Then the hands were shade dried until no water particle was visible on the fruit surface. Then the fruits were maintained under ambient storage condition. Subsequently the total sugar, acidity, disease incidence and shelf life of the fruits were taken on frequent intervals. Fruits were inspected for the incidence of disease and peel split and the affected fruits were removed.

Results and Discussion

Post harvest biochemical changes which lead to reduction in quality constituents are of great nutritional significance. During ripening, there is an increase in sugars and decrease in acidity and this was in accordance with the findings of Dhua *et al*. (1992) [4] in banana. The processes like accumulation of starch and fall in acidity were rapid in control whereas it was found to be slower in wax coated fruits irrespective of the concentration.

The total sugar content was significantly influenced by different fungicidal treatments, wax concentrations and its interactions on 16 DAS (Table 1). The maximum total sugar content was recorded in F_2 (22.53%) followed by F_3 (21.41%). Among the wax levels used, W_3 recorded the maximum total sugars of 23.30 per cent followed by W_4 (21.47%) which was on par with W_2 (21.15%). The fruits devoid of fungicide and wax were unfit for further evaluation due to disease incidence and decay. Among the interaction effect, F_2W_3 (*T. harzianum* + 8% wax) and F_3W_3 (benomyl + 8% wax) recorded the highest total sugars of 23.60 and 23.00 per cent respectively.

Control fruits registered the lowest TSS during last day of storage due to high rate of respiration attributing for depletion in acid and sugars. Conversion of starch to sugar was very fast in fruits under control because the increase in sugar content during storage might be due to the conversion of certain cell wall materials such as pectin and hemi cellulose into reducing sugars which requires high level of oxygen which was satisfied in unwaxed fruits. Hence the conversion of starch into sugar is very fast in control fruits. Faster rate of dehydration of fruits lead to conversion of polysaccharides to soluble sugars. Hence accumulation of sugars was faster than the unwaxed fruits. This is in corroboration with the findings of Das and Dash (1967) [3] and Sarkar *et al*. (1995) [10] in banana.

The data registered on the effect of fungicide and wax on percent disease index is presented in table 2. The disease incidence was minimum in F_2 (9.98%) followed by F_3 (11.69%) while the maximum was recorded in F_1 (20.48%). Among the waxes tried, the lowest disease index of 11.40 per cent was recorded in W_3 and it was highest in W_1 (17.15%). Significant interaction between fungicide and wax concentrations was observed. The lowest percent disease index of 6.05 per cent was recorded in F_2W_3 and it was highest in F_1W_1 (22.40%). To line up with the result lowest disease incidence was observed in oranges coated with shellac (Potjewijd *et al*., 1995) [9], guavas with carnauba wax (Mc Guire and Hallman, 1995) [7] and cucumber with nature seal (Baldwin, 1997) [2]. Bio fungicide effectively reduced the incidence of post harvest diseases. This might be due to the secretion of harmful extra cellular compounds and production of enzymes like chitinase and glucanase against the pathogens by *T. harzianum*. The enzymes will disrupt the membrane integrity of the pathogen by dissolving the cell wall substances like chitin and glucan. Earlier work of Sivakumar *et al*. (2002) [11] had also indicated that *T.harzianum* effectively controlled the brown spot, stem end rot and anthracnose disease in rambutan.

The acidity varied from 0.36 to 0.43 per cent. Among the wax concentrations tried, the acidity was higher in W_3 (0.40%) whereas the other concentrations were on par with each other. Among the treatment combinations, F_2W_3 (0.43%) recorded the maximum acidity, which was on par with F_1W_3 (0.42%) followed by F_1W_4 (0.41%) and F_3W_2 (0.41%). The maximum acidity noticed in wax coated fruits might be due to the reduced levels of respiration leading to minimal loss of acids and sugars. The loss of ascorbic acid was low in the coated commodities and is presumably due to reduced internal O_2 which retards the oxidation of ascorbic acid (Sumnu and Bayindirli, 1995) [12].

Comparing the different types of fungicides, F_2 (*T.harzianum*) and F_3 (Benomyl) registered the longest mean shelf life of 15.25 days. The longest shelf life of 15.75 days was recorded in W_3 which was on par with W_2 and W_4 (15.17 and 14.83 days). Among the interaction effects, F_2W_3 (*T.harzianum* + 8% wax) registered the longest shelf life of 17.50 days which was on par with F_3W_3 (17.00 days). The present results are in agreement with the observations made by Krishnamurthy and Kushalappa (1985) [5]. They correlated the delayed ripening of waxol treated Robusta banana kept in ventilated bags with decreased rate of softening and yellow colour development and an increase in acidity, total sugars and starch in the pulp. However Mc Guire (1997) [6] revealed a contradictory result on guava treated with carnauba wax (5%) remained green and had lower acidity and TSS. According to Mc Guire and Hallman (1995) [7] carnauba wax (5%) negatively affect the quality of guava fruits by increasing the blackening of peel after being exposed to ripening temperature from cold room.

Table 1: Effect of post-harvest treatments on Total sugars (%) and Acidity (%) of banana cv. Rasthali

	Total sugars (%) Day 16					Acidity (%)				
	W_1	**W_2**	**W_3**	**W_4**	**Mean**	**W_1**	**W_2**	**W_3**	**W_4**	**Mean**
F_1	*	*	*	*	-	0.38	0.36	0.42	0.41	0.40
F_2	*	21.35 27.81	23.60 29.78	22.65 28.45	22.53	0.40	0.39	0.43	0.38	0.39
F_3	*	20.95	23.00	20.29	21.41	0.40	0.41	0.38	0.38	0.39

		26.95	29.02	26.94						
Mean	-	21.15 27.42	23.30 29.51	21.47 27.86	-	0.39	0.39	0.40	0.39	0.39

	F	W	F X W	F	W	F X W
SEd	NS	0.005	0.008	0.340	0.390	0.680
CD(P=0.05)	NS	0.010	0.018	0.740	0.850	1.480

* Data could not be recorded due to termination of storage
Figures in bold represent the angular transformed values

Table 2: Effect of post harvest treatments on disease incidence (%) and shelf life of Banana cv. Rasthali

	Disease incidence (%)					**Shelf life (Days)**				
	W_1	**W_2**	**W_3**	**W_4**	**Mean**	**W_1**	**W_2**	**W_3**	**W_4**	**Mean**
F_1	22.40 28.25	20.05 26.60	19.95 26.53	19.50 26.21	20.48 26.90	12.00	13.00	13.00	13.50	12.88
F_2	12.75 20.92	12.30 20.53	6.05 14.24	8.80 17.26	9.98 18.24	12.00	16.00	17.50	15.50	15.25
F_3	16.30 23.81	12.40 20.62	8.20 16.63	9.85 18.29	11.69 19.84	13.00	16.50	17.00	15.50	15.25
Mean	17.15 24.33	14.92 22.58	11.40 19.13	12.72 20.58	14.05 21.66	12.33	15.17	15.75	14.83	14.46

	F	W	F X W	F	W	F X W
SEd	0.390	0.450	0.770	0.440	0.510	0.880
CD (P=0.05)	0.850	0.980	1.690	0.960	1.110	1.930

Figures in bold indicate the angular transformed values

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