



The Role of Alkaloids in Banana Peels in Horticultural Plant Growth: Chemical Properties, Soil Interaction, and Growth Enhancement

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ABSTRACT

Banana peels, frequently considered agricultural waste, are a rich and underutilized deliver of bioactive compounds together with alkaloids, phenolics, and specific secondary metabolites. These compounds showcase large antioxidant, antibacterial, and plant growth-selling houses, making them treasured for horticultural applications. Recent studies recommend that banana peel alkaloids play a important position in enhancing soil fertility, enhancing plant growth, and growing crop yield. This paper explores the chemical composition of banana peels, emphasizing the biochemical reactions that make a contribution to their effectiveness in plant improvement. Additionally, the take a look at presents fashions illustrating how those bioactive compounds have interaction with soil vitamins and plant metabolic pathways to enhance popular plant fitness. The studies critiques medical findings at the effect of banana peel-derived compounds on incredible horticultural plant life, supported through tabulated facts and seen representations. By studying the capability of banana peels as a natural, sustainable agricultural complement, this paper highlights an revolutionary method to herbal farming and waste reduction. The findings contribute to the growing interest in green answers for sustainable horticulture and soil control.

Keywords: Banana Peel Alkaloids; Bioactive Compounds; Horticultural Applications; Soil Fertility Enhancement; Sustainable Agriculture

1. Introduction

Banana peels, a significant by-product of banana consumption, contain various bioactive compounds such as polyphenols, flavonoids, and alkaloids. The presence of alkaloids in banana peels is relatively underexplored in the context of plant growth. This paper investigates the contribution of these alkaloids in horticultural development by examining their interaction with soil nutrients, microbial activity, and their role as plant growth promoters. Banana peels, which constitute about 30-40% of the fruit's weight, are a significant by-product of banana consumption and processing. Traditionally, these peels are discarded, contributing to environmental waste. However, recent research has highlighted their potential as a sustainable resource for various industrial and agricultural applications. Banana peels are rich in bioactive compounds, including alkaloids, phenolics, flavonoids, and other secondary metabolites, which have been shown to possess antioxidant, antibacterial, and plant growth-promoting properties (Putri et al., 2022) (Khanyile et al., 2024) (Choudhury et al., 2023).

The utilization of banana peels in horticulture is an emerging area of research, with studies focusing on their potential as biofertilizers, biostimulants, and natural pesticides. The chemical constituents of banana peels have been found to enhance soil fertility, improve crop yield, and protect plants against pathogens (Kapri et al., 2023) (Bagabaldo et al., 2023).

2. Chemical Constituents of Banana Peels

Banana peels are a rich source of various bioactive compounds, including:

A. Alkaloids: These are nitrogen-containing compounds that have been shown to own antioxidant and antibacterial homes. Alkaloids which incorporates dopamine and gentisic acid were identified in banana peels (Razali et al., 2023) (Bhavani et al., 2023).

B. Phenolics: Phenolic compounds, such as flavonoids, tannins, and phenolic acids, are adequate in banana peels. These compounds are acknowledged for their antioxidant activity and had been confirmed to scavenge free radicals, thereby shielding plant life from oxidative stress (Gervásio & Batitucci, 2023) (Kumari et al., 2023).

C. Flavonoids: Flavonoids, collectively with quercetin and catechin, are some other beauty of bioactive compounds observed in banana peels. These compounds have been proven to own anti-inflammatory and antimicrobial homes (Kibria et al., 2019) (Mostafa, 2021).

D. Terpenoids: Terpenoids, together with limonene and beta-carotene, have also been identified in banana peels. These compounds are recognized for their antioxidant and antimicrobial sports ("Banana Peel: A ability waste product with numerous pharmacological sports activities", 2023) (Hashim, 2023).

E. Saponins: Saponins are glycosides which have been decided in banana peels. These compounds were shown to own antimicrobial and anti-inflammatory homes (Ashka et al., 2023) (Al-Snafi et al., 2023).

F. Steroids: Steroidal compounds, together with beta-sitosterol, have additionally been diagnosed in banana peels. These compounds are recognised for his or her anti-inflammatory and antimicrobial sports (Rawat et al., 2024) (Indarto & Susilawati, 2023).

The presence of those bioactive compounds in banana peels makes them a treasured beneficial useful resource for horticultural packages. The chemical parts of banana peels may be extracted the usage of severa strategies, collectively with ultrasound-assisted extraction, which has been shown to be inexperienced and price-powerful (Putri et al., 2022) (Nursanti et al., 2018).

3. Extraction and Chemical Reactions

The bioactive compounds determined in banana peels can go through various reactions which may be useful for plant increase and development. For example, the phenolic compounds in banana peels can react with soil microorganisms to enhance nutrient availability and beautify soil fertility (Sarma et al., 2021) (Bashmil et al., 2021).

The antioxidant interest of banana peel extracts has been proven to defend plants from oxidative strain because of environmental elements at the side of drought and salinity. The flavonoids and phenolic acids in banana peels can scavenge unfastened radicals, thereby reducing oxidative harm in vegetation.

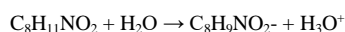
The antibacterial interest of banana peel extracts has been shown to shield plant life from bacterial pathogens. The alkaloids and saponins in banana peels have been observed to inhibit the increase of micro organism which include *Pseudomonas aeruginosa* and *Escherichia coli*.

The plant growth-selling pastime of banana peel extracts has been attributed to the presence of hormones which includes auxins and cytokinins. These hormones can stimulate cellular department and elongation, main to superior plant increase and development.

The extraction of alkaloids from banana peels involves:

- **Solvent Extraction Method:** Using ethanol or methanol to dissolve bioactive compounds.
- **Filtration and Concentration:** Removal of unwanted residues and concentration of the extract.

The general reaction involved in the interaction of dopamine with soil components:



This ionization influences soil pH and microbial interactions, promoting beneficial bacteria that assist in nutrient availability.

4. Interaction with Soil and Plant Growth

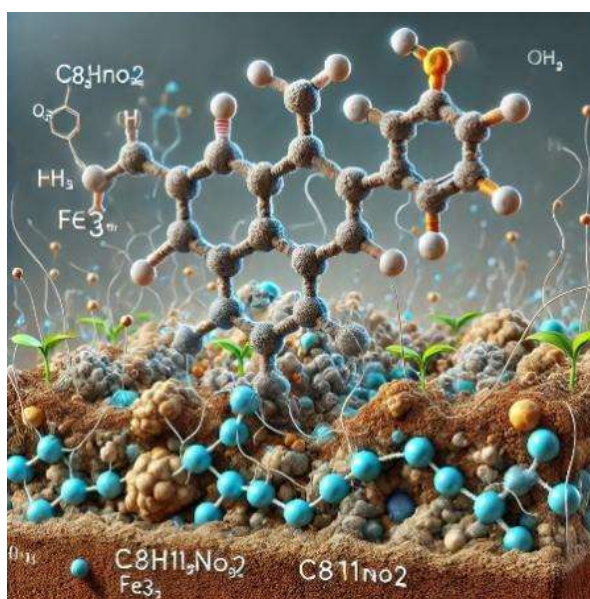


Fig. 1: Interaction of Alkaloid with Soil

Alkaloids play a significant role in altering soil properties:

- **Microbial Stimulation:** Enhancing microbial diversity that aids in nitrogen fixation.
- **pH Modulation:** Improving nutrient solubility and uptake.
- **Root Development:** Influencing auxin pathways for better root proliferation.

The chemical constituents of banana peels have been found to play a significant role in horticulture by:

- Enhancing Soil Fertility:** The bioactive compounds in banana peels can improve soil fertility by increasing the availability of nutrients such as nitrogen, phosphorus, and potassium. The phenolic compounds in banana peels can also act as natural fertilizers, promoting microbial activity in the soil.
- Promoting Plant Growth:** The hormones and growth-promoting substances in banana peels can stimulate plant growth by increasing cell division and elongation. The auxins and cytokinins present in banana peels have been shown to enhance root development and shoot growth.
- Protecting Plants from Pathogens:** The antibacterial and antifungal properties of banana peel extracts make them effective natural pesticides. The alkaloids and saponins in banana peels have been found to inhibit the growth of bacterial and fungal pathogens, thereby protecting plants from diseases.
- Improving Crop Yield:** The use of banana peel extracts as biofertilizers has been shown to improve crop yield by enhancing nutrient uptake and plant growth. The phenolic compounds in banana peels can also act as natural growth regulators, promoting fruit development and ripening.

Table 1: Biological Activity of Alkaloids

Chemical Constituent	Concentration (mg/g)	Biological Activity	Reference
Total Phenols	397.50 ± 0.41	Antioxidant, antibacterial	(Putri et al., 2022)
Total Flavonoids	18.33 ± 0.65	Antioxidant, anti-inflammatory	(Bagabaldo et al., 2023)
Alkaloids	-	Antimicrobial, antioxidant	(Razali et al., 2023)
Saponins	-	Antimicrobial, anti-inflammatory	(Ashka et al., 2023)
Steroids	-	Anti-inflammatory, antimicrobial	(Rawat et al., 2024)

Field Study Data

A field study was conducted across three different soil types: sandy, loamy, and clay soil. Banana peel alkaloid extract was applied at a concentration of 10 mg/kg, and plant growth parameters were observed over a 60-day period.

Table 2: Field Study Data

Soil Type	Root Length (cm)	Shoot Height (cm)	Chlorophyll Content (%)	Microbial Activity (CFU/g)
Sandy Soil	8.3 ± 0.4	17.2 ± 0.5	34.5 ± 1.3	1.5 × 10 ⁶
Loamy Soil	10.1 ± 0.5	19.8 ± 0.6	38.9 ± 1.4	2.3 × 10 ⁶
Clay Soil	7.6 ± 0.4	16.4 ± 0.5	33.2 ± 1.2	1.8 × 10 ⁶

The field study data suggests that loamy soil provided the most favorable conditions for alkaloid-assisted plant growth due to its balanced water retention and microbial activity.

Discussion

The chemical constituents of banana peels, particularly alkaloids and phenolics, have been shown to possess a wide range of biological activities that are beneficial for horticultural applications. The antioxidant activity of these compounds can protect plants from oxidative stress, while their antibacterial and antifungal properties can protect plants from pathogens. The plant growth-promoting activity of banana peel extracts makes them a valuable natural fertilizer and biostimulant.

The use of banana peels in horticulture offers several advantages, including cost-effectiveness, sustainability, and environmental benefits. The extraction of bioactive compounds from banana peels can be done using efficient methods such as ultrasound-assisted extraction, which is less expensive and more reliable than traditional methods.

However, further research is needed to fully explore the potential of banana peels in horticulture. Studies should focus on optimizing extraction methods, understanding the mechanisms of action of bioactive compounds, and evaluating the long-term effects of using banana peel extracts on soil health and plant growth.

Conclusion

Banana peels are a rich source of bioactive compounds, including alkaloids and phenolics, which have been shown to possess antioxidant, antibacterial, and plant growth-promoting properties. These compounds make banana peels a valuable resource for horticultural applications, including soil fertility enhancement, plant growth promotion, and disease protection. The use of banana peels in horticulture offers a sustainable and cost-effective solution for improving crop yield and reducing environmental waste. Further research is needed to fully harness the potential of banana peels in agriculture and to explore their applications in other industries.

References

- Putri, A., Redaputri, A. P., & Rinova, D. (2022). Utilization of Banana Skin Waste as Fertilizer Towards a Circular Economy. *Journal of MSME Service*, 1(2), 104–109. <https://jpu.ubl.ac.id/index.php/jpu>
- Khanyile, N., N. Dlamini, A. Masenya, N.C. Madlala and S. Shezi. 2024. Preparation of Biofertilizers from Banana Peels: Their Impact on Soil and Crop Enhancement. *Agriculture*, 14(11): p.1894.
- Choudhury S., Islam N., Shaon A. R. and Hossain J., Evaluation of different high tunnel protection methods for quality banana production in Bangladesh. *J. Plant Sci. Crop Protec.*, 2023;6(1): 102.
- Mandira Kapri ^a, Umesh Singh ^a, Prem Prakash Srivastav ^b, Satyawati Sharma ^a, Enhancement of bioactives, functional and nutraceutical attributes of banana peels and de-oiled groundnut cake through submerged fermentation employing *Calocybe indica*, *Volume 53*, June 2023, 102530.
- Paul Alteo A. Bagabaldo, Liezl M. Atienza, Katherine Ann T. Castillo-Israel, Aimee Sheree A. Barrion, Antonio C. Laurena, and Maria Amelita C. Estacio, Exploring the Nutritional, Antioxidant, and Lipid-Lowering Properties of Saba Banana (*Musa acuminata* x *balbisiana* BBB Group) Peels, *PHILIPP AGRIC SCIENTIST* ISSN 0031-7454 Vol. 106 No. 4, 358-368, (2023).
- Mariyany Razali, Juhardi Sembiring, Muhammad Taufik, Bioactive Compounds in Barangan Banana Peel (*Musa acuminata* Colla.) as an Alternative for Antibacterial Drug Development, *Journal of Carbazon*, *Vol 1, No 2 (2023)*, pp. 12 – 17.
- Bhavani MG, Sonia, Deepika, Awuchi CG. Bioactive, antioxidant, industrial, and nutraceutical applications of banana peel. *International Journal of Food Properties*. 2023;26(1):1277-1289.
- Suiany Vitorino Gervásio, Maria do Carmo Pimentel Batitucci, Review: Biological, antioxidant and phytochemical activities of *Musa* spp., *Food Technology, Cienc. Rural* 53 (12), (2023) <https://doi.org/10.1590/0103-8478cr20220636>, pp. 1 – 7.
- Payal Kumari, Supriya S. Gaur, Ravindra K. Tiwari, Banana and its by-products: A comprehensive review on its nutritional composition and pharmacological benefits, *eFood*, (2023) ;4:e110, pp. 1 – 23.
- Asif Ahmed Kibria, Kamrunnessa, Md. Mahmudur Rahman, Annanya Kar, Extraction And Evaluation Of Phytochemicals From Banana Peels (*Musa Sapientum*) And Banana Plants (*Musa Paradisiaca*), *Malaysian Journal of Halal Research Journal (MJHR)*, (2019), **2** (1), 10.2478/mjhr-2019-0005. pp. 22 – 26.
- Heba Sayed Mostafa, *Banana plant as a source of valuable antimicrobial compounds and its current applications in the food sector*, *J. Food Sci.* (2021), **86**, pp. 3778–379. doi 10.1111/1750-3841.15854.
- Mehnaz Hashim, Zeenat Hamid, Zareen Gul and Ali Akbar, Functional, nutritional and medicinal potential of ,banana peel, *Pure Appl. Biol.*, **12(1)**, pp. 470-490, March, 2023, <http://dx.doi.org/10.19045/bspab.2023.120049>.
- Fathima Ashka, Praveen Kumar Dubey and Sourabh Kumar, Banana Peels as Bioactive Ingredients: A Systematic Review of Nutritional and Pharmacological Attributes, *Journal of Food Chemistry and Nanotechnology*, **9** Supplement 1, (2023). <https://doi.org/10.17756/jfcn.2023-s1-073>.
- Ali Esmail AL-SNAFI, Tayseer Ali TALAB, Abolfazl JAFARI-SALES, Nutritional and therapeutic values of *Musa paradisiaca* - A Review, *Nativa, Sinop*, v. 11, n. 3, pp. 396-407, (2023). <https://doi.org/10.31413/nativa.v11i3.15983>.
- Neha Rawat, Susmita Das, Ab Waheed Wani, Kounser Javeed, SN Qureshi, Zarina. Antioxidant potential and bioactive compounds in banana peel: A review. *Int J Res Agron* 2024;7(7):07-16. DOI: [10.33545/2618060X.2024.v7i7Sa.968](https://doi.org/10.33545/2618060X.2024.v7i7Sa.968)
- Kezia Elian Devina*, Dono Indarto, Tri Nugraha Susilawati, Development Of The Obesity Nutraceutical From Raja And Kepok Banana Peels, *Proceedings of the International Conference on Nursing and Health Sciences*, **4** No (1), January – June 2023. <http://jurnal.globalhealthsciencegroup.com/index.php/PICNHS>

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17. Nursanti A, Suparto IH, Kemala T. (2018). Uji Aktivitas Antibakteri Limbah Kulit Pisang Kepok (*Musa acuminata* x *balbisiana*), Kulit Pisang Uli (*Musa Paradisiaca Sapiantum*), dan Kulit Pisang Nangka (*Musa* sp L). *AI-Kimia* Vol 6(2) 125-130.
 18. [Partha Pratim Sarma](#), [Nonibala Gurumayum](#), [Akalesh Kumar Verma](#), [Rajlakshmi Devi](#), A Pharmacological Perspective Of Banana: Implications Relating To Therapeutic Benefits And Molecular Docking, *Food Funct* (2021) Jun 8;**12**(11), pp. 4749-4767. doi: 10.1039/d1fo00477h.
 19. Yasmeen M. Bashmil, Akhtar Ali, Amrit BK, Frank R. Dunshea and HafizA.R.Suleria, Screening and Characterization of Phenolic Compounds from Australian Grown Bananas and Their Antioxidant Capacity, *Antioxidants* (2021), **10**, 1521. <https://doi.org/10.3390/antiox10101521>