Ciência Rural, Santa Maria, v.53:12, e20220636, 2023

http://doi.org/10.1590/0103-8478cr20220636

ISSNe 1678-4596

FOOD TECHNOLOGY

Review: Biological, antioxidant and phytochemical activities of *Musa* spp.

Suiany Vitorino Gervásio[1*] **Maria do Carmo Pimentel Batitucci**[1]

[1]Universidade Federal do Espírito Santo (UFES), 29075-910, Vitória, ES, Brasil. E-mail: suianygervasio@gmail.com. *Corresponding author.

ABSTRACT: Banana (*Musa* spp.) is a food with high nutritional value. Studies about its compounds have increased considerably due to the antioxidant and biological activities of the fruit. Thus, this article synthesized and organized data related to the phytochemical constituents, as well as antioxidant and biological activities of *Musa acuminata*, *Musa balbisiana* and *Musa paradisiaca,* and evaluated the mutual influence and correlation of these activities. A bibliographic review was performed using the scientific databases Google Scholar, SciELO, Periódicos CAPES, Scientific Electronic Library Online (SciELO), Science Direct, PubMed and Scopus, applying the following terms: *Musa* spp., antioxidant, biological and phytochemical activities, combined by the Boolean operator AND. A total of 28 articles were selected from 2017 to 2022. The results indicated that bananas are rich in flavonoids, showed good performance in DPPH and FRAP antioxidant assays and have antibacterial, anticancer and antifungal potential. Previous literature reported that phytochemical constituents improved antioxidant performance, thereby enhancing the biological activities described.
Key words: banana, biologically active molecules, chemical characterisation.

Revisão: atividades biológicas, antioxidante e fitoquímica de *Musa* spp.

RESUMO: Banana (*Musa* spp.) é caracterizada como um alimento que possui alto valor nutricional e, atualmente, pesquisas sobre seus compostos têm crescido de forma considerável, tendo em vista a presença de atividades antioxidantes e biológicas que o fruto possui. Dessa forma, o objetivo desse artigo é sintetizar e organizar informações sobre os constituintes fitoquímicos, as atividades antioxidantes e as atividades biológicas encontradas em *Musa acuminata*, *Musa balbisiana* e *Musa paradisíaca* e avaliar se tais atividades se relacionam e se há influência de uma sobre a outra. Para tanto, foi feita uma revisão bibliográfica nas plataformas: Google Acadêmico, SciELO, Periódicos Capes, Scientific Eletronic Libary Online (SciELO), Science Direct, PubMed e scopus, por meio dos termos *Musa* spp, antioxidant, activities biologics e phytochemical intercalados pelo operador booleano AND. O recorte temporal foi de 2017 a 2022 e 28 trabalhos foram selecionados para análise. Em relação à constituição fitoquímica foi possível concluir que as variedades avaliadas são ricas em flavonoides. Para a atividade antioxidante observou-se que *Musa* spp. apresentam boa performance nos testes antioxidantes do DPPH e FRAP. E para as atividades biológicas as espécies analisadas se destacaram pelo seu potencial como antibacteriano, anticancerígeno e antifúngico. Vários trabalhos revisados apresentaram que os constituintes químicos presentes nas espécies favorecem o bom desempenho antioxidante, esse, por sua vez, influencia positivamente no desempenho das atividades biológicas descritas.
Palavras-chave: banana, moléculas bioativas, caracterização química.

Banana (*Musa* spp.) is a tropical fruit with specific requirements for humidity, temperature and well-distributed precipitation for its ideal development. It is a complete herb consisting of roots, stems, leaves, fruits and seeds. Banana is a staple and affordable food that causes satiety, is rich in nutrients and is easy to reproduce and manipulate. Notably, the genus *Musa* is the fourth most important food commodity in the world (ALVES, 1999; REVADIGAR et al., 2017).

In Brazil, the per capita consumption of bananas is 25 kg per year, with the Southeast region being the largest producer in the country (EMBRAPA, 2021). Therefore, banana is of great importance for the Brazilian and world economy. Besides its value as a nutritional food, this genus is widely used in search of health benefits. Prior studies reported the existence of biological and antioxidant properties of *Musa* spp. associated with phytochemical constituents, which play a crucial role in preventing and treating diseases.

Given the benefits of banana (*Musa* spp.), this review article synthesized and organized information about the phytochemical constituents and antioxidant and biological activities reported in *Musa acuminata*, *Musa balbisiana* and *Musa paradisiaca* and evaluated the mutual influence and correlation of biological activities. The purpose was to assess: i) the most investigated biological activities of these species, ii) the most used methods/protocols in each analysis and iii) the main results obtained in the literature.

Received 11.17.22 Approved 02.25.26 Returned by the author 03.28.23
CR-2022-0636.R1
Editors: Rudi Weiblen Ivo Oliveira

The literature search was carried out in October 2021 and updated in November 2022. The following terms were used: *Musa* spp., antioxidant, biological activities and phytochemical, combined by the Boolean operator AND to find the papers associating the four search terms. The analysis period was from 2017 to 2022. The scientific databases used, and their respective number of articles found, were Google Scholar (281), SciELO (3), Periódicos Capes (1), Scientific Electronic Library Online (SciELO) (0), Science Direct (0), PubMed (0) and Scopus (0).

The inclusion criteria were the use of bananas as an object of study and evaluation of at least one of the following aspects: (i) antioxidant activities; (ii) analysis of phytochemical constituents; (iii) biological activities, such as cytotoxicity, anticytotoxicity, antiviral, antimicrobial and other properties; and (iv) description of the species/variety used in the study. At the end of the literature search, 30 full-text articles met the inclusion criteria and were analyzed.

Several studies were excluded, as they provided an incomplete description of the research object. This fact may be related to the lack of understanding of terms such as: "genus," "type," "variety," and "genotype." In general, the authors limit themselves to describing the genus (*Musa*) without specifying the genomic group or the variety and rarely use the popular name of the chosen variety. This is an essential point to be observed in future publications.

The articles refer to the species generically, using terms such as: "*Musa acuminata* Colla," "*Musa paradisiaca*," "*Musa* spp.," and "*Musa balbisiana* Colla." It is believed that these generic terms are often used because the studies included in this review described activities of interest for human health promotion and, therefore, did not detail the characteristics of the fruits. Thus, most research was carried out with bananas already used in food or that have some traditional use by people. Importantly, most studies investigated more than one variety of bananas and compared them.

Twenty-seven works opted for the extract to prepare the plant material, and maceration was the most used extraction method. The maceration time ranged from a minimum of 12 hours to a maximum of 3 washing cycles lasting 72 h each. One of the studies that did not use an extraction procedure applied the method of spraying the fruit pulp in liquid nitrogen, and this material was used to carry out the experimental tests.

Among the studies that prepared extracts, solvents with different polarities were frequently used to compare the influence of polarity on the results. Table 1 displays the solvents used. When the study involved only one extract, it was common to use methanol, ethanol, or water.

The most used solvents were ethanol and methanol, respectively. These solvents are commonly considered due to their characteristic of carrying a great number of chemical constituents without selecting certain groups. Numerous studies compared banana extracts with solvents of different polarities. AMRI & HOSSAIN (2018), for example, used methanol to prepare the crude extract, followed by a partition with *n*-hexane, chloroform, ethyl acetate,

Table 1 - Extraction solvents used in the studies included in this review.

Solvents	References
Ethanol	KIBRIA et al., 2019; MOLINA-SALINAS et al., 2019; PERUMAL et al.; 2020; UMAMAHESWARI et al., 2017; VALSALAM et al., 2019; SONIBARE et al., 2018; THAWEESANG, 2019; BASUMATARY & NATH, 2017; EVBUOMWAN et al., 2018; REVADIGAR et al., 2017; OYAWALUJA et al., 2020; and PANDA et al., 2020
Methanol	KIBRIA et al., 2019; AYOOLA-ORESANY et al., 2019; BEHIRY et al., 2019; DAIMARI & SWARGIARY, 2020; AMRI & HOSSAIN, 2018 and UMAMAHESWARI et al., 2017*.
Aqueous	KIBRIA et al., 2019; VALSALAM et al., 2019; PANDA et al., 2020 and FERRERAS, 2021
Hexane	MOLINA-SALINAS et al., 2019; NOFIANTI et al., 2021 and PANDA et al., 2020
Acetone	KIBRIA et al., 2019 AND PANDA et al., 2020
Ethyl acetate	MOLINA-SALINAS et al., 2019 AND NOFIANTI et al., 2021
Pseudostem exudate	ABDEL-GHANY et al., 2018
DMSO	BASHIR et al., 2021
70% ethanol	CHIANG et al., 2020; GHAFAR et al., 2019; BARROSO et al., 2019; LOYAGA-CASTILLO et al., 2020 and DEWI et al., 2019
Sap	ABDEL-GHANY et al., 2018
Stem juice	NGUYEN et al., 2017

n-butanol, ethanol and water. After the experimental tests, the authors concluded that all-polarity banana extracts showed potential medicinal applications and exhibited antioxidant activity by the DPPH method.

Different parts of the plant were used in the studies: fruit, leaves, bracts, inflorescences and pseudostem exudates. The fruit was the most used, and the pulp and peel were analysed separately. The authors highlighted that banana peel extracts showed more promising results for antioxidant and biological properties than pulp extracts. The other parts are described for more specific activities, which will be explored in the following sections.

Phytochemical constituents

The phytochemical profile was evaluated by 23 of the 28 selected articles. Table 2 depicts all the groups found in these works. The most frequent compounds were flavonoids, phenols, tannins and alkaloids, respectively. Few studies have mentioned the concentrations of each compound, evidencing flavonoids as the most abundant phytochemicals.

GOBBO-NETO & LOPES (2007) described the influence of edaphoclimatic factors on the secondary metabolism of plant species and, consequently, the phytochemical groups found. Such variations can be due to plant location, altitude, temperature, precipitation and management, in addition to the age of the plant, fruit maturation after harvest, the season of the year, whether it is flowering or non-flowering and other factors. Despite the importance of these characteristics, the articles did not explore their relevance and rarely described them.

Table 2 - Phytochemical constituents reported in the studies included in this review.

Phytochemicals	References
Flavonoids	KIBRIA et al., 2019; VALSALAM et al., 2019; BEHIRY et al., 2019; DAIMARI & SWARGIARY, 2020; OLIVEIRA et al., 2020, BASHIR et al., 2021 BASUMATARY & NATH, 2017; EVBUOMWAN et al., 2018; UMAMAHESWARI et al., 2017; REVADIGAR et al., 2017; GHAFAR et al., 2019 and DEWI et al., 2019
Glycoside flavonoids	BARROSO et al., 2019
Aglycone flavonoids	BARROSO et al., 2019
Phenols	KIBRIA et al., 2019; BEHIRY et al., 2019; SWARGIARY, 2020; BASHIR et al. 2021, THAWEESANG, 2019; BASUMATARY & NATH 2017, AMRI & HOSSAIN, 2018; REVADIGAR et al., 2017 and GHAFAR et al. 2019
Tannins	KIBRIA et al., 2019; VALSALAM et al., 2019; BASHIR et al.,2021; UMAMAHESWARI et al., 2017 and DEWI et al., 2019
Alkaloids	KIBRIA et al., 2019; VALSALAM et al., 2019, BASUMATARY & NATH,2017; EVBUOMWAN et al., 2018 and UMAMAHESWARI et al., 2017
Steroids	VALSALAM et al., 2019; BASHIR et al., 2021 and REVADIGAR et al., 2017
Polyphenols	SONIBARE et al., 2018; OLIVEIRA et al., 2020; UMAMAHESWARI et al., 2017 and BARROSO et al., 2019
Carbohydrates	KIBRIA et al., 2019; DAIMARI & SWARGIARY, 2020 and BASHIR et al., 2021
Saponins	KIBRIA et al., 2019 and UMAMAHESWARI et al., 2017
Glycosides	KIBRIA et al., 2019 and BASHIR et al., 2021
Cardiac glycosides	VALSALAM et al., 2019
Anthraquinone	VALSALAM et al., 2019
Terpenoids	KIBRIA et al., 2019 and BASHIR et al., 2021
Cinnamic acids	OLIVEIRA et al., 2020
Proteins	VALSALAM et al., 2019 and DAIMARI & ESWARGIARY, 2020
Reducing sugars	KIBRIA et al., 2019
Phytosterols	KIBRIA et al., 2019
Quinones	EVBUOMWAN et al., 2018
Coumarins	UMAMAHESWARI et al., 2017
Fatty acids	REVADIGAR et al., 2017
Phenolic acids	BARROSO et al., 2019
Catecholamines	BARROSO et al., 2019
Long-chain aliphatic compounds	BARROSO et al., 2019

AYOOLA-ORESANYA et al. (2020) reported a significant variation in total phenolic and total flavonoid contents among different *Musa* spp. accessions. The authors discuss the importance of characterising genotypes already used in food to recognize other properties of commercial banana varieties.

Regarding the phytochemical constituents, only four researches used mass spectrometry-based techniques to determine functional groups and metabolites in bananas. NGUYEN et al., 2017 reported the presence of p-hydroxybenzoic and gallic acids. REVADIGAR et al. (2017) identified 22 compounds, mainly steroids, fatty acids and long-chain aliphatic compounds. Remarkably, the researchers attributed the antioxidant and cytotoxic activities found in the experimental results to these secondary metabolites. OLIVEIRA et al. (2020) verified the predominance of flavonoids and cinnamic acids, of which 20 polyphenols were detected. PERUMAL et al. (2020) revealed the presence of Z-2-tridecen-1-ol, nonadecane-2,4-dione, α-ketostearic acid, 2,5-furan dione and dihydro-3-(2-tetradecenyl), which were reported as potent antioxidant substances.

Antioxidant activity

The antioxidant potential of the extracts was mainly determined by enzymatic and non-enzymatic methods. Table 3 describes all the tests carried out by the researches. The DPPH (2,2-diphenyl-1-picryl-hydrazyl) assay was the most recurrent and showed the best performance, followed by the FRAP (ferric reducing antioxidant power) assay. Other non-enzymatic tests, such as ABTS [2,2’-azinobis (3-ethylbenzothiazoline-6-sulphonic acid)] and nitric oxide radicals, were also performed but showed fewer promising results, suggesting that this is one reason they were less used in experiments with *Musa* species.

The investigations that assessed antioxidant activities commonly related them to phytochemical constituents and biological activities. This relationship is because bananas have antioxidant properties through different mechanisms of action. In the case of DPPH, the mechanism of action is free radical scavenging. The FRAP mechanism acts by reducing iron. The mechanisms of action can be easily applied in the human body, as they would participate in primary metabolic reactions for the organism’s survival. Thus, the antioxidant potential is positively associated with the biological activities that will be subsequently explored. In turn, according to the authors, the antioxidant activity described here is directly related to the predominant phytochemical compounds of the studied species.

Biological activities

The search for natural substances already consumed on a large scale and with biological activities is growing and accelerating. Accordingly, numerous studies have been conducted to confirm and elucidate the active properties of bananas and other foods widely used by traditional medicine throughout the world. Indeed, the traditional use is pointed out as a justification in various papers included in this review.

Table 4 presents the biological activities reported in the studies. Most of them confirmed an activity previously described by the region’s population where bananas were harvested or purchased. The most tested and promising activities

Table 3 - Antioxidant assays performed in the reviewed studies.

Antioxidant assay	References
DPPH	KIBRIA et al., 2019;VALSALAM et al., 2019, DAIMARI & SWARGIARY, 2020; THAWEESANG, 2019; BASUMATARY & NATH 2017; AMRI & HOSSAIN, 2018; CHIANG et al., 2020; REVADIGAR et al., 2017 and NOFIANTI et al., 2020
FRAP	SWARGIARY, 2020; SONIBARE et al., 2018; BASUMATARY & NATH (2017), CHIANG et al., 2020; REVADIGAR et al., 2017 and GHAFAR et al., 2019
ABTS	KIBRIA et al., 2019 and REVADIGAR et al., 2017
Nitric oxide (NO) radical	PERUMAL et al., 2020 and OLIVEIRA et al., 2020
Total antioxidant	VALSALAM et al., 2019
Superoxide radical inhibition	PERUMAL et al., 2020
Ferrous ion chelating ability	CHIANG et al., 2020

Table 4 - Biological activities described by the reviewed studies.

Part of the plant	Biological activity	References
Leaves, peel, pulp and bracts	Antibacterial	AYOOLA-ORESANYA et al., 2020; VALSALAM et al., 2019; BEHIRY et al., 2019; EVBUOMWAN et al., 2018; UMAMAHESWARI et al., 2017 and DEWI et al., 2019
Peel and inflorescence	Anticancer	VALSALAM et al., 2019; REVADIGAR et al., 2017 and BARROSO et al., 2019
Peel	Antifungal	BEHIRY et al., 2019 and LOYAGA-CASTILHO et al., 2020
Leaves	Toxicity	AYOOLA-ORESANYA et al., 2020; VALSALAM et al., 2019 and GHAFAR et al., 2019
Leaves	Antituberculosis	MOLINA-SALINAS et al., 2019
Leaves	Mycobactericidal	MOLINA-SALINAS et al., 2019
Fruit	Chemopreventive	OLIVEIRA et al., 2020
Peel	Antihyperglycemic	NOFIANTI et al., 2020
Stem juice	α-Glucosidase inhibition	NGUYEN et al., 2017

were antibacterial, anticancer, antifungal and antitoxic activities, both for healthy and cancerous cells. The confirmation of such properties indicated that ethnobiology is a key tool for guiding the development of basic research.

Regarding antibacterial potential, DEWI et al. (2019) documented a significant difference in the zone of inhibition of *Vibrio* sp. and reinforced the importance of prospecting for new antibacterial compounds, given the discussion on bacterial resistance. Noteworthily, the anticancer property is another well-recognized bioactivity of great interest since the number of cancer cases has been increasing over the years. BARROSO et al. (2019) investigated this activity using four distinct cell lines: hepatocellular carcinoma HepG2, malignant melanoma A-375, breast carcinoma MCF-7 and human colorectal adenocarcinoma Caco-2 cells. The findings revealed that banana extracts induced cell death in all cell lines tested through multiple mechanisms, including increased reactive oxygen species (ROS), apoptosis and necrosis.

CONCLUSION

In conclusion, the banana varieties evaluated in the studies are rich in flavonoids, show good performance in DPPH and FRAP antioxidant assays and exhibit antibacterial, anticancer and antifungal potential.

The phytochemical constituents present in the species contributed to the antioxidant profile of bananas, positively influencing the performance of the biological properties described by the authors.

Despite the number of publications devoted to this topic, the experimental tests carried out did not show great variety. Additionally, the descriptions of the material used and the extraction method make it difficult to compare the results, requiring the filtering of most works. Thus, further in-depth studies are needed to more accurately identify the varieties used and better specify fruit maturation levels and the parts used, as these characteristics directly affect biological activities.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for the scholarship granted, the Universidade Federal do Espírito Santo (UFES) and Leandro Barcellos for all the contribution and support during the development of this review.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no competing interests.

AUTHORS' CONTRIBUTIONS

The authors contributed equally to this work.

REFERENCES

ABDEL-GHANY, T. M. et al. Antioxidant, antitumor, antimicrobial activities evaluation of *Musa paradisiaca* L. pseudostem exudate cultivated in Saudi Arabia. **Bio Nano Science**, v.9, p.172-178,

2018. Available from: <https://doi.org/10.1007/s12668-018-0580-x>. Accessed: Oct. 05, 2021.

ALVES, E. J. **A cultura da banana**: Aspectos técnicos, socioeconômicos e agroindustriais. 2ª ed., Brasília: EMBRAPA, 1999.

AMRI, F. S. A.; HOSSAIN, M.A. Comparison of total phenols, flavonoids and antioxidant potential5 of local and imported ripe bananas. **Egyptian Journal of Basic and Applied Sciences**, v.5, p.245-251, 2018. Available from: <https://doi.org/10.1016/j.ejbas.2018.09.002>. Accessed: Oct. 15, 2021. doi: 10.1016/j.ejbas.2018.09.002.

AYOOLA-ORESANYA, I. O. et al. Effect-directed profiling and identification of bioactive metabolites from the field, in vitro-grown and acclimatized *Musa* spp. accessions using high-performance thin-layer chromatography-mass spectrometry. **Journal of Chromatography A**, v.1616, 2020. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S0021967319312221?via%3Dihub>. Accessed: Oct. 02, 2021. doi: 10.1016/j.chroma.2019.460774.

BARROSO, W. A. et al. Chemical composition and cytotoxic screening of *Musa cavendish* green peels extract: Antiproliferative activity by activation of different cellular death types. **Toxicology in Vitro**, 2019. Available from: <https://pubmed.ncbi.nlm.nih.gov/31018149/>. Accessed: Oct. 20, 2021. doi: 10.1016/j.tiv.2019.04.020.

BASHIR, F. et al. Phytochemistry and antimicrobial activities of different varieties of banana (*Musa acuminata*) peels available in Quetta City. **Polish Journal of Environmental Studies**, v.30, p.1531-1538, 2021. Available from: <http://www.pjoes.com/Phytochemistry-and-Antimicrobial-Activities-nof-Different-Varieties-of-Banana-*Musa*,122450,0,2.html>. Accessed: Oct. 16, 2021. doi: 10.15244/pjoes/122450.

BASUMATARY, S.; NATH, N. Assessment of chemical compositions and in vitro antioxidant properties of *Musa balbisiana* Colla inflorescence. **International Journal of Pharmaceutical Research**, v.10, 2017. Available from: <http://www.ijpronline.com/ViewArticleDetail.aspx?ID=5324>. Accessed: Oct. 16, 2021.

BEHIRY, S. I. et al. Antifungal and antibacterial activities of *Musa paradisiaca* L. peel extract: HPLC analysis of phenolic and flavonoid contents. **MDPI Processes**, v.4, 2019. Available from: <https://www.mdpi.com/2227-9717/7/4/215>. Accessed: Oct. 15, 2021. doi: 10.3390/pr7040215.

CHIANG, S. et al. Evaluation of the in vitro biological activities of banana flower and bract extracts and their bioactive compounds. **International Journal of Food Properties**, 2020. Available from: <https://www.tandfonline.com/doi/full/10.1080/10942912.2020.1856134> Accessed: Oct. 22, 2021. doi: 10.1080/10942912.2020.1856134.

DAIMARI; SWARGIARY, A. Study of phytochemical content and antioxidant properties of *Musa balbisiana* corm extract. **Indian Journal of Pharmaceutical Sciences**, 2020. Available from: <https://www.ijpsonline.com/articles/study-of-phytochemical-content-and-antioxidantproperties-of-*Musa*-balbisiana-corm-extract-4001.html>. Accessed: Oct. 15, 2021. doi: 10.36468/pharmaceutical-sciences.698.

DEWI, S. A. et al. Potensi ekstrak kulit pisang 'Kepok Kuning' (*Musa acuminata* x *Musa balbisiana*) sebagai antibakteri terhadap *Vibrio* sp. **Universitas Maritim Raja Ali Haji**, 2019. Available from: <http://repositori.umrah.ac.id/768/> Accessed: Oct. 18, 2021.

EMBRAPA. **Produção brasileira de 2021**. Available from: <http://www.cnpmf.embrapa.br/Base_de_Dados/index_pdf/dados/brasil/banana/b1_banana.pdf>. Accessed: Oct. 04. 2021.

EVBUOMWAN, L. et al. Evaluating the antibacterial activity of *Musa acuminata* (banana) fruit peels against multidrug resistant bacterial isolates. **International Journal of Novel Research in Life Sciences**, v.5, p.26-31, 2018. Available from: <https://www.semanticscholar.org/paper/EVALUATING-THE-ANTIBACTERIAL-ACTIVITY-OF-*Musa*-FRUIT-Evbuomwan-Jacob/d7902369cba1637c7c260eb797128dc7a5d40c66>. Accessed: Oct. 16, 2021.

FERRERAS, J. M. et al. Isolation, purification and characterization of proteins in 'Señorita' banana (*Musa acuminata* (AAA) 'Señorita') pulp with bioactive peptides exhibiting antihypertensive and antioxidant activities. **Applied Sciences**, v.11, 2021. Available from: <https://www.mdpi.com/2076-3417/11/5/2190>. Accessed: Oct. 20, 2021. doi: 10.3390/app11052190.

GHAFAR, S. A. A. et al. Antioxidant activity of *Musa paradisiaca* (Banana) soft pith and its cytotoxicity against oral squamous carcinoma cell lines. **Malaysian Journal of Science, Health & Technology**, v.3, p.8-11, 2019. Available from: <https://oarep.usim.edu.my/jspui/handle/123456789/5365>. Accessed: Oct. 21, 2021.

GOBBO-NETO, L.; LOPES, N. P. Plantas medicinais: Fatores de influência no conteúdo de metabólitos secundários. **Química Nova**, v.30, n.2, p.374–381, 2007. Available from: <https://doi.org/10.1590/S0100-40422007000200026>. Accessed: feb. 18, 2023.

KIBRIA , A. et al. Extraction and evaluation of phytochemicals from banana peels (*Musa sapientum*) and banana plants (*Musa paradisiaca*). **Malaysian Journal of Halal Research Journal**, v.2, 2019. Available from: <https://www.researchgate.net/publication/338346231_Extraction_and_Evaluation_of_Phytochemicals_from_Banana_Peels_*Musa*_sapientum_and_Banana_Plants_*Musa_paradisiaca*>. Accessed: Oct. 03, 2021. doi: 10.2478/mjhr-2019-0005.

LOYAGA-CASTILHO, M. et al. Antifungal activity of Peruvian banana peel (*Musa paradisiaca* L.) on *Candida albicans*: An in vitro study. **Journal of Contemporary Dental Practice**, v.21, p.509-514, 2020. Available from: <https://siis.unmsm.edu.pe/en/publications/antifungal-activity-of-peruvian-banana-peel-*Musa*-paradisiaca-l-on>. Accessed: Oct. 18, 2021. doi: 10.5005/jp-journals-10024-2827.

MOLINA-SALINAS, G. M. et al. Bactericidal effect of the leaf extract from *Musa* spp. (AAB Group, Silk Subgroup), cv. 'Manzano' against multidrug-resistant *Mycobacterium tuberculosis*. **Journal of Medicinal Food**, v.0, p.1-3, 2019. Available from: <https://pubmed.ncbi.nlm.nih.gov/31268391/>. Accessed: Oct. 08, 2021. doi: 10.1089/jmf.2019.0075.

NGUYEN, D. et al. Antidiabetic compounds in stem juice from banana. **Food Analysis, Food Quality and Nutrition**, v.35, p.407-413, 2017. Available from: <https://www.agriculturejournals.cz/publicFiles/172_2017-CJFS.pdf>. Accessed: Oct. 20, 2021. doi: 10.17221/172/2017-CJFS.

NOFIANTI, T. et al. Klutuk banana (*Musa balbisiana* Colla) peel fractions: antioxidant and antihyperglycemic potential.

International Journal of Applied Pharmaceutics, v.13, p.1-6, 2020. Available from: <https://innovareacademics.in/journals/index.php/ijap/article/view/41053>. Accessed: Oct. 20, 2021. doi: 10.22159/ijap.2021.v13s2.01.

OLIVEIRA, B. G. et al. Phenolic and glycidic profiling of bananas *Musa* sp associated with maturation stage and cancer chemoprevention activities. **Microchemical Journal**, v.153, 2020. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S0026265X19321332>. Accessed: Oct. 14, 2021. doi: 10.1016/j.microc.2019.104391.

OYAWALUJA, A. A.; et al., Extraction and estimation of pectins from unripe, ripe and overripe banana (*Musa acuminata* L.) and plantain (*Musa paradisiaca* L.) peels and their antioxidant activities. **Nig. J. Pharm. Res**. v.16, 2020. Available from: <http://www.nigjpharmres.com>. Accessed: Oct. 22, 2021. doi: 10.4314/njpr.v16i1.10.

PANDA, S. K. et al. Antiviral and cytotoxic activity of different plant parts of banana (*Musa* spp.). **Viruses**, v.12, 2020. Available from: <https://pubmed.ncbi.nlm.nih.gov/32429324/>. Accessed: Oct. 18, 2021. doi: 10.3390/v12050549.

PERUMAL, A. et al. Phytochemical analysis, antioxidant activities and gc-ms profiling of ethanol bract extract of *Musa paradisiaca* L. **Journal of Drug Delivery & Therapeutics**, v.10, p.167-175, 2020. Available from: <http://jddtonline.info/index.php/jddt/article/view/4273>. Accessed: Oct. 06, 2021. doi: 10.22270/jddt.v10i4-s.4273.

REVADIGAR, V. et al. Anti-oxidative and cytotoxic attributes of phenolic rich ethanol extract of *Musa balbisiana* Colla inflorescence. **Journal of Applied Pharmaceutical Science**, v.7, p.103-110, 2017. Available from: <https://www.bibliomed.org/?mno=224862>. Accessed: Oct. 18, 2021. doi: 10.7324/JAPS.2017.70518.

SONIBARE, M. A et al. Leaves metabolomic profiling of *Musa acuminata* accessions using UPLC-QTOF-MS/MS and their antioxidant activity. **Journal of Food Measurement and Characterization**, v.12, p.1093-1106, 2018. Available from: <https://www.*Musa*lit.org/seeMore.php?id=17408>. Accessed: Oct. 14, 2021.

THAWEESANG, S. Antioxidant activity and total phenolic compounds of fresh and blanching banana blossom (*Musa* ABB CV. Kluai 'Namwa') in Thailand. **Scilit**, v.639, 2019. Available from: <https://www.scilit.net/article/f3363c518e727eb717d9bb6666c91131>. Accessed: Oct. 16, 2021. doi: 10.1088/1757-899x/639/1/012047.

UMAMAHESWARI, A. et al. Phytochemical screening and antimicrobial effects of *Musa acuminata* bract. **International Research Journal of Pharmacy**, v.8, p.41-44, 2017. Available from: <https://www.irjponline.com/admin/php/uploads/2748_pdf.pdf>. Accessed: Oct. 16, 2021. doi: 10.7897/2230-8407.088142.

VALSALAM, S. et al. Biosynthesis of silver and gold nanoparticles using *Musa acuminata* Colla flower and its pharmaceutical activity against bacteria and anticancer efficacy. **Photochemistry and Photobiology**, v.201, 2019. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S101113441931293X>. Accessed: Oct. 07, 2021. doi: 10.1016/j.jphotobiol.2019.111670.