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BIOACTIVE POTENTIAL IN FRUITS FROM FIVE SPECIES OF AMAZONIAN PALM TREES

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ABSTRACT

Fruits have bioactive compounds, which can delay or inhibit the propagation of chain reactions generated by free radicals. The search for relevant sources of these bioactive compounds has drawn attention to the vast biodiversity of the Amazon biome represented by native and exotic fruits, with peculiar flavor and characteristics, which have in their composition phenolic compounds, flavonoids, carotenoids and other bio actives that act from the prevention to the treatment of clinical diseases. However, many fruits from palm trees have not yet been fully explored, even though they have potential to be used by the food, cosmetic and pharmaceutical industries. This review provides information on phenotypic characteristics, nutritional importance of five fruits: babassu, tucumã, peach palm, patauá and bacaba, as well as the notoriety of polyphenols and their actions in the human body. It was concluded that all the fruits of this study have high nutritional and functional value and are promising sources of compounds that contribute to reducing the risk of cancer and cardiovascular diseases, with some functions proven with in vitro and ex vivo tests. There is a need for greater chemical prospecting involving these species for quantification and complete qualification of the polyphenols given in these matrices.

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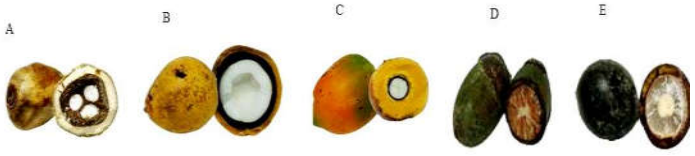
INTRODUCTION

Rondonia is a Brazilian state located in the Amazon region and characterized by having enormous biodiversity that includes numerous underexploited native and exotic fruit species (Santos *et al*., 2017). Most of the fruit species come from palm trees which have their botanical aspects widely published (Oliveira *et al*., 2014; Santos *et al*., 2017). The search for healthy and functional foods has sparked consumer interest in Amazonian palm fruits, as recent research describes nutritional and therapeutic properties and bioactive composition that play a significant role in human nutrition, thereby helping prevent diseases (Lima *et al*., 2011; Rojas-Garbanzo *et al*., 2016). The benefits of bioactive compounds are widely reported in research. For instance, Holanda *et al*., (2020) identified high levels of polyphenols in babassumesocarp and almonds, which contribute to reducing the incidence of neurodegenerative diseases.

Santos *et al*., (2020) reported high concentrations of carotenoids in peach palm oil, which is known to prevent cardiovascular and degenerative diseases and has antithrombosis, antimicrobial, antigenotoxic, and healing properties, among others. The lack of instrumental technology in the Amazonian region and the plethora of species contribute to the lack of information on phytochemicals present in these fruits. Nevertheless, the Brazilian Regional Food Guide, one of the initiatives of the Ministry of Health, aims to disseminate knowledge of various species while encouraging the consumption of a diversified diet with regional products (Ministério da Saúde, 2015). The cosmetic and pharmaceutical industries have also shown interest in Amazonian palm fruits since the antioxidant compounds present in these products can reduce free radicals generated by the oxidation process (Hidalgo *et al*., 2016). Products with patawa (*Oenocarpusbataua*) pulp have been developed to control hair loss, while patawa oil is commonly used as a fungicide; babassu (*Attalea speciosa*) mesocarp flour can be used as medicine to

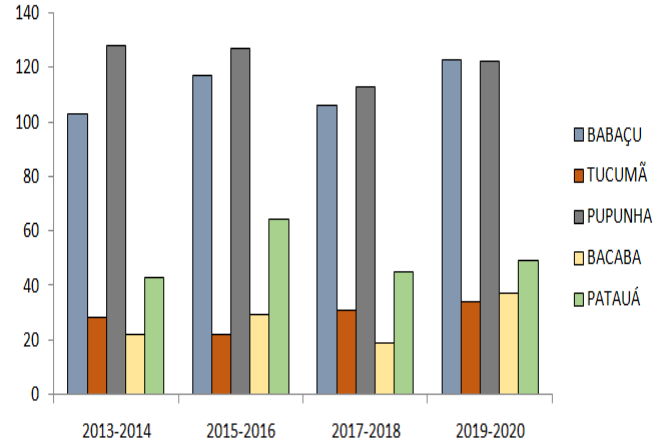
treat inflammatory and infectious diseases (Souza *et al*. 2011; Rezaire *et al*., 2014; Hidalgo *et al*., 2016). Given the above, this review aimed to provide information on the bioactivity of five palm fruits from the Amazon region: babassupalm (*Attalea speciosa*), tucuma (*Astrocaryum aculeatum*), peach palm (*Bactris gasipaes*), patawa (*Oenocarpus batauá*), and bacaba (*Oenocarpus bacaba*). A research was conducted on the scientific digital platforms: Scielo, Google Scholar, Portal Periódicos Capes, and VHL (Virtual Health Library) for articles published in recent years and related to the theme of the study using the keywords "bioactive," "antioxidants," "phenolic compounds," "carotenoids," "ascorbic acid," "flavonoids," "*Oenocarpus bacaba*," "*Oenocarpus bataua*," "*Attalea speciosa*", "*Astrocaryum aculeatum*"and "*Bactris gasipaes*".

Palm Trees of the Amazon Region: There are roughly 390 species of palm trees in Brazil, with most being native to the Amazon region, where there are 41 genres and 290 species (Oliveira *et al*., 2014). The genre *Attalea*, *Astrocaryum*, *Bactris* and *Oenocarpus* have attracted the interest of the scientific community in recent years, especially fruits of the species *Attalea speciosa*, *Astrocaryum aculeatum*, *Bactris gasipaes*, *Oenocarpus batauá*, and *Oenocarpus bacaba* (Figure I).



Source: the authors

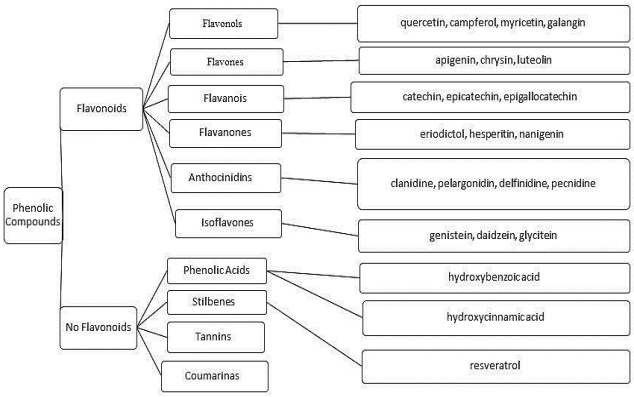
Figure 1. (A) Babassu (Attalea speciosa), (B) Tucumã (Astrocaryum aculeatum), (C) Peach palm (Bactris gasipaes), (D) Patawa (Oenocarpus Batauá), (E) Bacaba (Oenocarpus Bacaba).



Source: the authors

Figure 2. Scientific research on babassu, tucuma, peach palm, patawa, and bacaba published in 2013-2020

The babassu coconut measures 8-15 cm in length and has four fractions: epicarp, mesocarp (rich in starch), endocarp, and almonds. It has great importance due to its ecological, social, environmental, economic, and nutritional aspects (Silva *et al*., 2020). The tucuma is generally 3.2-5.6 cm long and 2.5-5.4 cm wide, with an often smooth and shiny epicarp, a mesocarp with yields corresponding to 35% of the total fruit, and colorations varying from yellow to orange (Rabelo, 2012; Carneiro *et al*., 2017). Peach palm fruits can vary in shape (from ovoid to cylindrical), and their sizes vary from 2.5 to 7.0 cm in length and from 2.5 to 6.0 cm in diameter. Their skin color varies from red, yellow, orange, yellowish-green, and orange-green, and the mesocarp is oleaginous, generally being dark orange, light orange, light yellow, or whitish-yellow (Rabelo, 2012; Rojas-Garbanzo *et al*., 2016; Santos *et al*. 2017; Santos *et al*., 2020).



Source: the authors

Figure 3.Class of phenolic compounds

The fruits of the patawapalm are oleaginous and are about 3.5 cm long and 1.75 cm wide (Rabelo, 2012); it is widely used in northern Brazil, primarily by the indigenous population who are known to produce the "patawa wine" (Hidalgo *et al*., 2016). This fruit has nutritional characteristics with high biological potential that has garnered the attention of the scientific community. Lastly, the bacaba, which belongs to the family Arecaceae, is roughly 1.5 centimeters long and 1.4 centimeters wide and has an epicarp and mesocarp with yields of approximately 25% of the fruit from which the "bacaba wine" is produced, an important drink in the diet of the local population given its nutritional and energetic characteristics (Rabelo, 2012; Souza *et al*. 2016; Col *et al*. 2018; Clemente *et al*., 2019). Amazon palms, in general, have attracted the attention of researchers worldwide and stand out economically in the sector of fruits, hearts of palm, oils, and as sources of numerous bioactive compounds (Silva, 2020). An estimated number of studies found in the scientific platforms regarding the babassu, tucuma, peach palm, patawa, and bacaba fruits for 2013-2020 is shown in Figure II. The biodiversity of the Amazonian flora is a resource of utmost importance for Brazil, considering that the chemical properties of the native palm fruits have a high biological potential to be taken advantage of when aiming to develop new technologies. The main characteristics of the native palm fruits from the Brazilian Amazon are listed in table I. The wide variety of Amazonian fruits corresponds with the diversity of chemical compounds found in these species. The molecular structures of the main bioactive compounds found in the fruits of this study are listed in table II.

Bioactive Compounds in Five Fruits of Amazonian pal Trees: Bioactive compounds of Amazonian palm fruits have important antioxidant characteristics that favor numerous benefits to human health (Souza *et al*. 2016). Finco *et al*., (2016) and Holland *et al*., (2020) reported that, in recent years, many studies have been conducted to identify the benefits of the bioactive compounds present in unconventional fruits. In fact, there is evidence that the antioxidants present in these species contribute to reducing the onset of chronic and degenerative diseases, including obesity, cardiovascular diseases, type 2 diabetes, and even some types of cancer. The main bioactive compounds identified in the investigated fruits and their advantages regarding human health are presented in table III.

Phenolic compounds: Phenolic compounds, also known as secondary metabolites, have been found in bacaba and patawa (Souza *et al*., 2016; Col *et al*., 2018). These compounds are divided into two large groups (figure III), namely: flavonoids and non-flavonoids (Ferrera *et al*., 2016). Unprecedented information was reported by Hidalgo *et al*., (2016) who isolated the piceatannol in the extract of patawa, this phenolic compound is described with superior pharmacological properties than resveratrol found in grape wine, which shows that the wine of patawa also presents high antioxidant potential.

Table 1. Characteristics of the fruits of palm trees native to the Brazilian Amazon

Name Popular / Scientific	Origin and production	Characteristics	Main food use	Biological potential to be explored	Reference
Babassu (*Attalea speciosa*)	The entire Amazon region and northeastern Brazil	Produces about 3 to 5 bunches per harvest, with each bunch holding up to 300 coconuts	Flours, oils	Used as a healing ointment	Santos *et al*. 2020; Silva *et al*. 2020.
Tucuma (*Astrocaryum aculeatum*)	The states of Amazonas, Acre, Rondonia, Amapá, Roraima, and part of Pará	The ripe fruit has a fibrous and gelatinous pulp and a characteristic odor. Intense orange peel and pulp	*In natura* consumption and ice cream, wine, and sandwich filling production	Tucuma oil is used with chemotherapy because it presents antigenotoxic potential	Lima *et al*. 2011; Carneiro *et al*. 2017; Santos *et al*. 2017;
Peach palm (*Bactrisgasipaes*)	The states of Pará, Acre, Amazonas, Rondônia, and MatoGrosso	Bunches can weigh up to 25 kg; slightly orange flesh; high nutritional content	*In natura* consumption, flour, oil, and hearts of palm	Bactericidal effects of peach palm oil against *Staphylococcus aureus*strains	Santos *et al*. 2017; Souza *et al*. 2017; Silva, 2020.
Patawa (*Oenocarpus batauá*)	The states of Acre, Pará Amazonas, Rondônia, and part of central-western Brazil	Fruits rich in sources of monounsaturated oils, thus being an excellent alternative raw material for agroindustries.	Fruit *in natura*, oil, heart of palm	The oil is used to treat bronchitis, tuberculosis, and respiratory diseases.	Rabelo, 2012; Hidalgo *et al*. 2016; Clemente *et al*. 2019.
Bacaba (*Oenocarpus bacaba*)	The states of Acre, Amapá, Amazonas, Pará, and Rondônia	Purple-black skin and white pulp.	Oil, heart of palm, fruit *in natura*, wine, jams	Potential for inducing apoptosis in breast cancer cells (MCF-7).	Finco *et al*. 2016; Souza *et al*. 2016; Santos *et al*. 2017.

Table II. Main molecular structures of the investigated fruits

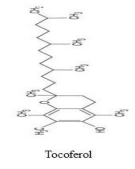
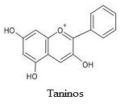
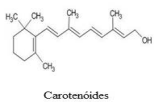
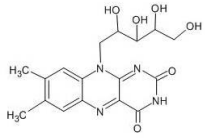
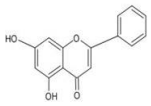
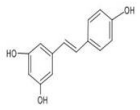
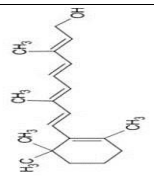
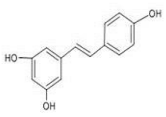
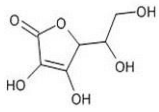
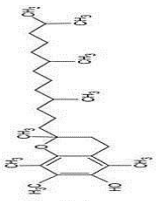
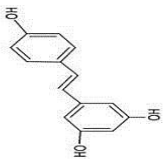
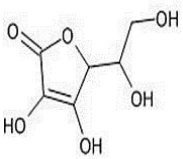
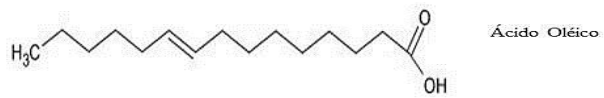
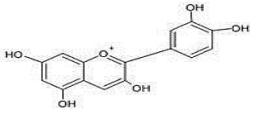
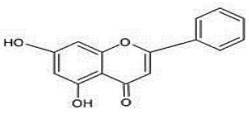
Fruits	Molecular structures of the main bioactive compounds	Referências
Babassu	 Tocoferol  Taninos  Carotenóides	Silva *et al*., 2020; Soares *et al*., 2020.
Tucumã	 Riboflavina  Flavonóide  Polifenóis	Azevedo *et al*., 2017; Mattos *et al*., 2020
Peach palm	 Carotenóides  Polifenóis  Ácido Ascórbico	Holanda *et al*., 2020; Matos *et al*., 2018.
Patawá	 Tocoferol  Ácido Ascórbico  Polifenóis	Rezaire *et al*., 2014; Hidalgo *et al*., 2016.
Bacaba	 Ácido Oléico  Antocianina  Flavonóide	Finco *et al*., 2016; Correa *et al*., 2019

Table III. Medicinal benefits of the bioactive compounds identified

Source	Bioactive compounds	Health benefits	References
Babassu	Triterpenes, tannins, tocopherols, fatty acids, phenolic compounds, and carotenoids	Inflammation, menstrual cramps, and leukemia treatment; scarring properties; gastric protection, antithrombosis and antimicrobial properties; arthritis, ulcers, and rheumatism treatment; helps prevent cardiovascular diseases, obesity, and dyslipidemias.	Silva *et al*., 2020; Soares *et al*., 2020.
Peach palm	Carotenoids, vitamins, polyphenols	Maintaining eye health; chemopreventive treatment for cancer; improves immune function; protects against cardiovascular diseases.	Santos *et al*., 2017; Holanda *et al*., 2020; Silva, 2020.
Tucuma	Carotenoids, riboflavins, polyphenols, flavonoids	Free radical neutralization; prevents cardiovascular and degenerative diseases by protecting the cell's genetic material; important for cell development and differentiation.	Azevedo *et al*., 2017; Matos *et al*., 2018; Mattos *et al*., 2020
Patawa	Polyphenols, vitamins, tocopherol, carotenoids	Hair loss control, bronchitis, tuberculosis, and malaria treatment; scurvy prevention; degenerative disease prevention.	Rezaire *et al*., 2014; Hidalgo *et al*., 2016.
Bacaba	Phenolic compounds, anthocyanins; flavonoids	Prevents cardiovascular diseases; antioxidant properties; antiproliferative effects on cancer cells, therefore being chemopreventive.	Finco *et al*., 2016; Correa *et al*., 2019.

Table IV. Biological properties of Amazonian palm fruits

Fruit	*In vitro / in vivo*	Subject	Effects	References
Babassu	*In vivo*	Rats	Anastomosis healing	Baldez *et al*., 2006.
	In vivo	Rats	Vascular protection against cardiovascular diseases	Silva *et al*., 2020.
Tucuma	*In vivo*	Mice	Reduced genotoxicity in cells and protective effects against oxidative stress	Carneiro *et al*. 2017.
	In vitro	Human cells	Antigenotoxic effects on human peripheral blood mononucleated cells	Filho *et al*., 2013
Bacaba	*In vitro*	Breast cancer cells	Antiproliferative effects on cancer cells (MCF-7)	Finco *et al*., 2016
Peach palm	*In vitro*	Bacteria	Inhibitory effects against *Staphylococcus aureus* strains (bacteria that cause hospital infections)	Filho *et al*., 2012.
Patawa	*In vitro*	Mosquitoes of the genus *Culex*and Aedes	Vector control of larval populations of the Aedesaegyptiand Culexquinquefasciatus mosquitoes, which cause diseases such as dengue and filariasis, among others.	Hidalgo *et al*., 2017

Collaborating, Rezaire *et al*., (2014) state that procyanidins correspond to 90% of the phenolics in Patawa and therefore there is a need for greater scientific exploration of this species as it is essential to inhibit free radicals, due to its antioxidant action.

Carotenoids: Carotenoids are natural pigments responsible for the red-orange coloration of many fruits and vegetables, to date more than 650 different types of carotenoids have been described in the literature (Lima *et al*., 2011; Matos *et al*., 2018; Rowles *et al*., 2020). Carotenoids are widely found in Amazonian palm fruits. Santos *et al*., (2015), Matos *et al*., (2018) and Lima *et al*., (2011) found in tucumã, peach palm and bacaba high levels of carotenoids, including beta-carotene and xanthophyll, which shows that ingestion of these species provides health benefits.

Flavonoids: Flavonoids are included in the class of phenolic compounds; these substances can act as reducing agents, free radical scavengers, and metal chelators. Therefore, their antioxidant capacity is the most studied biological function of this group (Cabrera *et al*., 2012; Ferrera *et al*., 2016). Research characterizes flavonoids as cancer cell inhibitory substances since they can repair genetic material and prevent inappropriate cell proliferation due to their antitumor, anti-inflammatory, and antioxidant properties, among others (Cabrera *et al*., 2012; Santos *et al*., 2017; Cedrim *et al*. 2018). Mattos *et al*., (2020) evaluated the ingestion of tucuma pulp using 14 rats as an experimental group and observed lower total cholesterol levels in these animals, stating that this may be directly related to the phytochemicals present in the tucuma fruit (e.g., flavonoids and carotenoids), evidencing the biological potential of this fruit against diseases related to high cholesterol levels. Dunshea *et al*., (2019) found significant amount of flavonoids, procyanidins, and cyanidin-3-O-glucoside in patawa fruit. The authors stated that palm fruits are significant sources of polyphenols that can be used in various sectors (e.g., food and pharmaceutical industries). Other authors also show benefits of bioactive compounds present in the fruits studied in this study, in table IV presents studies published in recent years that show the peculiarities of such fruits, demonstrating unprecedented results in relation to health.

The Amazon can be a natural research platform due to its biodiversity, including palm fruits, which are promising sources of bioactive compounds, and further studies involving these species will add value to the fruits and favor the sustainable development of the region.

CONCLUSION

There are few studies on the chemical prospection of the native Amazonian palm fruits babassu, tucuma, peach palm, patawa, and bacaba, which are abundant sources of polyphenols and contribute to lowering the risk of cancer and cardiovascular diseases. Despite the relevant findings presented herein, further research is needed to describe the potential of these fruits and quantify and qualify their phytochemicals, thus favoring the biotechnological use of these substances and spreading knowledge about these valuable raw materials.

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