

## Physico-Chemical Changes of Banana Cultivars under Modified Atmosphere Packaging at Ambient Condition

Z. W. Sherpa, B. Chakraborty, A. Chakraborty, M. Preema Devi, P. S. Medda, A. K. Sinha, A. Ghosh

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### ABSTRACT

An experiment was conducted to assess the physico-chemical changes of banana cultivars (Malbhog and Grand Naine) under modified atmosphere packaging at ambient condition. Freshly harvested banana hands with 80.0 % maturity of the cultivars Malbhog and Grand Naine were wrapped with cling film (2.0 % perforation) packaging material. In addition, a sachet made of filter paper containing 2.0 g  $\text{KMnO}_4$  was also placed inside the cover. The wrapped banana hands were kept in a CFB (Corrugated Fiber Board) boxes at ambient condition ( $20 \pm 2$  °C and 80-85 % RH).

The entire experiment was replicated thrice and the data were analyzed following Factorial Completely Randomized Design (FCRD). The results indicated that physiological loss in weight and spoilage percentage were increased as the storage day progressed. The spoilage was more in the cultivar Grand Naine (88.88 %) than Malbhog (10.25%) at tenth day of storage. The maximum TSS, titratable acidity, sugar and ascorbic acid were found to be the highest on sixth and eighth day of ambient storage under modified atmospheric packaging in the banana cultivar Malbhog and Grand Naine, respectively, indicating the optimum edible condition of the respective banana fruits. Overall, all the physico-chemical changes in banana fruits were more in the cultivar Grand Naine than Malbhog.

**Keywords** Banana, Modified atmospheric packaging, Physico-chemical,  $\text{KMnO}_4$ .

Z.W. Sherpa<sup>1</sup>, B. Chakraborty<sup>2\*</sup>, A. Chakraborty<sup>3</sup>, M. Preema Devi<sup>4</sup>, P. S. Medda<sup>5</sup>, A. K. Sinha<sup>6</sup>, A. Ghosh<sup>7</sup>

<sup>1</sup>PhD Research Scholar, <sup>2,3,4</sup>Assistant Professor, <sup>5,6,7</sup>Professor

<sup>1,3,4</sup>Department of Pomology and Post-Harvest Technology, Faculty of Horticulture, <sup>5</sup>Department of Plantation Crops and Processing, Faculty of Horticulture, <sup>6</sup>Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, <sup>2,7</sup>Regional Research Station (Terai Zone), Directorate of Research.

Uttar Banga Krishi Viswavidyalaya, Cooch Behar, Pundibari 736165, India

Email: [binayak.hort@gmail.com](mailto:binayak.hort@gmail.com); [binayak@ubkv.ac.in](mailto:binayak@ubkv.ac.in)

\*Corresponding author

### INTRODUCTION

Banana (*Musa × paradisiaca* L.) is one of the cheapest and nutrient-dense fruit known to mankind. This fruit is cultivated throughout the tropics in entire globe (Wairegi *et al.* 2010). India stands first in global banana production (Anon 2023). It is cultivated almost every states of our country and West Bengal is one of the leading state of banana cultivation in India (Bhanusree *et al.* 2015). The popular cultivars

of banana in northern part of West Bengal are Malbhog (Roy *et al.* 2010) and Grand Naine (Bhanusree *et al.* 2015). Proper post-harvest handling of banana is one of the most critical/vital step for maintaining the quality and assuring the product safety. Since, climacteric nature of banana fruit is prone to various kinds of post-harvest losses including rapid physiological changes, bruising injuries and lack of resistance capacity against microbial decay that accounts a loss reported to be ranging from 25.0 to 50.0 % during transportation to marketing (Akter *et al.* 2015). Hence, invention of appropriate storage method is necessary to enhance postharvest shelf-life and retain the nutritional and marketable quality of this important fruit crop of the world. Modified atmosphere packaging (MAP) has been considered as an ideal preservation technique that can able to protect the products from the decay causing microorganisms and secure the safety of the products (Wilson *et al.* 1993, Mostafidi *et al.* 2020). Further, this packaging technology is reported to be influenced the color, taste and flavor of the product (Fang and Wakisaka 2021). Additionally, use of ethylene absorbent in MAP storage helps to maintain the quality and storability of products many fold (Mortazavi *et al.* 2015). In this investigation,  $\text{KMnO}_4$  sachet (2.0 g) was used as an ethylene absorbent within the package. The aim of the experiment was to study physico-chemical changes that occurred in modified atmosphere package over the storage period and also to find out the best banana cultivar responded better to modified atmosphere packaging.

## MATERIALS AND METHODS

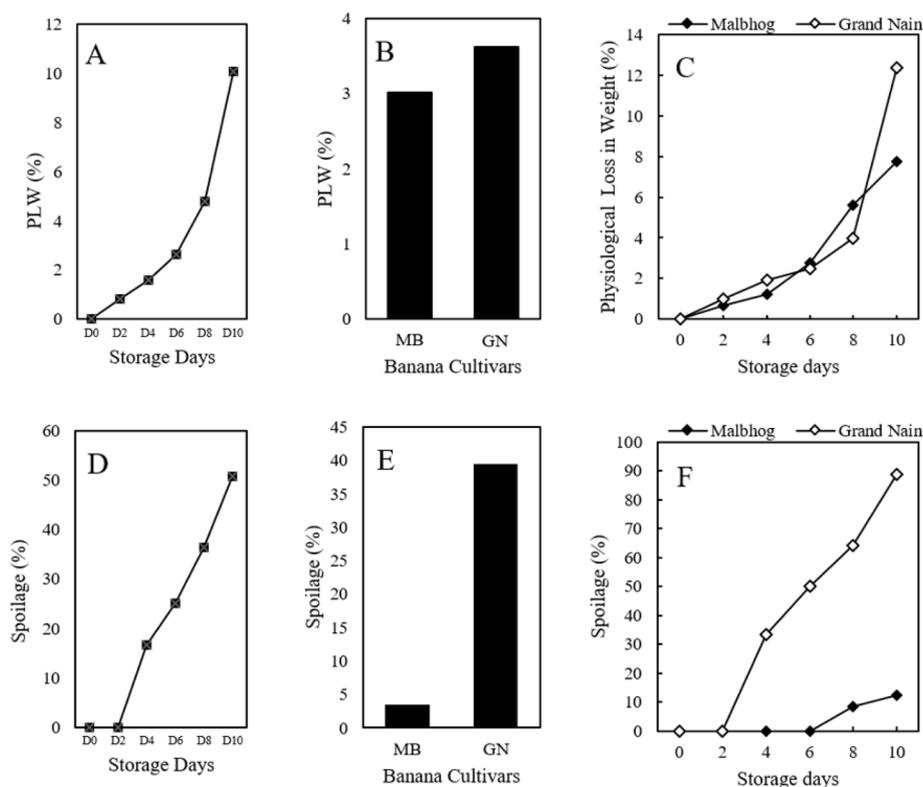
Banana fruit bunches of the cultivar Malbhog and Grand Naine were harvested from the Instructional Farm, Department of Pomology and Postharvest Technology, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal at green mature stage (80.0%). The hands were carefully separated from the fruit bunch containing 12-14 fingers in each hand. Further, each hand was carefully graded according to maturity, size and color and sorted the hands free from any damage caused by diseases and pests and devoid of any types of mechanical injuries. The graded and sorted hands of banana of both the cultivars were dipped in cold

water ( $10\pm 2^\circ\text{C}$ ) mixed with fungicide (Carbendazim 2g/l) for 20 minutes as precooling treatment and then lifted up the hands and placed on a wooden table for 1.0 hr air to be air dried. Then each banana hands were wrapped with cling film ( $12.7\ \mu$  thickness) having 2.0% perforation on area basis. A sachet made of filter paper containing 2.0 g  $\text{KMnO}_4$  was also placed inside the cover. Each such banana hands were kept in a corrugated fiber board (CFB boxes) and the boxes were stored at laboratory condition ( $20\pm 2^\circ\text{C}$  and 80-85 % RH). Fruit samples were drawn periodically after 0, 2, 4, 6 and 10 days of storage for assessment of physico-chemical characteristics. The physico-chemical parameters of banana fruits viz. PLW (physiological loss in weight), TSS ( $^\circ\text{Brix}$ ), titratable acidity (%), total sugar, reducing sugar, non-reducing sugars and ascorbic acid (mg/100 g of fruit pulp) were estimated as per the methods described by AOAC (1980). The entire experiment was replicated thrice and laid out in Factorial Completely Randomized Design (FCRD). The statistical analysis was performed in RStudio<sup>®</sup>, version 4.4.1 (R Core Team 2024).

## RESULTS AND DISCUSSION

### Physiological loss in weight and soilage

It is evident that physiological loss in weight of banana cultivars increased during storage (Fig. 1(A)). The rate of physiological loss in weight was steadily increased upto sixth day of storage and then a significant change in loss of weight was occurred. The banana cultivar Malbhog showed least change in physiological loss in weight as compared to the banana cultivar Grand Naine (Fig. 1(B), PLW (physiological loss in weight) was 7.74 % and 12.37 % in Malbhog and Grand Naine in tenth day of storage, respectively. A significant loss in weight was noted after fifth day of storage in banana cultivar Grand Naine (Fig. 1(C)). However, a steady loss in physiological weight was recorded in the banana cultivar Malbhog (Fig. 1(C)). The physiological loss in weight indicated a rapid loss of water due increased metabolic processes like respiration and transpiration (Kaur and Kaur 2017). The heat generated from the respiration process released from the fruits through evaporation of water causing loss in weight (Dharmasena and Kumari 2005). A rapid loss of physiological weight in



**Fig. 1.** Physiological loss in weight (PLW) and soilage percentage of banana cultivars under modified atmosphere packaging at ambient condition. (D: Days, MB: Malbhog, GN: Grand Naine).

the banana cultivar Grand Naine than the traditional cultivar like Rasthali (Malbhog) was also reported earlier (Kumar *et al.* 2023).

No spoilage of banana fruits in both the cultivars was noted upto second day of storage and after that a rapid rate of spoilage of banana fingers accounted 50.69% spoilage of banana fingers on tenth day of storage (Fig. 1D). Banana cultivar Grand Naine exhibited a significant loss of banana fingers due to spoilage than the cultivar Malbhog (Fig.1E). The spoilage of banana fingers was started from second day onwards in the banana cultivar Grand Naine and recorded upto 88.88% loss at tenth day of storage whereas, the spoilage of banana fingers in the cultivar Malbhog commenced from sixth day of storage and ended only 10.25 % of spoilage at tenth day of storage (Fig. 1F). Timilsina and Shrestha (2022) also recorded no spoilage of banana cultivar Malbhog upto sixth day of storage. Progressive increase in the spoilage

of banana fruits with the progress in storage period is also reported earlier (Tapas *et al.* 2016).

#### Total soluble solid and titratable acidity

Changes in total soluble solid (TSS) content of banana fruits in modified atmospheric storage from day zero to day ten are presented in Table 1. A steady increase in TSS content of banana pulp was recorded from day zero to fourth day of storage. Then a rapid increase in TSS content was observed on sixth and eighth day of storage indicating the edible/ripening stage of banana fingers at this stage (Mathias *et al.* 2021). After tenth day of storage the TSS content decreased rapidly. The change in TSS content in the cultivar Grand Naine was recorded more than Malbhog that indicated Malbhog can effectively be consumed for a longer period than Grand Naine (Kumar *et al.* 2023). However, similar changes in TSS content of banana cultivar Malbhog (Rasthali) and Grand Naine were also reported

**Table 1.** Biochemical changes of banana cultivars under modified atmospheric storage at ambient condition.

Storage days (D)	TSS (°Brix)	Titrateable acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugars (%)	Ascorbic acid (mg/100 g of fruit pulp)
Day Zero (D <sub>0</sub> )	10.20	0.25	12.94	9.12	3.82	3.86
Day Second (D <sub>2</sub> )	11.30	0.27	13.62	9.46	4.15	4.45
Day Fourth (D <sub>4</sub> )	14.48	0.30	14.77	10.14	4.63	6.23
Day Sixth (D <sub>6</sub> )	17.85	0.34	16.90	11.81	5.09	8.01
Day Eighth (D <sub>8</sub> )	21.72	0.37	18.92	13.24	5.68	7.43
Day Tenth (D <sub>10</sub> )	17.17	0.28	13.07	9.72	3.36	5.93
SEm ±	0.20	0.02	0.29	0.19	0.32	0.38
CD <sub>0.05</sub>	0.59	0.05	0.84	0.55	0.93	1.12
Banana cultivars (C)						
Malbhog (C <sub>1</sub> )	14.25	0.31	13.53	10.17	3.37	5.93
Grand Naine (C <sub>2</sub> )	16.66	0.29	16.54	11.00	5.54	6.03
SEm ±	0.12	0.01	0.17	0.11	0.18	0.22
CD <sub>0.05</sub>	0.34	NS	0.48	0.32	0.54	NS
Interaction (C × D)						
C <sub>1</sub> × D <sub>0</sub>	6.97	0.23	11.14	8.12	3.02	3.56
C <sub>1</sub> × D <sub>2</sub>	8.23	0.26	11.37	8.67	2.70	4.15
C <sub>1</sub> × D <sub>4</sub>	10.47	0.28	11.85	9.15	2.71	5.93
C <sub>1</sub> × D <sub>6</sub>	11.80	0.32	14.01	9.83	4.17	6.53
C <sub>1</sub> × D <sub>8</sub>	25.87	0.41	19.16	15.03	4.13	8.31
C <sub>1</sub> × D <sub>10</sub>	22.17	0.34	13.68	10.20	3.48	7.12
C <sub>2</sub> × D <sub>0</sub>	13.43	0.26	14.74	10.13	4.62	4.15
C <sub>2</sub> × D <sub>2</sub>	14.37	0.28	15.87	10.26	5.61	4.75
C <sub>2</sub> × D <sub>4</sub>	18.50	0.32	17.69	11.13	6.56	6.53
C <sub>2</sub> × D <sub>6</sub>	23.90	0.36	19.80	13.79	6.01	9.49
C <sub>2</sub> × D <sub>8</sub>	17.57	0.33	18.68	11.44	7.24	6.53
C <sub>2</sub> × D <sub>10</sub>	12.17	0.21	12.46	9.23	3.23	4.75
SEm ±	0.29	0.02	0.41	0.27	0.45	0.54
CD <sub>0.05</sub>	0.84	0.07	1.18	0.78	1.32	1.58

earlier (Muthuvel *et al.* 2019). The banana cultivar Grand Naine exhibited the maximum TSS content in the pulp at sixth day of storage whereas, the cultivar Malbhog attained maximum TSS content at eighth day of storage. Degradation of starch in banana pulp is reported to be responsible for increasing the TSS content (Adi *et al.* 2019). Accumulation of sugar due to rapid metabolism of starch occurred during storage and ripening of banana fruits (Mubarok *et al.* 2022).

Titrateable acidity of banana pulp was increased as storage period increased upto eighth day of storage, after that a decreasing trend of titrateable acidity of banana pulp was recorded (Table 1). On day zero the acidity of banana fruit was 0.25%, and at eighth day of storage, the acidity of fruit pulp reached maximum (37.0 %). Similar finding was also reported in banana (Agrawal *et al.* 2015). The least change in acidity content was recorded in the banana cultivar

Malbhog than Grand Naine. The acidity content of banana fruit pulp increased upto eighth and sixth days of storage in the cultivar Malbhog and Grand Naine, respectively. Mukherjee *et al.* (2023) also recorded increased acidity content of banana cultivar Malbhog upto eighth day of storage. The acidity showed a constant increase during the storage period. However, later the decrease in acidity might be the result of increased rate of respiration (Madhuwanthi and Marapana 2017).

### Sugar and ascorbic acid

The reducing, non-reducing and total sugar content in banana fruit pulp were increased as storage period progressed from day zero to day eighth and after than a sharp decrease in above parameters were decreased on day tenth (Table 1). The change in sugar content in the pulp of banana was recorded more in the cultivar

Grand Naine than Malbhog. Ripening related changes were reported to be more in Grand Naine than Rasthali might be responsible for increase in more sugar content in Grand Naine (Kumar *et al.* 2023). The total and reducing sugar content were noted maximum on sixth day of storage in banana cultivar Grand Naine whereas, these parameters were registered maximum in the banana cultivar Malbhog on eighth day of storage. Mukherjee *et al.* (2023) also recorded maximum total sugar content of banana cultivar Malbhog on eighth day of storage. However, the non-reducing sugar content of banana pulp in both the cultivars of banana was noted maximum on eighth day of storage. The breakdown of starch into simple sugars during the initial storage period might be responsible for the rise in total sugar content in banana fruits. Further utilization of sugars in the process of respiration might resulted in decrease of sugar content after day eighth. Similar results were also reported in guava (Bhooriya *et al.* 2020) and papaya (Rajkumar *et al.* 2006).

The ascorbic acid content of the banana fruits was increased upto sixth day of storage and thereafter, a sharp fall in ascorbic acid content was recorded (Table 1). The ascorbic acid content was more in the banana cultivar Grand Naine than Malbhog. Both the banana cultivars showed a pick in ascorbic acid content on sixth day of storage. Increase in ascorbic acid content in banana fruit pulp upto sixth days of storage indicted optimum maturity of banana fruits in storage (Fernando *et al.* 2014). Thereafter, decrease in ascorbic acid content might be attributed to reduction of precursor of L-ascorbic acid i.e., glucose-6-phosphate in rapid metabolic processes (Chakraborty *et al.* 2017). Similar results were also reported in banana (Fernando *et al.* 2014).

## CONCLUSION

Banana is a climacteric fruit. The ripening related changes occurred rapidly in this fruit. Hence, a cost-effective, market friendly storage technique had been tried to slowdown the rapid process of ripening related changes that usually associated with this fruit. The technique indicated that the banana cultivar Malbhog and Grand Naine could effectively be stored upto eighth and sixth day of storage at ambient condition, respectively.

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