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Role of Exogenous Melatonin in Enhancing Shelf Life of Traditional Banana Varieties

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: An experiment was conducted to examine the effect of various concentrations of melatonin on post harvest weight loss and shelf life of three traditional banana varieties *viz*. Ney Poovan, Nendran and Red Banana.
Study Design: Completely Randomized Design.
Place and Duration of Study: Post Graduate laboratory, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2022.
Methodology: Banana hands were dipped in 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 mM melatonin for 15 minutes and were stored at ambient temperature. The hands dipped in water were treated as control. Observations on physiological weight loss and shelf life were recorded till the fruits remained marketable.

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Results: The results depicted that fruits immersed in 1.0 and 1.5 mM melatonin for 15 minutes recorded lower weight loss (31.56, 30.55 and 24.90%) on 11th, 11th and 12th day of storage and longer shelf life by 3, 2.67 and 2.67 days in Ney Poovan, Nendran and Red Banana respectively.
Conclusion: The effects of melatonin were due to its efficiency in reducing transpiration and respiration and thereby lowering weight loss. The lowered metabolic activity not only mitigated weight loss but also maintained firmness and turgidity of the fruits and thereby prolonging the storability. It was evident from the results that melatonin treatment could be a good practice for extending postharvest life of banana by reducing the physiological loss in weight simultaneously maintaining the appearance.

Keywords: Banana; traditional varieties; post-harvest; melatonin; weight loss; shelf life.

ABBREVIATIONS

MT : Melatonin
PLW : Physiological loss in weight
% : Per cent
mM : milli Molar

1. INTRODUCTION

Banana is one of the most important fruit crops in the world [1] with a production of 131 million tones [2]. India, the largest producer of banana harvests 35.08 million tonnes from 9.61 lakh hectares and contributes more than a quarter of the world's production. The leading banana producing states in the country are Andhra Pradesh, Maharashtra and Gujarat. In Tamil Nadu, 3.93 million tonnes of banana was produced from 1.01 lakh hectares during 2021 [3].

Bananas and plantains botanically belong to the genus *Musa* and family Musaceae. Almost all cultivated bananas are natural hybrids and polyploids of two wild species *Musa acuminata* Colla (Genome A) and *Musa balbisiana* Colla (Genome B). Stover and Simmonds [4] reported that many desert varieties originated from *Musa acuminata* possessing diploid, triploid and tetraploid 'A' genome. *Musa balbisiana* also had its contribution for desert varieties by hybridizing with *Musa acuminata*. These two species viz., *Musa acuminata* and *Musa balbisiana* were believed to be evolved in Malaysia or Indonesia [5] and India, Myanmar, Thailand and Philippines [6] respectively. India being one of the major centres of origin, harbours more than 1000 banana varieties belonging to varied genomic groups. Among which few varieties *viz*., Matti, Semmatti, Manoranjitham, Peyan, Kunnan, Kadali, Virupakshi, Sirumalai, Ney Poovan, Nendran, Red Banana are localized to particular regions and been cultivated by farmers over generations. These traditional varieties are preferred by a wide range of people for their uniqueness in taste, flavour and nutritional properties [7].

Among different traditional varieties under cultivation, a few are highly preferred in export market such as Ney Poovan, Nendran, Red Banana and Matti. Ney Poovan (AB), a popular variety in Karnataka, Tamil Nadu, Bihar and Maharashtra is also known as Elakki Bale, Njali Poovan, Elarasi etc. It is preferred for its aroma, flavour and post green life. Nendran (AAB), the most popular dual-purpose variety of Kerala is highly preferred for chips making and it is rich in vitamin A (865.34-1143.87 µg/100g). Red Banana (AAA) also called as Sevvazhai, Agni Sagar, Chandrabale is the highly priced variety of South India and Western and Central India to some extent. It is a wholesome fruit with higher carotenoids and potassium [7].

Banana classified under climacteric fruits is usually harvested at pre-climacteric stage (fully matured but still green). At this stage, the respiration is low and the synthesis of ethylene is undetectable and hence possesses an acceptable storage life [8]. The deterioration in banana starts immediately after harvest of bunches and nearly 25% of India's production, worth INR 2500 crores is lost annually due to improper post harvest handling. Therefore, it is necessary to utilize the technological advances along with scientific background to reduce the post harvest losses of banana immediately after harvest and during storage [7].

Melatonin (N-acetyl-5-methoxytryptamine, MT), an indoleamine hormone is found to be present in almost all living organisms including humans and higher plants. It was first identified in bovine; secreted by pineal gland in response to darkness [9]. This pleiotropic molecule possesses antioxidant properties highlighting its potential utility in therapeutic modality [10]. This specific

property is also found to be present in plants after its identification in plants by Dubbels et al*.* [11] and Hattori et al*.* [12]. Being a potent antioxidant, MT directly removes reactive oxygen species (ROS), activating the antioxidant system and enhancing the effectiveness of other antioxidants [13]. This ubiquitous compound has the ability to preserve the post harvest quality and enhance the shelf life of various horticultural crops. Exogenous MT applied as post harvest dip prolonged the shelf life of banana [14], mango [15], pear [16] and plum [17]. Therefore, the objective of the present study was to assess the effect of exogenous MT in enhancing shelf life of traditional banana varieties *viz.* Ney Poovan, Nendran and Red Banana.

2. MATERIALS AND METHODS

The present study was conducted in the Post Graduate Laboratory, Department of Fruit Science, Horticultural College and Research Institute, TNAU, Coimbatore during 2022. Matured (80%) hands of Ney Poovan, Nendran and Red Banana were purchased from a Local Banana Market in Coimbatore. Analytical grade melatonin (MT) was purchased from M/s. Otto Chemie Pvt. Ltd., Mumbai, Maharashtra. The purity of the chemical was 99% and was dissolved in ethanol before use.

2.1 Fruit Samples and Treatments

The hands were graded and uniform sized damage free hands of the three banana varieties were randomly divided into seven groups with three replications in such a way that each treatment consisted of three hands. The hands were dipped in 0.1% Tween 20 for 1 minute and then were immediately dipped in six different concentrations of MT for 15 minutes (Table 1). The control fruits were immersed in water alone. After MT treatment, the fruits were subjected to air drying and stored at ambient room temperature in plastic crates. Observations on PLW and shelf life were recorded upto 11 days in Ney Poovan, Nendran and upto 12 days in Red Banana.

2.2 Observations Recorded

2.2.1 Physiological loss in weight

Physiological loss in weight (PLW) was determined based on the initial weight of the hand and the loss in weight was recorded on successive day during storage. The PLW was calculated using the following formula and expressed in percentage.

$$PLW\ (\%) = \frac{\text{Initial Weight-Final Weight}}{\text{Initial Weight}} \times 100$$

Table 1. Treatment details

Treatment	Concentration
M_1	Control (Water dip)
M_2	0.5 mM Melatonin
M_3	1.0 mM Melatonin
M_4	1.5 mM Melatonin
M_5	2.0 mM Melatonin
M_6	2.5 mM Melatonin
M_7	3.0 mM Melatonin

2.2.2 Shelf life

The shelf life of the fruits was evaluated on the basis of visual observations. It was expressed in number of days from the day of harvest till the fruits retain marketability. The hand was considered unmarketable when 50% of the fruits showed more than 50% blackening or spots or lesions.

2.3 Statistical Analysis

The experiment was laid under Completely Randomized Design and the collected data were analysed using one way ANOVA and significance was determined at $p < 0.05$ using Least Significant Difference. The linear relationship between PLW and shelf life was determined using Pearson's correlation coefficient. The statistical analysis was performed using R software (R version 4.3.1 (2023-06-16 Universal C Runtime)).

3. RESULTS

Application of melatonin as post harvest dip significantly reduced the weight loss and considerably increased the shelf life of banana varieties Ney Poovan, Nendran and Red Banana.

3.1 Physiological Loss in Weight

In Ney Poovan, the cumulative PLW ranged from 31.56 to 40.39 % on 11th day of ambient storage (Table 2). The physiological weight loss in 1.0 mM MT dipped fruits was the lowest (31.56%) which was on par with treatment M4 (31.74%) and the control fruits registered the highest PLW (40.39%). The PLW gradually decreased initially

and once ripening commenced, it increased. The peak weight loss was recorded in control, 0.5 and 3.0 mM MT dipped fruits on 9th day whereas it was recorded on 10th day in 2.0 & 2.5 mM MT dip treatments and on 11th day in 1.0 & 1.5 mM MT dip treatments (Fig. 1A).

The cumulative PLW of Nendran fruits treated with melatonin ranged from 30.55 to 32.58% on day 11 of ambient storage (Table 2). The lowest loss was observed in 1.0 mM MT dip treatment (30.55%) which was significantly different from all other treatments and the highest PLW was observed in control fruits (34.15%). The trendline of PLW was similar to Ney Poovan and the earlier peak was reached on 9th day in control and on day 11 in 1.0 & 1.5 mM MT dip treatments (Fig. 1B). The PLW was decreasing throughout the green phase and it started increasing gradually during the turning phase (green to yellow), the peak PLW was reached on the day of ripening which then decreased with fruit deterioration in Nendran.

The weight loss of Red Banana after treatment with various concentrations of melatonin ranged between 24.90 and 30.06 % on 12th day of storage (Table 2). The significantly lowest PLW (24.90%) was exhibited by 1.5 mM MT immersion and it was followed by 1.0 mM MT treatment (26.01 %). The highest loss was recorded in 2.0 mM MT dip (30.06 %) which was on par with control (29.52 %).

The trendline of PLW of Red Banana depicted similarity with other two banana varieties Ney Poovan and Nendran indicating that melatonin treatment exhibited similar effect on PLW irrespective of varieties under ambient storage (Fig. 1C). Thus melatonin considerably reduced the weight loss in comparison with the control and concentrations 1.0 mM and 1.5 mM were found to be effective in reducing the loss when compared to the remaining concentrations in all the three varieties.

Table 2. Effect of melatonin on physiological loss in weight (PLW - %) and shelf life (days) in traditional banana varieties

Treatment	Physiological loss in weight			Shelf life		
	Ney Poovan	Nendran	Red Banana	Ney Poovan	Nendran	Red Banana
M_1– Control	40.39[a]	34.15[a]	29.52[a]	8.33[b]	8.67[b]	9.33[c]
M_2 – 0.5 mM MT	34.25[d]	31.39[bcd]	28.47[b]	9.00[b]	9.33[b]	9.67[c]
M_3 – 1.0 mM MT	31.56[e]	30.55[d]	26.01[d]	11.33[a]	11.33[a]	11.33[ab]
M_4 – 1.5 mM MT	31.74[e]	31.06[cd]	24.90[e]	9.67[a]	10.67[a]	12.00[a]
M_5 – 2.0 mM MT	35.11[cd]	31.93[bcd]	26.63[cd]	9.33[b]	9.00[b]	10.00[bc]
M_6 – 2.5 mM MT	36.51[bc]	31.98[bc]	30.06[a]	8.67[b]	8.33[b]	10.33[bc]
M_7–3.0 mM MT	37.16[b]	32.58[b]	27.16[c]	8.67[b]	8.67[b]	9.33[c]
SEd	0.82	0.64	0.43	0.53	0.53	0.73
CD (p = 0.05)	1.76	1.39	0.94	1.14	1.15	1.58

Mean values followed by common letters are not significantly different

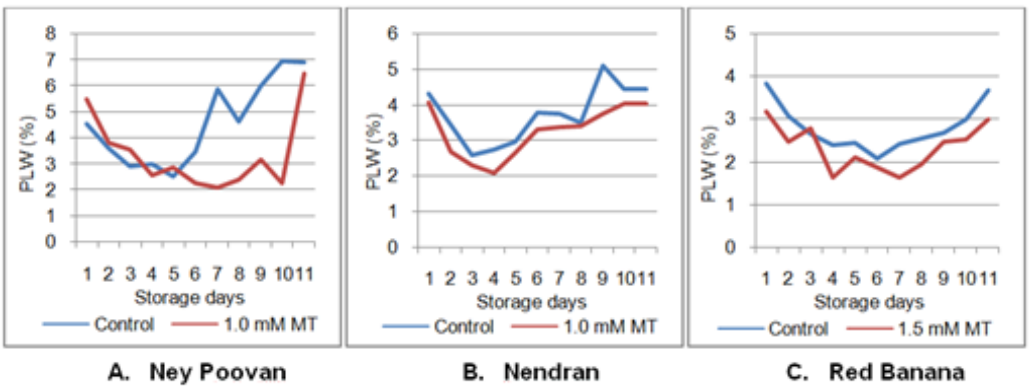

Fig. 1. Influence of melatonin on physiological loss in weight over the storage period of traditional banana varieties

3.2 Shelf Life

The average shelf life of Ney Poovan, Nendran and Red Banana hands were presented in Table 2. The lowest shelf life of 8.33, 8.67 and 9.33 days was recorded by control fruits and the respective highest shelf life was achieved by 1.0 mM MT dip treatment in Ney Poovan (11.33 days) and Nendran (11.33 days), and 1.5 mM MT dip treatment (12 days) in Red Banana which were 1.36, 1.30 and 1.28 times higher than their respective control.

The banana variety Ney Poovan had longer green life (7 days) which was only 3 days in banana variety Nendran yet their shelf life seemed to be similar indicating their genotypic trait of longer green and yellow life in Ney Poovan and Nendran respectively. The 1.0 and 1.5 mM MT dip treatments were considered best among all treatments in increasing the shelf life of banana.

4. DISCUSSION

The post harvest weight loss causes degradation in both quality and quantity of the stored produces. The term 'quality' includes changes in colour, nutrient content, flavour and the occurrence of decay while the term 'quantity' defines the amount of produce lost during storage notably water loss. There are numerous factors governing physiological weight loss such as transpiration, respiration, ethylene, decay/ diseases, temperature, relative humidity, atmospheric air composition, storage duration and light [18]; Lufu et al.,[19].

In the present study, exogenous melatonin applied at 1.0 and 1.5 mM concentrations as post harvest dip significantly reduced post harvest weight loss in banana varieties*viz.*Ney Poovan, Nendran and Red Banana.Higher weight loss corresponds to higher rate of metabolism in control treatments leading to more water loss as result of higher respiration and transpiration [20]. Melatonin treatment intervenes and reduces ethylene biosynthesis thereby reducing its level and delays the ripening of fruits as ethylene serves as a cofactor in respiration [21]. Water loss occurs mainly from the fruit surface and melatonin provides better skin strength by maintaining the firmness of the fruit which delays the occurrence of peak PLW [22]. Melatonin delays the climacteric peak thereby it restricts the metabolism thus reducing post harvest weight loss. The weight loss increased with increasing concentration of melatonin in all ~~the~~ three banana cultivars. This may be due to the overaccumulation of IAA brought about by exogenous melatonin treatment [23]. The elevated auxin level accelerates ripening as it stimulates respiration and induces pre-climacteric ethylene production [24].

The correlation coefficients between shelf life and physiological loss of weight in banana varieties Ney Poovan, Nendran and Red Banana were -0.82, -0.73 and -0.67 respectively. The corresponding coffecient of determination (r^2) were 0.672, 0.541 and 0.456. Hence, it was evident that shelf life had a strong negative correlation with physiological loss in weight and it was distinct that PLW had 40 to 70% contribution in determining the shelf of the banana. More the weight loss less is the storability of banana. This finding was in accordance with Finger et al. [25] who revealed that more than 5% fresh weight loss lead to 70% increase in respiration and 50% higher ethylene production in banana thus hastening ripening and reducing shelf life. Fruits treated with melatonin for 15 minutes exhibited lower weight loss ensuring longer shelf life than control fruits regardless of variety.

5. CONCLUSION

Melatonin treatment increased shelf life of banana fruits by 2 days stored under ambient conditions at 1.0 & 1.5 mM concentration with 15 minutes immersion by reducing the physiological loss in weight. In countries like India which lacks adequate cold storage facilities, post harvest dipping of banana in melatonin considerably increases shelf life under ambient conditions preventing losses and also paves way for international trade as it leaves no toxic residues on the fruits.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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