



**SHELF LIFE AND NUTRITIVE CONTENT OF PLANTAIN (*MUSA SPP.*) AS
AFFECTED BY CONCENTRATIONS OF GIBBERILLIC ACID TREATMENT**

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ABSTRACT

This study investigated the influence of different concentrations of gibberellic acid (GA_3) on the shelf life and nutritional quality of plantain (*Musa spp.*) during postharvest storage. Physiologically mature green plantain fruits were treated with 0.01%, 0.02%, and 0.03% GA_3 , while untreated fruits served as the control. The fruits were stored under controlled conditions, and observations were made on storage temperature, relative humidity, weight loss, peel colour, fruit firmness, pH, proximate composition, and selected chemical constituents. The data obtained were analysed using analysis of variance (ANOVA), and treatment means were separated with the Least Significant Difference (LSD) test at the 5% level of significance. The application of gibberellic acid effectively delayed the ripening process by reducing weight loss, slowing peel colour development, and maintaining fruit firmness throughout the storage period when compared with the untreated control. Treated fruits also exhibited higher dry matter content and lower moisture content, suggesting improved preservation of nutritional quality during storage. Furthermore, the chemical composition of GA_3 -treated fruits indicated better retention of essential nutrients than the control. Among the concentrations evaluated, 0.02% GA_3 consistently produced the most favourable results, providing an optimal balance between extended shelf life and the preservation of important nutritional attributes, particularly crude protein, ash content, and overall fruit quality. The findings demonstrate that postharvest application of 0.02% gibberellic acid is an effective and practical approach for extending the shelf life of plantain while maintaining its nutritional and market quality. Adoption of this treatment could contribute to reducing postharvest losses, improving food availability, and enhancing the economic value of plantain during storage and marketing.

Keywords: Plantain, Gibberellic-acid, Shelf, Post-harvest, Storage; Quality.

INTRODUCTION

Plantain (*Musa spp.*) is one of the most important staple food crops in tropical and subtropical regions, serving as a major source of carbohydrates, minerals, vitamins, and dietary energy for millions of people. Despite its nutritional and economic significance, plantain is highly perishable after harvest because it is a climacteric fruit. The ripening process is characterized by a rapid increase in ethylene production and respiration, which accelerates physiological changes such as peel colour development, fruit softening, starch degradation, and increased susceptibility to microbial infection. These changes substantially reduce shelf life and contribute to considerable postharvest losses during storage, transportation, and marketing (Akaagerger & Ejembi, 2025; Kandasamy *et al.*, 2025; Moreno *et al.*, 2020).

Postharvest losses remain a major challenge within the plantain value chain, particularly in developing countries where storage facilities and cold-chain infrastructure are often limited. Depending on handling practices and storage conditions, losses may range from 25% to 50%, thereby reducing market value, limiting food availability, and lowering farmers' incomes (García-Castaño *et al.*, 2025; Behera *et al.*, 2025; Samuel *et al.*, 2023). Environmental conditions such as temperature and relative humidity, together with varietal characteristics, strongly influence the rate of ripening and deterioration. Consequently, identifying practical postharvest technologies that delay ripening while preserving fruit quality has become an important area of research.

Among the available postharvest technologies, the application of plant growth regulators has received considerable attention. Gibberellic acid (GA_3) is particularly promising because it delays senescence by suppressing ethylene production, reducing respiration, maintaining membrane integrity,



and slowing the enzymatic processes responsible for fruit softening and chlorophyll degradation. Previous studies have shown that GA₃ treatments effectively delay peel yellowing, maintain firmness, and extend the storage life of bananas and plantains under different storage conditions (Al-Qurashi & Awad, 2019; Aquino *et al.*, 2020; Ghimire *et al.*, 2021; Behera *et al.*, 2025; Zhang *et al.*, 2023). Although numerous studies have demonstrated the effectiveness of GA₃ in extending shelf life, comparatively fewer investigations have examined its influence on the nutritional quality of plantain during storage. Delayed ripening does not always correspond with improved nutrient retention, as storage conditions may alter proximate composition, mineral content, functional properties, and other quality attributes (Oladeji *et al.*, 2025). Therefore, an effective postharvest treatment should not only prolong storage life but also preserve the nutritional and physicochemical characteristics that determine consumer acceptance and market value. This study was undertaken to evaluate the effects of different concentrations of gibberellic acid on the shelf life and nutritive quality of plantain during storage. Specifically, the study examined the influence of GA₃ on ripening rate, fruit firmness, peel colour development, weight loss, and selected physicochemical characteristics. It also assessed changes in proximate composition and other nutritional attributes to determine the concentration that provides the most effective balance between shelf-life extension and preservation of fruit quality.

MATERIALS AND METHODS

The experiment was conducted at the Crop laboratory of Department of Agriculture and Industrial Technology, School of Science and Technology, Babcock University, Ilishan Remo, Ogun state. Physiologically matured green, firm plantain fingers gotten from a known source was used. Other materials used for the research were; thermometers, wooden boxes, gibberellic acid, knife and color chart.

Preparation of the Storage Media

Wooden boxes of equal size and space were constructed locally, ventilation was provided by creating holes along sides and tops of the wooden boxes, then, the wooden boxes were labeled as appropriate.

Preparation of Plantain Fingers for Storage

Physiologically matured, green, and firm plantain of known history were obtained and treated by placing it in a cool room for up to 60 minutes so as to remove the field heat, the plantain bunches were de-bunched using a sharp knife and divided into portions without bias.

The plantain fingers were weighed and then sprayed with Gibberellic acid treatment as applicable for each storage media and was left to dry for 15 minutes

Application of Gibberellic Acid

Plantain fingers were weighed before the storage, during (every other day) and after storage Gibberellic acid was used to store the plantain at 0.01%C, 0.02%C, 0.03%C and the control (without the concentration) respectively. The Gibberellic acid was mixed with 100ml of water each to dissolve the Gibberellic acid before storage began.

Data Collection

- i. A thermometer was placed in the micro-environment (boxes) for daily temperature reading.
- ii. Color: The color of the green plantains was recorded and observed before storage and subsequent assessment was done every other day using color chart.

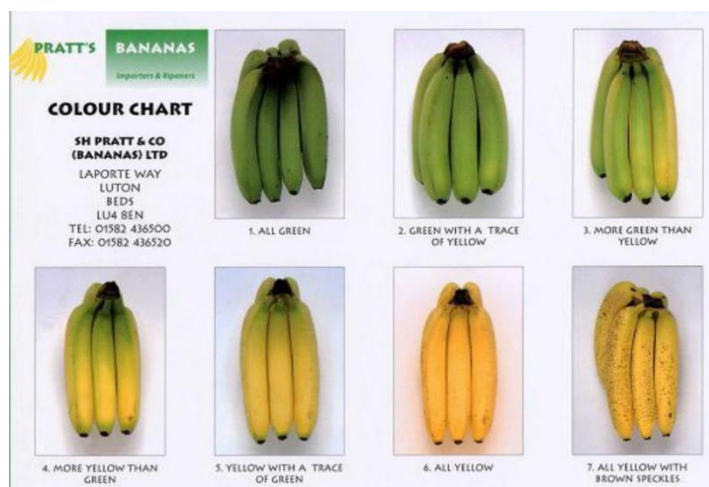


Figure 1: Colour Chart

- iii. Firmness: Degree of firmness was recorded by the use of penetrometer,
- iv. Determination of temperature: The initial temperatures of the storage condition was taken at the commencement of the experiment and subsequently taken every day using thermometer
- v. Proximate analysis: Plantains were subjected to pre-storage and post storage proximate analysis for each treatment. Analysis was conducted on each of the storage media;
 - a. Total Carbohydrate Determination: This was determined using AOAC {2012}. It was determined by difference between 100 and total sum of the percentage of fat, protein, moisture, ash and crude fiber. The total carbohydrate (%) $100\% - (\%fat + \%protein + \%moisture + \%ash + \%crude\ fibre)$.
 - b. Crude Protein Determination: About 0.2g of sample was weighed into a micro-kjeldahl flask. 5g of anhydrous sodium sulphate will be added or 4 tablets of kjeldahl catalyst sodium sulphate (each tablet will contain 1g of Na_2SO_4) followed with the addition 1g of copper sulphate and a speck of selenium or 1 tablet of kjeldahl catalyst selenium (each tablet contained 1g of $Na_2SO_4 + 0.05g$ Selenium). Was added into the mixture.
 - c. Crude Fiber Determination: The crude fiber was determined by adding about 1g of sample into 500ml conical flask, 100ml digestion reagent was added and washed down the sides of the flask, it was be boiled and refluxed for 40 minutes. A water jacketed condenser was used to prevent loss of liquid. The flask was removed from the heater and cooled under cold tap. It was filtered through a 15cm of no.4 what man paper. It was washed six times with hot water, once with mentholated spirit. The paper was opened out the residue was removed with a spatula and the fiber was transferred into a silica dish. It was dried at $105^\circ C$ overnight and transferred into a desiccator and weighed when cool. It was weighed at $600^\circ C$, over a night in muffle furnace, cooled in a desiccator and will be weighed

Calculation;

$$\% \text{ fiber} = \frac{\text{loss in weight on ashing}}{\text{weight of sample}} \times 100$$

- d. Moisture content: The moisture content was determined by washing the porcelain dishes in the moisture and was put inside the dish and dried in moisture oven at $70^\circ C$ - $80^\circ C$ for 20 hours and at $105^\circ C$. for the next 4 hours till weight is constant. The sample was cooled in the desiccators and the dried weight of the sample was taken plus dish. The percentage moisture content of the sample will be calculated as follows;

$$\% \text{ moisture} = \frac{\text{weight of moisture}}{\text{weight of sample}} \times 100$$



- e. Ash content: The ash content was determined by using a known weight of a sample, finely grinding it and drying it inside a porcelain crucible char bar sample on an electric heater or Bunsen flame inside a fume cupboard to drive off the smoke. The sample will be transferred into pre-head muffle furnace at 600°C and will be heated at this temperature for 2 hours. The white ash obtained will be weighed

$$\% \text{ash} = \frac{\text{ashweight(gm)}}{\text{sampleweight}} \times 100$$

Statistical Analysis

The data obtained from proximate analysis were subjected to analysis of variance (ANOVA) and means were separated using least significant means difference LSD at 5% probability level.

RESULTS AND DISCUSSION

Storage Temperature and Relative Humidity

The storage environment remained relatively stable throughout the experiment irrespective of the gibberellic acid concentration applied. Average temperature ranged from 28.48 to 28.80°C, while relative humidity varied only slightly between 33.02 and 33.12%. The narrow variation in environmental conditions indicated that all treatment groups were subjected to essentially identical storage conditions, thereby reducing environmental bias and allowing observed differences in fruit quality to be attributed primarily to the effects of gibberellic acid treatment rather than fluctuations in storage conditions. Temperature and relative humidity regulate respiration, transpiration and ripening in climacteric fruits. Stable conditions improve the reliability of postharvest studies (Kumar *et al.*, 2022; Yahia & Carillo-López, 2023).

Table 1: Temperature (°C) and Relative Humidity of the Storage Environment

Treatments	Average temperature	Average humidity
At 0.01% GA	28.797±0.14	33.015±0.09
At 0.02% GA	28.479±0.02	33.015±0.02
At 0.03%GA	28.578±0.03	33.118±0.03
Control	28.634±0.03	33.088±0.12
LSD (0.05)	0.073	0.336

Each value represents mean value of four replicates having different values within the same row are significantly different. (P<0.05)

Effect of Gibberellic Acid on Weight Loss

Fruit weight progressively declined throughout the sixteen-day storage period across all treatments, reflecting continuous moisture loss and respiratory metabolism during storage. Although all fruits experienced weight loss, the magnitude differed among treatments, suggesting that gibberellic acid influenced moisture retention during storage. Weight loss results primarily from transpiration and respiration. Gibberellic acid is known to reduce respiration and transpiration by delaying physiological ageing and maintaining membrane integrity (Nunes, 2021; Zhang *et al.*, 2023).

Table 2: Effects of GA₃ on Weight (kg) Loss of Plantain Fingers during Storage

Day	C1	C2	C3	C4	LSD(0.05)
0	194.083±5.72	225.786±6.37	189.535±4.6	199.594±6.56	0.312
2	192.494±6.61	201.509±4.84	190.408±4.05	199.613±7.08	0.484
4	191.746±3.69	193.675±4.76	181.209±4.63	188.659±5.93	0.325
6	177.859±2.31	182.519±4.86	170.512±4.10	177.383±5.94	0.349
8	170.377±4.62	174.345±4.61	165.733±2.66	166.029±6.90	0.579
10	165.417±3.682	168.955±4.15	154.888±3.63	161.91±6.23	0.212
12	157.372±3.99	159.777±4.11	147.443±3.17	153.486±4.63	0.201
14	120.059±5.26	118.381±2.32	116.331±4.80	117.824±2.54	0.926
16	114.702±4.24	113.819±3.26	111.123±4.79	113.931±3.09	0.921

Significant mean was separated at (P<0.05)

Table 3: Trends of the Weight Change (kg)

	C1	C2	C3	C4	LSD(0.05)
Initial weight	194.083±5.72	225.756±6.37	189.535±4.6	199.594±6.56	0.312
Final weight	114.702±4.24	113.819±3.27	111.123±4.79	113.931±3.09	0.921
weight change	79.381±3.32	121.937±6.27	78.412±0.83	85.663±3.91	0.297

Significant means were separated at (P<0.05)

Effect of Gibberellic Acid on Colour Development

Colour development followed the normal ripening pattern expected in climacteric fruits. Significant differences among treatments became evident from Day 6 onward, indicating that gibberellic acid delayed chlorophyll degradation and colour transition. This agrees with reports that GA suppresses ethylene biosynthesis and delays chlorophyll degradation (Aghdam *et al.*, 2022; Chen *et al.*, 2024).

Table 4: Effects of GA₃ on Color Change of Plantain Fingers during Storage

	C1	C2	C3	C4	LSD (0.05)
0	1±0	1±0	1±0	1±0	
2	2±0	2.05±0.05	2±0	2±0	0.426
4	2.95±0.17	2.8±0.29	3.4±0.18	3.15±0.09	0.219
6	5.5±0.41*	4.3±0.58*	4.8±0.29*	5±0.34*	0.101
8	6.25±0.05	6.1±0.25	6.05±0.22	6.25±0.28	0.884
10	6.4±0.2	6.4±0.14	6.1±0.238	6.4±0.34	0.769
12	6.45±0.17	6.5±0.173	6.45±0.126	6.5±0.3	0.996
14	6.5±0.173	6.5±0.15	6.65±0.206	6.8±0.2	0.677
16	6.5±0.173	6.85±0.15	7±0	7±0	0.029

Effect of Gibberellic Acid on Proximate Composition

Storage influenced carbohydrate, dry matter, crude protein, ash, lipid, moisture and crude fibre contents. GA-treated samples generally retained higher dry matter and lower moisture than the control, indicating better preservation of nutritional quality. These findings agree with Yahia and Carillo-López (2023) and Singh *et al.* (2024).

Table 5: Effects of Gibberellic Acid on Proximate Content of Plantain Fingers before and after Storage

Treatments	Carbohydrates (%)	Dry Matter (%)	Crude protein (%)	Ash content (%)	Crude lipid (%)	Moisture content (%)	Crude fibre (%)
Initial	66.4±0.2	79.4±0.22	15.30±0.4	8.40±0.3	4.40±0.1	20.60±0.2	8.40±0.3
0.01%C	71.588±6.06	77.25±2.55	11.45±0.8	6.875±3.33*	4.65±1.85	22.75±2.55	6.5±1.1
0.02% C	59.581±7.76	71.475±5.98	17.32±0.87	15.45±0.1*	6.975±1.725	28.525±5.975	7.4±3
0.03% C	69.213±2.44	76.3±1.1	14.95±2.65	6.07±6.07*	4.55±0.05	23.7±1.1	5.6±0.1
Control	65.794±6.92	69.12±4.4	11.475±1.025	11.41±1.09*	6.925±1.575	30.9±4.4	7.15±2.35
LSD (0.05)	0.244	0.255	0.130	0.100	0.543	0.492	0.915

Significant means were separated at (P<0.05)

Effect of Gibberellic Acid on Chemical Composition

The chemical composition analysis showed relatively small changes in vitamin B12, vitamin B6, MgO, P2O5 and ether extract following storage. GA-treated fruits generally maintained nutritional constituents better than untreated fruits, suggesting delayed oxidative deterioration (Aghdam *et al.*, 2022; Li *et al.*, 2024).

Table 6: Effects of Gibberellic Acid on Chemical Composition of Plantain Fingers before and after Storage

Treatments	Vitamin B12(mg) (%)	Vitamin B6(mg/100) (%)	MgO (%)	P2O5(%)	Ether extract
Initial	860.20±0.05	250.25±0.02	4.20±0.6	9.48±0.3	3.20±0.2
At 0.01%GA	831.45±8.85	253.93±1.39	4.41±0.03	5.754±0.55	5.9±2.4
At 0.02%GA	848.9±4.6	252.31±1.91	4.375±0.18	8.45±0.18	6.35±0.5
At 0.03%GA	829.45±3.95	259.195±0.85	4.365±0.09	8.86±0.56	5.4±2.2
Control	848.65±6.55	254.01±1.41	4.8850.3 ²	8.03±1.56	5±0.5
LSD(0.05)	0.099	0.064	0.124	0.096	

Significant mean was separated at (P<0.05)

CONCLUSION AND RECOMMENDATIONS

This study evaluated the effects of different concentrations of gibberellic acid (GA₃) on the shelf life and nutritive content of plantain (*Musa spp.*) during storage. The findings demonstrated that gibberellic acid significantly influenced several postharvest quality attributes by delaying the ripening process and preserving the physicochemical characteristics of the fruits. The relatively stable storage temperature and humidity ensured that the observed differences among treatments were attributable to the gibberellic acid treatments rather than environmental variations.

Although weight loss occurred in all treatments throughout the storage period, GA₃-treated fruits generally exhibited better moisture retention, delayed colour development, and greater firmness than the untreated control, indicating a slower rate of physiological deterioration. Similarly, the treated fruits maintained desirable nutritional qualities by preserving higher dry matter content and reducing excessive moisture accumulation during storage. The chemical composition analysis further showed that gibberellic acid treatments generally minimized deterioration in important nutritional constituents, confirming the effectiveness of GA₃ as a postharvest growth regulator.

Among the concentrations evaluated, **0.02% gibberellic acid** produced the most balanced overall performance by effectively delaying ripening while maintaining favourable nutritional composition, particularly crude protein, ash content, and other quality parameters. Although some quality attributes were also well preserved at 0.01% and 0.03%, the 0.02% concentration offered the most suitable compromise between shelf-life extension and nutrient retention. Overall, the study confirms that postharvest application of gibberellic acid is an effective strategy for reducing postharvest losses and maintaining the market and nutritional quality of plantain fruits. Based on the findings of this study, the following recommendations are proposed:



1. Postharvest application of 0.02% gibberellic acid is recommended for commercial storage of plantain because it provided the best balance between extending shelf life and preserving nutritional quality.
2. Farmers, produce handlers, marketers, and storage operators should adopt gibberellic acid treatment as part of integrated postharvest management practices to reduce spoilage, minimize economic losses, and improve the quality of plantain supplied to consumers.
3. Agricultural extension agencies should create awareness and provide training on the safe preparation and application of gibberellic acid for postharvest handling of plantain and other climacteric fruits.
4. Future studies should investigate the combined effects of gibberellic acid with other postharvest technologies such as modified atmosphere packaging, edible coatings, refrigeration, evaporative cooling systems, or natural plant extracts to further enhance shelf-life extension.
5. Additional research should evaluate the economic feasibility, consumer acceptability, sensory quality, and commercial scalability of gibberellic acid application under different storage conditions and across different plantain cultivars.
6. Further studies should also examine the long-term effects of gibberellic acid on bioactive compounds, antioxidant activity, vitamin retention, and food safety to provide a more comprehensive understanding of its impact on nutritional quality.

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