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# Impact of Edible Coating in Extending the Shelf life of Post-harvested Banana under Storage Condition

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**ABSTRACT: As per the report, postharvest losses are increasing; half of the fruits and vegetables lose annually. Extending banana shelf life during export is critical due to their high perishability. This edible coating ensures bananas arrive in optimal condition, enhancing marketability, fetching better prices, and increasing revenue for exporters. The present study aimed to investigate the efficiency of an edible coating on the physico-chemical and bio-chemical qualities of the post-harvest banana (*Musa* spp.) stored at the room temperature (25±2°C) for 15 days to assess the impact of coating on extending its shelf life by sustaining its nutritive properties. In general, as the storage period increases, the titratable acidity (TA), pH, firmness of the fruits decrease, while weight loss and total soluble solids increases. The current study showed that the edible coating act as a barrier between the physico-chemical nature of fruit and the external environment to preclude the direct interaction with atmospheric gases and microbes. The coating reduced the rate of respiration, color, weight loss, firmness as compared to control. An edible encasing could be a useful substitute to extend the postharvest life and maintain the quality of banana fruit.**

**Keywords:** Bio-coating, biochemical analyses, physiological analyses, shelf life, Banana, postharvest.

## INTRODUCTION

Preservation of food is the most challenging task, about half of the horticulture crops losses occur in many ways, along the production to postharvest losses (Singh and Packirisamy 2022). Food and agriculture organization of US reported more than 1300 million of food is wasted annually. Among them, about 45-55% of horticulture crops been wasted globally due to postharvest losses, which is very high compared to all other crops (Marelli *et al.*, 2016). Banana (*Musa* spp.) is the most staple food crop and widely cultivated in tropical and subtropical regions (Gol *et al.*, 2011), as it is rich in minerals vitamins and highly useful for the treatments of infant diarrhea, celiac disease and further patients suffering from arthritis, kidney disorders, blood pressure and heart problems (Stover and Simmonds 1987). For the purpose of domestic consumption, banana harvested before mature stage and during storage, they easily deteriorate due to quick ripening process (Suseno *et al.*, 2014). Several researches have established the storage techniques and reported to extend the shelf life of banana by different preservation methodologies. Among them, edible coating was found to be one of the best method of extending the postharvest shelf life of fruits and vegetables (Debeaufort *et al.*, 1998).

The application of the edible coating is promising to enhance the shelf life of fruits and vegetables. Several reports suggested that chitosan and algal extract had a very good coating on certain fruits (Manftoonazad, 2005; Changsiripom and Manuskwan 2011).

This study aims to assess the effectiveness of an edible coating derived from natural cellulose on inducing physiological and biochemical alterations in banana fruit, with the ultimate goal of prolonging its shelf life.

## MATERIAL AND METHODS

**Fruit materials.** To prevent postharvest infections, the fruits were surface cleaned with sodium hypochlorite (0.5%) for three minutes, and then they were left to air dry. Mature, healthy fruits that were not torn were chosen based on their consistency in shape, colour, and size as well as any visible flaws. These banana fruits were then divided into two experimental sets, each containing seven fruits, and a control set, also consisting of seven bananas. In an effort to lessen any harm from the coating, the treatment sets were coated with edible bio-coatings (MBT/BC-01 and MBT/BC-04a) for 10 minutes using a dipping procedure (Manftoonazad, 2005). This was followed by 30 minutes of air-drying at room temperature. Following 0 days of initial experimentation and 7 days of storage at room temperature (25±2°C), the treated banana fruits from both the experimental and control sets underwent the following physiological and biochemical examinations.

**Weight Loss Percentage (WLP).** Banana fruits weighed initially on $0^{th}$ day of treatments, and the amount of weight loss calculated by following formula (Changsiripom and Manuskwan 2011).

Weight loss (%) = $(W_1 - W_2) / W_1 \times 100$

Where, $W_1$ = Initial weight (g) and $W_2$ = Weight loss observed in the seven days intervals of treatment (g).

**Decay or Rotting Percentage.** The decay percentage was evaluated by the visual observation by scale ranging from 0 to 5. Where, 0 = no physiological and microbial decay signs and 5 indicates >50% decay and microbial infected samples were discarded in each sample (Changsiripom and Manuskwan 2011).

**Shelf Life.** The number of days needed for the banana fruits to reach the final stage of ripening was used to determine whether they were edible.

**Firmness.** A penetrometer that was portable was used to gauge how firm the fruits were. According to (Jha *etal*., 2013), the hardness was assessed at three distinct locations (proximal, distal, and centre), with values given in Pascal (Ps).

**Total Soluble Solids (TSS).** Dong *et al*. (2001) determined the TSS of banana fruit in °Brix reading range between 0% – 50%. The banana flesh was blended in a blender to create a homogeneous sample, and a drop of juice was then put on a portable refractometer's lens.

**pH and Titrable Acidity (TA):** The fruit samples' pH was measured using the procedure outlined by the AOAC (1994). Using phenolphthalein as an indicator, 5 ml of banana juice was titrated with 0.1 N sodium hydroxide to estimate the TA of the juice (AOAC, 1994).

**Statistical Analysis.** The standard deviation was computed and all assays were completed in triplicate. There were three replicates in the fully randomised experimental setup. The data were analyzed using Duncan's multiple range test (Bliss, 1967) to distinguish the means at a 95% confidence level, and analysis of variance (ANOVA) was employed to discover treatment impact.

## RESULTS AND DISCUSSION

*A. Weight Loss, Decay Percentage and Shelf Life*

The results (Fig. 1 & Table 1) illustrate how the WLPs of coated and uncoated bananas (control) changed during the course of storage. WLPs significantly decreased as a result of the coating procedure as compared to the control samples. Banana weight loss during ripening may be caused by water loss via a variety of physiological processes as well as substrate loss from respiration (Islam *et al*., 2001). As a semi-permeable barrier against oxygen, carbon dioxide, moisture, and solute movement, these coatings likely reduced respiration, moisture loss, and oxidation reaction rates compared to the control group, which is why there was a decrease in weight loss in the treatments (Jha *et al*., 2013). In comparison to other treatments and the control, the MBT/BC-01 coating was shown to be more effective in this trial in minimising weight loss.

At the conclusion of the storage period, the control samples' percentage of decay was around four to five times greater than that of the banana fruits coated with MBT/BC-01 and MBT/BC-04a (Fig. 1; Table 1). According to this theory, cellulose derivatives may cause the defence enzyme chitinase to be activated, which would then facilitate the breakdown of chitin, a frequent element of fungal cell walls, and stop the development of fungus on ripening fruits.

When compared to other treatments and the control, it was shown that the banana fruits treated with the MBT/BC-01 therapy could prolong their shelf life to a maximum of 14 days (Fig. 1 and 2; Table 1). Whereas, control fruits turned to black on 8$^{th}$ day (Fig. 2).

**Table 1: Effect of edible coatings on weight loss percentages (WLPS) and decay percentage of banana fruit during storage.**

| Storage period (Days) | Treatments | | |
|---|---|---|---|
| **WLP** | **MBT/BC-01** | **MBT/BC-04a** | **Control** |
| **0** | $0.00\pm0.00^{f}$ | $0.00\pm0.00^{f}$ | $0.00\pm0.00^{f}$ |
| **7** | $76.97\pm0.38^{e}$ | $84.30\pm0.58^{d}$ | $84.27\pm0.55^{d}$ |
| **14** | $164.1\pm0.90^{c}$ | $172.1\pm0.88^{b}$ | $184.3\pm0.88^{a}$ |
| **Decay percentage** | | | |
| **0** | $0.00\pm0.00^{e}$ | $0.00\pm0.00^{e}$ | $0.00\pm0.00^{e}$ |
| **7** | $6.00\pm0.58^{d}$ | $7.00\pm0.58^{d}$ | $21.67\pm0.88^{c}$ |
| 14 | $21.00\pm0.05^{c}$ | $61.33\pm0.88^{b}$ | $96.67\pm0.33^{a}$ |

Note- [1]Values are represented in mean ± SE of three replicates (n=3). According to Duncan's Multiple Range Test (DMRT), values followed by alphabets with the same letter show that there is no significant difference and different alphabets with significant different at P≤0.05; The CV for WLP=1.12 and Decay percentage=3.35.

**Table 2: Effect of edible coatings on firmness of banana fruit during storage.**

| Storage period (Days) | Treatments | | |
|---|---|---|---|
| **Firmness (Pascal)** | **MBT/BC-01** | **MBT/BC-04a** | **Control** |
| **0** | $8.0\pm0.57^{a}$ | $8.0\pm0.057^{a}$ | $8.6\pm0.33^{a}$ |
| **7** | $8.1\pm0.05^{a}$ | $4.13\pm0.08^{b}$ | $1.6\pm0.05^{d}$ |
| **14** | $3.26\pm0.06^{bc}$ | $3.3\pm0.33^{c}$ | $1.2\pm0.14^{d}$ |

Note- [1]Values are represented in mean ± SE of three replicates (n=3). According to Duncan's Multiple Range Test (DMRT), values followed by alphabets with the same letter show that there is no significant difference and different alphabets with significant different at P≤0.05; The CV is 9.89.

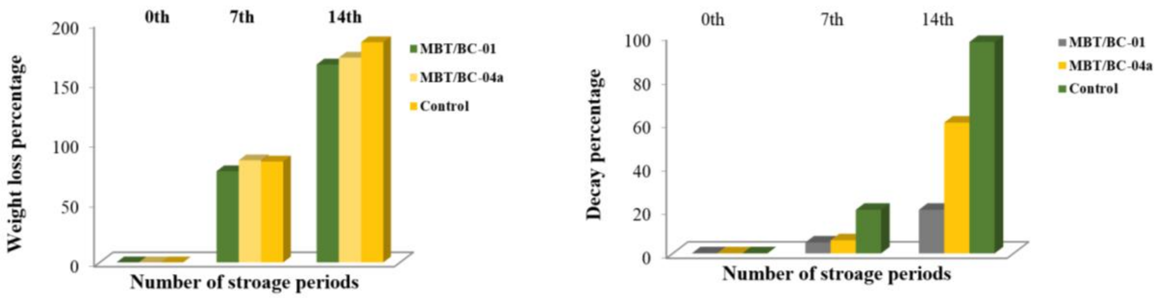


**Fig. 1.** Weight loss and decay percentage of bio-coated banana.


**Fig. 2.** Bio-coating technique of Banana.

The positive effect of cellulose-derived coating could create a modified atmosphere (MA) within the fruit under storage condition and greatly influenced the metabolism process inside the fruit. Artificial MA caused a halt in the production of ethylene, which delayed the ripening of coated fruits by lowering their internal oxygen content. This, in turn, extended the fruits' storage life beyond what was intended.

*B. Firmness*

Over the course of storage at the same temperature, the stiffness progressively diminished (Fig. 3; Table 2). The findings showed that the MBT/BC-01 and MBT/BC-04a coatings considerably preserved the firmness of bananas throughout storage and served as a barrier to prevent nutrient and water loss. The maximum firmness of the coated fruits was maintained by the MBT/BC-01 coating until the fourteenth day of storage at room temperature. Previous studies have attributed this phenomena to the breakdown of the fruit's intermediate lamella structures and main cell wall, which may have an impact on the fruit's texture changes after storage (Yang *et al.*, 2007). According to Lin *et al*. (2003), climacteric fruits (bananas) lose their firmness throughout the ripening process due to a breakdown of the cell wall and a decrease in the turgor pressure inside the cells caused by water loss. The data acquired regarding the firmness of the MBT/BC-01 and MBT/BC-04a treatments amply demonstrates that, at room temperature (25±2°C), the coated fruits have maintained a much superior level of firmness than the control (uncoated) fruits. The process may result from coated fruits' decreased pectin-degrading enzyme activity and suppression of water loss, which are strongly linked to the softness of the fruit and slowed metabolic rates during senescence (Zhou *et al*., 2011).

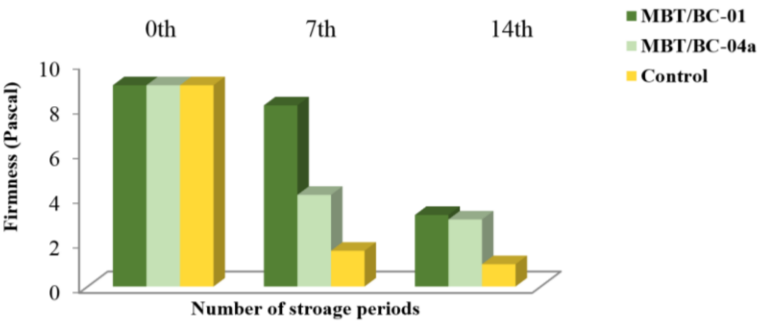


**Fig. 3.** Firmness of bio-coated banana.

*C. Total Soluble Solids (TSS)*

Over the course of the 14-day storage period, coated banana fruits had a slower rise in TSS than the control fruit, which saw a quick increase (Fig. 4; Table 3). Free sugar concentrations gradually rose during storage, however the coating procedure significantly slowed down the rate of rise. This was most likely caused by the semi-permeable cellulose-based film that developed on the fruit's surface, which significantly altered the internal environment and the coated fruits' endogenous $CO_2$ and $O_2$ contents, delaying the ripening process (Bai *et al*., 1988).

*D. pH and Titrable acidity*

When compared to other coated fruits, the uncoated (control) fruit was shown to have higher pH values (Fig. 5; Table 3). When compared to fruits without coating, coated fruits shown a significant improvement in pH maintenance. After $14^{th}$ days of storage, fruit coating with MBT/BC-01 showed a slower rate of increase in pH (1.3 fold less) as compared to control fruits (Fig. 2; Fig. 5; Table 3).

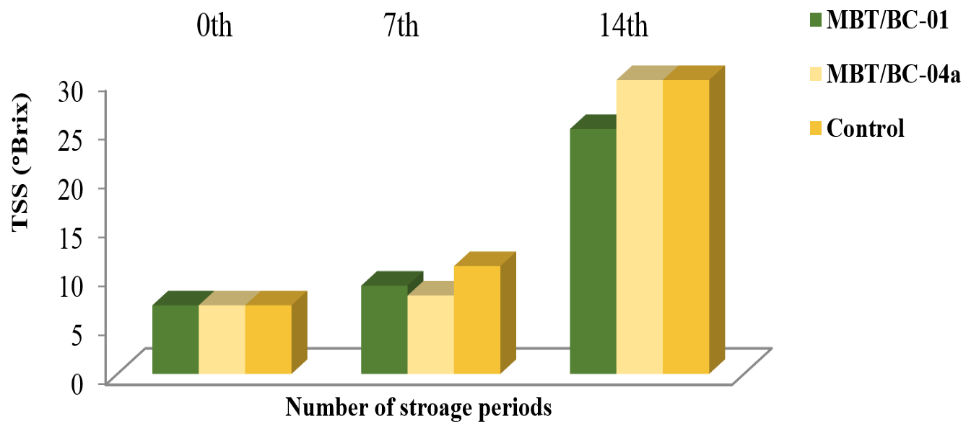


**Fig. 4.** Total soluble solids of bio-coated banana.

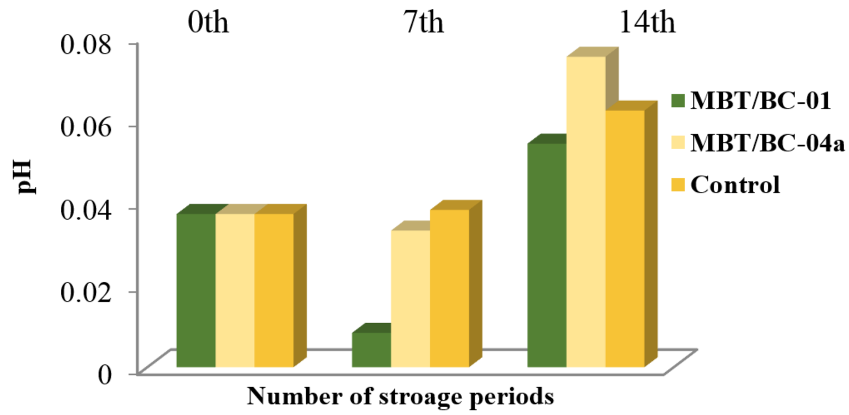


**Fig. 5.** pH and titrable acidity content of bio-coated banana.

**Table 3: Effect of edible coatings on total soluble solids, pH and titrable acidity of banana fruit during storage.**

| Storage period (Days) | Treatments | | |
|---|---|---|---|
| **TSS (Brix)** | **MBT/BC-01** | **MBT/BC-04a** | **Control** |
| **0** | 7.0±0.57$^{d}$ | 6.3±0.33$^{d}$ | 6.6±0.33$^{d}$ |
| **7** | 9.0±0.57$^{cd}$ | 8.3±0.33$^{cd}$ | 11±0.57$^{c}$ |
| **14** | 24.0±0.57$^{b}$ | 26.6±2.84$^{b}$ | 30.3±0.33$^{a}$ |
| **pH** | | | |
| **0** | 5.56±0.08$^{a}$ | 5.6±0.05$^{a}$ | 5.6±0.05$^{a}$ |
| **7** | 5.2±0.03$^{b}$ | 4.3±0.05$^{d}$ | 4.2±0.033$^{d}$ |
| **14** | 4.6±0.12$^{c}$ | 4.6±0.03$^{c}$ | 4.5±0.033$^{c}$ |
| **Titrable acidity (Molar)** | | | |
| **0** | 0.003±0.0036$^{e}$ | 0.003±0.0036$^{e}$ | 0.003±0.0036$^{e}$ |
| **7** | 0.008±0.0001$^{g}$ | 0.032±0.0003$^{f}$ | 0.037±0.0003$^{d}$ |
| **14** | 0.053±0.005$^{c}$ | 0.074±0.0005$^{a}$ | 0.063±0.0005$^{b}$ |

**Note-** [1]Values are represented in mean ± SE of three replicates (n=3). According to Duncan's Multiple Range Test (DMRT), values followed by alphabets with the same letter show that there is no significant difference and different alphabets with significant different at P≤0.05; The CV for TSS= 11.2, pH= 2.34 and Titrable acidity= 1.72.

The slowdown of pH is might be due to the effect of bio-chemical, structural, and physiological alternations undergone during respiration and the accumulation of dry matter content in coated fruits over control (Rico *et al*., 2010). Coating delays the senescence of the fruit, which slows down pH and TA changes. According to Jiang and Li (2000), the increased TA content in coated fruits may have functioned as a protective $O_2$ barrier or as a decrease in $O_2$ supply to the fruit surface, which slowed the rate of respiration. Increased levels of acidity or citric acid during fruit ripening may be caused by the fruit's metabolic activities using carbohydrates.

*E. Impact of Edible Coating on Banana Shelf Life*

Edible coatings have been studied and applied in the agricultural industry as a method to extend the shelf life of post-harvested fruits, including bananas. The impact of edible coatings on extending the shelf life of post-harvested bananas includes the following factors:

Edible coatings create a barrier that helps to reduce the rate of moisture loss from the bananas. This is crucial in preventing dehydration and maintaining the fruit's firmness and quality. Coatings can regulate the exchange of gases, such as oxygen and carbon dioxide, which are critical factors in the ripening process. This regulation helps slow down the ripening of bananas, extending their shelf life.

Some edible coatings may contain antimicrobial agents that help inhibit the growth of microorganisms on the fruit surface, reducing the risk of decay and spoilage and coatings provide a protective layer against external factors like dust, dirt, and contaminants, preserving the visual appeal of the bananas.

## CONCLUSIONS

The results of this study show that, in comparison to the control group and other treatment methods, the application of MBT/BC-01 coatings on banana fruit significantly retards a number of factors, including weight loss, decay percentage, total soluble solids, pH, and titrable acidity. This suggests that MBT/BC-01 protects banana fruits better than other coatings. It is noteworthy because it is essential to sustaining the fruit's overall quality traits, prolonging its shelf life, and safeguarding its important qualities throughout storage. To summarise, the findings indicate that MBT/BC-01 has promising potential as a preventive intervention to improve the quality and post-harvest life of banana fruits.

**Author's contribution.** SKG conceived the initial work idea. NR and SS and PDV performed the laboratory experiments and data analysis. MGS provided the laboratory facilities for the experimental analysis. SKG, NR and SS worked on the data interpretation of the work. NR prepared the first draft copy of the manuscript and the corrections were made and finalized by SKG and approved the final manuscript.

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