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Extending shelf life of Ney Poovan banana through active packaging for export market

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ABSTRACT

The present study focuses on the impact of active packaging technology on the Ney Poovan banana variety, aiming to extend its shelf life for export purpose. The experiment comprised four treatments: an ethylene absorber, a moisture absorber, a control group, and packaging in vacuum-sealed polythene bags. These banana samples were subsequently stored at two different temperatures, namely room temperature (RT) and 13.5°C. The results obtained from the experiment indicated that the fruits packed with an ethylene absorber exhibited an extended shelf life of 72 days when stored at 13.5°C. The fruits remained fresh for 20 days when stored at RT. These ethylene-treated fruits also displayed the highest pulp-to-peel ratio (PPR) of 7.34 when held at 13.5°C, while the highest acid content (0.673%) was registered at RT. On the other hand, the control group fruits stored at RT tended to show the highest TSS content (29°Brix). The fruits stored at RT, irrespective of the treatments exhibited the highest content of TSS (21.11°Brix). The physiological loss in weight increased gradually during storage in both temperatures but was low in fruits packed with moisture absorbers. Though the ethylene evolution rate increased towards extended storage in both temperatures, the concentration was less in fruits packed with ethylene absorber.

Keywords: *Musa* sp., AB genome, PLW, Export quality.

INTRODUCTION

Banana stands as the leading fruit crop of India in terms of area and production, securing the second position next to mango in domestic and export markets. Most of the banana trade occurs within the country. India proudly holds the title of being the largest producer of bananas, with a remarkable production of 32.45 million tons from 8.78 lakh hectares (NHB, 11). In India, significant banana production takes place in states such as Andhra Pradesh, Maharashtra, Tamil Nadu, Karnataka, Kerala, Bihar, West Bengal, and Gujarat. Ney Poovan (AB), a diploid banana variety, is widely cultivated as a commercial mono crop in Karnataka and Tamil Nadu. This slender plant yields substantial bunches weighing 15 to 30 kg after a growth period of approximately 12 to 14 months. The dark green hue of the banana transforms into a golden yellow colour, signifying the ripening stage. Ney Poovan (AB) variety holds significant potential for export opportunities, as its fruits possess remarkable qualities such as delightful aroma and delicious flavour. Pre-harvest spray and growth regulators enhance the bunch characters and yield (Mulagund *et al*., 10). These attributes make it a desirable choice for enhancing foreign exchange through exports.

The primary destinations for banana exports from India include Germany, Qatar, Bahrain, Saudi Arabia, Nepal, and the United States. However, despite these efforts, the export value of bananas stands at Rs. 1300 crores, contributing less than 0.4% of the global trade. The major challenges faced in postharvest banana handling are their limited shelf life (6 - 10 days) under tropical climatic conditions. Additionally, inadequate storage techniques further impact the export value of Indian bananas. The high moisture content tends to lead the fruit quality deterioration causing, leading to significant economic losses from harvest to consumption. Therefore, it is crucial to identify appropriate storage and packaging techniques to enhance the shelf life of bananas to strengthen this fruit's domestic and export trade values.

The active packaging approach establishes a connection between the packaged produce, the packaging materials used, and the surrounding environment to effectively extend the shelf life of the product. This method enhances the sensory attributes and maintains the overall quality of the final product (Bhat, 3). Therefore, active packaging is considered a dependable technique within the arena of food packaging (Singh *et al.,* 14). With this in mind, the present study aimed to explore and standardize an active packaging material that can effectively prolong the shelf life of Ney Poovan bananas for long-distance transportation, particularly in export markets.

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MATERIALS AND METHODS

The research was conducted at the National Research Centre for Banana, Trichy during 2020-2021. The selected fruits were harvested at 75% maturity, brought to the laboratory of Postharvest Technology of NRCB, and handled as per the standard protocol. The banana hands were treated initially with fungicides comprising of sodium hypochlorite solution (0.01%) followed by Carbendazim (0.2%) for five min after that, allowed to dry at room temperature (28.5±2° with 70% RH). Then, the bananas were packed using different treatments, *viz.,* ethylene absorber (potassium permanganate) + moisture absorber (silica gel) (T_1), ethylene absorber (T_2), moisture absorber (T_3), and Control (T_4) (Fig.1). The bananas were packed in vacuum using HDPE bags having a thickness of 0.018 mm with O_2 and CO2 transmission rates of 15.50 cm/$m^2$and 35.00 cm^3/m^2, respectively, and water vapour transmission rate of 77 g/m^2/ 24 h / atm and stored at two different temperatures - RT (28.5±2° with 65-70% RH) and 13.5° with 80-85% RH. The data were summarized using the mean of five independent measurements (n=5).

Various parameters were evaluated to analyze the ripened banana fruits. The assessment included measuring fruit weight, length, circumference and determining the pulp-peel ratio (PPR). Total soluble solids (TSS) were measured using a digital refractometer (JS7, RUDOLPH Research, Hackettstown, NJ). The titratable acidity was determined by titrating method (AOAC, 2). The contents of total sugar and starch were estimated as per the method of Hodge and Hofreiter (6). The peel colour was categorized as either green or yellow, indicating fruit shelf life. Shelf life was determined by the duration in which the fruit maintained good sensory quality and acceptance. The physiological loss in weight was measured at three days intervals and expressed in percentage. Shelf life was calculated in days by counting fruits' green and yellow life. Ethylene evolution was recorded using portable ethylene analyzer (Bioconservacion, Spain). Sensory evaluation of the ripened banana fruits was performed by untrained judges aged 25 to 60 years, using a nine-point hedonic scale. The overall acceptability (OAA) was assessed, considering sensory attributes such as colour, flavour, texture, and taste (Amerine *et al.,* 1).

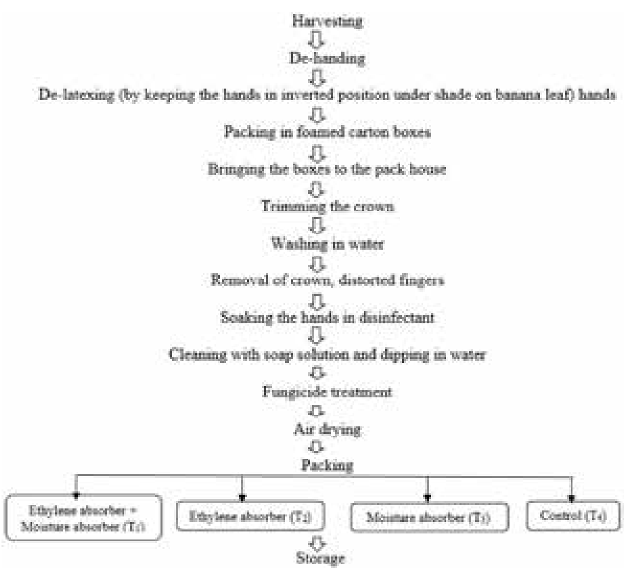

Fig. 1. Postharvest handling protocol of Ney Poovan banana fruits.

The experiment was designed using a completely randomized design (CRD) with five replicates, ensuring the statistical robustness of the results. The data obtained from the study were subjected to statistical analysis using SPSS version 2.1 software (IBM SPSS, Chicago, IL).

RESULTS AND DISCUSSION

Initially, the fruit weight, length, circumference, diameter, PPR, TSS, acidity, total sugars and starch of Ney Poovan banana at harvest were determined, and the results are given in Table 1. The selected fruits were kept along with different active packaging systems at two different temperatures (RT and at 13.5°C) to study the shelf life of the fruits.

The shelf life of the fruits was assessed as green life and yellow life, and the results obtained are indicated in Fig. 2. The treatments stored at RT had lesser shelf life than that stored at 13.5°. The storage of bananas at lower temperature could lessen the rate of respiration, production of ethylene, and ripening. The treated bananas had longer shelf life (20 days) than the control, having a shelf life of 10 days only at RT, whereas, at 13.5°, the shelf life of treated

Table 1. Physico - chemical parameters of 'Ney Poovan' banana at harvest.

Parameters	Fruit weight (g)	Fruit length (cm)	Circumference (cm)	Caliper (mm)	PPR	TSS (°Brix)	Acidity (%)	Total Sugar (%)	Starch (%)
Mean	15.10	13.16	9.80	27.05	2.64	3.44	0.22	0.95	21.20
SD	1.56	0.63	0.28	1.16	0.09	0.06	0.02	0.05	1.08

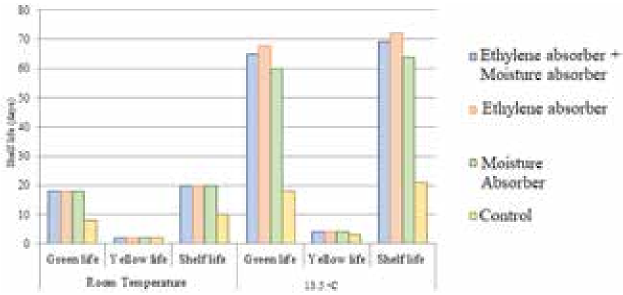

Fig. 2. Shelf life of bananas under different active packaging system

bananas ranged from 64 to 72 days, and in control, it was only 21 days. Of the treatments, bananas packed with ethylene absorber could have prevented the accumulation of ethylene in banana packs, thus extending its shelf life to 72 days.

The data relating to the changes in PPR, TSS, acidity, total sugar and starch between different active packaging systems and temperatures are presented in Table 2. PPR is a good indicator of banana ripening. A significant variation ($p \leq 0.05$) was found in the PPR of the banana fruits during ripening at both temperatures (RT and 13.5°). There was an increase in PPR during the ripening of bananas, which might be due to the softening of the peel and more moisture migration from the peel to the pulp of the different treatments. PPR was high in the bananas packed with ethylene absorber (7.34) at 13.5°, followed by the moisture absorber (7.24) at RT. The results of the present study are in line with the findings of Kudachikar *et al.* (8), Kumar *et al.* (9) and Sarkar *et al.* (13). In the studies of Suresh Kumar *et al*. (15), the ripened bananas had more PPR than un-ripened bananas due to the movement of water molecules from peel to the pulp by osmotic pressure gradient, and also peel losses its moisture to the environment through transpiration process.

The assessment of TSS of the banana fruits indicated the upregulation of TSS levels during the ripening, which might be due to the breakdown of starch into sugars. TSS of the un-ripened fruit (3.44˚Brix) increased significantly during ripening (29.64˚ Brix). The banana fruits stored at RT had more TSS (25 to 29˚Brix) than those stored at 13.5°C (20 to 27˚Brix). The highest TSS (29.64˚Brix) was found in the untreated fruits stored at RT, followed by the moisture absorber at 13.5°C (26.71°Brix). The increase in the TSS of the fruits ripened at RT might be due to the continuous and rapid ripening process that occurred at room temperature, as compared to cold storage, where a reduced rate of biochemical reactions (TSS) took place (Gaikwad *et al*., 4).

The unripened fruits had an acidity of 0.22 %, which was comparatively lower than the ripened bananas. The treated fruits had a higher content of acid (0.61 to 0.67%) than untreated ones (0.57 and 0.60%) at both temperatures after ripening. The highest acidity (0.673%) was recorded in the bananas packed with ethylene absorber at RT, followed by moisture absorber at RT (0.670). During the ripening stage, the acidity level increases due to the presence of malic acid, oxalic acid and citric acid. With an increase in respiration and ripening, the TSS increases and acidity decreases when the bananas are stored at ambient temperature. The results obtained in the present research work are in acceptance with the previous findings of Sarkar *et al.* (13).

The starch present in the banana fruits are converted into simple sugars such as glucose, fructose, sucrose etc., which increase the sweetness towards the approach of ripening. The highest total

Table 2. Effect of active packaging on physico - chemical parameters of 'Ney Poovan' banana after ripening.

S. No.	Parameter	PPR	TSS (°Brix)	Moisture (%)	Acidity (%)	Total Sugars (%)	Total starch (%)	OAA
1.	T_1R_1	4.91	26.39	66.50	0.660	20.21	1.70	6.83
2.	T_1R_2	5.61	20.66	66.59	0.620	14.38	2.70	7.16
3.	T_2R_1	4.84	25.52	66.47	0.673	19.19	2.17	6.95
4.	T_2R_2	7.34	22.58	66.22	0.630	15.43	1.95	6.77
5.	T_3R_1	7.24	25.36	67.10	0.670	19.79	2.13	6.58
6.	T_3R_2	7.04	26.71	66.89	0.616	16.22	1.08	6.84
7.	T_4R_1	7.12	29.64	67.00	0.603	21.11	1.05	7.74
8.	T_4R_2	4.82	26.38	67.21	0.570	21.03	1.13	6.90

* PPR – Pulp to Peel Ratio, TSS - Total Soluble Solids, OAA - Overall Acceptance

T_1R_1 - Ethylene Absorber + Moisture Absorber at room temperature; T_1R_2 - Ethylene Absorber + Moisture Absorber at 13.5˚C; T_2R_1 - Ethylene Absorber at room temperature; T_2R_2 - Ethylene Absorber at 13.5˚C; T_3R_1 - Moisture Absorber at room temperature; T_3R_2 - Moisture Absorber at 13.5°C; T_4R_1 - Control at room temperature; T_4R_2 - Control at 13.5°C.

sugar content was present in bananas treated in control (21.11%) at RT, followed by control (21.03%) at 13.5°C. The total sugars were higher in the treatments stored at RT (19.19% to 21.11%) than in the fruits stored at 13.5°C temperature (14.38% to 21.03%). The active packaging system significantly reduces the total sugar content of banana fruits because of slow ripening (Gaikwad *et al.*, 4). The rapid fluctuations observed in the total and reducing sugar contents of the banana fruits stored at room temperature (RT) can be attributed to the accelerated ripening process, which converts starch into sugars. However, the treatments employed in this study were found to exert an inhibitory effect on the ripening process of the banana fruits, resulting in a slower rate of starch conversion into sugars. Our research observations aligned with the finding of Bhat (3) and Golding *et al.* (5) in the modified atmospheric packaging of banana fruits.

The starch content of the bananas packed in different active packaging systems and stored at different temperatures indicated that the starch content of the ripened bananas was lower (1.05% to 2.70%) than the un-ripened banana (21.20%) due to the breakdown of complex starch molecules to sugars during ripening. The highest starch content (2.70%) was found in the fruits treated with ethylene absorber + moisture absorber at 13.5°C, followed by the bananas packed with ethylene absorber at RT (2.17%). The total sugars were increased during banana ripening, whereas total starch was decreased due to the conversion of starch into sugars. The obtained outcomes conform with Opara *et al.*'s findings (12).

Physiological loss in weight (PLW) primarily arises from the combined effects of transpiration, respiration, and other metabolic processes (Kumar *et al.*, 9). The PLW of banana fruits stored at RT was increased during storage at different temperatures in the present study (Fig. 3-4). During storage, PLW gradually increased at both temperatures, although it was low in the bananas stored at 13.5°C. Among the different treatments, PLW was less in T3 (8.62%) (Moisture absorber), followed by T_1 (9.81%) and T_2 (10.21%) during 70 days of storage at 13.5°C. At RT, there was the short shelf life with low PLW in T_3 (20.62%) (Moisture absorber), followed by T_1 (21.22%) and T_2 (21.82%) during 18 days of storage. The low moisture loss is an indication of the freshness of the produce. The treated bananas had less transpiration and respiration losses than the control due to active ingredients in the stored bananas. Therefore, it increased the shelf life of bananas and treated bananas had low moisture loss, and were suitable for distance markets. Similar results were obtained by Krishna Kumar and Tirupathi (7).

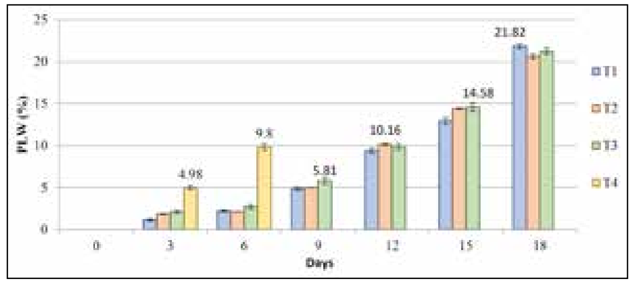

Fig. 3. Physiological loss in weight (PLW) of banana during storage at RT.

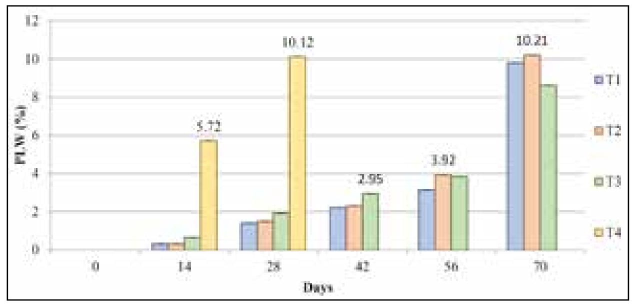

Fig. 4. Physiological loss in weight (PLW) of banana during storage at 13.5°C.

The ethylene evolution rate during storage of bananas at two different temperatures (RT and 13.5 °C) is presented in Fig. 5-6. The ethylene evolution was higher in bananas stored at RT than at 13.5 °C. The highest ethylene production was observed in control (0.07% in the 8th day of storage) over treatments. At the end of storage at 13.5 °C, the ethylene evolution rate was high in T_3 (0.07% on the 60th day of storage), followed by T_1 (0.068% on the 65th day of storage) and T_2 (0.072% on 68th day of storage). Similarly, at RT storage, the ethylene concentration was higher in T_3 (0.088%), followed by T_1 (0.082%) and T_2 (0.080%). Fruits stored in active packaging material; the ethylene absorber had less ethylene concentration than other treatments. This was due to the ethylene absorber absorbed the

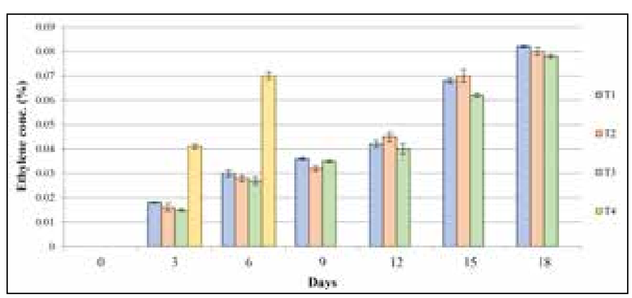

Fig. 5. Ethylene evolution rate of banana during storage at RT.

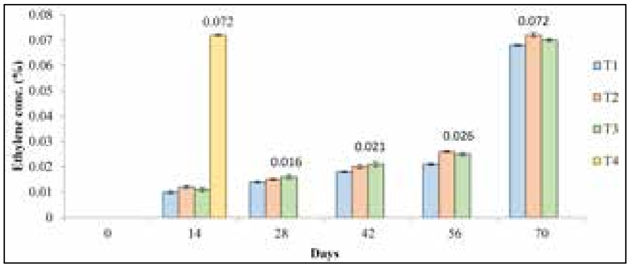

Fig. 6. Ethylene evolution rate of banana during storage at 13.5°C.

ethylene produced during storage (Yadav *et al.*, 16). OAA is the indicator to find the suitability of banana fruits for consumption. Banana fruits stored at low temperature (13.5°C) also scored a higher sensory score than those stored at RT.

AUTHORS' CONTRIBUTION

Conceptualization of research (KNS, PSK and SU); Designing of experiment (KNS and PSK); Contribution of experimental materials (KNS, PSK and KK); Field/ Lab experiments and data collection (KNS and KK); data interpretation (KNS, PSK, KK and RS); Preparation of the manuscript (KNS, PSK and RS).

DECLARATION

Authors declare that we do not have any conflict of interest.

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REFERENCES

1. Amerine, M.A., Pang born, RM and Rossler, E.B. 1965. *Principles of Sensory Evaluation of Food*. Academic Press, New York and London.

2. AOAC, 1996. *Official Methods of Analysis* (16th Edn.), Arlington, VA.

3. Bhat, S. 2013. Minimal processing and preservation of fruits and vegetables by active packaging. *Int. J. Herbal Medicine*, **1**: 131-138.

4. Gaikwad, K.K., Singh, S., Shin, J. and Lee, Y.S. 2020. Novel Polyisoprene based UV-activated oxygen scavenging films and their applications in packaging of Beef Jerky. LWT *Food Sci. Technol*. **117**: 108643.

5. Golding, J.B., Ekman, J.H. and McGlasson, W.B. 2005. Regulation of Fruit Ripening. Stewart Postharvest Review. *Postharvest Biol. Technol.* **3**: 1-5.

6. Hodge, J.E and Hofreiter, B.T. 1962. In: *Methods in Carbohydrate Chemistry*. (Eds. Whistler, R.L and Be Miller, J.N), Academic Press, New York.

7. Krishnakumar, T. and Thirupathi, V. 2014. Effect of 1-Methylcyclopropene (1-MCP) on postharvest quality and shelf life of partially ripened bananas. *Trends Biosci.* **7**: 3680-86.

8. Kudachikar, V.B., Kulkarni S.G. and Keshava Prakash M.N. 2011. Effect of modified atmosphere packaging on quality and shelf life of 'Robusta' banana (*Musa* sp.) stored at low temperature. *J. Food Sci. Technol*. **48**:319–24.

9. Kumar, T.K., Bhagavan, B.V.K., Mamatha, K., Rani, A.S. and Subbaramamma, P. 2018. Response of 1-MCP on physiological and physical characteristics in banana (*Musa paradisiaca* L.) cv. TellaChakkerakeli during storage. *Int. J. Curr. Microbiol. App. Sci.* **7**: 3135-44.

10. Mulagund, J., Kumar, S., Soorianathasundaram, K. and Porika, H. 2015. Influence of post-shooting sprays of sulphate of potash and certain growth regulators on bunch characters and fruit yield of banana cv. Nendran (French plantain *Musa* AAB). *The Bioscan*. **10**: 153-59.

11. NHB, 2021. http://www.nhb.gov.in/StatisticsViewer.aspx?enc=MWoUJibk35dW2g36TUJWAoZqESmAYFi7h2irlsmjlINTcFl1rG/kLbq8ZQbWUvuM.. Accessed on 30th Aug 2022.

12. Opara, U.L., Al-Yahyai, R., Al-Waili, N., Said, F.A., Al-Ani, M., Manickavasagan, A. and Al-Mahdouri, A. 2013. Postharvest responses of 'Malindi' Cavendish banana to various storage conditions. *Int. J. Fruit Sci.* **13**: 373-88.

13. Sarkar, T., SayanSau, Joshi, V., Sarkar, T. and Sarkar, S. 2017. Effect of modified and active packaging on shelf life and quality of banana Cv. Grand Naine. *The Bioscan*. **12**: 95-100.

14. Singh, S., Gaikwad, K.K. and Lee, Y.S. 2019. Development and application of a pyrogallic

acid-based oxygen scavenging packaging system for shelf life extension of peeled garlic. *Sci. Hortic*., Amsterdam, **256**:108548.

15. Suresh Kumar, P., Renganathan, R., Shiva, K.N., Kamaraju, K., Thangavelu, R., Kumar, V. and Uma, S. 2020. Influence of caliper grade threshold and storage environment on the postharvest behaviour of Red Banana (AAA). *Indian J. Hortic*. **77**:532-40.

16. Yadav, R., Ray, A. and Khatkar, B.S. 2015. A study of active packaging (AP) technology on banana fruit. *J. Basic App. Engg. Res*. **2**:1518-1522.

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