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# *Musa sapientum* L. (banana): potential for drug development

***Ludmylla Fernanda Almeida Pereira***

***Wellyson da Cunha Araújo Firmo***
http://lattes.cnpq.br/2261911621272178

***Denise Fernandes Coutinho***
http://lattes.cnpq.br/7346399893912346

**Abstract:** Fruits are sources of vitamins, sugars and bioactive compounds associated with reducing the risk of diseases, such as those related to the heart system, gastrointestinal tract, bacterial infections, diabetes, among others. In addition to being widely used in the production of functional foods, in recent years, the pharmaceutical industry has been researching various fruits to be used in the production of medicines. Among the plant species that produce fruits appreciated all over the world, Musa *sapientum* L., popularly known as banana tree, stands out. The objective of this article was to carry out an integrative review of the scientific literature on the plant species *Musa sapientum* L. (Musaceae), highlighting its biological properties already demonstrated in pre-clinical tests. The search was carried out in Pubmed, Google Scholar and ScienceDirect databases, using appropriate descriptors and inclusion and exclusion criteria. A total of 735 files were identified, after the screening process, 52 articles were selected and analyzed. The results showed that the fruit of this species has already been extensively studied from the point of view of biological activities, especially antibacterial, antioxidant, antidiabetic, anti-inflammatory. The scientific articles analyzed confirm the traditional use of this fruit in the treatment of diseases and that many have already been evaluated through pre-clinical trials. However, no clinical study has ever been conducted with this fruit. Thus, it is concluded that there are numerous proven biological properties for the species *M. sapientum,* data that can encourage further research, generating more use and elucidating issues that have not yet been clarified for the development of effective and safe drugs.

**Keywords:** Musaceae; Traditional medicine; banana tree.

## INTRODUCTION

Fruits are essential foods in a healthy diet, as they present several essential elements for health, such as vitamins, minerals, fibers and other bioactive compounds that favor the maintenance of health [1].

The species Musa sapientum L., popularly known as banana tree, belonging to the Musaceae family, is a typical tropical fruit tree, whose fruit is considered a basic and important food in this region. It is cultivated in several countries, mainly in tropical and subtropical regions, being originally from Southeast Asia [2,3].

The fruits of this species, called silver banana, are a source of vitamins, sugars and bioactive compounds associated with reducing the risk of diseases, such as those related to the gastrointestinal tract, bacterial infections and diabetes. It is a tree, forming shoots that turn into fruiting stems and these fruits are green or yellow, long in shape and produced in clusters. Its leaves appear in the center of the pseudostem [3].

Several studies indicate that the fruits of this species have a varied chemical composition, being significant sources of phenolic compounds, including phenolic acids, flavonoids and glycosides. They stand out for having antioxidant action, mainly related to carotenoids, vitamin C (ascorbic acid) and vitamin A (retinol), in addition to phenolic components [4].

Historically, products from medicinal plants originated in common sense knowledge and were scientifically proven through research with the advancement of science, ranging from pre-clinical to clinical studies, enabling the development of safe and effective drugs [5]. Considering the importance of proving the pharmacological actions of plant species, this research aimed to carry out a study of the species Musa sapientum, in order to identify the scientific advances associated with its biological properties, especially its fruits, for the dissemination of updated information and identification of gaps in their studies.

## MATERIAL AND METHODS

This is an integrative review study, as well as a critical one, which was carried out in the electronic databases: Pubmed, Google Scholar, Periódicos CAPESand ScienceDirect. The descriptors were used: Musa sapientum, biological activity, using the Boolean operator "AND". The inclusion criteria adopted in this research were articles with full text available, published between 2011 and 2021, which presented an evaluation of the biological activities of M. sapientum extracts.

Review articles, dissertations, theses, books, duplication of articles on different platforms, name of another species of Musa spp. in the title, articles that did not describe which part of *M. sapientum used* and did not understand biological activity. Those that could not be read in full were also excluded.

To complement the research, clinical studies with this species were raised with the following descriptors "Musa sapientum" and "clinical trial", in the same databases described above.

After the selection, the reference list of the selected ones was also verified to carry out the crossing of the data found, within the established inclusion criteria. Then, they were submitted to an exploratory and selective reading on the topic to identify the related data according to the objective. After analyzing the titles and abstracts, the files that met the criteria were read in full. Data were organized in a Microsoft® Excel spreadsheet. The process is described in Figure 1.

## RESULTS AND DISCUSSION

From the analysis of the 52 articles included in the review, it was identified that the species *Musa sapientum* has already been submitted to numerous pre-clinical biological assays, highlighting the most studied actions: antibacterial (19%), antioxidant (18%), antidiabetic (13 %), anticarcinogenic (7%), antiulcerogenic (6%), anti-inflammatory (4%), hepatoprotective (4%), antiparasitic (4%), antihypercholesterolemic (3%), antidiarrheal (3%). The other activities such as: healing, antifungal, anticonvulsant, analgesic, anxiolytic, antidepressant, anti-wrinkle, antimelanogenesis, diuretic, anti - atherosclerosis and anti-colitis were found in only 1 article each, totaling 1% each, such information is shown in the Figure 2. These numbers are independent of the number of articles in total included, but the quantity of identified biological activity, since different biological activities are studied in several articles.

In producing countries, bananas, such as Brazil, play a major role in the social and economic impact, serving as income for producers who use the crop to employ several people, considering that it contributes to the development of the region [6].

Another important point to note is the question of plant metabolism. Plants represent true living laboratories that produce different metabolites classified as primary and secondary. The primary ones are related to the vital processes of these species, such as carbohydrates, proteins, lipids, nucleic acids, among others. Secondary metabolites are produced to relate plants to the environment in which they live, allowing their survival. The main examples of secondary metabolites are flavonoids, tannins, alkaloids, terpenes, etc [7]. fruits present the pulp as part used in food, and their peels are considered by-products, as they are wasted in this process. The pulp of the fruit of *Musa sapientum* L. stands out for having a high content of sugars (carbohydrates) and vitamins. Its peels have already been studied and the presence of

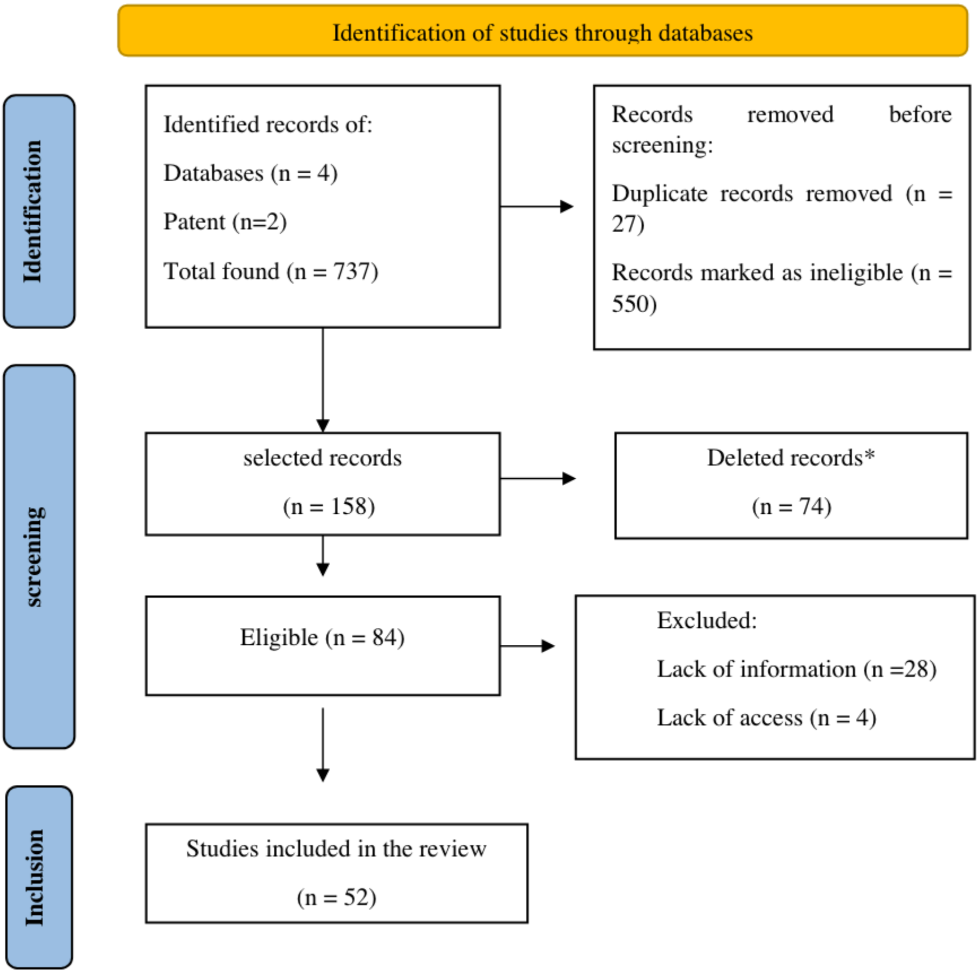


Figure 1. Flowchart PRISMA 1 - Identification of studies via databases. Source: PRISMA adapted by the author (2022). * means outside the inclusion criteria.

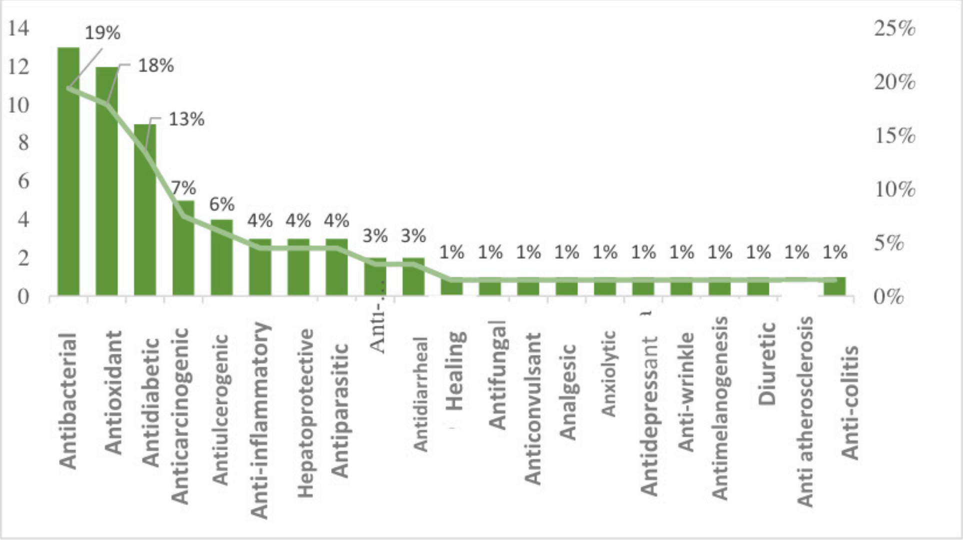


Figure 2. Distribution of articles in relation to the biological activity performed.

Source: Authors ( 2022).

steroids, flavonoids, tannins, leukocyanidin has been verified. These metabolites have different physicochemical properties, such as polarities, and are the main responsible for their biological activities, highlighting the secondary metabolites.

To carry out a study of the biological activity of a plant, these metabolites need to be extracted. When these are not volatile, the classic extraction involves the participation of one or more solvents and the product of the process is called extract. From a plant species, several extracts of different polarities and consequently different chemical compositions can be obtained [7]. To determine the quality of an extract, there are basic parameters: part of the plant used, the solvent, the concentration (drug-solvent) used, the extraction method and time. The ethanolic solvent or its mixture with alcohol, corresponds to the extract most used in phytochemical studies, due to its cost-benefit, being able to extract large amounts of both primary and secondary metabolites, and despite being polar, they can also extract nonpolar components. Ethanol or hydroethanolic extracts are considered the most appropriate for the scientific study of the biological activity of plants and may present several metabolites such as tannins, polyacetylenes, flavonols, terpenoids, steroids, alkaloids, etc. [8].

Com a finalidade de sintetizar os dados obtidos, a Tabela 1 foi elaborada para classificar a parte utilizada da banana no estudo, bem como o tipo de extrato e qual atividade biológica foi exercida. In this survey carried out on *M. sapientum,* it was observed that the most used extract for the studies of the biological activities of this species was the ethanolic extract (51.46%), followed by the methanolic extracts (23.30%), aqueous (13.59%), hexane (3.88%), acetone (3.88%), chloroform (1.94%) and ethyl acetate (0.97%).

## ANTIMICROBIAL ACTIVITY

In fourteen selected articles on antimicrobial activity, the extraction methodology was used, using different solvents, and the following extracts were evaluated: ethanolic, aqueous alkaline, acetone, methanolic, hexane and ethyl acetate. These studies confirmed the activity against Gram negative bacteria such as: *Escherichia coli, Enterobacter* spp., *Klebsiella pneumoniae, Pseudomonas aeruginosa* and Gram-positive bacteria: *Bacillus cereus, Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermidis, Propionibacterium acnes, Salmonella* spp., *Enterococcus faecalis, Streptococcus* spp, *Lactobacillus* sp. One of the studies cited antibiofilm activity caused by *C andida albicans* [9, 10, 11, 12, 13, 14, 15, 16, 17, 52, 55, 56, 57].

The most used method to evaluate this activity was disk diffusion followed by broth microdilution, both methods are necessary to obtain reliable results, but not necessarily the same result will be obtained in the different methods, since there is the influence of diffusion in media. different culture. Just as the choice of method can change the result, the choice of different solvents can also lead to different actions, by distinguishing the metabolites obtained in the different extractions [11].

Siddique et al. (2018) [14] evaluated antibacterial activity on different microorganisms *S. aureus, B. subtilis, P. aeruginosa, E. coli,* using different extracts, aqueous and ethanolic. The results show that the aqueous extract obtained from the peel of the fruit of *M. sapientum* showed greater antibacterial activity compared to the ethanolic extract of the same part. Sithya et al. (2018) [2] showed greater sensitivity against *S. aureus* compared to *E. coli bacteria when using M. sapientum* flower alkaline extract, making Gram-positive bacteria more

| Biological activity | used part | Extract | Methodology | Reference |
|---|---|---|---|---|
| **antibacterial _** | fruit peel | ethanolic and aqueous | disk broadcast | Siddique et al (2018) |
| | Flower | alkaline extraction | disk broadcast | Sitthya et al (2018) |
| | Leaves and pseudostem | Ethanol and acetone | Microdilution in broth | Jouneghani et al (2020) |
| | bark | methanolic | disk broadcast | Mordi et al (2016) |
| | Pseudostem and rhizome | Chloroform, acetone, hexane, methanol and ethyl acetate | MIC | Kandasamy (2016) |
| | Seed | methanolic | disk broadcast | Hossain (2011) |
| | fruit peel | AT | disk broadcast | Ruangtong (2020) |
| | fruit peel or | ethanolic | disk broadcast | Kusuma (2020) |
| | Sheets | methanolic | disk broadcast | Sahaa (2013) |
| | fruit peel | Aqueous | well diffusion | Chabuck (2013) |
| | Pulp | Aqueous, hexane and ethanolic | disk broadcast | Ned (2015) |
| | fruit peel | Ethanol, methanol, acetone and aqueous | well diffusion | Aboul- Eneim (2016) |
| | fruit peel | Aqueous | culture medium | Lino (2011) |
| **antioxidant** | fruit peel | ethanolic and aqueous | DPPH and ferric reducing activity | Siddique et al (2018) |
| | leaves and pulp | methanolic | DPPH | Ayoola (2017) |
| | Bark, pulp and seed | methanolic | DPPH, iron reducing activity, reducing ability of cupric ion and phosphomolybdenum | Imam (2011) |
| | Pulp | AT | Ability to scavenge the 2,2-azinobis 3-ethylbenzothiazoline 6-sulfonate (ABTS) radical | Adedayo (2016) |
| | Flower | ethanolic | DPPH | Khongkhon (2017) |
| | spadix | methanolic | DPPH | Choudhury (2019) |
| | fruit peel | methanolic | DPPH | Ajah (2020) |
| | bark and pulp | Hexanic and Ethanolic | DPPH | Dahham (2015) |
| | Sheets | methanolic | DPPH | Sahaa (2013) |
| | fruit peel | ethanolic | Total antioxidant capacity and DPPH assay | Baskar (2011) |
| | fruit peel | Ethanol, methanol, acetone and aqueous | DPPH | Aboul- Eneim (2016) |
| | Sheets | ethanolic | DPPH | Yoo (2016) |

| | | | | |
|---|---|---|---|---|
| **antidiabetic** | Fruit | ethanolic | Determination of glucose adsorption capacity, glucose uptake by yeast cells in *vitro* | Bhinge (2018) |
| | Sheets | methanolic | Alloxan- induced diabetes *in vivo* | Adewoye (2016) |
| | Flower | ethanolic | Streptozotocin -induced diabetes *in vivo* | Borah (2017) |
| | fruit peel | ethanolic | *In vivo* induced diabetes | Navghare (2017) |
| | fruit peel | methanolic | *In vivo* oral glucose tolerance tests | Al- Mahamud (2018) |
| | fruit peel | methanolic | *In vivo* oral glucose tolerance tests | Morshed (2019) |
| | Sheets | methanolic | Alloxan -induced diabetes *in vivo* | Adewoye (2013) |
| | fruit peel | ethanolic | Diabetes induction, cytokine estimation | Kumar (2013) |
| | Stalk | Aqueous | *In vivo* test from the measurement of glucose uptake, subcellular membrane fractionation and western blot analysis | Jaber (2013) |
| **anti-inflammatory** | Flower | ethanolic | Inhibitory effect of nitric oxide | Khongkhon (2017) |
| | fruit peel | methanolic | *In vivo* colitis induction | Ajah (2020) |
| | fruit peel | ethanolic | Inhibitory effect of nitric oxide | Mpharm (2012) |
| **anticarcinogenic** | bark and pulp | Hexanic and Ethanolic | *in vitro* cell culture | Dahham (2015) |
| | Flower | ethanolic | Culture of leukemia cells from murine macrophages | Khongkhon (2017) |
| | shoot* | ethanolic | *In vivo* assay, histology and enzymatic evaluation Resumen | Akinlolu (2021) |
| | fruit peel | AT | cell culture | Ruangtong (2020) |
| | Sheets | hydromethanolic | cell culture | Bayala (2020) |
| **hepatoprotective** | Stalk | Aqueous | Antioxidant parameters of liver tissue *in vivo* | Dikshit (2016) |
| | Re bento* | ethanolic | *In vivo* assay of enzymatic evaluation | Akinlolu (2021) |
| | Sheets | methanolic | Measurement of the lipid peroxidation marker *in vivo* | Dikshit (2016) |
| **antiulcerogenic** | Stalk | Ethanol and chloroform | *In vivo* ulcer induction | Gangwar (2014) |
| | Fruit | Aqueous | In vitro aspirin-induced ulcer | Goodies (2017) |
| | fruit peel | ethanolic | Evaluation of induced gastric ulcer healing | Kumar (2013) |
| **Healing** | fruit peel | Aqueous | Gel production from the extract, *in vitro observation* of the healing process | Lino (2011) |

| | | | | |
|---|---|---|---|---|
| **antidiarrheal** | flower and bark | methanolic | Castor oil induction of diarrhea, intestinal motility test | Panda (2018) |
| | Seed | methanolic | Diarrhea induced *in vivo* by castor oil and magnesium sulfate | Hossain (2011) |
| **antiparasitic** | fruit peel | ethanolic | Parasitemia suspension at 0.5% in a 96-well plate | Leesombun (2019) |
| | Stalk | ethanolic | Collection and evaluation of activity at different concentrations against *Pheretima posthuma* | Adithya (2019) |
| **antifungal** | Sheets | methanolic | Disk diffusion, determination of minimum inhibitory concentration, minimum fungicidal concentration | Ige (2015) |
| **anticonvulsant** | Stalk | Aqueous | Pentylenetetrazole -induced seizures *in vivo* | Reddy (2018) |
| **analgesic** | bark | ethanolic | *in vivo* acetic acid induction tests | Sumathy (2014) |
| **anxiolytic** | Stalk | Aqueous | Animal models for anxiety, elevated plus maze test and open field | Reddy (2017) |
| **antidepressant** | Sheets | Aqueous | Forced swimming test (FST) and tail suspension test (TST), while *in vivo* elevated plus maze (EPM) tests | Salako (2019) |
| **anti-wrinkle** | Sheets | ethanolic | Cell culture, ELISA, RT-PCR and *in vivo clinical test* | Yoo (2016) |
| **anti-melanogenesis** | fruit peel | ethanolic | Cell culture, tyrosine and melanin assay, in vitro protein determination | Phacharapiyankul (2021) |
| **diuretic** | Flower | ethanolic | Measurement of total volume, concentration of sodium, potassium and chloride ions in urine *in vivo* | Misra (2011) |
| **anti-hypercholesterolemic** | Stalk | methanolic | Serum lipid profile and atherogenic index | Dikshit (2016) |
| | Sheets | methanolic | Serum lipid profile measurement | Adewoye (2016) |
| **anti-atherosclerosis** | fruit peel | ethanolic | Atherogenic diet *in vivo* and histopathological | Prameswari (2017) |
| **anti-colitis** | fruit peel | methanolic | Induced colitis, stool consistency assessment and histological analysis | Adegoke (2016) |

Table 1. Biological Activities of the species Musa sapientum L., highlighting the part used, type of extract, biological activity and method used.

Source: Authors (2022). NA: not reported. *rebento é o estágio inicial de uma planta, representando o broto.

susceptible due to lack of outer membrane.

The study carried out by Kandasamy et al. (2016) [12] showed in descending order the antibacterial activity of the analyzed solvents, namely chloroform, acetone, hexane, methanolic and ethyl acetate. The chloroform extract showed inhibition against all bacteria tested, namely *S. aureus, E. fecalis, B. cereus* and *B. subtilis.* Among the Gram-negatives, hexane showed inhibition against *Salmonella typhi, P. aeruginosa* and *E. coli.* Unlike the study produced by Jouneghani et al. (2020) [15] who showed less activity using the solvent hexane and significant activity when using acetone and ethanol against Gram-positive *B. cereus* and *E. faecalis* and between Gram-negative *S. enterica* and *S. sonnei.* This differentiation can be attributed to the different collection sites, including seasonality, circadian rhythm, part used, development, climate, as well as the polarity of the solvents used [9].

Kusuma et al. (2020) [16] used the disk diffusion method to assess whether the ethanolic extract of *M. sapientum bark* has activity against the microorganisms that cause acne *Propionibacterium acnes* and *S. epidermidis,* in *in vitro tests.* This property of inhibiting the growth of these bacteria, destacando-se a casca, dessa espécie para ser empregada na produção de um natural anti-acne agent.

Antibiofilm activity, using broth microdilution, with extract obtained from leaves and pseudostem of *M. sapientum* against *C. albicans* was proven in the ethanolic, acetone and hexane extracts and no activity was verified in the aqueous extract ( JUNEGHANI *et al.*, 2020). Crude methanolic extract obtained from the peel of the fruit of *M. sapientum* showed antimicrobial activity in disc diffusion against *Bacillus* spp., *E. coli, Pseudomonas* spp., *Klebsiella pneumoniae, S. aureus* and *Streptococcus* spp [13].

The antifungal action obtained from a preliminary study involving methanolic extract of *M. Sapientum leaves* demonstrated activity against *Trichophyton rubrum* and *Trichophyton canis.* Given the global context of the limitation of antifungals, preliminary research involving microorganisms is important to follow up on more robust studies in order to develop new drugs [65].

For antidiarrheal activity, the major agents causing diarrhea caused by *S. aureus, E. coli, S. typhi* and *C. albicans were described.* The methanolic extract of seeds from *M. sapientum* exerted an antidiarrheal function after observing the reduction of feces [10] this may be related to the promotion of the growth of *Lactobacillus* sp. and reduced growth of *E. coli* and *S. typhi* as demonstrated in the study developed by Jiurong et al (2020) [17]. Furthermore, Panda et al. (2018) and Hossain et al. (2011) [64,10] induced diarrhea with castor oil to test the methanolic extract, obtained through the flower and bark and seed, respectively, obtaining a positive result regarding the reduction of effects.

## ANTIOXIDANT ACTIVITY

The antioxidant activity of vegetables may be related to several metabolites, highlighting phenolic compounds, carotenoids and vitamins A and C. due to their ability to act as reducing agents, scavengers of free radicals [18]. Given this concept, each extract, obtained with a certain solvent, may present a different concentration of bioactive compounds and consequently different antioxidant actions.

Antioxidants are generally defined as substances that delay or prevent the oxidation of the substrate, DPPH is a chemical method that has the ability to determine the antioxidant capacity of a compound in the scavenging of free radicals, it is the first choice because it is a fast, practical method and good stability, presenting more solubility in organic solvents [19].

Siddique et al. (2018) [14], Ayoola et al. (2017) [20] and Adedayo et al. (2016) [21] demonstrated in their studies a direct and positive correlation in the radical scavenging activity of total phenolic content (CFT), total flavonoid content (CTF) and DPPH. Indicating that the amount of total flavonoid phenols acts directly in the elimination of free radicals.

Different parts of *M. sapientum used* for antioxidant activity tests, such as fruit peel, pulp, seed and flower, showed antioxidant potential of the plant, especially the fruit in different concentrations and different solvents used in the extraction [20, 22, 23, 58, 59, 56, 60].

In gas chromatography and mass spectrometry analysis of the methanolic extract obtained from *M. sapientum flower powder,* the presence of phytosterols, phenols, carboxylic acid and vitamins were described as main components being responsible for antioxidant and anti-inflammatory activity [24].

## ANTIDIABETIC ACTIVITY

The antidiabetic activity of the fruit (banana) of *Musa sapientum* can be attributed to the insulin-secreting activity, increasing serum insulin in the groups previously treated with the extract. Decreased intestinal glucose absorption is probably due to the presence of alkaloids, pectins, saponins, tannins and gallic acid [24, 29, 30].

Bhinge et al. (2018) [29] used *M. sapientum bark powder* obtained after extraction with ethanol solvent to reduce postprandial glucose levels *in vitro,* using yeast cells, obtaining a mechanism mediated by increased glucose adsorption which decreased the rate of diffusion at the cellular level, which may characterize the fruit as a potential for antidiabetic activity.

Results showed that the methanolic and ethanolic extracts of *M. sapientum fruit peels in vitro,* have the ability to reduce high blood glucose when used for treatment, both in oral glucose tolerance tests to evaluate antihyperglycemic activity and in animals hyperglycemic [31, 32, 33, 61, 62].

Borah et al. (2017) [30] used ethanolic extracts from the stem and flower of *M. sapientum,* demonstrating in their study that the flower extract showed greater antihyperglycemic activity in diabetic animals, with an increase in serum insulin compared to the extract of the flower. stalk.

Another work showed that the juice of the peel of the fruit of *M. sapientum* significantly reduces the level of glucose in the blood of diabetic rats. The authors also concluded that *M. sapientum fruit peel juice,* when ingested with the drug metformin, improves bioavailability and increases the maximum concentration of the drug in plasma compared to the control group [34], emphasizing that *M sapientum* can be used as an auxiliary component for glycemic control.

## ANTI-INFLAMMATORY ACTIVITY

In the study reported by Ajah et al. (2020) [25], where they evaluated the anti-inflammatory activity of the methanolic extract of *M. sapientum fruit peel,* observed a decrease in the degree of inflammation and depth of necrosis after inducing colitis in rats, due to the fact that banana peel exhibits DPPH radical scavenging properties, as they have high concentrations of phenolic components, thus being a source of antioxidant with anti-inflammatory capacity.

As well as the presence of components such as nitric oxide, phytosterols, phenols, vitamins from *M. sapientum* contribute to ensure the anti-inflammatory activity developed by this fruit [23,24, 63].

## ANTICARCINOGENIC ACTIVITY

The aqueous extract of *M. sapientum fruit peel,* when treated with zinc acetate, has been shown to inhibit the growth of a range of cancer cells, present in skin cancer, colorectal cancer and liver cancer. without affecting normal cells, showing potential anticancer activity [35]. *M. sapientum* is cited as a promising source of anticancer components in the study which demonstrated that hexane extract from banana peel inhibited the growth of the colon cancer cell line [36].

The ethanolic extract of *M. sapientum fruits* has anticancer potential, due to its chemical components that can target cancer stem cells. In the study developed, they evaluated the genes of resistance to multiple drugs and a biomarker of cancer stem cells ( CSCs ) and the result indicates that there is a compound in the fruit of *M. sapientum* capable of specifically eliminating CSCs and, in addition, confers the potential of antiproliferation and drug resistance when comparable to standard anticancer drugs. These results are preliminary and require further evaluations for the discovery of specific compounds that can eliminate cancer cells and act on the genes studied [37].

Despite being a promising anticancer source, hydroethanolic extract of *M. sapientum leaves showed* no inhibitory effect on LNCap of prostate cancer and HeLa cervical cancer cells with IC 50 > 1000 μg/mL [38].

## HEPATOPROTECTIVE ACTIVITY

For evaluation a ação hepatoprotetora of *M. sapientum,* an anthracene - induced hepatotoxicity (DMBA) protocol in rats was used. Rats with damaged livers were treated with an ethanolic extract from the stem of the species under study, which showed a regenerating effect on the liver [37]. Another study showed that the aqueous extract of the stem of *M. sapientum has a* hepatoprotective effect comparable to the standard drug, by preventing the increase in the level of liver enzymes such as aspartate aminotransferase, alanine aminotransferase and alkaline phosphatase. This species-specific hepatoprotective effect is probably due to the antioxidant property present [42].

## ANTI-ULCEROGENIC ACTIVITY

Gangwar et al. (2014) and Kumar et al. (2013) [43,61] performed the extraction of the stem of *M. sapientum* using the ethanolic solvent and chloroform to treat ulcer that was induced in vivo in rats, obtaining a positive and favored result due to the flavonoids present, producing a cytoprotection affirming the efficacy.

Aqueous extract of *M. sapientum* showed anti-ulcerogenic activity with a significant decrease ($p <0.05$) in the induced ulcer in an experimental model, the effect being potentiated with the addition of vitamin C [44].

## ANTI-PARASITIC ACTIVITY

*Muse* spp. is traditionally used to treat worms that cause intestinal infections, the study developed by Ezea et al. (2019) [39] used the methanolic extract of the root to verify the anthelmintic activity, against *Ascaris lumbricoides, Moniezia benedeni* (sheep tapeworm) and *Eisenia fetid*. The results showed paralysis of the worms as well as death in accordance with the study developed by Adithya et al. (2019) [40] where the ethanolic extract from the stem of *M. sapientum* acted against *Pheretima posthuma,* which showed anthelmintic activity dose-dependente.

As for the anti-plasmodium and anti-toxoplasma activity, the ethanolic extract of the bark do fruto de *M. sapientum* e,inhibited the growth of *Toxoplasma gondii* with $IC_{50}$ of 90.4 μg/mL. In that same study, the extract was less effective in inhibiting the growth of *Plasmodium falciparum,* necessitating further research. Therefore, the data show that the ethanol extract óofo fruto de *M. sapientum* is a potential source of new drugs for the treatment of infection caused by *T. gondii* [41].

## ANTICONVULSANT ACTIVITY

Another important activity described for *M. sapientum* was the anticonvulsant activity of the aqueous extract of its stem. In pentylenetetrazole induced seizures, the extract showed a significant increase between the latency period for the onset of spasms and decreased seizure duration compared to the control group, suggesting that the natural product has potential in the use of epilepsy. However, further studies are needed that can identify all active compounds to relate to the pharmacodynamic profile of this pathology [46].

## ANALGESIC ACTIVITY

Sumathy et al. (2014) [26] evaluated the analgesic capacity of M. sapientum bark of *the* ethanolic extract, through *in vivo* tests in hot plate, tail flick and acetic acid induction, which corresponds to a fast and reliable model of evaluation. The results showed that the bioactive compounds, present in the extract of this fruit, have analgesic capacity in the tests evaluated.

## ANXIOLYTIC ACTIVITY

Reddy et al (2017) [47], using the elevated plus maze test and open field in an experimental model in mice, were able to observe that the aqueous stem extract of *M. sapientum* reduced spontaneous motor activity, compared to the drug diazepam in rats or mice, with significant anxiolytic activity being observed. To determine this assessment, the antioxidant activity of *M. sapientum was verified,* since oxidative stress is cited as an important factor in the development of anxiety disorder. Other results also show antidepressant activity of the fruit extract, through the mediation between the α1 adrenergic and D2 dopaminergic receptors through the forced swimming, tail suspension and elevated cross maze tests [48].

## ANTI-WRINKLE ACTIVITY

Aesthetics is an area that is growing in the market, thus necessitating the search for natural cosmetics that have the ability to combat the main complaints. Fibroblasts are responsible for the production of collagen and elastin that contribute to the fight against aging in the aesthetic context, Yoo et al. (2016) [60] concluded that the ethanolic extract of *M. sapientum leaves* has the ability to promote the expression of procollagen and COL1A1 genes, demonstrating the ability to be a raw material of a cosmetic with efficacy in wrinkles.

## ANTIMELANOGENESIS ACTIVITY

O *M. sapientum* bark ethanolic extract proved to be an effective depigmenting agentda pele, tendo potencial para a cosmetics area. Este extrato, through the AKT signaling pathway, decreased the expression of the MITF gene that induces the expression of enzymes in melanin synthesis. All results indicate that it can serve as an anti -inflammatory activity. melanogenesis [45].

## DIURETIC ACTIVITY

The concentration of ions such as sodium, potassium and chloride in the urine serve for evaluation in terms of diuresis. Furosemide is the standard drug on the market, in the research developed by Mishra et al. (2011) [66] showed significant activity in comparison with the drug present on the market, through the evaluation of ion concentrations.

### ANTI-HYPERCHOLESTEROLEMIC ACTIVITY

In the study developed by Adewoye et al. (2016) [28], *M. sapientum* leaves were used for methanolic extraction, having the ability to electrolyte restoration of sodium, potassium and phosphate ions, significantly reducing ($p < 0.05$) the altered lipid profile such as cholesterol, triglycerides, LDL and the increase in HDL in diabetic animals, corroborating the study developed by Dikshit et al. (2016) [28] who investigated the action of the methanolic extract in hypercholesterolemic rats, obtaining the reduction after treatment with the extract, demonstrating anti-hypercholesterolemic activity.

### ANTI-ATHEROSCLEROSIS ACTIVITY

Banana peel has shown effectiveness in preventing atherosclerosis, a disease that forms inside the arteries. This bark contains flavonoids that are able to inhibit the translocation of nuclear factor kappa B (NF-κβ) and increase the expression of the enzyme endothelial nitric oxide synthase (eNOS), which are essential for the homeostasis of the vascular system. The linear regression analyzed shows that the extract decreased NF-κβ activity by 82.1% and increased eNOS by 95.2%, showing efficacy in disease prevention [49].

### ANTI-HEMOLYTIC ACTIVITY

Islam et al. (2017) [50] report that the methanolic extract of *M. sapientum leaf* has an anti-hemolytic effect, protecting human erythrocytes from lysis induced by hydrogen peroxide. O teste de hemólise é um teste presuntivo de toxicidade de espécies vegetais [51].

### CLINICAL STUDY

No clinical studies were registered in scientific articles according to the review performed.

### PATENT

Mendonça (2016, 2020) [52,53] has two patent deposits, one identified with the number BR 10 2016 030105 0 A2 of a gel produced from the bark of 10% green *M. sapientum capable of healing tissue injuries.* The other patent is under the number BR 10 2020 013887 1 A2 of the powder composed of the green banana peel (*M. sapientum*) for the treatment of peristomal dermatitis, being evaluated the effectiveness as well as the healing time.

## CONCLUSION

The use of medicinal plants by the population, in the treatment of various pathological conditions, serves as a theoretical basis for developing research, in order to scientifically prove their biological activities. The plant *Musa sapientum* L. is popularly known as banana-prata, and is used by the population for traditional treatments of various problems. The present review analyzed the pre-clinical studies already carried out with several parts of the *M. sapientum species,* in which the biological activities already tested in relation to this plant were identified. It was found that the fruit was the most studied part, highlighting that it presents the peel, considered a by-product of the food industry that is normally discarded, generating environmental impacts. The most tested biological action was antibacterial, having been verified activity against several positive Gram and negative Gram bacteria. The studies were carried out with different extracts that may have different compositions and actions, even though they are produced from the same part of the plant.

Although the fruits of Musa sapientum have already been submitted to several pharmacological action studies, no clinical study has been carried out to date, even though there are two products with healing action and for dermatitis.

The data found can serve as an incentive to complement scientific studies, including pre-clinical and clinical studies, which allow the development of safe and effective drugs to be used by the population. These works can also generate possible important patents in the pharmaceutical, cosmetic and food areas and can reduce the generation of by-products that lead to the accumulation of garbage and consequent environmental impact on our planet.

## DECLARATION OF CONFLICT OF INTEREST

No conflict of interest.

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