

## Emerging source of bioactive compounds from Arecaceae family: a systematic review

Fonte emergente de compostos bioativos da família Arecaceae: uma revisão sistemática

Fuente emergente de compuestos bioactivos de la familia Arecaceae: una revisión sistemática

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### **Abstract**

The use of plants for medicinal purposes is performed empirically by traditional knowledge with the use of preparations that seek to extract their active principles, and are considered to be fundamental to human health. In this context, the aim of the present study was to of this study was to carry out a systematic review of the biological activities of the Arecaceae family distributed throughout Brazil. This research was carried out through a comprehensive search using the following databases, Scopus, Portal Periódicos Capes, PubMed, Google Scholar and Science Direct, using the following descriptors: “Arecaceae” and “Biological properties of the family Arecaceae”, checked at [www.theplantlist.org/](http://www.theplantlist.org/) to check synonyms. It was possible to identify numerous biological activities in the arecaceae family, among the most recurring ones, the antioxidant, antimicrobial and anti-inflammatory activity. These activities are justified by the presence of fatty acids, phenolic compounds, alkaloids and terpenes. Studies routinely report lauric acid as a major in the plants of this family, which makes it a potential compound to cure or assist in the treatment of various diseases.

**Keywords:** Medicinal plants; Brazilian biodiversity; Biological activities; Arecaceae.

## Resumo

A utilização de plantas com fins medicinais é realizada empiricamente pelos conhecimentos tradicionais com a utilização de preparações que buscam extrair seus princípios ativos, e são consideradas fundamentais para a saúde humana. Nesse contexto, o objetivo deste estudo foi realizar uma revisão sistemática das atividades biológicas da família Arecaceae distribuída por todo o Brasil. Esta pesquisa foi realizada por meio de uma busca abrangente nas bases de dados Scopus, Portal Periódicos Capes, PubMed, Google Scholar e Science Direct, utilizando os seguintes descritores: “Arecaceae” e “Propriedades biológicas da família Arecaceae”, verificados em <[www.theplantlist.org/](http://www.theplantlist.org/)> para verificar sinônimos. Foi possível identificar inúmeras atividades biológicas na família das Arecaceae, entre as mais recorrentes, a atividade antioxidante, antimicrobiana e antiinflamatória. Essas atividades são justificadas pela presença de ácidos graxos, compostos fenólicos, alcalóides e terpenos. Os estudos rotineiramente relatam o ácido láurico como um dos principais nas plantas desta família, o que o torna um composto potencial para curar ou auxiliar no tratamento de várias doenças.

**Palavras-chave:** Plantas medicinais; Biodiversidade brasileira; Atividades biológicas; Arecaceae.

## Resumen

La utilización de plantas para fines medicinales es realizada empíricamente por los conocimientos tradicionales con la utilización de preparos que buscan extraer sus principios activos y son considerados fundamentales para la salud humana. En este contexto, el objetivo del estudio fue realizar una revisión sistemática de las actividades biológicas de la familia Arecaceae repartida por todo el Brasil. Esta investigación fue realizada a través de una búsqueda integral en las bases de datos Scopus, Portal Periódicos Capes, PubMed, Google Scholar y Science Direct, utilizando los siguientes descriptores “Arecaceae” y “Propriedades biológicas da familia Arecaceae”, verificados en <[www.theplantlist.org/](http://www.theplantlist.org/)> para la verificación de sinónimos. Fue posible identificar muchas actividades biológicas en la familia de las Arecaceae, entre las más recurrentes, la actividad antioxidante, antimicrobiana y antiinflamatoria. Esas actividades son justificadas por la presencia de ácidos grasos, compuestos fenólicos, alcaloides y terpénicos. Los estudios rutinariamente reportar el ácido láurico como un de los principales en las plantas de esta familia, lo que torna un compuesto potencial para curar o auxiliar en el tratamiento de variadas enfermedades.

**Palabras clave:** Plantas medicinales; Biodiversidad brasileira; Actividades biológicas; Arecaceae.

## 1. Introduction

The use of medicinal plants as an alternative to treat several diseases is an old habit in different cultures, which remains until nowadays, especially in developing countries (Mattos, Camargo, Sousa, & Zeni, 2018; Padilha et al., 2017). Some reasons for the use of medicinal plants are due to its low cost, easy access and the belief that natural products are safer when compared to synthetic drugs (Silva & Santana, 2018; Filho, 2010). Thus, several research on medicinal plants are focused on discovering bioactive molecules with benefits to human health and low toxicity (Al-Okbi, 2014; Lee, Lee, Tsai, & Su, 2012), demanding studies to identify plant compounds and related biological activities (Lana, Martins Necchi, Casoti, & Manfron, 2012). For this reason, the phytochemistry study of plants with medicinal properties represents an essential step to define their composition and provides evidence of potential biological activities and mechanism of action (León-mejía et al., 2011; Vinod, Tiwari, & Meshram, 2011).

Natural chemical compounds have been used to treat health problems and historically their derivatives are extremely important as nutraceuticals, supplements and therapeutic agents (Lescano & Kassuya, 2014). However, besides the therapeutic purpose, in some cases, the plant chemical compounds may present toxic effects, such as the terpenoids, alkaloids, tannins and glycosides (Pereira & Cardoso, 2012).

Additionally, the use of medicinal plants may present better therapeutic results when compared to synthetic substances. Thus, the preliminary phytochemical analysis is a very important step for the beginning of the phytochemical study of the plant to be studied, and may show several classes of bioactive compounds, among them: flavonoids, reducing sugars, alkaloids, tannins, lignins, saponins, steroids (Joy et al., 2019). Therefore, plants present bioactive compounds that can be toxic, mutagenic, carcinogenic and teratogenic, especially when they are consumed without restriction, so, it is important to evaluate the toxicity with biological activities (López-Romero et al., 2018).

Brazil has the greatest biodiversity worldwide, being a source of natural molecules with high biological potential (Khan et al., 2018). Thus, studies that demonstrate the potential of medicinal plants found in Brazilian biomes are essential for

maintaining the conservation of species, as well as providing scientific evidence regarding the invaluable source of new bioactive molecules for diverse purposes, including for the treatment of several diseases, many of them still without effective treatment (Brasil, 2011).

The Arecaceae family is one the biggest family worldwide and it is strongly distributed in tropical zones, with 181 genus and 2600 species (Emilio et al., 2019; Henrique, Koolen, & Soares, 2019). This family is extremely valuable due to its diversity of species, in Brazil it comprises 37 genera and 293 species, occurring in all Brazilian biomes (Leitman, Soares, Henderson, Noblick & Martins, 2015). The species from this family present morphological and functional differences, like bush species, woody trees, or even grasses (Balslev, Laumark, Pedersen, & Grández, 2016; Santos, Aguiar-Dias, Amarante, & Coelho-Ferreira, 2013). Additionally, there is a big variety of edible fruits, like nuts, berries, or drupes, with different textures, forms, colors, and chemical compositions (Blok, Katan, Jos, & Meer, 1996; James, Gibson, & Cleland, 2000).

**Figure 1.** *Acrocomia aculeata* (Jacq.) Lodd. ex Martius. A: specimen in natural habitat. B: infructescence.



Source: Rodrigues et al. (2011).

**Figure 2.** *Cocos nucifera* (Arecaceae). A: specimen in natural habitat. B: fruit.



Source: Adapted from (Belviso et al., 2013) and (Bessa et al., 2016)

Most species from this family are reported in the literature due to their biological potential, an example is *Syagrus coronata*, which is used for fruit production. This species also has emerged as to its medicinal potential, due to its leishmanicidal activity (Rodrigues et al., 2011), antioxidant (Belviso et al., 2013) and antimicrobial (Bessa et al., 2016). Another species is *Butia odorata*, which is known due to its antioxidant and antitumor potential (Boeing et al., 2019), hypolipidemic and anti-inflammatory (Ramos, Silva, Oliveira, Bona, Hofmann, & Chaves, 2020), antihyperglycemic (Vinholes, Lemos, Lia, Franzon, & Vizzotto, 2017), and antibacterial activity (Maia, 2019). The species *Syagrus schizophylla* also has a range of biological activities, such as antioxidant, antimicrobial (Nonato et al., 2018) analgesic, antipyretic and anti-inflammatory (Elhakim, Abdel-Baky, & Bishay, 2017), antimalarial (Tayler et al., 2019), and antibacterial (Joy et al., 2019). Most of those pharmacological properties are reported in ethnobotanical studies and have been proved in scientific research.

In this context, the present study aimed to carry out a systematic review of the biological activities from the Arecaceae family with occurrence in Brazilian territory.

## 2. Methodology

The search for articles was performed between the months of September and December of 2020, using the species names, verified in [www.theplantlist.org/](http://www.theplantlist.org/) in case of synonyms. The searched databases were Scopus, Portal Periódicos CAPES, PubMed, Google Scholar and Science Direct, using the descriptors: “Arecaceae” and “Biological properties of the family Arecaceae”.

This research was carried out through a search between the months of September to December 2020, with the names of the species verified on the site [www.theplantlist.org/](http://www.theplantlist.org/) to check synonyms. A comprehensive search for articles was carried out using Scopus, Portal Periódicos Capes, PubMed, Google Scholar and Science Direct, using the following descriptors: “Arecaceae” e “biological properties of the family Arecaceae”. Studies published between 2010 and 2020 were included. Complete articles containing the descriptors included in the abstract or keywords were selected. Duplicate articles in the search platforms, review articles, articles of genetic and taxonomic scope and studies on plant metabolism were excluded. The other articles were then selected based on the title, abstract and keywords. Finally, the complete articles were analyzed according to the following criteria (1): phytochemistry; (2): ethnobotanical uses; (3): bioactivities; (4): bioactivities of compounds isolated in the Arecaceae family; (5): types of products used.

## 3. Results and Discussion

### Extracts

Among the articles, 30 of them investigated extracts from 19 different genus and their biological activities, as shown in Table 1. The most used vegetal parts were the fruits (72%). As for essential oil, the leaves were the most used part (66%), followed by the fruits (33%) and fixed oil; the fruits were used in all research.

**Table 1.** Biological activities from Arecaceae species.

<b>Specie</b>	<b>Biological activity</b>	<b>Type of product</b>	<b>References</b>
<i>Hyphaene thebaica</i>	Antioxidant and Antimicrobial	Methanolic and Ethanolic extract	(Aboshora et al., 2014)
<i>Phoenix dactylifera</i>	Determination of the nutritional class of compounds present and antioxidante	Ethanol extract	(Abdul-hamid et al., 2020)
<i>Oenacapus bataua</i>	Antimicrobial	Ethanol extract	(Aranaga et al., 2020)
<i>Euterpe precatoria</i>	Antimicrobial	Ethanol extract	(Aranaga et al., 2020)
<i>Cocos nucifera</i>	Antitoxic	Ethanol extract	(Adaramoye & Oladavies, 2015)
<i>Attalea speciosa</i>	Antimicrobial and immunomodulatory	Ethanol extract	(Barroqueiro et al., 2016)
<i>Orbignya phalerata</i>	Th1 immunomodulatory activity	Aqueous extract	(Guerra, Silva, Aragão-frança, Oliveira, & Feitosa, 2011a)
<i>Hyophorbe indica</i>	Antioxidant activity, $\alpha$ -glucosidase inhibition and hypoglycemic activity.	Ethanol extract	(William et al., 2018)
<i>Cocos nucifera</i>	Antimicrobial	Aqueous, ethanol, chloroform and diethyl extracts	(Joy et al., 2019)
<i>Cuminum cyminum</i>	Antimicrobial	Aqueous extract	(Karamian & Kamalnejad, 2019)
<i>Melia azedarach</i>	Larvicide	Methanolic extract	(Koc, Evren, & Cetin, 2016)
<i>Phoenix theophrasti</i>	Larvicide	Methanolic extract	(Koc et al., 2016)
<i>Styphnolobim aponicum</i>	Larvicide	Methanolic extract	(Koc et al., 2016)
<i>Pyracantha coccinea</i>	Larvicide	Methanolic extract	(Koc et al., 2016)
<i>Cocos nucifera</i>	Antimicrobial	Aqueous extract	(Kadja, Atsain-allangba, Kouamé, & Janat, 2020)
<i>Phoenix dactylifera</i>	Hepatoprotetor	Methanolic extract	(Okwuosa, Udeani, Umeifekwem, & Augustine, 2014)
<i>Attalea speciosa,</i>	Antimicrobial	Ethanol extract	(Oliveira et al., 2016)
<i>Mauritia flexuosa</i>	Antimicrobial	Ethanol extract	(Oliveira et al., 2016)
<i>Acrocomia aculeata</i>	Antimicrobial	Ethanol extract	(Oliveira et al., 2016)
<i>Phoenix dactylifera</i>	Protective effect against oxidative testicular damage	Aqueous extract	(Jahromi, Rasooli, Kamali, Ahmadi, & Sattari, 2017)
<i>Bactris setosa</i>	Antioxidant	Aqueous extract	(Rosa, Arruda, Egle, & Arruda, 2016)
<i>Phoenix loureiroi</i>	Intestinal anti-inflammatory activity	Methanolic, ethyl, chloroform extract, ethyl acetate	(Murugan, Saravanan, & Parimelazhagan, 2018)
<i>Cocos nucifera</i>	Antiparasitic and anticâncer	Dichloromethane and methanol extracts	(Tayler et al., 2019)
<i>Cocos nucifera</i>	Synthesis of silver nanoparticles	Methanol extract	(Mariselvam et al., 2014)
<i>Raphia vinifera</i>	Cytotoxicity	Chloroform and methanolic extracts	(Chi, Sop, Mbaveng, & Ombito, 2020)

<i>Ravenea rivularis</i>	Antioxidant, anti-inflammatory and cytotoxicity against Hep-G2	Metanolic, hexanic, ethyl acetate and butanolic extracts	(Elgindi, Singab, Mahmoud, & Abdullah, 2015)
<i>Orbignya phalerata</i> ,	Immune responses	Aqueous extract	(Guerra et al., 2011a)
<i>Raphia hookeri</i>	Antimicrobial and modulation	Methanol extract	(Nguenang et al., 2018).
<i>Caryota mitis lour</i>	Analgesia, antipyretic and anti-inflammatory.	Aqueous and ethanolic extract	(Elhakim et al., 2017)
<i>Cocos nucifera</i>	Antifungal and antioxidante	Methanolic extract	(Thebo et al., 2016)
<i>Hyophorbe indica</i>	Antioxidant, anti-hypoglycemic and metabolite profile.	Ethanol extract	(William et al., 2018)
<i>Ráfia gentiliana</i>	Anti-hyperglycemic and hyperglycemic	Aqueous and ethanolic extract	(Mpiana, Masunda, Longoma, Tshibangu, & Ngbolua, 2013)
<i>Mauritia flexuosa</i>	Antioxidant and antimicrobial	Chloroform extract, ethyl acetate and ethanolic	(Nonato et al., 2018)
<i>Phoenix dactylifera</i>	Hepatoprotection	Methanolic extract	(Okwuosa et al., 2014)
<i>Euterpe oleracea</i>	Antioxidant	Aqueous extract	(Minighin et al., 2019)
<i>Mauritia flexuosa</i>	Antimicrobial and antioxidante	Fraction	(Nonato et al., 2018)
<i>Orbignya speciosa</i>	Antinociceptive	Fraction	(Pinheiro, Boylan, & Fernandes, 2012)
<i>Raphia farinifera</i>	Cytotoxicity	Fraction	(Tapondjou, Siems, Bottger, & Melzing, 2015)
<i>Euterpe oleracea</i>	Anti-inflammatory and antinociceptive	Fixed oil	(Favacho et al., 2011)
<i>Livistona australis</i>	Antioxidant and anti-hyperlipidemic	Fixed oil	(Kassem & Afifi, 2014)
<i>Acrocomia aculeata</i>	Diuretic and anti-inflammatory	Fixed oil	(Lescano & Kassuya, 2014)
<i>Attalea phalerata</i>	Cytotoxicity, Genotoxicity and Clastogenicity	Fixed oil	(Lima et al., 2016)
<i>Attalea phalerata</i>	Cytotoxicity, Genotoxicity and Clastogenicity	Fixed oil	(Lima et al., 2016)
<i>Chamaerops humilis</i>	Antimicrobial	Essential oil	(Inouye, Yamaguchi, & Takizawa, 2001)
<i>Euterpe oleracea</i>	Genotoxicity and clastogenics / anagenic potential	Essential oil	(Marques et al., 2016)

Source: Authors.

### Antioxidant activity

The endogenous antioxidant system is essential to maintain integrity and body homeostasis, since several reactive oxygen species (ROS) are constantly generated in cells as products of cellular metabolism. Although these ROS have benefic functions on the organism, at high concentrations they induce toxic effects and are associated with several diseases (Alves et al., 2010; Santos et al., 2014).

Arecaceae species have demonstrated antioxidant potential. The extract obtained from *Hyphaene thebaica* fruits present antioxidant activity in DPPH reduction assay (Aboshora et al., 2014). As for *Hyophorbe indica* leaf extract, which presents compounds known as antioxidants, like gallic acid, catechin and citric acid, also present an antioxidant effect, being able to reduce the DPPH radical, and achieving the IC<sub>50</sub> of 35.35 ± 0,18 µg/mL (Aboshora et al., 2014). The extract

from *Bactris setosa*, with a higher content of flavonoids, presents antioxidant activity, in FRAP and  $\beta$ -carotene oxidation assays (Rosa et al., 2016). *Mauritia flexuosa* showed antioxidant activity being able to reduce the ABTS radical and chelate 80.9% of Fe+2 *in vitro*, available at 700  $\mu$ g/mL (Nonato et al., 2018). Other Arecaceae species that also showed antioxidant activity *in vitro* models are *Euterpe Oleracia* (Minighin et al., 2019), *Hyophorbe indica* (William et al., 2018), *Cocos nucifera* (Kadja et al., 2020; Thebo et al., 2016), and *Ravena rivularis* (Elgindi et al., 2015)

Kassem (Kassem & Afifi, 2014) studied the lipophilic fraction obtained from *Livistona australis* fruit (LALF), which presented oleic acid as major content (59.05%), palmitic acid (20.59%), phytol-diterpene (7.98%) and linoleic acid (0.79%).

Oleic acid (OA) is the main component among the fatty acid contents of LALF. Oleic acid, linoleic acid and phytol inhibited hyperlipidemia probably through the oxidation reaction. The LALF content can play a role with strong antioxidant activity in inhibiting lipid peroxidation and protecting against oxidative degradation of biologically active substances. *In silico* studies, with oleic acid, indicates that it acts as a competitive inhibitor with nitric oxide on the active site of nitric oxide synthase (Kassem & Afifi, 2014). The unsaturated fatty acids play important roles in the immunological system and inflammatory process (Menéndez et al., 2006; Weatherill et al., 2005).

According to the literature, even if some of the studies do not bring exactly the compounds present in the extracts, they still have at least the metabolite class present in these extracts, as disposed of in Table 2. It was possible to observe that the aforementioned studies have in common the occurrence of phenolic and flavonoid compounds, which are known antioxidant molecules (Balasudram, Sundram, & Samman, 2006), being used in several industries, such as food, aesthetics, pharmaceuticals, and textile.

**Table 2.** Phytochemical compounds present in Arecaceae family.

Species	Vegetal part	Chemical compounds	References
<i>Hyphaene thebaica</i>	Fruit	Unidentified	(Aboshora et al., 2014)
<i>Phoenix dactylifera</i>	Fruit	Unidentified	(Abdul-hamid et al., 2020)
<i>Oenacapus bataua</i>	Root	Unidentified	(Aranaga et al., 2020)
<i>Euterpe precatória</i>	Root	Unidentified	(Aranaga et al., 2020)
<i>Cocus nucifera</i>	Fruit	Unidentified	(Adaramoye & Oladavies, 2015)
<i>Attalea speciosa</i>	Fruit	Unidentified	(Barroqueiro et al., 2016)
<i>Orbignya phalerata</i>	Fruit	Unidentified	(Guerra et al., 2011a)
<i>Hyophorbe indica</i>	Leaves	Citric acid, procyanidin B3, epicatechin, procyanidin B2, catechin, catechin derivative, procyanidin B1, apigenin-c-hexoxide-c-hexoxide, Kaempferol, Kaempferol derivative, quinic acid derivative, gallic acid	(William et al., 2018)
<i>Cocos nucifera</i>	Leaves	Tannin, lignins, flavonoids.	(Joy et al., 2019)
<i>Cuminum cyminum</i>	Leaves	Total phenol, flavonoid, ascorbic acid, starch, reducing sugars.	(Karamian & Kamalnejad, 2019)
<i>Melia azedarach</i>	Fruit	Unidentified	(Koc et al., 2016)
<i>Phoenix theophrasti</i>	Fruit	Unidentified	(Koc et al., 2016)
<i>Styphnolobim aponicum</i>	Fruit	Unidentified	(Koc et al., 2016)

<i>Pyracantha coccinea</i>	Fruit	Unidentified	(Koc et al., 2016)
<i>Cocos nucifera</i>	Fruit peel	Coumarins, flavonoids, steroids, tannins and triterpenes	(Kadja et al., 2020)
<i>Phoenix dactylifera</i>	Leaves	Unidentified	(Okwuosa et al., 2014)
<i>Attalea speciosa</i> ,	Leaves	Unidentified	(Oliveira et al., 2016)
<i>Mauritia flexuosa</i> ,	Leaves	Unidentified	(Oliveira et al., 2016)
<i>Acrocomia aculeata</i>	Leaves	Unidentified	(Oliveira et al., 2016)
<i>Phoenix dactylifera</i>	Leaves	Unidentified	(Jahromi et al., 2017)
<i>Bactris setosa</i>	Leaves	Unidentified	(Rosa et al., 2016)
<i>Phoenix loureiroi</i>	Leaves	Unidentified	(Murugan et al., 2018)
<i>Cocos nucifera</i>	Peel, Leaf and Fruits	Unidentified	(Tayler et al., 2019)
<i>Cocos nucifera</i>	Inflorescence	Unidentified	(Mariselvam et al., 2014)
<i>Raphia vinifera</i>	Fruit	Saponins (1-4)	(Chi et al., 2020)
<i>Ravenea rivularis</i>	Leaves	Lupeol acetate, betulinic acid, apigenin, luteolin, luteolin-7-O- $\beta$ -D-glucopyranoside, ferulic acid, caffeic acid and chlorogenic acid	(Elgindi et al., 2015)
<i>Orbignya phalerata</i> ,	Fruit	Unidentified	(Guerra et al., 2011a)
<i>Raphia hookeri</i>	Fruit	Alkaloids, triterpenes, steroids and polyphenols, including flavonoids.	(Nguenang et al., 2018)
<i>Caryota mitis lour</i>	Leaves	Unidentified	(Elhakim et al., 2017)
<i>Cocos nucifera</i>	Fruit	Unidentified	(Thebo et al., 2016)
<i>Hyophorbe indica</i>	Leaves	Unidentified	(William et al., 2018)
<i>Ráfia gentiliana</i>	Fruit	Unidentified	(Mpiana et al., 2013)
<i>Mauritia flexuosa</i>	Fruit	Unidentified	(Nonato et al., 2018)
<i>Phoenix dactylifera</i>	Fruit	Unidentified	(Okwuosa et al., 2014)
<i>Euterpe oleracea</i>	Fruit	Unidentified	(Minighin et al., 2019)
<i>Mauritia flexuosa</i>	Fruit	Flavonoids	(Nonato et al., 2018)
<i>Orbignya speciosa</i>	Leaves	Unidentified	(Pinheiro et al., 2012)
<i>Raphia farinifera</i>	Fruit	Unidentified	(Tapondjou et al., 2015)
<i>Euterpe oleracea</i>	Fruit	Palmitic acid, palmitoleic acid and oleic acid	(Favacho et al., 2011)
<i>Livistona australis</i>	Fruit	Oleic acid, linoleic and palmitic acids, diterpene-phytol	(Kassem & Afifi, 2014)
<i>Acrocomia aculeata</i>	Fruit	Oleic acid, palmitic acid and linoleic acid.	(Lescano & Kassuya, 2014)
<i>Attalea phalerata</i>	Fruit	$\beta$ -carotene and $\alpha$ -carotene	(Lima et al., 2016)
<i>Attalea phalerata</i>	Fruit	$\beta$ -carotene	(Lima et al., 2016)
<i>Chamaerops humilis</i>	Leaves and fruit	Unidentified	(Inouye et al., 2001)
<i>Euterpe oleracea</i>	Fruit	Oleic, palmitic and palmitoleic fatty acids	(Marques et al., 2016)

Source: Authors.



### Anti-inflammatory and protective activities

Inflammation can be defined as an organism natural response to several types of stimuli, which in turn culminates into tissue damage. During this process, many molecular mechanisms are activated which induces histologic and vascular alterations in the affected area (Ashley, Weil, & Nelson, 2012). Despite that, the inflammation may induce deleterious effects when it persists on the organism and the inflammatory response is too strong. Several *Arecaceae* species demonstrate anti-inflammatory effect.

*Phoenix loureiroi* extract was able to reduce intestinal inflammation, in mice, due to oral administration at a concentration of 5 mg/kg, corroborating with the popular use of the fruit to treat intestinal pain (Murugan et al., 2018). Elhakim et al. (2017) verified the anti-inflammatory potential of *Caryota mitis*, its extract was able to attenuate the inflammatory response in mice paw edema induced by carrageenan at a concentration of 400 mg/kg. Besides that, the research also highlighted the absence of toxicity, presenting an average lethal dose (LD<sub>50</sub>) higher than 5000 mg/kg. As for *Ravenea rivularis*, which extract, presented antioxidant activity, also present anti-inflammatory activity. Is worth to noting that the inflammation process is related to oxidative stress, therefore, it may be possible that the molecules found in the extract present both effects, antioxidant and anti-inflammatory, promoting an efficient attenuation on inflammation process and the diseased related to it (Elgindi et al., 2015).

As for the oils and fatty acids, some authors state that it can reduce the levels of cytokines, like the IL-1  $\alpha$ , TNF-  $\alpha$ , IL-6 e IL-1  $\beta$ , which will result in an anti-inflammatory response (Blok et al., 1996; W. James et al., 2018). Oleic acid, palmitic acid and palmitoleic acid are identified as the main components that play important physiological roles in the human body, due to their chemical structure, these compounds have become the focus of interest for pharmaceutical and food companies (Blok et al., 1996; James et al., 2018) and as seen in the table 2, the oils obtained from *Arecaceae* species are usually rich in those compounds.

According to Favacho et al. (2011), the oil obtained from *Euterpe oleracea* fruits showed anti-inflammatory activity *in vivo* in paw edema and ear erythema induced by croton oil. The average effective dose was 1226.8 mg/kg, and the results showed that *E. oleracea* oil presents an anti-inflammatory effect by inhibiting prostaglandins biosynthesis. The microencapsulated oil from *Acrocomia aculeata* fruits also presented anti-inflammatory in paw edema, and pleural edema models, both induced by carrageenan (Lescano & Kassuya, 2014), both species have oleic acid as major compound.

The relation between oleic acid and the therapeutic potential for the treatment of inflammatory diseases is that it can induce tissue repair, as discussed by Grimm et al. (2002), its occurs due to changes in metalloproteinases balance, which are key molecules for the process of tissue healing. As for Calder (2002), the omega-3 unsaturated fatty acid can affect the expression of pro-inflammatory cytokine genes, altering cell membrane's characteristics, cell signaling, cell mobility, the interaction of receptors, membrane and the formation of secondary signs (Grimm et al., 2002).

The balance of the dietary lipids is intended to control the inflammatory response when exacerbated by the intake of unsaturated fatty acids. Studies express those fatty acids participate in the modulation of calcium signaling (Soldati et al., 2002), protein kinase C (May & Calder, 1993), activation of phospholipase C, production of inositol-1,4,5-triphosphate (IP<sub>3</sub>) and diacylglycerol (DAG). In addition, they are the primary precursors of lipid mediators during the inflammatory process, such as arachidonic acid and prostaglandins (Soldati et al., 2002). With that in mind, there is several pathways that fatty acids can act to attenuate the inflammatory process.

As for the protective effect, it is related with the capacity of a molecule or product prevent damages into a certain cells or tissue before it starts an inflammation process. Some *Arecaceae* species showerd protective effect in different system, like the hepatoprotective effect described for *Phoenix dactylifera* (Okwuosa et al., 2014), which in turn presented an LD<sub>50</sub> higher than 6000 mg/kg. The same species also presented a protective effect in bovine testicles (Jahromi et al., 2017). Investigating *Cocos*

*nucifera* extract, intending to revert toxic effects induced by cisplatin in mice, Adaramoye and Ola-davies (2015) obtained positive results by administrating 200 mg/kg daily on mice diet, they also noticed a decrease in lipid peroxidation and intensification of antioxidant enzymes activity. And finally, the extract obtained from *Orbignya phalerata* presented a protective effect by modulating the inflammatory response, and the fruit extract from this species associated or not with aluminum particles increased interferons and interleukins concentration (Guerra, Silva, Aragão-frança, Oliveira, & Feitosa, 2011b).

### Antimicrobial activity

In the last 10 years, at least 10 Arecaceae species were studied as potential antimicrobial activity. The ethanolic extract from *H. thebaica* fruits showed strong antibacterial activity against *Staphylococcus aureus* and *Salmonella typhi*, in the disk diffusion method, it is worth noting that the extract showed positive results against two types of bacteria cells, a Gram-positive and Gram-negative respectively, still, the control drugs, gentamicin, and ampicillin, showed higher zone of inhibition when compared to the extract (Aboshora et al., 2014).

A similar methodology was employed to test the extract from *C. nucifera* leaves, rich in tannin, lignin, and flavonoids, it was able to inhibit *Escherichia coli* growth, with an inhibition halo of 5 mm, 50% less compared to the drug control, ciprofloxacin (a 1 µg) (Joy et al., 2019). Tayler et al. (2019) evaluated the antiparasitic effect from *C. nucifera* Against several parasites, like *Leishmania donovani*, *Trypanosoma cruzi*, and *Plasmodium falciparum*, which showed positive results.

Aranaga et al. (2020), evaluated the antimicrobial potential from several plant extracts, between then: *Onecapaus bataua* and *Euterpe precatoria*, which were able to inhibit the PKnB kinase enzyme, essential to *Mycobacterium tuberculosis*. The IC<sub>50</sub> from the first species was of 60.9 µg/mL, while the second one showed 77.4 µg/mL, both being able to inhibit the enzymatic activity, however, it was not able to inhibit bacteria growth. The extract capacity of inhibiting the enzymatic activity brings new perspectives to the search of bacteria metabolism modulation mediated by plant extracts, turning them more susceptible, or not, to antibiotics drugs.

An example of modulatory effect was observed in *Raphia hookeri* extract, which was able to decrease the antibiotic concentration until 50% when combined with chloramphenicol, kanamycin, streptomycin, erythromycin, and tetracycline. Also, according to the author, this effect was due to the metabolites present in *R. hookeri*, which could inhibit the efflux bomb present in bacteria, which is a factor that grants bacteria the resistance effect (Nguenang et al., 2018). *M. flexuosa* showed a similar effect, inducing susceptibility to conventional antibiotics in Gram-positive, Gram-negative and *Candida* species (Nonato et al., 2018).

Another species, rich in phenolic compounds and flavonoids, is *Attalea speciosa*, which was able to inhibit the growth of *S. aureus* resistant to methicillin strains, *Enterococcus faecalis* and *Pseudomonas aeruginosa in vitro*, as also an excellent antiseptic *in vivo* model, being able to modulate the immunologic system, into a less intensive response (Barroqueiro et al., 2016).

An alternative approach is the use of natural products to decrease the virulence for bacteria strains, like inhibiting the biofilm expression. The oil from *Syagrus coronata*, rich in octanoic, dodecanoic, decanoic and γ-eudesmol was able, not only to inhibit and kill bacteria strains resistant to antibiotics, as act over bacterias strains capable of forming a biofilm, with MIC between 156 and 625 µg/mL, and MBC of 312 to 1250 µg/mL (B. S. Santos et al., 2019). The oil from *Chamaerops humilis* leaves, whose authors emphasized that the fact of the leaves present more oil than the fruits, due to the anatomic structures have several storage glands, present antibacterial action against *S. aureus*, *E. coli*, and *P. aeruginosa* (Okkacha, Edine, & Raja, 2013).

The bioproducts development has also been applied to the Arecaceae family, and it has proved to be efficient, as related by Karamian and Kamalnejad (Karamian & Kamalnejad, 2019). The authors synthesized nanoparticles of silver with the extract from *Cuminum cyminum*, with strong antibacterial activity. Although other studies with bioproducts made from *M. flexuosa* and *A. aculeata* didn't show any promising effect against *S. aureus*, *E. faecalis*, *E. coli* and *P. aeruginosa*, *C. albicans* and *C. parapsioliis*.

### Cytotoxicity and anticancer

The use of medicinal plants has been growing progressively, mainly since they have biological activity and are used as a source of new molecules and effects obtained by the synthetic drugs currently commercialized, and may even confer a more potent effect, with a potential for less physiological damage. In addition, the cost of herbal medicines is generally reduced, increasing access to this resource, ensuring quality treatment, with chances of cure and better quality of life (Kharchoufa, Merrouni, Yamani, & Elachouri, 2018; Prasansuklab, Brimson and Tencomnao, 2020).

Even with a lower potential for intoxication, some plant species may present a risk of toxicity, mainly because they produce neurotoxins, cytotoxins and metabolic poisons that will disturb the structural and functional integrity of internal organs, such as the liver, heart, kidneys, gastrointestinal system and lungs. In addition, the dose is also important, as some substances can show positive activity for some illnesses in minimal concentrations, but if there is an increase in the dose, that previously therapeutic compound becomes toxic to the organism and can cause tissue or cellular injuries, especially whether carcinogenesis, hormonal dysregulation and the interruption of reproductive and developmental processes (Kristanc & Kreft, 2016; Nembo, Hescheler, & Nguemo, 2020; Shabbir, Shahzad, & Gobe, 2014).

Euterpe oleraceae, the Brazilian açai, is rich in fatty acids, like vanillic acid, palmitic acid, linolenic acid, linoleic acid and oleic acid. This species well-known for its popular fruit, which is famous in the whole country, but specially the North region.

The chromatographic analysis identified a range of fatty acids in the fruit, such as vanillic acid, palmitic acid,  $\gamma$ -linolenic acid, linoleic acid and oleic acid. Toxicity was assessed in rats at doses of 30 mg/Kg, 100 mg/Kg or 300 mg/Kg. Only at a concentration of 300 mg/Kg the animals showed signs of intoxication, such as diarrhea and hair bristles. In addition to acute toxicity, genotoxicity was performed by comet and micronucleus assays from leukocyte samples from peripheral blood, liver, bone marrow and testicular cells taken from animals that were subjected to the acute test (Marques et al., 2016).

In the comet assay, genetic material was used to measure DNA damage, such as single and double-strand breaks, alkaline sites, DNA-DNA and DNA-protein cross-links. Thus, it was verified that there was no damage, indicating that the oil did not present genotoxicity. According to the micronucleus assay, clastogenicity (chromosome breakdown) and aneugenicity (chromosomal delay due to dysfunction of the mitotic apparatus) were measured, as well as it was possible to estimate the proportion of polychromatic erythrocytes concerning normochromatic erythrocytes, suggesting any disturbances in hematopoiesis. Thus, the study reported a non-genotoxic effect on bone marrow cells, with an average micronucleus of 2.16 to 2.5 at concentrations of 30 mg/kg and 100 mg/kg, while the control reported a presence of an average of 8.5 micronucleated cells. With that, it is possible to affirm that *E. oleracea* oil does not present genotoxicity, however, from the concentration of 300 mg/kg, it is possible to observe an imbalance in homeostasis (Marques et al., 2016).

Studies with *Attalea phalerata* Mart. ex Spreng., well known as "bacuri" *in vivo* and *in vitro* models, were carried out to evaluate toxicity using the *Artemia salina* and MTT assay models, in addition to the comet and micronucleus assays. The results showed that bacuri oil did not induce cell death in the *Artemia salina* and MTT experiments and did not present cytotoxicity. The oil also did not cause significant damage to the DNA of the rats in the four doses used when compared to

the negative control group, in addition to not showing a significant increase in micronucleated polychromatic erythrocytes (MNPCEs) for the four doses tested. Thus, the study suggested that this species widely used by popular medicine does not cause cytotoxicity, genotoxicity and clastogenicity, and its main component was  $\beta$ -carotene (Lima et al., 2016).

Chi (Chi et al., 2020) isolated 4 saponins from *Raphia vinifera*, being toxic in average concentrations of 3.55 to 7.14  $\mu$ M in cell lines sensitive to drugs CCRF-CEM, whereas in cell lines resistant to drugs, CEM/ADR5000 concentration mean ranged from 9.19 to 12.29  $\mu$ M, showing an anticancer potential, since the cell lines tested are leukemic cells. The saponins present in this species induced a cytotoxic effect in a drug-resistant phenotype, showing a potential alternative in the treatment of cancer unresponsive to conventional drugs. Tayler (Tayler et al., 2019), when evaluating the action of *Cocos nucifera*, verified the potential for anticancer activity in MCF-7 breast cancer cell line, all *in vivo* tests, obtaining promising results.

Arboviruses comprise a group of viral diseases transmitted by arthropods (mosquitoes) and have been plaguing the world, causing epidemic crises mainly in developing countries (Mayer, Tesh, & Vasilakis, 2016). Recently, the most prominent outbreaks are dengue (DENV), Zika virus (ZIKV) and chikungunya (CHIKV), which are associated with symptoms of hemorrhagic fever, microcephaly and arthritic disease, respectively (Palmer, Dittmar, Gordesky-gold, Hofmann, & Cherry, 2020). The *Aedes aegypti* mosquito is an important vector for the transmission of arboviral pathogens of dengue, chikungunya, Zika virus and yellow fever. Its life cycle (stage of eggs, larvae and pupae) occurs in an aquatic way until reaching its full development, becoming adult and aerial life. Due to the need for aquatic development, in regions where standing water facilitates its dissemination, therefore, poor regions with few resources for sanitation and water treatment are the places with the highest incidence of the mosquito and consequently the diseases associated with it (Luz, Mesquita, Amaral, & Coutinho, 2020; Omondi et al., 2019). *Phoenix dactylifera* L. is a species widely cultivated in the Arabian Peninsula and especially in Saudi Arabia. The extraction of the essential oil from the spathe (a region that protects the flowers) by hydrodistillation obtained the majority of 3,4-dimethoxytoluene (73.47%), 2,4-dimethoxytoluene (9.47%) and  $\beta$ -karyophyllene (5, 47%). In the repellency test, both essential oil and the two major oils (3,4-dimethoxytoluene and 2,4-dimethoxytoluene) were used. According to the results, the essential oil, 3,4-dimethoxytoluene and 2,4-dimethoxytoluene presented a minimum effective dose of 0.051, 0.063 and 0.063 mg / cm<sup>2</sup>, respectively. These results can illustrate a repellent effect, because when we compare these data with that obtained by the standard DEET repellent (N, N -diethyl-3-methylbenzamide) with a minimum effective dose of 0.018 mg/cm<sup>2</sup>, a statistically relevant result. With this, it is possible to verify that the mixture between the oil components is more potent than isolated products, this is due to the synergy between oil compounds, the same does not occur when using the isolated molecule (Demirci, Tsikolia, Barbier, Agramonte, & AlqasoumiL, 2013).

According to Santos (L. M. M. Santos et al., 2017), a study was carried out using oil of *Syagrus coronata*, for larvicidal and ovicidal activity. *S. coronata* is a typical Caatinga species, popularly known as “ouricuri” or “licuri”. According to gas chromatography (GC) analysis, the oil showed prominence for octanoic acid (40.55%) and dodecanoic acid (40.48%). In the larvicidal test, the larvae were reduced by half after 48 hours in the concentrations of 21.07, 19.72 and 51.78 ppm for the samples of oil, dodecanoic acid and octanoic acid, respectively. According to the oviposition, the oil affected the oviposition of the females more intensely, reducing the number of eggs by 35% compared to the control, while the octanoic acid reduced by 31%. The results indicated that the larvicidal activity is due to the action of dodecanoic acid, while the effect of oviposition is probably related to the presence of octanoic acid. Finally, the *Phoenix theophrasti* extract has larvicidal activity, at a concentration of 1000 ppm against larvae of the *Culex pipiens* insect (Tayler et al., 2019).

### Hypoglycemic activity

William (William et al., 2018) demonstrated the hypoglycemic potential of the *Hyophorbe indica* extract, through the in vivo assay of  $\alpha$ -glucosidase inhibition with IC<sub>50</sub>  $36.52 \pm 0.08 \mu\text{g} / \text{mL}$ . *Raphia gentiliana*, on the other hand, was able to decrease the concentration of glucose in the blood by 27 and 56% after one and two hours, respectively, after ingesting the fruit extract at a concentration of 0.2 g/Kg. In this same study, it was reported that the extract changed the glycemic index by -3.1% and the glycemic load by -1.36% in humans (Mpiana et al., 2013).

## 4. Final Considerations

The development of the present study showed that the Arecaceae family has a composition rich in fatty acids, phenolic compounds, alkaloids and terpenes, with the main compound of the family lauric acid, a compound already used as a therapeutic alternative to help various diseases. Among the most recurrent biological activities, we can report the antioxidant, antimicrobial and anti-inflammatory activity.

Thus, it is possible to consider that the abundance and the processing capacity of the plants of the Arecaceae family in Brazil bring us the need for more in-depth studies, which allows us to investigate other important activities for future therapeutic innovations. In addition, by adding in-depth scientific research, it will bring the possibility of developing a local production chain, valuing and generating income in the traditional communities that popularize its use. It is also important to note that the development of research on bioactive molecules of Brazilian biodiversity not only brings therapeutic innovations, but also promotes the emergence and development of traditional communities, valuing customs, culture and the history of sub-existence.

The relevance and importance of this work lies in the review of the medicinal potential of the Arecaceae family, and this data collection could serve as a basis for collaboration in future studies and projects for the development of new therapeutic applications for phytotherapies, cosmetics and food.

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