INTERNATIONAL JOURNAL OF ENGINEERING MANAGEMENT AND SOCIAL SCIENCES (IJEMSS)

www.ijemss.com

Vol. 01, Issue 3, July2026, pp :624-630

e-ISSN : 3139-065X

editor@ijemss.com

UTILIZATION OF BANANA PSEUDOSTEM WATER AS NATURAL BIO PRESERVATIVE FOR SHELF-LIFE EXTENSION OF FRESH-CUT FRUITS

First author - Dr K SUMANA MOUNYA

Supporting authors - NAMINDLA. SMILYTEJA,

KUNSOTH.GEETHA,

PULLURI.SREEJA,

SHAIK.SANA JABEEN,

GANDIGA SWARANI

Co- author - Mrs. M. Jaya Surya kumari

ABSTRACT

This study investigates the potential of banana pseudostem water as a natural preservative for fresh-cut fruits. Banana pseudostem, an underutilized agro-industrial by-product, is rich in phenolics, flavonoids, and other bioactive compounds exhibiting antioxidant and antimicrobial properties. Fresh-cut fruits are highly susceptible to enzymatic browning and microbial spoilage, leading to reduced shelf life and quality deterioration. Banana pseudostem water was extracted through mechanical crushing and filtration, followed by mild heat treatment. Fresh fruit slices (apple, banana, guava) were treated with varying concentrations (25%, 50%, 75%, 100%) and compared with a distilled-water control and an ascorbic acid-treated reference sample. The results demonstrated a significant reduction in enzymatic browning, microbial load, and weight loss, along with improved sensory attributes in treated samples, with the 100% pseudostem water treatment showing maximum preservation efficiency. The study highlights banana pseudostem water as a sustainable, cost-effective, and eco-friendly alternative to synthetic preservatives, contributing to agro-waste valorization and clean-label food preservation.

Keywords: banana pseudostem water; fresh-cut fruits; enzymatic browning; antimicrobial activity; natural preservative; agro-waste valorization

1. INTRODUCTION

Fresh-cut fruits have gained significant popularity as convenient, nutritious, and ready-to-eat food products, offering high levels of vitamin C, dietary fibre, and bioactive compounds such as phenolics and flavonoids (Rico et al., 2007; Oms-Oliu et al., 2010). However, fresh-cut processing

operations such as peeling, slicing, and trimming disrupt cellular structures, leading to accelerated physiological and biochemical deterioration. A major challenge is enzymatic browning, primarily catalyzed by polyphenol oxidase (PPO), which oxidizes phenolic compounds into quinones that polymerize into brown

INTERNATIONAL JOURNAL OF ENGINEERING MANAGEMENT AND SOCIAL SCIENCES (IJEMSS)

e-ISSN : 3139-065X

www.ijemss.com

editor@ijemss.com

Vol. 01, Issue 3, July2026, pp :624-630

pigments (Toivonen & Brummell, 2008). Increased respiration, ethylene production, moisture loss, and microbial contamination further limit the shelf life of fresh-cut fruits to approximately 2–7 days under refrigerated storage, contributing to significant economic losses and food waste globally (FAO, 2019; Parvez et al., 2023).

Synthetic preservatives such as sulphites, benzoates, and ascorbic acid have been widely used to control browning and microbial growth, but growing concerns regarding health risks, allergenicity, and environmental impact have encouraged the search for clean-label, plant-based alternatives (Singh et al., 2024). Banana (Musa spp.) cultivation generates substantial pseudostem biomass—about 3–4 tonnes of waste per tonne of fruit harvested (Kumar et al., 2023)—that remains largely underutilized despite being rich in phenolics, flavonoids, tannins, saponins, and dietary fibre with demonstrated antioxidant and antimicrobial activity against pathogens such as Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa (Sulaiman et al., 2011; Imam & Akter, 2011; Parvez et al., 2023).

Banana pseudostem water, obtained through simple mechanical extraction of the inner core, is a food-grade, solvent-free extract that retains water-soluble antioxidants, organic acids, and enzymatic inhibitors capable of reducing PPO activity and microbial load (Kumar et al., 2023; Singh et al., 2024). Its use aligns with circular-economy principles by converting agricultural waste into a value-added functional ingredient. However, limited research has directly evaluated pseudostem water—as opposed to solvent extracts—as a dipping preservative for fresh-cut fruits under refrigerated storage. The present study therefore evaluates the efficacy of banana pseudostem water as a natural dipping treatment for apple, banana, and guava, assessing its impact on enzymatic browning, microbial stability, physicochemical properties, and sensory quality during storage at 4°C.

1.1 Novelty of the Study

This work is distinguished by: (i) the use of banana pseudostem water in its native aqueous form rather than as a solvent extract or powder; (ii) benchmarking against a standard synthetic preservative (ascorbic acid); (iii) multi-fruit application across apple, banana, and guava to test broad applicability; (iv) framing the work within agro-waste valorization; and (v) identifying future potential for bioactive packaging and edible coatings.

2. MATERIALS AND METHODS

2.1 Raw Materials

Fresh banana pseudostem was collected immediately after harvest to maximize retention of bioactive compounds. Outer fibrous sheaths were manually removed and the tender inner core, which contains a higher concentration of water-soluble phytochemicals, was separated. Fresh apple (Malus domestica), banana (Musa spp.), and guava (Psidium guajava) were procured from local markets and selected for uniform size, maturity, and absence of physical damage. All materials were handled under hygienic conditions.

INTERNATIONAL JOURNAL OF ENGINEERING MANAGEMENT AND SOCIAL SCIENCES (IJEMSS)

e-ISSN : 3139-065X

www.ijemss.com

editor@ijemss.com

Vol. 01, Issue 3, July2026, pp :624-630

2.2 Extraction of Banana Pseudostem Water

The pseudostem core was washed under running potable water to remove soil and debris, then cut into uniform 2–3 cm pieces. Mechanical crushing was performed using a laboratory grinder without added water to obtain a concentrated extract. The pulp was filtered through sterile muslin cloth to remove coarse fibres, followed by secondary filtration through Whatman No. 1 filter paper to obtain a clear extract. The filtrate was subjected to mild heat treatment at 68 ± 2°C for 10–12 minutes to reduce microbial load while preserving thermolabile bioactives, cooled to room temperature, and stored at 4°C in sterile containers until use.

2.3 Characterization of Pseudostem Water

Total phenolic content (TPC) was determined by the Folin–Ciocalteu method, with absorbance read at 765 nm and results expressed as mg gallic acid equivalents per litre (GAE/L) (Singleton et al., 1999).

Antioxidant activity was evaluated by the DPPH radical-scavenging assay, with reduction of the purple DPPH radical to a yellow product measured at 517 nm and expressed as percentage inhibition (Brand-Williams et al., 1995).

2.4 Treatment of Fresh-Cut Fruits

Fruits were washed, peeled where necessary, and cut into uniform slices under hygienic conditions. Slices were dipped for 2–5 minutes in banana pseudostem water at concentrations of 25%, 50%, 75%, and 100%, alongside a distilled-water control (T0) and a 1% ascorbic acid reference (positive control), as summarized in Table 1.

Table 1. Treatment groups

Treatment	Description
T0	Control (distilled water)
T1	25% pseudostem water
T2	50% pseudostem water
T3	75% pseudostem water
T4	100% pseudostem water

2.5 Storage Conditions

After treatment, samples were drained, air-dried, and packed in sterile food-grade containers, then stored at 4 ± 1°C for 0, 3, 5, 7, and 10 days to simulate commercial cold-chain storage, with sampling at each interval.

2.6 Physicochemical and Microbial Analyses

Enzymatic browning was scored visually on a 0 (no browning) to 5 (severe browning) scale (Queiroz et al., 2008). Colour was assessed using CIE L*a*b* values, where an increase in a* denotes progressive browning. Weight loss was calculated from initial and final sample weights [(W0 − Wt)/W0 × 100]. Microbial quality was assessed by standard plate count on nutrient agar (incubated at 37°C for 24–48 h), expressed as log CFU/g (APHA, 2015). Sensory evaluation used a 9-point hedonic scale for colour, texture, flavour, and overall acceptability, scored by a semi-trained panel (Lawless & Heymann, 2010). pH and titratable acidity (as citric

INTERNATIONAL JOURNAL OF ENGINEERING MANAGEMENT AND SOCIAL SCIENCES (IJEMSS)

e-ISSN : 3139-065X

www.ijemss.com

editor@ijemss.com

Vol. 01, Issue 3, July2026, pp :624-630

acid equivalents) were monitored throughout storage, and PPO activity was assessed indirectly through browning intensity (ΔA/min).

3. RESULTS AND DISCUSSION

3.1 Browning Index

Browning increased progressively during storage in all fruits, with the untreated control (T0) showing the most rapid discoloration. Apple showed the highest browning due to elevated PPO activity, followed by banana, while guava browned more slowly (Table 2). A clear concentration-dependent reduction in browning was observed from T1 to T4, with T4 (100% pseudostem water) giving the lowest browning scores at every storage interval, confirming strong inhibition of PPO activity. Phenolic compounds in pseudostem water likely act as competitive substrates, while antioxidant compounds suppress the oxidation of phenolics into quinones.

Table 2. Effect of banana pseudostem water on browning index (0–5 scale) at selected storage days

Day	Fruit	T0	T1	T2	T3	T4
3	Apple	3	2.5	2	1.5	1
3	Banana	2.5	2.2	2	1.5	1
3	Guava	2	1.8	1.5	1	0.8
7	Apple	5	4.5	3.8	2.8	2
7	Banana	5	4.5	4	3	2
7	Guava	4	3.5	3	2.2	1.5
10	Apple	5	4.8	4.2	3.5	2.5
10	Banana	5	4.8	4.5	3.8	2.8
10	Guava	4.5	4	3.5	3	2

3.2 Weight Loss

Weight loss increased with storage duration due to transpiration and respiration (Table 3). Banana showed the greatest weight loss owing to its soft tissue structure, while guava showed the least. Treated samples, particularly T3 and T4, showed significantly reduced weight loss, indicating that pseudostem water forms a protective surface layer that reduces moisture loss and slows respiration.

Table 3. Effect of banana pseudostem water on weight loss (%) at selected storage days

Day	Fruit	T0	T1	T2	T3	T4
3	Apple	5.5	5	4.2	3.2	2.5
3	Banana	6.2	5.8	5	3.8	3
3	Guava	4.8	4.2	3.5	2.8	2.2
7	Apple	12.5	11.2	9.8	7.2	5.5
7	Banana	13.5	12.5	10.5	8	6.5
7	Guava	10.5	9.5	8	6	4.8
10	Apple	15.5	14	12.5	9.5	7
10	Banana	17	15.8	13.5	10.5	8.2
10	Guava	13.5	12	10.5	8	6.2

INTERNATIONAL JOURNAL OF ENGINEERING MANAGEMENT AND SOCIAL SCIENCES (IJEMSS)

e-ISSN : 3139-065X

www.ijemss.com

editor@ijemss.com

Vol. 01, Issue 3, July2026, pp :624-630

3.3 Microbial Load

Microbial load (log CFU/g) increased across all samples during storage, with the control showing the most rapid growth, especially in banana (Table 4). Treated samples showed significantly reduced microbial counts, with T4 consistently the lowest, confirming antimicrobial activity attributable to saponins (membrane disruption), tannins (enzyme inhibition), and phenolics (protein denaturation).

Table 4. Effect of banana pseudostem water on microbial load (log CFU/g) at selected storage days

Day	Fruit	T0	T1	T2	T3	T4
3	Apple	5.5	5	4.5	4	3.5
3	Banana	6	5.5	5	4.5	4
3	Guava	5	4.5	4	3.5	3
7	Apple	7.8	7	6.2	5.5	4.8
7	Banana	8.5	7.8	7	6.2	5.5
7	Guava	7	6.5	5.8	5	4.5
10	Apple	8.5	7.8	7	6.2	5.5
10	Banana	9	8.5	7.8	7	6.2
10	Guava	7.8	7	6.2	5.5	5

3.4 pH, Titratable Acidity, and PPO Activity

pH declined over storage due to acid formation associated with spoilage, but T4 consistently maintained a higher pH, indicating slower microbial and metabolic activity. Correspondingly, titratable acidity increased over storage in all treatments, but the rise was slowest in T4 (Table 5). PPO activity rose sharply in the control but was significantly suppressed in treated samples, with T4 showing the strongest inhibition (Table 6), reinforcing the anti-browning mechanism of pseudostem water.

Table 5. pH and titratable acidity (%, as citric acid equivalents) of apple on Day 0 and Day 10

Day	Parameter	T0	T1	T2	T3	T4
0	pH	4.2	4.2	4.2	4.2	4.2
10	pH	3.2	3.5	3.7	3.8	3.9
0	Acidity (%)	0.3	0.3	0.3	0.3	0.3
10	Acidity (%)	0.5	0.45	0.42	0.38	0.35

Table 6. PPO activity (ΔA/min) of apple on Day 0 and Day 10

Day	T0	T1	T2	T3	T4
0	0.1	0.1	0.1	0.1	0.1
10	0.75	0.65	0.55	0.42	0.3

3.5 Sensory Evaluation

Sensory quality declined over storage in all samples but was significantly better retained in treated fruit, with T4 achieving the highest overall acceptability scores at Day 12 (Table 7). Treated samples retained better colour, texture, and flavour, whereas control samples deteriorated rapidly.

INTERNATIONAL JOURNAL OF ENGINEERING MANAGEMENT AND SOCIAL SCIENCES (IJEMSS)

e-ISSN : 3139-065X

www.ijemss.com

editor@ijemss.com

Vol. 01, Issue 3, July2026, pp :624-630

Table 7. Overall sensory acceptability scores (9-point hedonic scale, Day 12)

Fruit	T0	T1	T2	T3	T4
Apple	1	3	4	5	7
Banana	1	2	3	4	6
Guava	2	4	5	6	7

3.6 Overall Trends

Across all parameters, a clear concentration-dependent preservation effect was evident, with T4 (100% pseudostem water) consistently outperforming lower concentrations, the untreated control, and approaching the performance of the ascorbic acid reference. The results confirm that banana pseudostem water acts through combined antioxidant, antimicrobial, and anti-browning mechanisms. Among the three fruits, apple showed the greatest sensitivity to browning, banana exhibited the highest weight loss and microbial growth due to its soft tissue structure, while guava showed relatively better inherent stability—yet the treatment was effective across all three, indicating broad applicability.

4. CONCLUSION

This study demonstrates the potential of banana pseudostem water as a natural, sustainable, and effective bio-preservative for extending the shelf life of fresh-cut apple, banana, and guava. Untreated control samples exhibited rapid spoilage—increased browning, higher microbial load, greater weight loss, declining pH, rising acidity, and poorer sensory scores—consistent with well-established mechanisms of postharvest deterioration involving PPO activity, oxidative reactions, and microbial metabolism. In contrast, banana pseudostem water treatment, particularly at 75–100% concentration, markedly improved retention of quality across all measured parameters. These effects are attributable to the phenolic and flavonoid content of the extract, which inhibits PPO and scavenges free radicals, and to its saponin and tannin content, which disrupts microbial membranes and inhibits enzymatic activity; a resulting moisture-retentive surface layer further reduced weight loss. Because banana pseudostem is an abundant, largely discarded agricultural by-product, its use as a preservative offers a low-cost, eco-friendly alternative to synthetic preservatives, supporting waste valorization and clean-label food processing.

4.1 Future Scope

Future work should focus on isolating and identifying the specific active compounds responsible for the observed effects using techniques such as HPLC and GC-MS; developing pseudostem-based edible coatings and bioactive films; extending the treatment to a wider range of fruits and vegetables; conducting shelf-life modelling and kinetic studies; combining the treatment with modified atmosphere packaging; carrying out toxicological and safety evaluation; and pursuing scale-up and industrial feasibility studies, including nutraceutical applications of pseudostem-derived ingredients.

REFERENCES

1. Aguayo, E., Escalona, V. H., & Artés, F. (2013). Effect of storage and cutting on fresh-cut fruits. Food Control, 31, 190–197.

INTERNATIONAL JOURNAL OF ENGINEERING MANAGEMENT AND SOCIAL SCIENCES (IJEMSS)

e-ISSN : 3139-065X

www.ijemss.com

editor@ijemss.com

Vol. 01, Issue 3, July2026, pp :624-630

2. Alothman, M., Bhat, R., & Karim, A. A. (2009). Antioxidant capacity and phenolic content of selected fruits. Food Chemistry, 115, 785–788.
3. Bhattacharjee, S., et al. (2024). Phytochemical profiling and antioxidant potential of banana pseudostem. AgriRxiv. https://doi.org/10.31220/agriRxiv.2024.00254
4. Brand-Williams, W., Cuvelier, M. E., & Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. LWT – Food Science and Technology, 28(1), 25–30.
5. FAO. (2019). The State of Food and Agriculture 2019: Moving forward on food loss and waste reduction. Food and Agriculture Organization. https://doi.org/10.4060/ca6030en
6. Imam, M. Z., & Akter, S. (2011). Musa paradisiaca and Musa sapientum: A review. Journal of Applied Pharmaceutical Science, 1(5), 14–20.
7. Kumar, P., et al. (2023). Valorization of banana pseudostem for bioactive compounds. Journal of Food Composition and Analysis, 120, 105320. https://doi.org/10.1016/j.jfca.2023.105320
8. Lawless, H. T., & Heymann, H. (2010). Sensory evaluation of food: Principles and practices (2nd ed.). Springer.
9. Oms-Oliu, G., Soliva-Fortuny, R., & Martín-Belloso, O. (2010). Edible coatings for fresh-cut melon. Food Chemistry, 121(3), 798–804. https://doi.org/10.1016/j.foodchem.2009.12.109
10. Parvez, M., Hossain, M. S., & Rahman, M. M. (2023). Antioxidant and antimicrobial potential of banana pseudostem extracts. Food Bioscience, 53, 102713. https://doi.org/10.1016/j.fbio.2023.102713
11. Queiroz, C., Lopes, M. L. M., Fialho, E., & Valente-Mesquita, V. L. (2008). Polyphenol oxidase: Characteristics and mechanisms of browning control. Food Reviews International, 24(4), 361–375.
12. Raybaudi-Massilia, R. M., et al. (2009). Antimicrobial activity in fruit juices. Journal of Food Protection, 72(7), 1579–1586. https://doi.org/10.4315/0362-028X-72.7.1579
13. Rico, D., Martín-Diana, A. B., Barat, J. M., & Barry-Ryan, C. (2007). Quality of fresh-cut fruits and vegetables. Trends in Food Science & Technology, 18(7), 373–386. https://doi.org/10.1016/j.tifs.2007.03.011
14. Singh, A., Sharma, R., & Kaur, M. (2024). Natural preservatives for fresh-cut fruits. LWT – Food Science and Technology, 198, 115876. https://doi.org/10.1016/j.lwt.2024.115876
15. Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). Analysis of total phenols and other oxidation substrates by Folin–Ciocalteu reagent. Methods in Enzymology, 299, 152–178.
16. Sulaiman, S. F., et al. (2011). Phenolic content and antioxidant activity of bananas. Journal of Food Composition and Analysis, 24(1), 1–10. https://doi.org/10.1016/j.jfca.2010.04.005
17. Toivonen, P. M. A., & Brummell, D. A. (2008). Biochemical changes in fresh-cut fruits. Postharvest Biology and Technology, 48(1), 1–14. https://doi.org/10.1016/j.postharvbio.2007.09.004