LUMEN ET VIRTUS
ISSN: 2177-2789

VALORIZATION OF BANANA FLOWER RESIDUES: POTENTIAL THERAPEUTIC AND ANTIOXIDANT APPLICATIONS

https://doi.org/10.56238/levv15n41-022

Date of submission: 04/09/2024 **Date of publication:** 04/10/2024

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ABSTRACT

Various parts of the banana tree (Musa spp.), such as leaves, fruits, inflorescences, roots, peels and stems are used in traditional medicine, in several cultures around the world, for the treatment of diarrhea, ulcers, pain, inflammation, and diabetes mellitus. The inflorescence, in turn, stands out as a promising by-product of the banana agroindustry, since it is rich in micronutrients and bioactive compounds relevant to the human health, such as β-sitosterol, flavonoids, saponins, and phenolics like catechin and isoquercetin. Studies reveal that the consumption of banana inflorescences can provide various health benefits, including improved intestinal function, weight management and reduced risk of cardiovascular diseases. For this work, a bibliographic narrative review was carried out with a focus on the valorization of banana flower residues, exploring its therapeutic and antioxidant potential. The research was developed through the analysis of scientific articles and relevant studies, highlighting the bioactive properties of these by-products and their potential applications in the pharmaceutical and food industries. This review showed that banana inflorescences are rich in phenolic compounds, flavonoids and terpenoids, which have antioxidant, antidiabetic, anti-inflammatory and antimicrobial properties. Therefore, these by-products can be used by the pharmaceutical and food industries and can contribute to the circular economy and sustainable management of agricultural resources.

Keywords: Banana Inflorescences. Bioactive Compounds. Antioxidant Potential.

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INTRODUCTION

The Musaceae family is widely recognized for including some of the world's most significant fruits, such as bananas and plantains (Christelová *et al*., 2011). While bananas, scientifically known as *Musa spp*., have Asian origins, plantains (*M. paradisiaca*), which result from the combination of Musa acuminata and Musa balbisiana, are predominant in Africa, especially in Central and Western regions (Embrapa, 2019; Ploetz *et al*., 2007).

Various parts of *Musa spp*., including leaves, fruits, inflorescences, roots, peels, and stems (Figure 1), are used in traditional medicine to treat several health conditions, such as diarrhea, ulcers, pain, inflammation, and diabetes mellitus (Nirmala *et al*., 2012). This medicinal use is widespread and observed in various cultures around the world, particularly in the Americas, Asia, Oceania, India, and Africa (Tsamo *et al*., 2015).

Among the various by-products generated by the banana agro-industry, the inflorescence stands out as a promising nutritional resource. It is rich in micronutrients and bioactive compounds relevant to human health (Lau *et al*., 2020; Silva *et al*., 2023). Bioactive compounds such as β-sitosterol, flavonoids, saponins, and phenolics like catechin and isoquercetin are present in the inflorescence (Bortolanza; Nunes; Quináia, 2024; Fingolo *et al*., 2012).

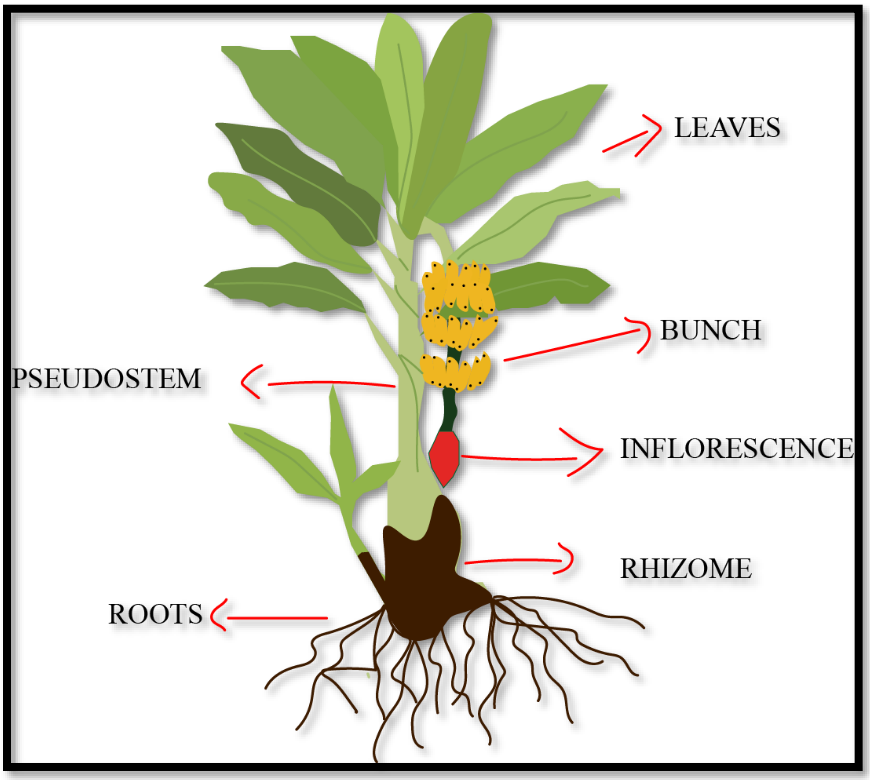
The consumption of banana inflorescences can provide various health benefits, including improved intestinal function, weight management, and reduced risk of cardiovascular diseases (Nogueira *et al*., 2022). Moreover, these bioactive compounds serve as a beneficial alternative for postpartum mothers, aiding in breastfeeding (Amornlerdpison *et al*., 2020).

Once frequently discarded during harvest, the inflorescence is now gaining attention as a functional food ingredient due to its nutritional value and bioactive compounds (Lau *et al*., 2020; Bortolanza; Nunes; Quináia, 2024). The utilization of these parts can have a significant impact on both functionality and income generation for small-scale farmers, while also contributing to environmental waste reduction (Nogueira *et al*., 2022).

For this study, a literature review was conducted focusing on the valorization of banana flower residues, exploring their therapeutic and antioxidant potential. Various scientific articles and studies were analyzed to highlight the bioactive properties of these byproducts, as well as their potential applications in the pharmaceutical and food industries (Ravindran; John; Jacob, 2021). The methodology included collecting data from reliable sources and critically evaluating the presented results.

The objective of this study is to emphasize the benefits of the bioactive compounds present in banana flowers and bracts, promoting awareness of the importance of utilizing these resources sustainably and efficiently.

Figure 1. Banana Tree (*Musa spp.*).



Source: Created by the authors (2024).

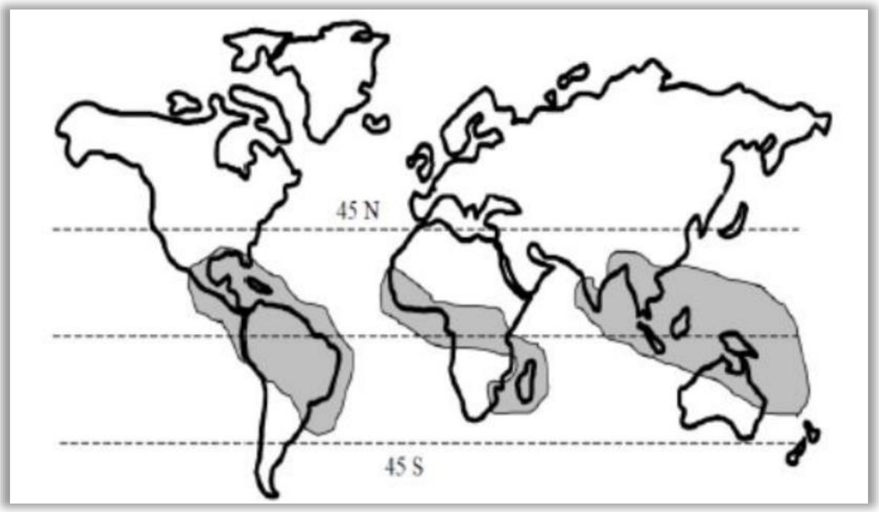
THEORETICAL FRAMEWORK

MUSA SPP

Cultivation, Geographic Distribution, and Global Consumption of Banana Plants

Banana cultivation, typically a tropical crop, is predominantly carried out between the latitudes of 30° S and 30° N of the Equator, with ideal conditions lying between 15° South and North. In Brazil, banana plants are cultivated in all states, adapting to a wide variety of ecosystems. Although the ideal conditions for their growth include tropical climates with temperatures ranging between 15°C and 35°C (Figure 2), and preferably 18°C at night and 25°C during the day, banana plants can also be cultivated in cold subtropical regions or semi-arid tropics, although extreme temperatures and water scarcity may limit their productivity. Generally, the closer to the Equator, the better the climatic conditions for cultivation, given the plant's need for constant warmth, high humidity, and well-distributed rainfall (De Olanda Souza *et al.*, 2022; Silva *et al.*, 2012; Van Den Bergh *et al.*, 2012).

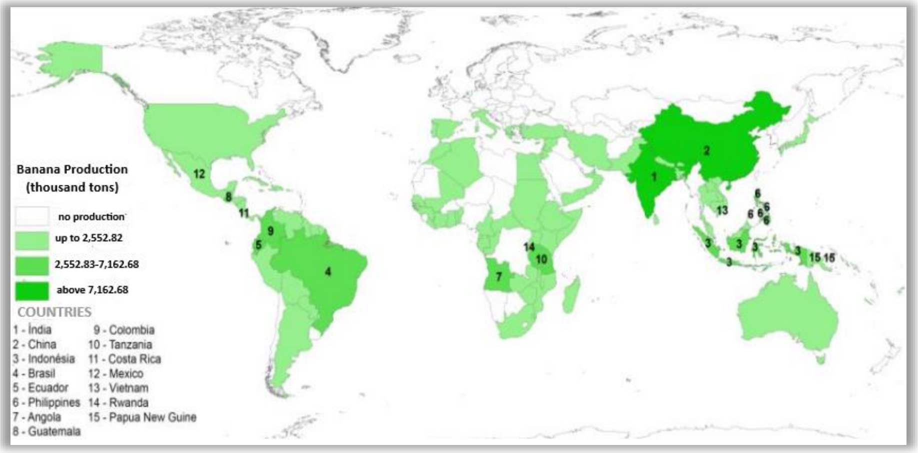
Figure 2. Distribution of Banana Culture in the World



Source: Adapted from Vieira (2011, p.3).

Bananas are widely consumed globally, both in their natural form and in various processed forms such as fried, baked, sweets, and chips. In 2017, the FAO (Food and Agriculture Organization of the United Nations) reported that bananas are produced in 128 countries, making it one of the most popular fruits worldwide (Figure 3).

Figure 3 – Spatial Distribution of World Banana Production.



Source: Adapted from FAO – Spatial Distribution of Banana (2017).

DIVERSITY AND GENETIC IMPROVEMENT

The Musa genus, belonging to the Musaceae family, encompasses over 50 species with various subspecies, taxonomically divided into five distinct sections. Callimusa and Rhodochlamys are known for their ornamental uses. The Ingentimusa section stands out for having only one species, *Musa ingens*. The section Australimusa includes the edible banana *Musa maclayi* and *Musa textilis*, cultivated for fiber production. However, the most significant section is Eumusa, which contains the majority of banana cultivars used in agriculture. This section houses ten species, such as *Musa acuminata* and *Musa balbisiana*, which are fundamental for commercial banana production (Souza, 2002; Ribeiro, 2010).

Genetic studies reveal that varieties such as *Musa paradisiaca* and *Musa sapientum* are, in fact, hybrids, and not separate species. This classification is based on groups with 10 or 11 chromosomes. Diploid forms of *Musa acuminata* (genome A) crossed with *Musa balbisiana* (genome B) have given rise to edible hybrid diploids (AA, AB, BB) and triploids (AAA, AAB, ABB). The complexity increases with the occurrence of tetraploidy (AAAA, AAAB, AABB, ABBB) and the potential contribution of a third wild species, indicating a significant human intervention in the diversification of these hybrids, thus complicating the nomenclature of bananas (Simmonds; Shepherd, 1955; Martins *et al*., 2005; Castro; Kluge; Sestari, 2008; Santos, 2012).

In the context of the genetic complexity of the Musa genus, significant efforts are being made to develop genetically enhanced banana plants. EMBRAPA in Brazil and the Honduran Agricultural Research Foundation are leaders in this field, developing tetraploid hybrids (AAAB), such as FHIA 17 (AAAA) and FHIA 18 (AAAB). These new hybrids, designed to resist pathogens such as *Mycosphaerella fijiensis Morelet*, *Mycosphaerella musicola*, and *Fusarium oxysporum* f.sp. *cubense*, offer a dual advantage: they are resistant to nematodes and fungi, reducing the dependency on fungicides, and consequently, improving the quality of the products by decreasing the use of chemical products in the cultivars (Nomura *et al*., 2020).

The BRS Pacoua is a variety of the Pacovan banana type, developed by EMBRAPA Cassava and Fruit Culture, recommended mainly for the Northern region of Brazil, particularly Pará. It is characterized by its resistance to fruit drop and high rusticity, qualities valued in family farming. Commonly used in agroforestry systems, BRS Pacoua is often intercropped with crops like black pepper, guarana, cupuaçu, and cocoa. This variety is popular for fresh consumption and has good commercial acceptance in Pará (Amorim *et al.,* 2013).

The banana cultivar BRS Vitória stands out for its resistance to key diseases such as Black Sigatoka, Yellow Sigatoka, and Panama disease, as well as anthracnose in post-harvest. These characteristics provide significant economic advantages for producers. BRS Vitória has high-quality fruits with a longer shelf life, making it commercially attractive. Its fruits, when ripe, feature an intense yellow peel, cream pulp, sweet flavor, and lower acidity compared to the common silver banana, making it appealing to consumers (Reis *et al.,* 2016; Silva *et al.,* 2020).

The cultivar also excels in productivity, exceeding 44 tons per hectare from the second cycle under ideal cultivation conditions, and adapts well to different planting spacings. Its resistance to major banana diseases, including Panama disease and the Sigatokas, is particularly valuable, given that these diseases can cause significant production losses. The BRS Vitória, being resistant and productive, meets the demand for bananas in the State of Amazonas and is a viable alternative for expanding banana cultivation in areas affected by these diseases (Weber *et al.,* 2017).

CHEMICAL COMPOSITION

Bananas are an energetic food consumed worldwide in both their green and ripe forms due to their nutritional value (Table 1), offering sugars, polyunsaturated fatty acids, sterols, minerals such as potassium, and vitamins such as pro-vitamin A and vitamins B1, B2, and C. Moreover, they are rich in bioactive compounds, including glycosides and acids like malic and oxalic acids. Heating at 65°C for 30 minutes can reduce the enzymatic activity of the pulp without degrading the total phenolics (Arinzechukwu & Nkama, 2019; Mathew & Negi, 2017; Rao *et al*., 2016).

Table 1. Chemical Composition of *Musa spp.*

Parameter	Content (g)
Energy	371kJ (89Kcal)
Moisture	65.5-75.3
Protein	0.9-4.9
Lipids	0.3-2.9
Crude Fiber	1.6-2.9
Sugars	23.9-43.8
Ash	0.9-2.22
Vitamins	(mg, daily value)
Pantothenic Acid	0.334 (7%)
Pyridoxine	0.4 (31%)
Choline	9.8 (2%)
Vitamin C	8.7 (10%)
Minerals	(mg)
Magnesium	27 (8%)
Phosphorus	22 (3%)
Potassium	358 (8%)
Sodium	1 (0%)
Zinc	0.15 (2%)

Source: Adapted from Kookal & Thimmaiah (2018); Dotto, Matemu, & Ndakidemi (2019).

BIOACTIVE CONSITITUENTS PROFILE

Bananas' bioactive components are categorized into polyphenols, phytosterols, triterpenoids, fatty acids, and fibers, which are associated with a broad range of beneficial biological activities. The polyphenols, including hydroxybenzoic acids such as gallic and hydroxycinnamic acids like caffeic, along with flavonoids such as catechins and flavonols like quercetin, are recognized for their antioxidant properties and antidiabetic activities. These compounds also exhibit cytotoxic activities, induce apoptosis, and possess antimicrobial and anti-inflammatory effects. Phytosterols and triterpenoids, including compounds like β-sitosterol and lupeol, contribute to cardiovascular protection, while fatty acids, such as oleic and linoleic, and both soluble and insoluble fibers complement the nutritional and therapeutic profile of the banana, enhancing its value in healthy diets and disease prevention (Lau *et al*., 2020; Ajijolakewu *et al*., 2021).

INFLORESCENCE OF *MUSA SPP*

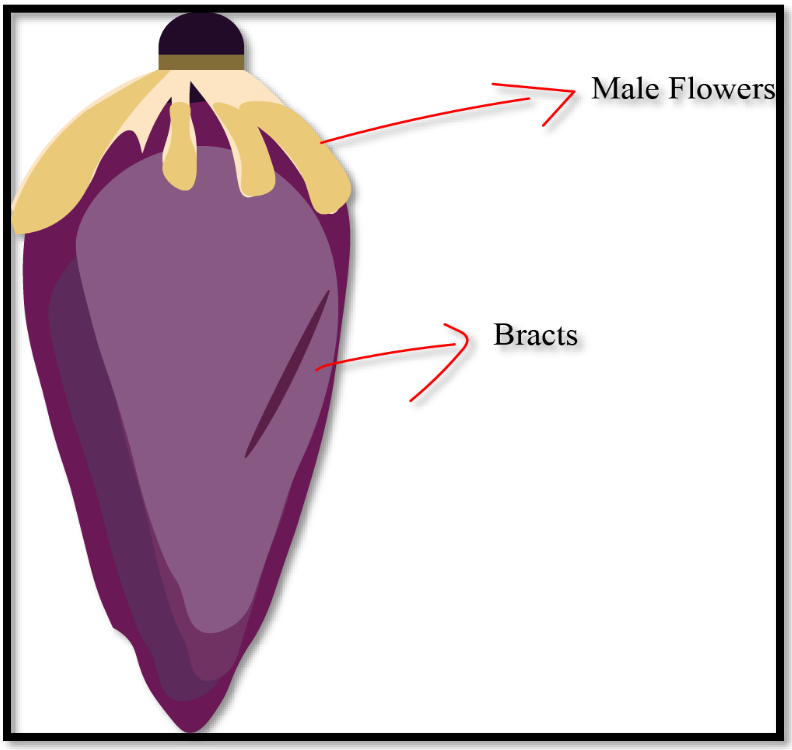
Description, Culinary use and Bioactive Potential

The structure known as the banana flower, often referred to as "umbigo" (navel), "banana flower," "banana heart," or "flower bud," encompasses male flowers wrapped in characteristic red-purple bracts (Figure 4). In banana cultivation, the bract is removed to favor fruit development, making the inflorescence a common agricultural waste (Rodrigues, 2020). While many farmers discard it during harvest, in Asian countries, it is a common ingredient in culinary preparations. In Brazil, however, its use is more typical in rural areas, in snacks or salads, linked to socioeconomic factors (Fingolo *et al*., 2012; Khanum *et al*., 2000). Additionally, it is considered that the consumption of cooked flowers has great potential for diabetes control (Kumar* *et al*., 2012).

Over time, various studies have explored the biological impacts of the banana inflorescence. These investigations have revealed several properties, including galactagogue effects (Mahmood; Omar; Ngah, 2012), anti-inflammatory (Lee, K. H. *et al*., 2011), antioxidant (Ahmad, Bashir Ado *et al*., 2015), and antihyperglycemic activities (Jawla; Kumar; Khan, 2012).

Recent studies reinforce these findings, indicating that the banana inflorescence extract possesses antidiabetic and antilipidemic properties (Ara; Tripathy; Ghosh, 2019; Vilhena *et al*., 2020). Furthermore, banana bracts are rich in fibers and have antioxidant properties, making them an economical alternative for obtaining bioactive compounds (Begum; Deka, 2019; K B, A *et al.,* 2019).

Figure 4 - Inflorescence of *Musa spp.*



Source: Created by the authors (2024).

CHARACTERIZED COMPOUNDS AND PROVEN BIOLOGICAL ACTIVITIES

The presence of chemical constituents in *Musa spp*. inflorescences is noteworthy, with flavonoids being particularly highlighted. According to studies by Ganugapati, Baldwa, and Lalani (2012), these flavonoids have been characterized and shown to possess significant antioxidant properties. These phytochemicals, particularly abundant in the bracts of the flowers, include subgroups such as anthocyanins and flavanones. Anthocyanins contribute to the vibrant colors and provide protection to the plants, while also offering cardiovascular benefits and improvements in vision for consumers. Flavanones, specifically naringenin and hesperetin, were identified in *Musa spp*. flowers and are recognized for their high antioxidant potential, as described by Ren *et al*. (2011) and Sharma *et al*. (2015). Additionally, these compounds play a therapeutic role in diabetes management and the prevention of its complications, demonstrating the therapeutic value of *Musa spp*. inflorescences and justifying the growing research into their pharmaceutical and nutraceutical applications.

Musa spp. inflorescences are also a rich source of phenolic acids, a range of compounds that includes gallic acid, catechol, protocatechuic acid, gentisic acid, vanillic acid, caffeic acid, syringic acid, p-coumaric acid, ferulic acid, and epicatechin. These phenolic acids have been shown to be effective as α-amylase and aldose reductase inhibitors, as reported by Alim *et al*. (2017) and Tundis, Loizzo, and Menichini (2010), playing a crucial role in reducing blood sugar levels. This property highlights the therapeutic potential of *Musa spp*. flowers in diabetes management, emphasizing the importance of these compounds in modulating metabolic processes and glycemic control.

Furthermore, *Musa spp*. flowers, specifically *Musa paradisiaca* and *Musa balbisiana*, are characterized by the presence of significant terpenoids. These include compounds such as seringin, benzyl alcohol glycoside, (65R)-roseoside, 1,1 dimethylallyl alcohol β-glycoside, 3'1-norcycloaundenone, cycloartenol, and (24R)-4α,24-trimethyl-5α-cholesta-8,25(27)-dien-3β-ol. These terpenoids have shown to be effective as α-glucosidase and α-amylase inhibitors, suggesting a therapeutic potential in regulating carbohydrate digestion and blood sugar levels. The discovery of these compounds in *Musa spp*. expands the understanding of the bioactive capabilities of the plant, paving the way for new pharmacological and nutritional applications.

In addition, *Musa spp*. has shown promise as a source of antimicrobial and phytochemical compounds that could be integrated into modern medicine, as suggested by Ajijolakewu *et al*., 2021, and Mostafa *et al*., 2021 (Table 2).

Table 2 – Identified Antimicrobial Compounds

Plant Part	Compound	Action	Reference
Banana Oil	1-Nonadecene, β-caryophyllene	Antimicrobial	Fahim *et al*. (2019)
	1,2-benzenedicarboxylic acid, δ-3-Carene, β-Myrcene	Antifungal	
Banana Fruit	Tetradecanoic Acid, Hexadecanoic Acid, DL – Limonene, Epicatechin	Antibacterial	(Pereira; Maraschin, 2015)
Banana Peel	Gallocatechin, Dopamine	Antibacterial	(Vu *et al*., 2018)
	Ferulic acid, gallic acid, chlorogenic acid, hydroxybenzoic acid, malic acid	Antimicrobial	(Suleria *et al*., 2020)
Banana Pseudostem	Gentisic acid, malic acid	Antimicrobial Antifungal	(Mokbel; Hashinaga, 2005)
	(+)-Catechin, Cinnamic Acid, Caffeic Acid	Antimicrobial	(Saravanan; Aradhya, 2011)
Banana Flower	Lupeol, Umbelliferone	Antimicrobial	(Chiang *et al*., 2020)

Source: Adapted from Mostafa (2021).

The banana plant is increasingly recognized for its applications in the food industry due to its antimicrobial properties and the potential use of its various parts. It can serve as a functional ingredient in baked goods, dairy products, beverages, and meat, providing fibers/prebiotics and acting as a natural antioxidant. Additionally, waste from banana production — about 80% of the plant's total mass — can be repurposed, enhancing sustainability. Bioactive compounds such as dopamine and ferulic acid contribute to its antimicrobial properties, which can improve food safety. The components of the banana plant are also being studied for the creation of biodegradable packaging, offering a solution to plastic waste disposal (Tibolla, 2018; Mostafa 2021).

METHODOLOGY

The present research was conducted through a narrative bibliographic review using the following databases: PubMed, Google Scholar, and Scielo. The search was filtered by free full-text access, clinical trials, meta-analyses, randomized clinical trials, and reviews. Additionally, the search was conducted using the following keywords: Banana inflorescences, Bioactive compounds, Antioxidant potential.

CONCLUSION

This review highlighted one of the underutilized byproducts generated by banana farming, which in some regions are used as food and medicinal resources, as they are rich in phenolic compounds, flavonoids and terpenoids. These bioactive compounds have several antioxidant, antidiabetic, anti-inflammatory and antimicrobial properties, which can be used by the pharmaceutical and food industries. Furthermore, these by-products can contribute to the circular economy and sustainable management of agricultural resources. Therefore, it is necessary to carry out more studies in this area that is still little explored.

REFERENCES

1. Ahmad, B. A., Zakari, A. I., Bello, A. I., & Isah, M. S. (2015). Phytochemical screening, antioxidant activity of pure syringin in comparison to various solvents extracts of *Musa paradisiaca* (banana) (fruit and flower) and total phenolic contents. *International Journal of Pharmacy and Pharmaceutical Sciences*, 7(5), 242-247.

2. Ajijolakewu, K. A., Ibrahim, M., Yusuf, A., & Salihu, A. (2021). A review of the ethnomedicinal, antimicrobial, and phytochemical properties of *Musa paradisiaca* (plantain). *Bulletin of the National Research Centre*, 45(1), 86.

3. Alim, Z., Durna, D., Bayindir, M., & Gokturk, S. (2017). Inhibition behaviours of some phenolic acids on rat kidney aldose reductase enzyme: An in vitro study. *Journal of Enzyme Inhibition and Medicinal Chemistry*, 32(1), 277–284.

4. Amorim, E. P., Ferreira, C. F., & Silva, S. O. (2013). Banana breeding at Embrapa Cassava and Fruits. In *Acta Horticulturae* (pp. 171–176). Disponível em: https://www.actahort.org/books/986/986_18.htm

5. Ara, F., Tripathy, A., & Ghosh, D. (2019). Possible antidiabetic and antioxidative activity of hydro-methanolic extract of *Musa balbisiana* (Colla) flower in streptozotocin-induced diabetic male albino Wistar strain rat: A genomic approach. *ASSAY and Drug Development Technologies*, 17(2), 68–76.

6. Arinzechukwu, C. S., & Nkama, I. (2019). Production and quality evaluation of fruit bars from banana (*Musa sapientum*) and cashew (*Anacardium occidentale*) apple fruit blends. *Asian Food Science Journal*, 1–16.

7. Begum, Y. A., & Deka, S. C. (2019). Chemical profiling and functional properties of dietary fibre rich inner and outer bracts of culinary banana flower. *Journal of Food Science and Technology*, 56(12), 5298–5308.

8. Bortolanza, A., Nunes, C. N., & Quináia, S. P. (2024). Inflorescência da bananeira: Uma opção a mais na dieta alimentar. *Cuadernos de Educación y Desarrollo*, 16(1), 955–965.

9. Castro, P. R. de C., & Kluge, R. A. (2008). *Manual de fisiologia vegetal: Fisiologia de cultivos*. Agronômica Ceres.

10. Chiang, S.-H., Huang, K.-Y., Chen, S.-P., & Hsu, W.-H. (2021). Evaluation of the in vitro biological activities of banana flower and bract extracts and their bioactive compounds. *International Journal of Food Properties*, 24(1), 1–16.

11. Christelová, P., Valarik, M., Hribová, E., De Langhe, E., & Dolezel, J. (2011). A multi gene sequence-based phylogeny of the Musaceae (banana) family. *BMC Evolutionary Biology*, 11(1), 103.

12. De Olanda Souza, G. H., Amorim, E. P., Ferreira, C. F., & Oliveira, A. F. (2022). Agroclimatic zoning for bananas under climate change in Brazil. *Journal of the Science of Food and Agriculture*, 102(14), 6511–6529.

13. Dotto, J., Matemu, A. O., & Ndakidemi, P. A. (2019). Nutrient composition and selected physicochemical properties of fifteen Mchare cooking bananas: A study conducted in northern Tanzania. *Scientific African*, 6, e00150.

14. EMBRAPA. (2019). Registradas as primeiras variedades de banana-da-terra do Brasil. Disponível em: https://www.embrapa.br/busca-de-noticias/-/noticia/41393172/registradas-as-primeiras-variedades-de-banana-da-terra-do-brasil

15. Fahim, M., Mahboob, M., Pasha, A., Aslam, R., & Rahman, M. (2019). TLC-bioautography identification and GC-MS analysis of antimicrobial and antioxidant active compounds in *Musa × paradisiaca* L. fruit pulp essential oil. *Phytochemical Analysis*, 30(3), 332–345.

16. Fingolo, C. E., De Paula, R. L., & Salomão, L. C. (2012). The natural impact of banana inflorescences (*Musa acuminata*) on human nutrition. *Anais Da Academia Brasileira De Ciencias*, 84(4), 891–898.

17. Ganugapati, J., Baldwa, A., & Lalani, S. (2012). Molecular docking studies of banana flower flavonoids as insulin receptor tyrosine kinase activators as a cure for diabetes mellitus. *Bioinformation*, 8(5), 216–220.

18. Jawla, S., Kumar, Y., & Khan, M. (2012). Antimicrobial and antihyperglycemic activities of *Musa paradisiaca* flowers. *Asian Pacific Journal of Tropical Biomedicine*, 2(2 Suppl), S914–S918.

19. K B, A., Nandini, C., Kumar, V., & Gowda, M. (2019). Short chain fatty acids enriched fermentation metabolites of soluble dietary fibre from *Musa paradisiaca* drives HT29 colon cancer cells to apoptosis. *PloS One*, 14(5), e0216604.

20. Khanum, F., Yashoda, H. M., & Siddalinga Swamy, M. (2000). Dietary fiber content of commonly fresh and cooked vegetables consumed in India. *Plant Foods for Human Nutrition (Dordrecht, Netherlands)*, 55(3), 207–218.

21. Kookal, S. K., & Thimmaiah, A. (2018). Nutritional composition of staple food bananas of three cultivars in India. *American Journal of Plant Sciences*, 9(12), 2480–2493.

22. Kumar, K. P. S., Bhowmik, D., & Chiranjib, B. T. (2012). Traditional and medicinal uses of banana. *Journal of Pharmacognosy and Phytochemistry*, 1(3), 51–63.

23. Lau, B. F., Cheong, K. L., Seng, K. Y., & Roslan, R. (2020). Banana inflorescence: Its bio-prospects as an ingredient for functional foods. *Trends in Food Science & Technology*, 97, 14–28.

24. Lee, K. H., Choi, E. M., Kim, H. S., & Song, K. S. (2011). Evaluation of anti-inflammatory, antioxidant and antinociceptive activities of six Malaysian medicinal plants. *Journal of Medicinal Plant Research, 5*(23), 5555-5563.

25. Mahmood, A., Omar, M. N., & Ngah, N. (2012). Galactagogue effects of Musa x paradisiaca flower extract on lactating rats. *Asian Pacific Journal of Tropical Medicine, 5*(11), 882-886.

26. Martins, A., Caron, B. O., & Lenz, A. M. (2005). Levantamento etnobotânico de plantas medicinais, alimentares e tóxicas da Ilha do Combu, Município de Belém, Estado do Pará, Brasil. *Revista Brasileira de Farmacognosia, 86*.

27. Mathew, N. S., & Negi, P. S. (2017). Traditional uses, phytochemistry and pharmacology of wild banana (Musa acuminata Colla): A review. *Journal of Ethnopharmacology, 196*, 124-140.

28. Mokbel, M. S., & Hashinaga, F. (2005). Antibacterial and antioxidant activities of banana (Musa, AAA cv. Cavendish) fruits peel. *American Journal of Biochemistry and Biotechnology, 1*(3), 125-131.

29. Mostafa, H. S. (2021). Banana plant as a source of valuable antimicrobial compounds and its current applications in the food sector. *Journal of Food Science, 86*(9), 3778-3797.

30. Nirmala, M., Das, B. V., Rao, K. B., & Raju, M. S. (2012). Hepatoprotective activity of Musa paradisiaca on experimental animal models. *Asian Pacific Journal of Tropical Biomedicine, 2*(1), 11-15.

31. Nomura, E. S., Müller, R. G., & Almeida, S. S. (2020). *Cultivo da bananeira*. Campinas: CDRS. Disponível em: https://www.cati.sp.gov.br/portal/themes/unify/arquivos/produtos-e-servicos/acervo-tecnico/producao_vegetal/Manual_tecnico_82_Cultivo_da_Bananeira.pdf. Acesso em: 06 set. 2024.

32. Pereira, A., & Maraschin, M. (2015). Banana (Musa spp) from peel to pulp: Ethnopharmacology, source of bioactive compounds and its relevance for human health. *Journal of Ethnopharmacology, 160*, 149-163.

33. Rao, U. S. M. (2016). Phytochemical screening, total flavonoid and phenolic content assays of various solvent extracts of tepal of Musa paradisiaca. *Malaysian Journal of Analytical Science, 20*(5).

34. Ravindran, A., John, J., & Jacob, S. (2021). Nutritional, functional and shelf-life assessment of processed banana inflorescence (Musa paradisiaca). *Journal of Postharvest Technology*, 58-70.

35. Reis, R. C., Oliveira, J. F., & Freitas, R. J. (2016). Physicochemical and sensorial quality of banana genotypes. *Pesquisa Agropecuária Tropical*, 89-95. Disponível em: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1983-40632016000100089&lng=en&tlng=en. Acesso em: 6 set. 2024.

36. Ren, L., Qin, X., & Liu, G. (2011). Structural insight into substrate specificity of human intestinal maltase-glucoamylase. *Protein & Cell, 2*(10), 827-836.

37. Ribeiro, G. D. (2010). *Algumas espécies de plantas reunidas por famílias e suas propriedades*. Porto Velho: Embrapa Rondônia. Disponível em: https://ainfo.cnptia.embrapa.br/digital/bitstream/item/54453/1/livro-plantastropicais-2.pdf. Acesso em: 06 set. 2024.

38. Rodrigues, A. S. (2020). *Extração e caracterização de diferentes constituintes da inflorescência de bananeira e aplicação em produtos cárneos*. Universidade Federal de Santa Maria.

39. Santos, J. M. dos. (2012). *Estudo do potencial cicatrizante, antimicrobiano e antiedematogênico da Musa paradisiaca L.*. Universidade Federal de Alagoas.

40. Saravanan, K., & Aradhya, S. M. (2011). Polyphenols of pseudostem of different banana cultivars and their antioxidant activities. *Journal of Agricultural and Food Chemistry, 59*(8), 3613-3623.

41. Scherer, R. F., Lichtemberg, A. V., & Coelho, L. D. (2020). BRS SCS Belluna – um novo cultivar de banana para processamento e consumo fresco. *Anais* [...]. Disponível em: https://www.semanticscholar.org/paper/BRS-SCS-BELLUNA-%E2%80%93-um-novo-cultivar-de-banana-para-e-Scherer-Lichtemberg/51470e3d4d42d70af10f471685586d815a49cb95. Acesso em: 6 set. 2024.

42. Sharma, M., Khan, N., & Rashid, R. (2015). Emerging potential of citrus flavanones as an antioxidant in diabetes and its complications. *Current Topics in Medicinal Chemistry, 15*(2), 187-195.

43. Silva, A. D., Arantes, A. M., & Costa, F. P. (2012). Irrigação da bananeira. *Anais* [...]. Disponível em: https://www.semanticscholar.org/paper/Irriga%C3%A7%C3%A3o-da-bananeira.-Silva-Arantes/86da0f9c7161b6a674ca55f48627a7a3b2354fc0. Acesso em: 6 set. 2024.

44. Silva, L. E. P. D., Ferreira, M. J., & Silva, M. J. (2020). Características de qualidade de bananas cv. BRS Vitória em elevada maturação cultivadas em Bananeiras-PB. *Research, Society and Development, 9*(9), e381996854.

45. Simmonds, N. W., & Shepherd, K. (1955). The taxonomy and origins of the cultivated bananas. *Journal of the Linnean Society of London, Botany, 55*(359), 302-312.

46. Souza, S. A. C. D. de. (2002). *Avaliação da variabilidade genética em Musa spp. utilizando marcadores microssatélites*. Universidade de São Paulo.

47. Suleria, H. A. R., Barrow, C. J., & Dunshea, F. R. (2020). Screening and characterization of phenolic compounds and their antioxidant capacity in different fruit peels. *Foods, 9*(9), 1206.

48. Tibolla, H., Pelissari, F. M., & Menegalli, F. C. (2018). Cellulose nanofibers produced from banana peel by chemical and mechanical treatments: Characterization and cytotoxicity assessment. *Food Hydrocolloids, 75*, 192-201.

49. Tsamo, C. V., Nishimwe, K., & Womeni, H. M. (2015). Phenolic profiling in the pulp and peel of nine plantain cultivars (Musa sp.). *Food Chemistry, 167*, 197-204.

50. Tundis, R., Loizzo, M. R., & Menichini, F. (2010). Natural products as α-amylase and α-glucosidase inhibitors and their hypoglycaemic potential in the treatment of diabetes: An update. *Mini Reviews in Medicinal Chemistry, 10*(4), 315-331.

51. Van den Bergh, I., Zhang, C., & Roux, N. (2012). Climate change in the subtropics: The impacts of projected averages and variability on banana productivity. *Acta Horticulturae*, 89-99. Disponível em: https://www.actahort.org/books/928/928_9.htm. Acesso em: 6 set. 2024.

52. Vieira, L. C. R. (2011). *Avaliação de cultivares de bananeira na microrregião de Aquidauana - MS*. Dissertação (Mestrado). Universidade Estadual de Mato Grosso do Sul.

53. Vilhena, R. O., Lobo, D. A., & Moreira, A. P. (2020). Antidiabetic activity of Musa x paradisiaca extracts in streptozotocin-induced diabetic rats and chemical characterization by HPLC-DAD-MS. *Journal of Ethnopharmacology