Orbital
The electronic journal of chemistry

the electronic journal of chemistry

Review | http://dx.doi.org/10.17807/orbital.v14i3.17430

A Systematic Review of the Photoprotective Potential of Native Edible Plants from Mato Grosso do Sul, Brazil

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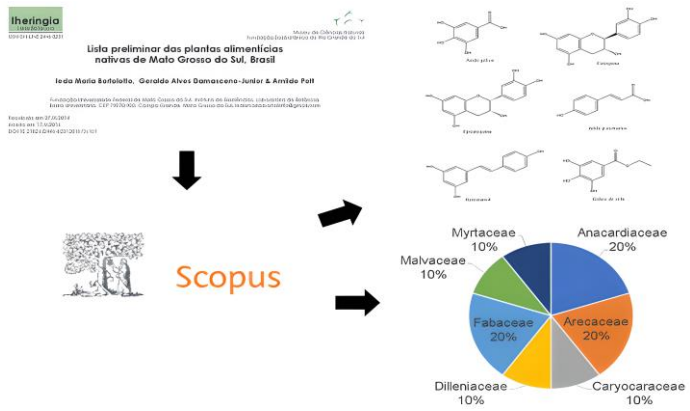
The state of Mato Grosso do Sul (Brazil) has a rich biodiversity, with varied biomes and many native species. Simultaneously, the plants in the region have been studied for their chemical and biological potential, including photoprotective properties and applications in phytocosmetics. Edible plants have potential application based on the presence of photoprotective and antioxidant compounds in their chemical composition. In this context, the aim was to review systematically studies on the photoprotective action of native food plants from Mato Grosso do Sul in the Scopus database, delimiting for articles published between 2000 and 2020. Only 4.08% of the species presented articles exploring the photoprotective activity, distributed in 10 articles. The extracts evaluated were varied, with different formulations. 40% of the articles addressed ethanolic extracts, 20% hydroethanolic extracts, and 40% vegetable fixed oil. The lowest sun protection factor reported was for the aqueous extract of the fruit pulp of *Hymenaea martian* Hayne (SPF 0.66) and the highest was for a formulation using *Schinus terebinthifolius* Radi extracts added to Lanette cream (SPF 32.40). The native food plants of Mato Grosso do Sul are still little explored regarding their photoprotective action, with a lack of *in vivo* studies.

Graphical abstract



Keywords

Biodiversity
Phytocosmetics
Natural resource

Article history

Received 22 Nov 2021
Revised 01 Aug 2022
Accepted 24 Aug 2022
Available online 01 Oct 2022

Handling Editor: Fernanda R. Garcez

1. Introduction

Sunlight is very important for life on Earth, as it provides the major source of energy for all living things on the planet. Furthermore, sunlight provides physical and mental health to humans and takes part in producing the steroid hormone known as vitamin D3 in humans [1] through the photochemical reaction of 7-dehydrocholesterol in the skin [2].

Low exposure to sunlight is also related to reduced levels of serotonin in the brain [3], thus, reduced exposure can induce insomnia and depression problems [4]. However, excessive exposures can cause skin damage [5, 6] depending on the

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time and intensity of exposure, genetic factors, and skin type [7]. An example of this is the risk of developing melanoma and non-melanoma skin cancer in outdoor workers because of prolonged exposure to sunlight [8].

Among the aspects that influence the ideal dose of sun exposure are geographic factors such as the latitude and altitude of the place in question. Countries in regions close to the Earth's poles have reduced solar irradiation, which is still drastically affected by seasonality [9]. The presence of clouds can cause a fluctuation in UV irradiation, as well as the exposure time [10].

Exposure time is also relevant to the effect of UV radiation on humans. Excessive exposure for a short period can cause skin pigmentation and sunburn, while long exposures can lead to skin aging and cancer [11].

The penetration of UV rays is related to the wavelength. According to ANVISA, UV radiation between 320 and 400 nm is called UVA, between 290 and 320 nm UVB, and 200 to 290 nm UVC [12]. UVA radiation penetrates deeply into the dermis, and UVB radiation is mostly absorbed in the epidermis [13], while UVC radiation is highly energetic and harmful to human health but is not found naturally in the biosphere [2]. Thus, overexposure to UVA radiation is mainly responsible for wrinkles, sagging and photoaging due to its ability to generate DNA-damaging reactive oxygen species (ROS) while UVB radiation causes burns, a burning sensation, cataracts, and skin cancer, due to molecular rearrangements that generate harmful photoproducts [13, 14].

Sunlight irradiated on earth has only 5% in the UV region [15], but part of this radiation is absorbed by the atmosphere, with UVC radiation being filtered by the atmosphere and UVB being partially absorbed by the ozone layer [16]. Between 97 and 99% of the radiation between 200 and 315 nm is absorbed in the ozone layer, however, anthropic actions have resulted in the reduction of the ozone layer, leading to greater penetration of UV rays and consequently a higher incidence of UVB rays in the troposphere [17, 18].

Sunscreens have great relevance for protecting the skin against damage by solar radiation [19]. Using these protectors is the main cosmetic approach against the harmful effects of UV radiation, preventing premature skin aging and diseases. They can be found in the oil and hydroalcoholic lotions, aerosols, and oil gels, among others [20].

Sunscreens are divided into physical and chemical filters. Physical filters are inorganic compounds capable of reflecting or absorbing radiation [21], which act as a physical barrier, formed by a film of particles, preventing the passage of radiation [23]. Chemical protective filters usually contain chemical compounds with a carbonyl, hydroxyl, amine, or methoxyl conjugated to an aromatic ring [21, 22]. Chemical protective agents have an electron donor group commonly in the *ortho* or *para* position. Upon absorbing ultraviolet radiation, electrons in the highest energy full molecular orbital are excited to the empty low energy molecular orbital and when they return to the ground state, they release energy as heat [22].

The UV/Vis light absorption properties of an organic compound are directly related to the chemical structure of the compounds, with the electronic transitions $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ from the and $n \rightarrow \pi^*$ from the conjugation of π bonds occurring as a consequence UV excitation, being influenced by amount and position of electron donor groups [24-26]. In this process, electrons pass from a lower to a higher energy state (HOMO→LUMO transition), with both orbitals being delocalized between the aromatic rings in the case of polyphenolic compounds [26].

With the growing interest in green cosmetics, some vegetable extracts and oils have been studied for sun protection products because of their photoprotective effects [27]. The choice of natural extracts used in cosmetics is based on solubility and chemical composition, considering that the photoprotective action of these inputs is usually associated with phenolic compounds such as flavonoids, phenolic acids, polyphenols, and tannins [28].

Phytocosmetics are prepared with plant inputs that are associated with the pharmacological activity of the product [29]. In Brazil, there is still no specific legislation for phytocosmetics, hence, the addition of plant extracts in cosmetics must follow the legislation applicable to conventional cosmetics [30].

New technologies have been developed along with the exploration of plant extracts to overcome solubility challenges, mainly related to nanotechnology, thus allowing the exploration of extracts that do not present favorable characteristics for formulations [31].

The presence of phenolic compounds and other secondary metabolites in plants is associated with evolutionary adaptations concerning abiotic stress tolerance, among which is the incidence of UV radiation [32]. The production of these compounds is related to the incidence of UV radiation on plants, with flavonoids showing great relevance because they present an expressive absorption between the wavelengths of 250 to 270 nm and 335 to 360 nm, and plants from tropical regions (including Brazil) showing higher levels of flavonoids than temperate plants [32].

Brazil is considered the country with the greatest biological diversity on the planet, as it accounts for 20% of the total number of species in the world, with an estimate between 350.000 and 550.000 species [33]. The state of Mato Grosso do Sul, in the central-west region of Brazil, stands out in three different biomes, Atlantic Forest, Pantanal, and the Cerrado, which is the dominant biome [34]. Bortolotto et al. [35] carried out a survey of native edible plant species from Mato Grosso do Sul, obtaining 294 different species, distributed in 160 different genera.

In this context, edible plants represent an excellent source of phenolic compounds, representing the primary source of this class of compounds in the human diet [36, 37, 38]. The presence of these compounds makes these plants show potential for the formulation of phytocosmetics. In addition, residues from the processing of these plants also present bioactive compounds [39, 40].

Sopyan et al. [41] developed a photoprotective formulation using tomato fruit extract (*Solanum lycopersicum* L.), with an SPF of 22.24 at a concentration of 1.5% of the extract. Khelker et al. [42] studied the potential of extracts of turmeric rhizome (*Curcuma longa* L.) and orange peel (*Citrus sinensis* (L.) Osbeck) obtaining SPF of 3,086 for *C. sinensis* and of 0,330 for *C. longa*.

Piva et al. [43] studied the photoprotection of aqueous extracts of three basil species (*Ocimum basilicum*, *O. gratissimum,* and *O. kilimandscharicum*) with SPF between 1.0 and 8.4, while Cavalcante [44] studied the SPF of essential oils of these same species obtaining values between 0.36 and 2.28 at a concentration of 200 μg mL^{-1}.

Another advantage of using food plants in the search for new photoprotective extracts is the antioxidant activity [45]. The hydroxyls as substituents on the aromatic rings of phenolic compounds allow the scavenging of ROS and other

radicals, as the hydroxyls can donate electrons, and hydrogen or act as chelates for metal ions that catalyze oxidation [36].

One more radiation of interest for phytocosmetics is infrared-A radiation (IRA) that operates as a photostimulation acting on the mitochondria Cytochrome C Oxidase (CCO) enzyme [46], stimulating cell proliferation, tissue repair, and modulation of damage caused by UV radiation [47]. Harmful effects on the skin have been shown *in vitro* and *in vivo* studies in rats when IRA is in excess, thus raising concerns about inadequate exposure to this type of radiation [48]. The randomized, double-blind study by Grether-Beck et al. [49] demonstrated that incorporating antioxidants in sunscreens results in effective protection against ROS produced by ARI in healthy volunteers.

Besides plant extracts, fixed oils are also used in cosmetic products [50]. Such oils can also be part of the emulsion formulation, considering that part of the organic compounds usually used in sunscreens is oil soluble [51].

According to ANVISA [52], the formulation of sunscreens and multifunctional cosmetics should be carried out based on the list of allowed compounds, thus the exploration of natural products is important to expand this list and forward, business opportunities, as reiterated by Guaratini et al. [53].

As reported, the goal was to survey the Scopus database of articles published between 2000 and 2020 that study the photoprotective action of food plants native to the state of Mato Grosso do Sul.

2. Material and Methods

2.1 Systematic review methodology

The plants chosen for the review were those reported in the list of food plants native to Brazil found in Mato Grosso do Sul, prepared by Bortolotto et al. [35].

The review took place in the Scopus databases, using the combinations of terms in separate searches: "scientific name of the plant" AND "SPF" and "scientific name of the plant" AND "photoprotective", searching in titles, abstracts, and keywords (**Fig.1**). Genus and species names of plants were used in searches as scientific names. The research was carried out by delimiting all articles published between 2000 and 2020.

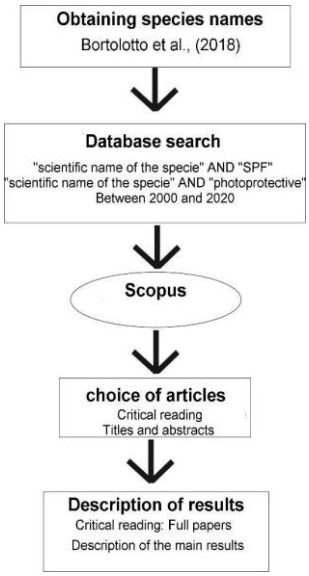

Fig. 1. Review system flowchart.

3. Results and Discussion

3.1 Results described in the studies

To select the articles, we performed a critical reading of the abstracts and titles to assess which studies evaluated the photoprotective effect of plant extracts or their formulations. After selecting the articles relevant to the review, a critical reading of the articles in full was carried out, analyzing the methodologies used, and the data obtained. Only scientific articles were considered, excluding book chapters, event abstracts, and literature reviews.

Finally, the research results were tabulated, and descriptions of the main findings related to the topic were made.

Bortolotto et al. [35] reported two hundred and ninety-four native food species, being selected 12 species (4.08%) in the focus of this survey. The main families were Myrtaceae with 4 species, Fabaceae with 2 species, Arecaceae with 2 species, and the others had only 1 species each (**Table 1**).

Table 1. Species obtained after screening the articles.

Genus	Species	Traditional Name	An
Anacardiaceae	*Schinus terebinthifolius* Radi[I]	Aroeira[a]	2
Arecaceae	*Acrocomia aculeata* (Jacq.) Lodd. ex Mart.[II]	Bocaiuva[b]	1
Arecaceae	*Mauritia flexuosa* L.f.[II]	Buriti[b]	1
Caryocaraceae	*Caryocar brasiliense* Cambess[III]	Amêndoa de espinho[b]	1
Dilleniaceae	*Curatella americana* L.[III]	Folha de lixa[b]	1
Fabaceae	*Arachis hypogaea* L.[III]	Amendoim[b]	1
Fabaceae	*Hymenaea martiana* Hayne[III]	Copaíba[b]	1
Malvaceae	*Guazuma ulmifolia* Lam.[III]	Araticum bravo[b]	1
Myrtaceae	*Campomanesia adamantium* (Cambess.) O. Berg[III]	Guavira[c]	1
Myrtaceae	*Campomanesia sessiliflora* (O. Berg) Mattos[III]	Guabiroba verde[c]	1
Myrtaceae	*Campomanesia guazumifolia* (Cambess.) O. Berg[III]	Sete-Capotes[c]	1
Myrtaceae	*Campomanesia xanthocarpa* (Mart.) O. Berg[III]	Guabiroba[b]	1

AN = Articles number; I = Searched on 03/09/2021; II = Searched on 04/09/2021; III = Searched on 05/09/2021. a= Diniz et al. [54]; b = Dataplamt [55]; c= Catelan et al. [56].

The species were distributed in 10 articles, 40% of which used ethanol as the extracting solvent, 20% used mixtures of ethanol and water, and 40% of the studies used plant fixed oil.

Most articles [57–63] used the methodology proposed by Mansur et al. [64], which employs UV/Vis spectroscopy to measure the SPF. Couteau et al. [65] used a similar method described by Diffey and Robson [66].

$$SPF = CF \sum_{290}^{320} EE(\lambda) \times I(\lambda) \times Abs(\lambda) \quad (1)$$

Mansur's method [64] uses the absorbance (Abs) of a sample, considering its dilution (CF), solar intensity (I), and entheogenic effect of radiation (EE) (Equation 1). erythema is the redness caused by sunburn [67].

The erythemal efficiency (*EE×I*) was previously calculated by Sayre et al. [68] for each wavelength used (**Table 2**).

In this way, the calculation based on the *in vitro* data of the sample estimates the SPF by correlating the associated values of the erythema formation capacity by wavelength with the absorbance of the sample, performing a dilution correction [64, 69].

The photoprotective effect of the plant extracts has been closely associated with phenolic compounds [70], as well as the antioxidant potential [71], pointed out as an advantage in formulating phytocosmetics [72]. In this sense, it was also possible to observe that several authors analyzed the correlation between phenolic compounds and antioxidant activity with photoprotective action (**Table 3**).

Table 2. Erythemal efficiency values by wavelength.

Wavelength (nm)	EE x I (Normalized)
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.0180

Source: Sayre et al. [68].

Table 3. Antioxidant potential and phenolic compounds described in the studies in this review.

Test	Species	Part of the Plant (Solvent)	Value Obtained	Compounds Identified	Reference
AP (DPPH)	*Schinus terebinthifolius*	Pulp (Et)	Absent	1. Gallic acid	[57]
AP (DPPH)		Fruit peel (Et)	6.1 μg mL^{-1}	2. Catechin	
AP (FRAP)		Pulp (Et)	488.6μmol TE g^{-1}	3. Epicatechin	
AP (FRAP)		Fruit peel (Et)	3484.7 μmol TE g^{-1}	4. *p*-Coumaric acid	
PC		Pulp (Et)	73.6 mg GAE g^{-1}	5. Resveratrol	
PC		Fruit peel (Et)	452.5 mg GAE g^{-1}	6. Ethyl gallate	
AP (DPPH)		Leaf (Et:Wa 9:1)	5.77 μg mL^{-1}	1. Gallic acid	[58]
PC		Leaf (Et:Wa 9:1)	384.64 mg GAE g^{-1}	6. Ethyl gallate	
AP (DPPH)	*Acrocomia aculeata*	Almond (Oi)	Absent		[59]
AP (DPPH)		Fruit pulp (Oi)	23.89 μg mL^{-1}		
AP (ORAC)		Almond (Oi)	Absent	7. Oleic acid	
AP (ORAC)		Fruit pulp (Oi)	42.02 μM TE g^{-1}	8. Linoleic acid	
PC		Almond (Oi)	Not detectable		
PC		Fruit pulp (Oi)	2.69 mg GAE g^{-1}		
AA	*Caryocar brasiliense*	Fruit pulp (Oi)	2.921 mg mL^{-1}	9. Palmitic acid	[60]
PC		Fruit pulp (Oi)	163.24 mg GAE g^{-1}	7. Oleic acid	
Fl		Fruit pulp (Oi)	76.32 mg QE g^{-1}	10. Stearic acid	
AP (DPPH)	*Curatella americana*	Leaf (Et)	11.06 μg mL^{-1}	-	[61]
AP (DPPH)		Bark (Et)	5.17 μg mL mL^{-1}		
PC		Leaf (Et)	45.52 mg GAE g^{-1}		
PC		Bark (Et)	57.14 mg GAE g^{-1}		
Fl		Leaf (Et)	5.89 mg QE g^{-1}		
Fl		Bark (Et)	1.80 mg QE g^{-1}		
AP (DPPH)	*Guazuma ulmifolia*	Fruits (Et:Wa 1:1)	8.94 μg mL^{-1}	-	[62]
PC		Fruits (Et:Wa 1:1)	24.26 %		
PC	*Campomanesia adamantium*	Leaf (Et)	477.99 mg GAE g^{-1}	-	[56]
Fl		Leaf (Et)	348.67 mg QE g^{-1}		
PC	*Campomanesia sessiliflora*	Leaf (Et)	435.67 mg GAE g^{-1}	-	[56]
Fl		Leaf (Et)	299.79 mg QE g^{-1}		
PC	*Campomanesia guazumifolia*	Leaf (Et)	444.78 mg GAE g^{-1}	-	[56]
Fl		Leaf (Et)	312.73 mg QE g^{-1}		
PC	*Campomanesia xanthocarpa*	Leaf (Et)	486.37 mg GAE g^{-1}	-	[56]
Fl		Leaf (Et)	369.22 mg QE g^{-1}		

GAE = Gallic acid equivalent; QE = Quercetin equivalent. AP = Antioxidant Potential; PC = Phenolic compounds; Fl = Flavonoids; ORAC = Oxygen radical absorption capacity; DPPH = Inhibition test with 1,1-diphenyl-2-picrylhydrazyl; FRAP = Ferric reducing ability of plasma; Et = Ethanol; Wa = Water; Oi = Fixed Oil. -: The studies of references 51,55,56 and 57 do not present identified compounds.

Phenolic compounds can be present in plant extracts in free form or linked to proteins and sugars, being found mainly in plant organisms [73]. These compounds may present electron donor groups at these positions in their aromatic rings, making them compounds with potential for use as photoprotection [22, 73].

The chemical structure of polyphenolic compounds can be classified by the number of carbons in the bridge between the aromatic rings, being considered xanthonoids for C6-C1-C6, stilbenoids, anthraquinones, and anthrones for C6-C2-C6, flavonoids for C6-C3-C6 and curcuminoids for C6-C7-C6, which can be open bridges or forming heterocycles [74].

The antioxidant activities of the extracts were determined by three different colorimetric methods. The DPPH (2,2-diphenyl-1-picrylhydrazyl) method is based on reducing the absorbance at a wavelength associated with purple color due to the scavenging of the DPPH radical that accepts hydrogen (H) from the antioxidant compound [75]. One standardized method for determining the antioxidant capacity of a substance is the ORAC (oxygen radical absorbance capacity) assay. The ORAC assay is based upon the inhibition of the peroxyl radical-induced oxidation initiated by thermal decomposition of azocompounds such as [2,2'-azobis (2-amidino-propane) dihydrochloride (AAPH)] [76]. The ferric reducing antioxidant power (FRAP) assay is a method that

measures the reduction of ferric ion (Fe^{3+}) ligand complex to the intensely blue-colored ferrous (Fe^{2+}) complex by antioxidants in an acidic medium [77].

These methods provide different information regarding the antioxidant mechanisms involved, with ORAC involving hydrogen transfer and FRAP involving electron transfer [78].

The method used by the articles to quantify the phenolic compounds uses the Folin-Ciocalteu reagent (phosphotungstic acid, phosphomolybdic acid, and lithium salt) which oxidizes the phenolic compounds in the sample resulting in a mixture of tungsten oxide and molybdenum that present a blue color quantifiable [79], and the lithium salt acts to prevent the degradation of the reagent in an alkaline medium [80]. The quantification of compounds occurs through a calibration curve with a standard compound. All studies used gallic acid as a standard (**Table 3**).

All studies that quantified flavonoids performed a reaction of the sample with aluminum chloride ($AlCl_3$), forming complexes with flavonoids that present an indigo coloring that allows quantification. Catelan et al. [56] used rutin as a standard compound in the elaboration of the calibration curve, while Nunes et al. [60] and Pegorin et al. [61] used quercetin as a standard (**Table 2**).

Phenolic compounds were also quantified by chromatography. Comparing the retention time of standards in high-performance liquid chromatography (HPLC), Oliveira et al. [57] identified phenolic compounds: gallic acid, catechin, epicatechin, p-coumaric acid, and resveratrol (**Fig. 2**) in the ethanol extract of the fruit and rind of the fruit of *Schinus terebinthifolius* Radi. Bulla et al. [58] identified the compounds gallic acid and ethyl gallate (**Fig. 2**) when comparing retention time with HPLC standards in the 90% ethanol: water extract of *S. terebinthifolius* leaf, and the structures were confirmed by using the technique of nuclear magnetic resonance (NMR).

The ethanol extract of the *S. terebinthifolius* fruits peel presents SPF higher than the whole fruit [57]. Accordingly, the fruit's rind has an SPF of 26.82 at 2 mg mL^{-1}, while the whole fruit has a value of 16.14 at the same concentration. In the work by Oliveira et al. [57], ethanol extracts from the skin and pulp of *S. terebinthifolius* showed low or absent toxicity in placental cell cultures. In the study by Bulla et al. [58], the extract obtained from the leaf of *S. terebinthifolius* with a mixture of ethanol: water (9:1) had an SPF of 2.403 at a concentration of 10% (w/v), 6.895 at a concentration of 25% (w/v).

Oliveira et al. [57] also evaluated the SPF of *S. terebinthifolius* extracts added to Lanette cream at concentrations of 5% and 10%, obtaining the highest SPF for the 10% mixture at 5 mg mL^{-1} for the ethanol extract of fruit rind, being 32.40.

Another species that was evaluated as a cream formulation was *Caryocar brasiliense* Cambess, where an SPF of 11.40 was obtained for incorporating fruit pulp oil without adding synthetic sunscreen, but no synergy was observed with octyl methoxycinnamate [60]. Pegorin et al. [60] also verified that the oil from the pulp of *C. brasiliense* does not present toxicity in rat fibroblasts. The fatty acids palmitic (52.1%), oleic (44.6), and stearic (1.84%) were the majority in the fruit pulp of *C. brasiliense* (**Fig. 3**) and its photoprotective activity was associated with the presence of phenolic compounds (**Table 3**) [60]. Pegorin et al. [60] also report that the formulation has stability in centrifugation tests, heat stress, maintaining pH, spreadability, and organoleptic characteristics during storage for 28 days.

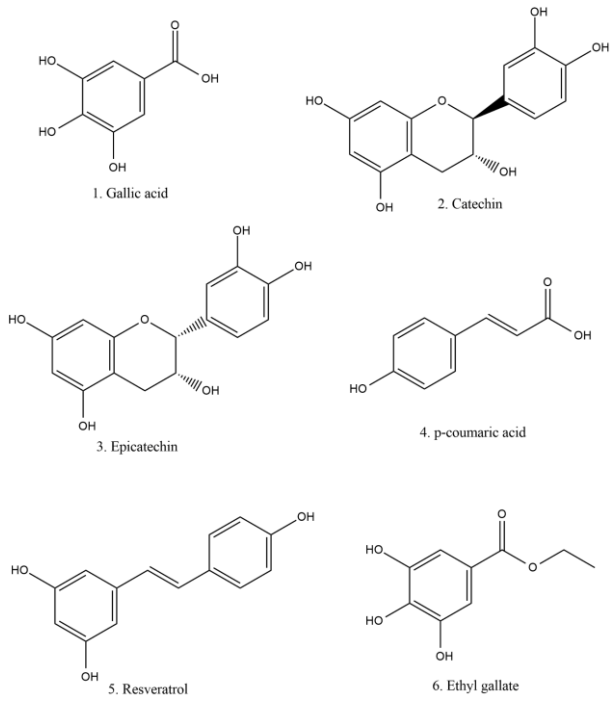

Fig. 2. Identified structures of phenolic substances in *S. terebinthifolius* extracts. Source: Authors (2022) based on the description of Oliveira et al. [57] and Bulla et al. [58].

The identification of fatty acids (FA) in oils used in cosmetic formulations is relevant, as different compositions result in different effects on the physicochemical characteristics of the final product [81]. The FA composition affects melting point [82] and solubility [83]. The presence of FA can also interact with the skin lipid barrier [84].

Dario et al. [59] determined the fatty acid composition by GC-MS of the pulp and almond oil of the fruit of *A. aculeata*, obtaining mostly oleic acid (78.10%) for the pulp and linoleic acid for the almond (59.62%) (**Fig. 3**). Furthermore, these same authors formulated nanostructured lipid carriers with *Arachis hypogaea* L. oil, obtaining an SPF of 27.7, presenting in its composition phenolic compounds and carotenoids.

Dario et al. [59] evaluated other parameters associated with photoprotection in *C. aculeata* oil presenting a critical wavelength (λc) of 341 nm for almond oil, 370 nm for pulp oil, and 373 nm for the nanostructured formulation of almond oil and pulp oil. Regarding the UVA/UVB ratio, the *C. aculeata* pulp oil was 0.430 and 0.550 for the nanostructured almond oil formulation and 0.562 for the pulp oil formulation [59]. Both properties are associated with the absorption of radiation in the UV region [12]. For the species *Guazuma ulmifolia* Lam, the extract obtained from the bark with ethanol: water (1:1) was evaluated in the study by Munhoz et al. [62], achieving an SPF of 19.05 when added to the standard sunscreen formula, and the formulation showed stability after 24 hours of storage.

The study by Oliveira et al. [63] also performed a phytochemical analysis of the pulp and seed of *H. martian*, identifying flavonoids and tannins, mono and diterpenes and anthracene derivatives for pulp, and seed identified flavonoids and tannins and anthracene derivatives.

The species *H. martiana* had also its SPF quantified with values of 0.66 for the ethanol extract of the fruit pulp and 4.54 for the aqueous extract of the seed [63]. Another species that also belongs to the Fabaceae family that was studied was *Curatella americana* L., with the ethanolic extract of the leaf presenting an SPF of 12.77 and the bark of 14.74 in the study

by Nunes et al. [61].

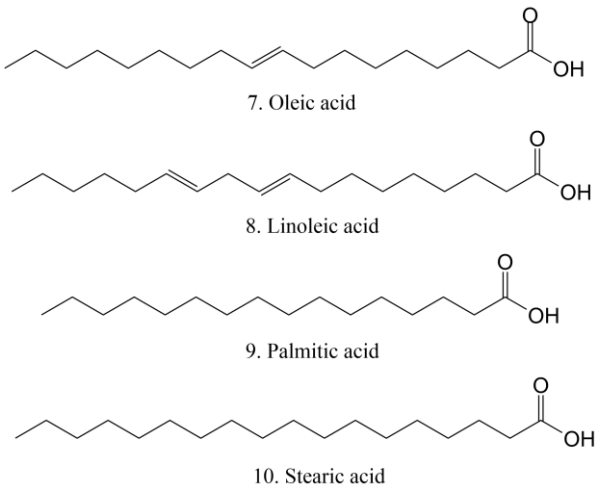

Fig. 3. Major compounds of the fixed oils of *A. aculeata* (7 and 8) and *C. brasiliense* (7, 9 and 10). Source: Authors (2022) based on the description of Dario et al. [59] and Pegorin et al. [60].

Cytotoxicity is another important factor in the elaboration of phytocosmetics. Zanatta et al. [85] conducted a study evaluating the photoprotective effect of emulsions containing oil of *Mauritia flexuosa* L.f on keratinocytes and fibroblast cell lines, concluding that the emulsion containing sorbitan monooleate and PEG-40 castor oil can reduce UV radiation damage, especially when associated with panthenol. However, Zanatta et al. [85] did not quantify the FPS of the extracts.

As for the species *Acrocomia aculeata* (Jacq.) Lodd. ex Mart, the SPF of almond oil, was 1.1 and 4.3 for the fruit pulp oil [59]. These authors also carried out formulations in a nanostructured lipid system, obtaining the best value of 31.8 for the formulation of the associated almond oil.

Catelan et al. [56] studied the photoprotective effect of ethanol extracts from the species *C. adamantium* (Cambess.) O. Berg, *C. sessiliflora* (O. Berg) Mattos, *C. guazumifolia* (Cambess.) O. Berg and *C. xanthocarpa* (Mart.) O. Berg, as well as their mixtures and their incorporation into octyl methoxycinnamate. The highest value obtained for the isolated extract was 5.58 for *C. xanthocarpa* at a concentration of 8%, while the highest value for incorporation of octyl methoxycinnamate was 19.63 for the mixture of 4% *C. adamantium*, 4% *C. xanthocarpa* and 8% octyl methoxycinnamate [56].

There is a lack of *in vivo* studies on the photoprotective effects of plant extracts and their formulations with these species described in **Table 1**. It was also observed the absence of quantification of other spectroscopic parameters mentioned by Velasco et al. [86] and ANVISA [12], as λ_c and the UVA/UVB ratio. More complete studies are needed regarding the chemical composition involving the stability of formulations of extracts or preparations.

4. Conclusions

Despite the rich biodiversity present in the state of Mato Grosso do Sul (Brazil), still few studies exploring the photoprotective activity of edible native plants exists, and only 4.08% of the analyzed species presented studies within the Scopus database for photoprotective action.

Acknowledgments

Fundação de Apoio ao Desenvolvimento do Ensino, Ciência e Tecnologia do Estado de Mato Grosso do Sul (FUNDECT), Financiadora de Inovação e Pesquisas (FINEP), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) TLAC and GACP (Finance Code 001) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) CALC (process 312671/2021-0).

Author Contributions

T. L. A. C. = Conceptualization; Investigation; Methodology; Writing – original draft; G. A. C. P. = Investigation; Writing – original draft; C. A. L. C. = Supervision; Writing – review & editing.

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How to cite this article

de Castro, T. L. A.; Pinto, G. A. C.; Cardoso, C. A. L. *Orbital: Electron. J. Chem.* **2022**, *14*, xx. DOI: http://dx.doi.org/10.17807/orbital.v14i3.17430