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Integrative review on the content of fatty acids, carotenoids and flavonoids of the Arecaceae of the Cerrado

Revisão integrativa sobre o conteúdo de ácidos graxos, carotenoides e flavonoides das Arecaceae do Cerrado

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ABSTRACT
The Cerrado, the world's most biodiverse tropical savanna, has had 25% of its native vegetation devastated in recent years. The family Arecaceae, commonly known as palm trees, is one of the ethnobotanical families present in this biome. They are well known for their fruits with antioxidant, anti-inflammatory and hypocholesterolemic characteristics. It is estimated that there are about 6,000 species of plants in the Cerrado, but only 30% of them are fully known as to their benefits and potentials. Therefore, the objective of this study is to perform an integrative review on the content of fatty acids, flavonoids and carotenoids of the main fruits of the Cerrado palms: Licuri (*Syagrus coronata*), guariroba (*Syagrus oleracea)*, buriti (*Mauritia flexuosa*), buritirana (*Mauritiella armata*), macaúba (*Acrocomia aculeata*), butiá (*Butia odorata*) e coquinho-azedo (*Butia capitata*). From the search strategies, the databases Science Direct, Google Scholar and CAPES Journals were used. Only articles published between 2019 and 2023 that answered the guiding question were considered. The main carotenoid identified was β-carotene, and the main flavonoids found were: catechin, rutin and quercetin. Several fruits presented saturated, monounsaturated and polyunsaturated fatty acid contents Therefore, the presence of these compounds indicates the potential use of the fruits of the Cerrado palm trees, with promising application in the industry.

Keywords: Cerrado, metabolites, native fruits, palms.

RESUMO
O Cerrado, a savana tropical de maior biodiversidade do mundo, teve 25% de sua vegetação nativa devastada nos últimos anos. A família Arecaceae, comumente conhecida como palmeiras, é uma das famílias etnobotânicas presentes nesse bioma. São conhecidas por seus frutos com características antioxidantes, anti-inflamatórias e hipocolesterolêmicas. Estima-se que existam cerca de 6.000 espécies de plantas no Cerrado, mas apenas 30% delas são totalmente conhecidas quanto aos seus benefícios e potenciais. Portanto, o objetivo deste estudo é realizar uma revisão integrativa sobre o conteúdo de ácidos graxos, flavonoides e carotenoides dos principais frutos das palmeiras do Cerrado: Licuri (Syagrus coronata), guariroba (Syagrus oleracea), buriti (Mauritia flexuosa), buritirana (Mauritiella armata), macaúba (Acrocomia aculeata), butiá (Butia odorata) e coquinho-azedo (Butia capitata). A partir das estratégias de busca, foram utilizadas as bases de dados Science Direct, Google Scholar e Periódicos CAPES. Foram considerados apenas os artigos publicados entre 2019 e 2023 que responderam à pergunta norteadora. O principal carotenoide identificado foi o β-caroteno, e os principais flavonoides encontrados foram: catequina, rutina e quercetina. Vários frutos apresentaram teores de ácidos graxos saturados, monoinsaturados e poliinsaturados. Portanto, a presença desses compostos indica o potencial de uso dos frutos das palmeiras do Cerrado, com promissora aplicação na indústria.

Palavras-chave: Cerrado, metabólitos, frutos nativos, palmeiras.

1 INTRODUCTION

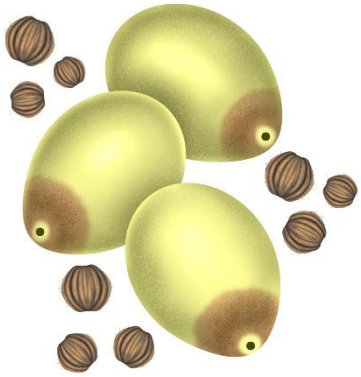
Brazilian biodiversity is known to be home to 15% of the world's total living species (MORAIS *et al.*, 2022). Originally, Brazil was called "Pindorama", which means "land of many palm trees" in the Tupi-Guarani language (DE SOUZA, FLORISVALDO GAMA *et al.*, 2020). Brazilian palm trees have socio-ethnobotanical and ecological importance for indigenous and native peoples of the Amazon rainforest, Atlantic Forest, Cerrado and Caatinga. In addition, they are not only used as sources of food and subsistence, but also in the production of fuel, folk remedies, fiber, forage shelter and traditional handicrafts (COELHO *et al.*, 2022; PEIXOTO ARAUJO *et al.*, 2021).

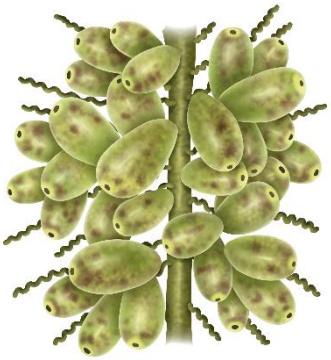
The family Arecaceae, commonly known as palm trees, are plants found in warm temperate and humid tropical regions (CANTU-JUNGLES *et al.*, 2017; DE SANTANA LOPES *et al.*, 2019). These palms are native to South America, extending as far north as Central America, Trinidad and the West Indies (JOBIM *et al.*, 2014). Taxonomically, the Arecaceae are part of the monocot group comprising 188 genera and approximately 2570 different species (CANTU-JUNGLES *et al.*, 2017; DE SANTANA LOPES *et al.*, 2019; PEIXOTO ARAUJO *et al.*, 2021).

In addition, they are well known for their fruits that can be consumed both in natura and in the form of jellies, ice creams, juices and fermented beverages (BARBOZA *et al.*, 2022). The intake of these native fruits in tropical regions has been growing due to their claims of antioxidant, anti-inflammatory and hypocholesterolemic activity and the high content of vitamins, carotenoids and polyphenols (MORAIS *et al.*, 2022). There are several genera of great occurrence in the Brazilian biomes, such as *Syagrus, Bactris, Astrocaryum, Acrocomia* and *Mauritia* (MORAIS *et al.*, 2022; TEIXEIRA; IBAÑEZ; BLOCK, 2022).

Licuri (*Syagrus coronata*), guariroba (*Syagrus oleracea)*, buriti (*Mauritia flexuosa*), buritirana (*Mauritiella armata*), macaúba (*Acrocomia aculeata*), butiá (*Butia odorata*) e coquinho-azedo (*Butia capitata*) are the main fruits of the palm trees of the Cerrado (WEICHERT *et al.*, 2023; EMBRAPA, 2023) (See Table 1). This biome, which is also known as tropical Savannah, is considered the second biome of Brazil in territorial extension (204.7 million hectares) and biodiversity of fauna and flora (MARIANO *et al.*, 2022). It is distributed in the states of Bahia, Piauí, Pará, Maranhão, Rondônia, Mato Grosso, Tocantins, Goiás, Mato Grosso do Sul, Paraná, São Paulo, Minas Gerais and the Federal District, and also incorporates parts of the territory of neighboring countries such as Bolivia and Paraguay (ANTUNES *et al.*, 2021). It is estimated that there are about 6,000 species of plants in the Cerrado, but only 30% of them are fully known as to their benefits and potential (LIMA *et al.*, 2022). Table 1 shows the characteristics of these palm trees.

Table 1. Arecaceae fruits of the Cerrado

Scientific name	Popular name	Description of the palm tree	Mainly uses	Illustration
Syagrus coronata	Licuri and ouricuri	Median height ranging from 6 to 10 meters, flowering and fruiting with higher incidence in the months of March to August. The fruit is a drupe with abundant endoderm, ovoid and fleshy. The ripe fruits have yellow, sticky and sweet pulp. The seeds, when dried, are dark in color and have a hard coat that coats the almond (BARBOSA *et al.*, 2021; CREPALDI *et al.*, 2001).	The pulp and almonds are consumed in natura and also used in the production of cocadas. Oil is extracted from the dried almond, in addition to being used as food for livestock, birds and wild animals (DRUMOND, 2007).	

Syagrus oleracea	Guariroba, gueroba, guarirova, gariroba, catolé and bitter heart of palm	It can reach up to 20 meters in height with mature infructescence occurring during the months of September to October. The fruits are ellipsoid, yellowish-green in color and smooth, containing thick, fleshy mesocarp, with a sweet and fibrous flavor(CARNEIRO; ROLIM; FERNANDES, 2003).	The heart of palm is used in salads, sauces and preserves. The fruits are consumed and from the almond oil is extracted and sweets are produced. The fruits and leaves are used in animal feed (DOS REIS; PINTO; FALEIRO, 2016).	
Mauritia flexuosa	Buriti, miriti carandá guaçu, moriche muriti, palmeira-buriti, palmeira-dos-brejos, aguaje, bariti and carangucha	Dioecious palm from 2 to 35 m in height its flowering occurs from April to August, fruiting after 9 months. Its fruits are ellipsoid-oblong, covered by corneal scales, reddish-brown in color at maturity. Below the reddish-brown scales is a thin layer of oily pulp, followed by endocarp and seed (BARBOSA *et al.*, 2021; SAMPAIO; CARRAZZA, 2012).	It provides animal feed, fertilizer, building materials, ornaments, household items, furniture, medicines, cosmetics, toys and even musical instruments. From its pulp are made juices, sweets, ice creams, jellies, oils and wines (BRAGA-SOUTO *et al.*, 2022; FERREIRA, 2005; KOOLEN *et al.*, 2013).	
Mauritiella armata	Buritirana, buriti mirim, buriti bravo, xiriri and yumuna aguajillo	Stipes usually multiple, measuring about 20 meters in height, with fruiting between September and January. Climacteric fruits of oval shape agglutinated in the branches, but of smaller size than the fruits of buriti. They have fibrous mesocarp with a soft pulp of coloration ranging from yellow to green (DE SOUZA, FLORISVALDO GAMA *et al.*, 2021).	Pulp is consumed in natura or in the form of jams, jellies, drinks, wines and oils (DE SOUZA, FLORISVALDO GAMA *et al.*, 2021).	
Acrocomia aculeata	Macaúba, bocaiúva, macaiba, coco-baboso and coco-de-espinho	It reaches up to 25 meters in height and fruiting occurs between October and January. Fruits are globose drupes, ranging from olive green to yellow or brown or brownish when ripe, hard shelled, yellow pulp, viscous and sweet surrounding a seed, of commercial importance by the prese (RAMALHO-CARVALHO, 2014).	The pulp is consumed in natura and prepared in the form of soft drinks, sweets, jellies and for oil extraction. The almond can be consumed roasted, in natura, in the form of sweets or oil (MOOZ; CASTELUCCI; SPOTO, 2014).	

Butia odorata	Butiá, Butiá-vinagre, Guariroba-do-campo, Coquinho, Butiá-de-praia, Macumá, Butiá-felpudo, Butiazeiro and Coqueiro-cabeçudo.	It can reach up to 12 meters in height and is lined with remnants of the base of its leaves. Its ovoid fruits have varied size and can be seen in yellow, orange or reddish colors. The mesocarp is fleshy and the endocarp contains 1 to 3 ovoid or triangular seeds (BÜTTOW *et al.*, 2009; FARIA *et al.*, 2008).	Juices, jellies, ice creams, liqueurs and even cachaça accompaniment. Bittersweet sauce, syrup for desserts and ice cream, gourmet butiazada (to rum), juice, nectar, vinegar, bonbons, liqueur with honey, pulp for ice cream and baked goods (BÜTTOW *et al.*, 2009; RIVAS; BARBIERI, 2018).	
Butia capitata	Coquinho-azedo, coquinho, coco-cabeçudo, and butiá-azedo	Palm tree that can reach 6 meters in height and bears fruit between June and January. Its fruit has a yellow coloration when ripe, with an elongated and oval shape. The epicarp is smooth and fibrous, the mesocarp is fleshy, fibrous and yellow, the endocarp woody and dark brown with about 1 to 2 seeds (FARIA *et al.*, 2008; MOURA *et al.*, 2010; PEREIRA, STHEFANO LOURENÇO *et al.*, 2021).	Pulp consumed in natura or frozen (FARIA *et al.*, 2008; MOURA *et al.*, 2010; PEREIRA, STHEFANO LOURENÇO *et al.*, 2021).	

Source: Illustration by Ribeiro, L.V.(2023)

In general, from these fruits you can obtain vegetable oils rich in essential fatty acids. Fatty acids are very important for the formation and maintenance of cell membranes, as well as having lubricant, emollient and anti-inflammatory properties, which help restore the skin's natural oiliness and protect it from environmental damage. Medium-chain triglycerides, for example, in addition to being important in the inflammatory process, promote the regeneration of cells and tissues, which improves the immune response and wound healing via angiogenesis and epithelialization (ALVES *et al.*, 2019). These fatty acids have been shown to improve factors associated with type 2 diabetes by lowering total cholesterol and density lipoprotein (LDL) levels, decreasing aspartate transaminase (AST) activity, and decreasing body weight (BW) and body mass index (BMC) (NUNES *et al.*, 2020).

Fruits of the Arecaceae family are reported as good sources of fatty acids and antioxidant compounds such as phenolics (LAHLOU *et al.*, 2022). Frequent intake of compounds such as carotenoids and flavonoids has also been associated with decreased incidence of chronic-

degenerative diseases (CHISTÉ *et al.*, 2021) due to the physiological functions they exert in the human body (SILVA, DARLISSON SLAG NERI *et al.*, 2022).

Carotenoids are pigments naturally present in many food matrices and represent an important source of vitamin A. Deficiency of this vitamin is a major problem in many populations around the world and is associated with serious health problems such as diarrhea, dermatitis and stress (VARGAS-MURGA *et al.*, 2016). The absence of pro-vitamin A carotenoids can cause a spectrum of eye disorders that manifest in night blindness and macular degeneration caused by photo-oxidative damage (NASCIMENTO-SILVA; SILVA; SILVA, 2020). In addition, some recent studies have reported that vitamin A is involved in maintaining body weight as it aids in the control of energy homeostasis by modulating the production of leptin and inflammatory cytokines (DE SOUZA MESQUITA *et al.*, 2021).

Flavonoids, on the other hand, are also a class of substances that occur naturally in fresh fruits and vegetables and because they are excellent compounds with antioxidant potential, their intake is necessary (DA SILVA, LEIRSON RODRIGUES; DE FIGUEIREDO; DE MORAIS, 2021; DA VEIGA CORREIA *et al.*, 2022). Kim *et al.* (2015) reported a broad spectrum of biological activities for flavonoid glycosides, including antioxidants, immunomodulators, and anticarcinogens. Rutin, for example, has anticancer properties, mediated by the induction of apoptosis, suppression of cell proliferation and prevention of metastasis (NUNES *et al.*, 2020).

The guiding question of this study arose from the observation that there were many recent review articles on the Arecaceae family, but most of them were Amazonian fruits (AVILA-SOSA *et al.*, 2019; DE SOUZA, FLORISVALDO GAMA *et al.*, 2020; JARAMILLO-VIVANCO *et al.*, 2022; MORAIS *et al.*, 2022; PEIXOTO ARAUJO *et al.*, 2021; TEIXEIRA; IBAÑEZ; BLOCK, 2022; TOMCHINSKY; GONÇALVES; FERREIRA, 2021). Therefore, considering that the Cerrado is the second largest biome in Brazil and the largest in the world when it comes to biodiversity, there is a need to know more about what has been investigated about the native palm trees of the Cerrado. Thus, the metabolites chosen for this investigation are in parallel with what was seen about the Amazonian fruits that focused mostly on lipids, carotenoids and phenolic compounds.

In this way, the palm trees of the Cerrado should be studied due to their economic and industrial potential. In addition to the potential for economic exploitation, the Arecaceae also have botanical relevance, as some species are threatened with extinction (TEIXEIRA; IBAÑEZ;

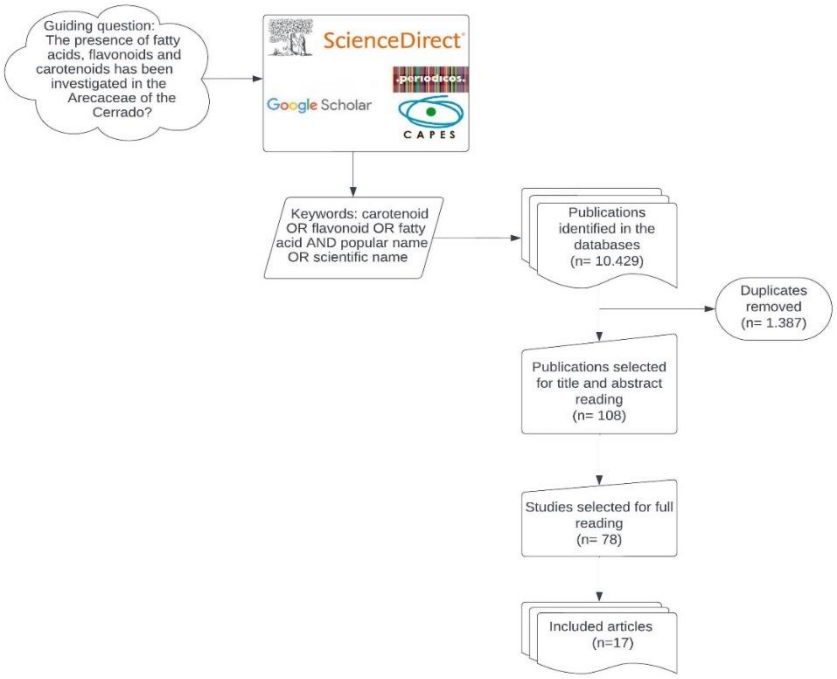
BLOCK, 2022). Therefore, this integrative review will explore the data regarding the content of carotenoids, flavonoids and fatty acids on the palm trees of the Cerrado, in order to identify the recent gaps in studies regarding the chemical composition of these fruits, as well as to value the fruits of this biome still so little explored.

2 METHODOLOGY

This integrative review was based on the methodology described by Correia *et al.*, (2022), Nogueira *et al.*, (2022) e Ramos *et al.*(2022) (DA VEIGA CORREIA *et al.*, 2022; NOGUEIRA *et al.*, 2022; RAMOS; SILVA; *et al.*, 2022) focused on the following guiding question: "The presence of fatty acids, flavonoids and carotenoids has been investigated in the Arecaceae of the Cerrado?". For this, the databases "Science Direct", "Google Scholar" and "CAPES Journals" were used in the search for articles published in the last 5 years (2019-2023).

According to Figure 1, the pre-selection of articles took place from the reading of the titles and abstracts. After excluding duplicates and reading the title and abstract, 108 articles were chosen for full reading. This complete reading sought to identify whether the article identified and/or quantified the compounds of interest in this study, as well as whether the plants studied were from the Cerrado. Thus, after a complete reading of the papers, only 17 were included. Other inclusion criteria were: articles published from 2019 onwards, in the databases cited and available in full in Portuguese or English. The exclusion criteria were: articles published before 2019, not fully available in the databases and after identification and reading, those that worked with fruits from other Brazilian biomes.

Figure 1. Scheme of the article search and selection process.



Source: Authors (2023)

The search strategy chosen was the combination of descriptors that addressed the popular and scientific names of the seven Arecaceae plants selected for the present study, associated sometimes with the term "flavonoid", sometimes with the term "carotenoid" and sometimes with the term "fatty acid" according to each database. To refine the search for articles, the AND/OR search operators were used (Table 2).

Table 2. Keywords used in the search of articles in the databases

SEARCH STRATEGY	NUMBER OF JOBS
carotenoid AND Guariroba OR *Syagrus oleracea*	307
carotenoid AND buritirana OR *Mauritiella armata*	95
carotenoid AND moriche palm OR *Mauritia flexuosa* OR buriti	1644
carotenoid AND butia palm OR *Butia odorata*	263
carotenoid AND *Syagrus coronata* OR licuri palm	108
carotenoid AND *Acrocomia aculeata* OR macauba OR macaw palm	702
carotenoid AND coquinho-azedo OR *Butia capitata*	220
fatty acid AND guariroba OR *Syagrus oleracea OR* gueroba	476
fatty acid AND moriche palm OR *Mauritia flexuosa* OR buriti	2268
fatty acid AND buritirana OR *Mauritiella armata*	101
fatty acid AND butia palm OR *Butia odorata*	235
fatty acid AND *Acrocomia aculeata* OR macauba palm OR macaw palm	1216
fatty acid AND *Syagrus coronata* OR licuri palm	214
fatty acid AND coquinho-azedo OR *Butia capitata*	257
flavonoid AND buriti OR *Mauritia flexuosa*	965
flavonoid AND butia OR *Butia odorata*	196

flavonoid AND coquinho-azedo OR *Butia capitata*	146
flavonoid AND Guariroba OR *Syagrus oleracea*	0
flavonoid AND buritirana OR *Mauritiella armata*	4
flavonoid AND *Syagruscoronata* OR licuri palm	1
flavonoid AND *Acrocomia aculeata* OR macaúba OR macaw palm	1011

Source: Authors (2023)

3 RESULTS AND DISCUSSION

In total, 5 articles related to carotenoids, 7 to fatty acids and 6 to flavonoids were selected. Only in one article was both the content of flavonoids and fatty acids mentioned. The low number of articles selected is due to the fact that, of the 78 articles selected for full reading, which addressed the compounds investigated, only 17 used the fruit of the Cerrado. Of the 61 articles discarded, 59% used fruits from the Amazon biome. For the correct definition of the biomes, the IBGE (Brazilian Institute of Geography and Statistics) website was used.

Table 3 shows the carotenoid content of the Arecaceae of the Cerrado. It can be observed that buriti is the plant matrix richest in carotenoids, with β-carotene being the most abundant species.

Table 3. Content of carotenoids identified in the Arecaceae of the Cerrado

FRUIT	CAROTENOIDS CONTENT	PLACE OF COLLECTION OF THE FRUIT (BRAZIL)	REFERENCE
Oil from buriti pulp	760.5 µg β-carotene/g oil	Bom Jardim de Goiás, GO.	(CRUZ *et al.*, 2020)
Buriti pulp	414 to 918 µg/g	Caxias, MA.	(SILVA, DARLISSON SLAG NERI *et al.*, 2022)
Oil from macaúba pulp	30-240 mg/kg β –carotene, according to the fruit genotype	Formosa, GO.	(ANTONIASSI *et al.*, 2020)
Butia pulp and seed	Pulp: 8.56 mg/100 g; Seed:1.83 mg/100 g β-carotene	Montes Claros, MG.	(BARBOSA *et al.*, 2021)
Extract of the coquinho-azedo pulp	139.93 µg/g	Montes Claros, MG.	(PEREIRA, GABRIEL STHEFANO LOURENÇO *et al.*, 2023)

Source: Authors (2023)

It can be observed that buriti is the plant matrix richest in carotenoids, with β-carotene being the most abundant species. β-carotene and its trans isomers are directly associated with antioxidant activity because they are responsible for the elimination of various free radicals, as well as promoting protection against mitochondrial apoptosis (PEIXOTO ARAUJO *et al.*, 2021). Considered a natural antioxidant, β-carotene is the precursor to vitamin A and therefore buriti

could be used to prevent vitamin A deficiency (ANTONIASSI *et al.*, 2020). This vitamin is essential for all tissues in the body because it fights free radicals, boosts the immune system and helps keep the antibody level high (CRUZ *et al.*, 2020). Comparing the content of total carotenoids found in different plant samples, the buriti pulp presented a value of 5.3, 7.9, 4.7, 34, 8.8, 39, 7.8 times higher than tomato, guava, carrot, mango, acerola, papaya and pumpkin, respectively (SILVA, DARLISSON SLAG NERI *et al.*, 2022).

Table 4 shows the fatty acid content of the Arecaceae of the Cerrado identified. Among the fatty acids identified in all samples, saturated fatty acids (SFA), palmitic acid (C16:0) and stearic acid (C18:0) stand out; oleic acid (C18:1) as monounsaturated fatty acid (MUFA) and linoleic acid w-6 (C18:2) as polyunsaturated fatty acid (PUFA).

Table 4. Content of fatty acids identified in the Arecaceae of the Cerrado (in %)

FRUIT	PLACE OF COLLECTION OF THE FRUIT (BRAZIL)	SFA	MUFA	PUFA	REFERENCE
Guariroba seed oil	Montes Claros, MG	85.13	9.87	2.0	(VELOSO *et al.*, 2022)
	Santo Antônio da Barra, GO	85.54	13.46	0.99	(WENCESLAU *et al.*, 2021)
Oil from buritirana pulp*		23.5	69.90	6.5	
Oil from buritirana peel*	Porto Nacional – TO	24.65	65.35	12.5	(DE SOUZA, FLORISVALDO GAMA *et al.*, 2021)
Whole buritirana fruit oil without seed *		23.15	68.10	7.75	
Oil from macaúba pulp*	Formosa, GO	22.23	22.54	21.43	(ANTONIASSI *et al.*, 2020)
Oil from buriti pulp	Bom Jardim de Goiás, GO	25.26	73.05	1.66	(CRUZ *et al.*, 2020)
Extract of the coquinho-azedo pulp	Montes Claros, MG.	25.91	45.69	27.16	(PEREIRA, GABRIEL STHEFANO LOURENÇO *et al.*, 2023)

*Average. SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids.
Source: Authors (2023)

Palmitic and stearic acids are the main SFA in the human brain and play an essential role in the structure and function of the uterus. Palmitic acid (C16:0) is the most widely disseminated SFA in nature, and can be detected in vegetable oils, fish oil, milk and adipose tissue of land animals (DO NASCIMENTO SILVA; CAVALCANTE; DA SILVA, 2023).

On the other hand, oleic acid (C18:1) is the fatty acid most found in nature and found in several products, as well as being the biological precursor of the ω-9 family. Oleic acid is the main MUFA found in the human brain and can be synthesized by all mammals, including humans (ALVES *et al.*, 2019). It is associated with beneficial effects related to cancer prevention, in addition to the prevention of inflammatory and autoimmune diseases (PARODI, 2016). As well as representing important MUFAs to consider for drug formulations for use in wound healing (ALVES *et al.*, 2019).

The potential stability of oleic acid during heating associated with its low number of unsaturations and its synergism with antioxidants, making the oil more resistant to oxidation (CRUZ *et al.*, 2020; SERRA *et al.*, 2019). For example, the high content of carotenoids combined with the high concentration of monounsaturated fatty acids, contributes to the high nutritional quality and stability of the oils during heating (CRUZ *et al.*, 2020).

Unsaturated fatty acids such as ω-6 (linoleic acid) are essential for humans, being both precursors of eicosanoids and regulators of intracellular signaling. They have multiple health benefits, including antithrombotic, anti-inflammatory and antioxidant actions, as well as in the prevention of chronic diseases such as cardiovascular diseases (INNES; CALDER, 2018; SERRA *et al.*, 2019). Do Nascimento Silva *et. al* (2023) report that among the main functions of PUFAs in the brain, hypothalamic regulation in hepatic glucose production, food intake and analgesia stand out (DO NASCIMENTO SILVA; CAVALCANTE; DA SILVA, 2023).

Buriti has a large amount of monounsaturated fatty acids, especially oleic acid, which compares to the amounts present in olive oil and sunflower oil. The oil of this fruit can be used for margarine production, due to its high oxidative stability (SERRA *et al.*, 2019). It also has a positive effect on the control of cholesterol in metabolism, so that the composition of buriti oil corroborates the presence of antioxidant and anti-diabetic activities (MORAIS *et al.*, 2022; QUINTERO-ANGEL; MARTÍNEZ-GIRÓN; ORJUELA-SALAZAR, 2022). Both buriti and macaúba oils can be fractionated to produce more stable oil fractions and capable of being used in the production of ice cream, chocolate and margarine (MAGALHÃES; DE SOUSA TAVARES; NUNES, 2020).

According to Souza et al. (2019), the fruit of macaúba is very nutritious, containing immunoadjuvant, anti-inflammatory and antioxidant characteristics, being also a source of nitrogen, phosphorus, potassium, calcium, manganese, iron, copper, zinc and bromine. Its oil

contains characteristics similar to canola and soybean oils, with the predominance of lauric and oleic acids as unsaturated fatty acids (SOUZA, GREDSON KEIFF *et al.*, 2019). The mesocarp of macaúba fruits is rich in oil, and can be made up of up to 56% of oil in dry matter. Studies indicate that the oil has no anti-nutritional factors, and has desirable amounts of monounsaturated fatty acids, carotenoids, tocopherols, and tocotrienols, as well as other micronutrients that aid in lowering human blood cholesterol (PRATES-VALÉRIO; CELAYETA; CREN, 2019). Thus, its oil is stable and has antioxidant characteristics and reduces the incidence of cardiovascular diseases. The addition of macaúba oil in the diet of rats with type 2 diabetes resulted in a decrease in hyperglycemia, reduced the concentration of triglycerides, LDL and increased HDL levels (NUNES *et al.*, 2020).

The antioxidant activity of these fruits is also related to the presence of phenolic compounds. Flavonoids make up a large part of the phenolic compounds. They are molecules of low molecular weight consisting of polyphenols characterized by 15 carbon atoms in their fundamental nucleus (NOGUEIRA *et al.*, 2022). In plants, they are essential for plant growth and reproduction. They are found in plant species such as fruits, seeds, bark, roots, flowers and contribute to confer sensory characteristics such as color and astringency (RODRIGUES, DAIANE BATISTA *et al.*, 2021; SILVA, MAURO R. *et al.*, 2019). Table 5 shows that for the same fruit the type and amount of flavonoids may vary according to the part studied. Even in small amounts, these compounds have physiological effects through their antioxidant action, playing an essential role in the processes of inhibition of the risk of cardiovascular diseases and various chronic-degenerative diseases, such as diabetes, cancer and inflammatory processes (GUEDES *et al.*, 2017; MIGUES *et al.*, 2018), and are concentrated in different parts of the plant (DA VEIGA CORREIA *et al.*, 2022)

Table 5. Flavonoid content identified in the Arecaceae of the Cerrado

FRUIT	FLAVONOID CONTENT	PLACE OF COLLECTION OF THE FRUIT (BRAZIL)	REFERENCE
Oil from buriti pulp	0.05986 mg/g	Balsas–MA	(OLIVEIRA *et al.*, 2020)
Buriti	Pulp: 0.74 mg CE[1]/g of freeze-dried sample; Whole fruit without seed: 0.53mg CE[1]/g of freeze-dried sample; Peel: 0.29mg CE[1]/g of freeze-dried sample; Seed: 0.02 mg CE[1]/g of freeze-dried sample.	Fazenda Moreira, localizada em Porto Nacional, Brasil.	(DE SOUZA, FLORISVALDO GAMA *et al.*, 2022)

Buritirana leaves	Catechin identification	Pandeiros – MG	(MATOS *et al.*, 2022)
Macaúba mesocarp	32.31 mg ERU^2/100g of flour or 51.75 mg ERU^2/L ethanolic extract of flour.	Poconé - MT	(CORREIA *et al.*, 2022)
Buritirana pulp	Rutin identification (quercetin was identified, but the value was below the limit of quantification).	Porto Nacional – TO	(DE SOUZA, FLORISVALDO GAMA *et al.*, 2022)
Pulp, peel, and seed of buritirana	Quercetin; 5-deoxyleucopelargonidin; apigenin hexoside; catechin hexoside; kaempferol coumaroyl deoxyhexoside; apigenin caffeoylhexoside; catechin dihexoside; myricetin coumaryl robinobioside deoxyhexoside	Porto Nacional – TO	(DE SOUZA, FLORISVALDO GAMA *et al.*, 2021)

Source: Authors (2023)

Catechin, rutin and quercetin were the main flavonoids identified. Catechin is a flavanol compound widely present in many food sources. In addition to having an anticarcinogenic effect (MATOS *et al.*, 2022), this molecule positively influences neuroinflammation by providing neuroprotection (FARKHONDEH *et al.*, 2020) and has been reported to have neuroprotective effects on cell death and cytotoxicity (CONTE; PELLEGRINI; TAGLIAZUCCHI, 2003; NOBRE *et al.*, 2003). In addition, the administration of high doses of catechin positively influenced some immune pathways and oxidative stress signaling (ASSMANN *et al.*, 2021). Rutin and quercetin have pharmacological properties such as anti-inflammatory action and antioxidant power, acting on free radicals responsible for degenerative diseases and aging and cell death (RODRIGUES, CARLOS EDUARDO *et al.*, 2022).

Therefore, it can be observed that no data were found on the licuri of the Cerrado. It is worth mentioning that most of the studies focused on the analysis of the pulp of the fruits, without taking into account the potential of the other parts of the fruits. Many species of the Cerrado are still underutilized by local communities because the lack of scientific knowledge or the low incentive to develop innovative technologies and processes have prevented these communities from exploiting to the maximum the productive potential of this biome. It is worth mentioning that the species of Arecaceae may differ morphologically and functionally according to the ecosystem in which they occur, therefore, the importance of understanding more about the Arecaceae of the Cerrado.

4 CONCLUSIONS

It appears that only buriti and macaúba were investigated regarding the content of the three compounds investigated. The sour coquinho was evaluated for the content of carotenoids

and fatty acids, the buritirana was evaluated for the content of flavonoids and fatty acids. Butiá was investigated for carotenoid content, while guariroba was only investigated for fatty acid content. The main fatty acids reported in the fruits of the Arecaceae of the Cerrado were: palmitic, stearic, oleic and linoleic acids. The main carotenoid was β-carotene and catechin, rutin and quercetin stands out among the flavonoids.

It is known that these primary and secondary metabolites are produced by almost all plants, but the lack of knowledge about the type and quantity may be one of the factors why the fruits of these palms are little explored and consequently have few applications in industry.

Therefore, this integrative review elucidates the potential of the fruits of the palm trees of the Cerrado, as well as the gap of studies related to their bioactive compounds and their fatty acid composition. This scarcity of data hinders the insertion of these fruits in human food, besides underestimating the potential of the Cerrado. It is necessary that future studies investigate the fruits of this biome, including those less analyzed, in order to highlight their possible functional potential.

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