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Spondias purpurea L. (Anacardiaceae): traditional uses, chemical composition and biological activities[1]

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Resumo

Esta revisão relata informações sobre a planta *Spondias purpurea* L. (Anacardiaceae), descrevendo o uso medicinal, perfil fitoquímico e suas atividades biológicas publicadas. Foi realizada revisão bibliográfica constando de artigos com o nome científico da planta, publicados nas bases de dados Pubmed, Science Direct, Web of Science, SciFinder, Google Acadêmico e periódicos Capes e uma busca de anterioridade de patentes, utilizando os bancos de dados European Patente Office, World Intellectual Property Organization, United States Patent and Trademark Office, Spacenet e Instituto Nacional de Propriedade Intelectual. Os resultados mostram que *S. purpurea* tem sido tradicionalmente usada para tratar várias doenças, como problemas gástricos, diabetes e colesterol. Estudos fitoquímicos da fruta e casca desta planta têm mostrado que são ricos em compostos fenólicos, ácidos orgânicos e compostos voláteis. No entanto, há pouca informação fitoquímica referente às folhas e outras estruturas desta planta. Os estudos sobre as atividades biológicas da planta são principalmente de extratos brutos, com os seguintes efeitos terapêuticos: atividades antimicrobianas, antifúngicos, antioxidantes e antiúlcerogênico. Nas buscas de dados referentes à produção patente, poucas patentes relacionadas com essa planta foram encontradas. Sugere-se que mais estudos de identificação dos compostos bioativos, atividades biológicas e citotoxicidade sejam realizados, para explorar o potencial de *S. purpurea* como fonte de agentes terapêuticos.

Palavras-Chave: Etnobotânica, etnofarmacologia, fitoquímica, *Spondias purpurea*.

Abstract

This review reports information about the plant *S. purpurea* L. (Anacardiaceae), describing its medicinal use, phytochemical profile and published biological activities. A literature review was conducted consisting in articles containing the scientific name of the plant, published in the databases PubMed, Science Direct, Web of Science, SciFinder, Google Scholar and Capes journals and a search for prior patents using the databases European Patente Office, World Intellectual Property Organization, United States Patent and Trademark Office, Spacenet and Instituto Nacional de Propriedade Intelectual. The results show that *S. purpurea* has traditionally been used to treat various diseases such as gastric disorders, diabetes and cholesterol. Phytochemical studies of the fruit and bark of the plant have shown that it is rich in organic acids, phenolic and volatile compounds. However, there is little phytochemical information concerning the leaves and other structures of this plant. Studies on the biological activities of the plant are mainly on crude extracts with the following therapeutic effects: antimicrobial, antifungal, antioxidant and anti-ulcer activities. In the searches for patent data, one found few patents related to *Spondias purpurea*. It is suggested that further studies are carried out to identify the bioactive compounds, biological activities and cytotoxicity, in order to explore the potential of *S. purpurea* as a source of therapeutic agents.

Keywords: Ethnobotany, Ethnopharmacology, Phytochemistry, *Spondias purpurea*.

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1. Introduction

The genus *Spondias* (Anacardiaceae) comprises agricultural plants, including the fruit seriguela (*Spondias purpurea*), cajá (*S. mombim* L.), umbu (*S. tuberosa* Arruda) and cajá-manga (*S. cytherea* Sonn). In several regions of Brazil, species of *Spondias* are used for medicinal purposes, furthermore, has economic importance, since it is used for production of fruits, juices, jams, ice cream and alcoholic beverages (SILVA et al., 2014), besides these species has been reported for a significant number of essential oils (LEMOS et al., 1995).

Spondias purpurea is distributed plant in various parts of the world, such as Mexico, Central America and widely found in Northeast Brazil (Ceva-antunes et al., 2006) and frequently cited in ethnobotanical surveys (Freitas et al., 2012; Barboza da Siva et al., 2012). Therefore, a thorough understanding of the possible pharmacological effects of *S. purpurea* is needed. This review focuses on the botany, ethnomedicinal uses, phytochemistry, pharmacology and toxicology of *S. purpurea*.

2. Methodology

An extensive bibliographic search was undertaken to identify works on these medicinal plants published in journals and data banks during the period between 1979 and 2014. Were consulted published monographs, theses, proceedings of scientific congresses, websites and technical research publications.

Database searches were performed through the internet using Pubmed, Science Direct, Web of Science, SciFinder, Google Scholar and Capes journals. Keywords used in the search were: *Spondias; Spondias purpurea*; seriguela and Anacardiaceae. Was also investigated the technological forecasting using the databases European Patent Office, World Intellectual Property Organization, United States Patent and Trademark Office, National Institute of Intellectual Property (INPI) and Spacenet.

The keywords used in the search were *Spondias*, *Spondias purpurea* and seriguela.

3. Bibliographic review

3. 1 Plant Botany

3.1.1 Occurrence and Distribution

The plant *S. purpurea* belongs to the genus *Spondias*, of the family Anacardiaceae, which comprises more than 70 genera and over 600 species, which are mainly trees and shrubs growing in tropical, subtropical and temperate zones (Engels et al., 2012). There are at least 180 common names for the species *S. purpurea* (Miller and Schaal, 2005*;* Bicas et al., 2011) among these seriguela (Augusto et al., 2000; Ceva-antunes et al., 2006), red mombin, purple mombin, ciruela, Spanish plum, jocote, ciruela mexicana and hog plum (Miller and Schaal, 2005).

Spondias purpurea is a plant native to the tropical semi-arid forests of Mesoamerica originated in Mexico and Central America where wild populations are still found (Bicas et al., 2011; Miller and Schaal, 2005). Some cultivars are also grown in Florida (Macia and Barfod, 2000), India and South America (Augusto et al., 2000). In Brazil it is found in the Northeast, Minas Gerais, Rio de Janeiro, Mato Grosso, Mato Grosso do Sul, São Paulo and Espírito Santo (Ceva-antunes et al., 2006; Omena et al., 2012).

3.1.2 Botanical description

S. purpurea may be considered a fast growing plant, even though it grows on rocky slopes in shallow, infertile soils (Pimenta-Barrios and Ramírez-Hernández, 2003). *S. purpurea* is deciduous, polygamous-dioecious, with compound intermarginal imparipinnated leaves with a sheath. The flowers are small with varied colors (greenish white, pink, purple or deep red), arranged in short racemes (Ruenes-morales et al., 2010) (Figure 1).

The small trees (3–10 m) produce oval, smooth and shiny fruits that ripen throughout the year, depending on the variety, and vary widely in color from green to yellow, orange, red and violet (Popenoe, 1979). In the period of maturation, the stage of the beginning of yellow pigment seems to be the one with the best values for the parameters related to mass, volume, length and diameter of the fruit. However, the best time to harvest has proved to be the predominant red coloration stage, which is when it reaches the high levels of vitamins (Freire et al., 2011; Martins et al., 2003a; Martins et al., 2003b). The main botanical variety of seriguela (red mombin) is produced from

September to October. However, other botanical varieties of *Spondias purpurea* are harvested during the dry season (February–May) and the beginning of the wet season (June–July) (Leon and Shaw, 1990; Bautista-Baños et al., 2000).

The kernels of the fruit of *S. purpurea*, mostly, are sterile, causing the plant to propagate asexually by budding, layering, tissue culture, cuttings and grafting, the last two being the most commonly used for gender (Sousa et al., 2010; Lima et al., 2002). Although *S. purpurea* has adapted well to the region of South America, some phytopathological problems affect the fruit quality (Freire, 2001).

Figure 1: The leaves and flowers of *S. purpurea* L. Fonte: The Virtual Field Herbarium

3.2 Economic importance

S. purpurea has economic importance, with the production of fruits, juices, jams, ice cream and alcoholic beverages (Koziol and Macía, 1998). In temperate countries, the genus *Spondias* is one of the most important genera because they are tropical fruit trees for domestication and exploited for their commercial value (Lima et al., 2002).

Furthermore, the fruit of this plant represents an alternative crop that can be used to diversify the horticultural production, increase productivity in regions with low-fertility soils, and form part of strategies seeking to aid the recovery of poor, shallow soils. Therefore, more studies on physiology and technology with this plant should be done to achieve better commercial traits, such as size, shape, color, yield and nutritional value (Maldonado-Astudillo et al., 2014).

Todisco et al. (2014) evaluated the quality and stability of *S. purpurea* components for a period of 120 days of storage; it was possible to verify that the product could have sufficient stability to be marketed.

3.3 Traditional uses

Spondias purpurea has been in continuous use for different purposes, such as nutritional, medicinal and agricultural ones. In Mexican communities, people usually use the plant in the form of infusion of fresh leaves, taken as a remedy for stomach and flatulence (Alfaro, 1984). Decoction of the leaves and bark is used for anemia, diarrhea, dysentery and skin infections (Caceres et al., 1990; Zamora-Martínez and de Pascual Pola, 1992; Cáceres et al., 1993).

In Brazil, *S. purpurea* has been mainly used against symptoms of stomachache and diarrhea; however, there have also been reports of its use for diabetes and lowering cholesterol. Most uses occur in the form of tea using the leaves of the plant (Oliveira et al., 2010; Carniello et al., 2010; Nascimento and Conceição, 2011; Freitas et al., 2012; Barboza da Siva et al., 2012).

3.4 Phytochemistry

From a phytochemical point of view, members of the Anacardiaceae family are rich in secondary plant metabolites, in particular phenolic compounds, with interesting biological activities (Bicas et al., 2011; Engels et al., 2012). Phytochemical studies on the fruit, gum and peel of *Spondias purpurea* were found, with components such as polysaccharide, volatile components, terpens, flavonoids, whereas few phytochemical studies of the leaves were found. Most chemical studies described in Table 1 characterized the components by HPLC (High Performance/Pressure Liquid Chromatography) and GC (Gas chromatography), and few studies were conducted on the isolation and identification of the plant components.

3.5 Pharmacological activities

3.5.1 Antimicrobial activities

The plant *S. purpurea* was tested *in vitro* and *in vivo* for activity against bacteria and fungi using bark, fruit and leaf . Miranda-Cruz et al. (2012) considered *S. purpurea* as a promising antimicrobial source in its ethanol extract. In addition, one showed *S. purpurea* antifungal activities suggesting that future work include the

isolation of the active components of these extracts (Bautista-Baños et al., 2000; Bautista-Baños et al., 2002; Pizana et al., 2010) (Table 2).

3.5.2 Antiprotozoal activity

S. purpurea showed no activity against protozoa *Leishmania donovani, Plasmodium falciparum, Trypanosoma brucei rhodesiense* and *Trypanosoma cruzi* (Gachet et al., 2010) (Table 2).

3.5.3 Larvicidal activity

Studies by Lima et al. (2011) showed larvicidal activity (*Aedes aegypti*) of essential oil of *S. purpurea*.

3.5.4 Antiulcerogenic activity

One showed that the ethanol extract of *S. purpurea* reduced ulcerations at all concentrations administered and promoted no change in volume or gastric pH, suggesting that the extract of *S. purpurea* may constitute a potential target for use in antiulcer therapy (Dantas, 2012).

Table 1: List of chemical constituents isolated from *Spondias purpurea*.

Plant part	Name of compound	References
Leaf	β-caryophyllene (11.16%), δ-cadinene (10.29%), torreyol (11.63%) and T-muurolol (10.09%)*	Lemos et al. (1995)
Fruit	hexanal 6.95% and hexadecanoic acid 18.51% (components volatile)*	Koziol and Macía (1998)
Fruit	alcohols, esters, aldehydes, ketones and terpene hydrocarbons *	Augusto et al. (2000)
Pulp of the fresh fruit	27 compounds were identified, 2 ketones, 4 alcohols, 7 aldehydes, 9 esters and 5 terpenic hydrocarbons*	Ceva-antunes et al. (2006)
Gum exudate	galactose (59%), arabinose (9%), mannose (2%), xylose (2%), rhamnose (2%) and uronic acids (26%) (polysaccharide)**	Martínez et al. (2008)
Leaf	ß-caryophyllene and a-humulene oils*	Brito (2010)
Peel extracts	quercetin, rhamnetin, kampferol, and kaempferide (flavonoids)*	Engels et al. (2012)

Methodology: *detected, **identified

3.5.5 Antioxidant activity

Spondias purpurea L. indicated the presence of antioxidants (Engels et al., 2012). Their study shows the profile of its phenolic compounds, which is of particular interest given the increasing evidence of beneficial effects of phenolics on human health. Studies in Brazil have shown that the fruit has high antioxidant activity in test of radical sequestration (DPPH) (Almeida et al., 2011; Barboza da Siva et al., 2012; Gregoris et al., 2013). Other species of the Anacardiaceae family *Spondias pinnata* (Hazra et al., 2008) and *Mangifera indica* (Schieber et al., 2003), contain substances such as flavonoids and xanthones, gallotannins and benzophenone derivatives, with a possible similar antioxidant activity.

Omena et al. (2012) showed that *S. purpurea* (seeds and peel) extracts displayed the highest antioxidant activities. *S. purpurea* seed ethanol extracts presented an acetylcholinesterase (AChE) inhibition zone similar to that of the positive control, carbachol. AChE inhibition assay with chlorogenic acid, one of the main constituents of *S. purpurea* seeds, revealed that this acid showed activity similar to that of the control, physostigmine. These data suggest that these extracts are potentially important antioxidant supplements for the everyday human diet, pharmaceutical and cosmetic industries and the large amount of chlorogenic acid found in *S.*

purpurea seeds may explain, in part, its better performance in most antioxidant assays and its inhibition of acetylcholinesterase activity (Table 2).

3.5.6 Toxicity activity

Dantas (2012) examined the acute toxicity of extracts from the leaves of *S. purpurea* against *Artemia salina* (microcrustaceans). It was noted that they presented toxicity only 48 hours of exposure (LC_{50} 823µg/mL) and that Swiss mice ethanol extract showed low acute toxicity, as evidenced by the absence of relevant clinical signs, as well as the absence of death throughout the observation period at a dose of 2000mg/kg. Fonseca et al. (2013) showed that seed extracts from *S. purpurea* were not toxic against *Artemia salina*.

In their studies on ethanol extracts of *S. purpurea* seed, peel and pulp, Omena et al. (2012) did not show cytotoxicity using sheep corneal epithelial cells (Table 2).

Table 2: Results from bioassays performed in *Spondias purpurea*.

Bioassay	Plant part	Pharmacological results	Reference
Antibacterial	Leaf	*Escherichia coli* (10mg), *Shigella flexneri* (+/-) (10mg), *Salmonella typhi* (+/-), *Salmonella enteritidis* (-), *Shigella dysenteriae* (-)	Caceres et al. (1990b)
Antibacterial MIC	Leaf	*Bacillus cereus* (7.5 mg/mL)	Miranda-Cruz et al. (2012)
Antiprotozoal	Bark	Inactive against *Leishmania donovani*, *Plasmodium falciparum*, *Trypanosoma brucei rhodesiense* and *Trypanosoma cruzi*	Gachet et al. (2010)
Larvicidal	Leaf	*Aedes aegypti* (LC_{50} 39.7µg/mL)	Lima et al. (2011)
Antifungal (decreased germination of sporangium spore)	Leaf	*Rhizopus stolonifer*	Baustista-Banõs (2000)
Antifungal (Inhibition of sporulation)	Leaf and stem	*Colletotrichum gloeosporioides*	Baustista-Banõs (2002)
Antifungal (Inhibition of sporulation and micelial)	Powders and leaf	*Fusarium oxysporum* (mycelia growth 57.2%)	Pizana et al. (2010)
Acute toxicity	Leaf	Negative (2000mg/kg, 14 days)	Dantas (2012)
Cytotoxicity *Artemia salina*	Leaf	Leaves 823µg/mL (48h)	Dantas (2012)
Cytotoxicity *Artemia salina*	Seed	Seed 0.5g/mL	Fonseca et al. (2013)
Cytotoxic effect on corneal epithelial cells of sheep	Seed and peel	100 ppm	Omena et al. (2012)
Antiulcerogenic	Leaf	250 mg/kg	Dantas (2012)
Antioxidant activity	Seed	Acetylcholinesterase Inhibition	Omena et al. (2012)
	Peels	UV spectra	Engels et al. (2012)
	Fruit	DPPH	Almeida et al. (2011), Silva et al. (2012), Gregoris et al. (2013)
	Frozen Fruit Pulp	FRAP and DPPH (few phenolic compounds and antioxidant activity.)	Zielinski et al. (2014)

3.6 Search for prior patents

Few patents related to *Spondias purpurea* plant were found. One has been described about a cosmetic composition, bath preparation or cleansing composition containing moisturizing *Spondias purpurea* ingredient(s) with sustainable moisturizing effect for a long period of time and exhibiting high efficacy on the skin in terms of prophylaxis, mitigation or amelioration of dryness, rough skin, chap, dandruff, itch and inflammatory diseases; and on the hair, in

terms of dryness, split hair, cut hair and glossing (Ohara et al., 2001).

Some patents have been found with the keyword "*Spondias purpurea*". However, they were not in fact the product obtained from the plant, for example (i) about a byproduct used as oviposition deterring pheromones against fruit flies (Diptera*:* Tephritidae) of economic importance. This substance can be used to reduce the damage caused by these insects on fruits which are cultivated in commercial and semi-commercial orchards, in garden orchards and in isolated trees in residential gardens, for example *S. purpurea*, which was used as the host plant of these fruit flies (Aluja et al., 2003). And (ii) the invention relates to compositions comprising extracts from plants and the use thereof in methods for increasing the uptake of vitamin C into cells and the plant *S. purpurea* is mentioned from various plants (Wolf, 2010).

4. Conclusion

S. purpurea is a plant used in various regions of the world, and in northeastern Brazil it has economic importance due to its use in food and medicinal purposes. It is also used for stomachache and diarrhea; however, there have also been reports of its use for diabetes and high cholesterol.

As for the chemical elucidation, one found studies on structures such as fruit, bark and gum, but little is known about the phytochemical profile on the leaves of this plant. However, the chemical studies are generally detection studies. Thus, more studies on the isolation and identification of the compounds of this plant should be performed.

After such review, it was observed the *in vitro* antioxidant potential in the structures of the bark and the fruit of this plant. Thus, it is suggested that *in vivo* antioxidant activities are performed. There is evidence regarding the biological activities with bactericidal and fungicidal activity. However, further studies need to be done with modern methods. *S. purpurea* may constitute a potential target for use in anti-ulcer therapy. Activity of low toxicity was reported in *Spondias purpurea* tests with *Artemia salina*, rats and sheep corneal epithelial cells, but further studies should be done to better elucidate the toxicology of this plant. It is suggested that studies are carried out with tumor cells.

Disclosure

This article is unpublished and not being considered for any other publication. The author(s) and reviewers did not report any conflict of interest during their evaluation. Therefore, the Journal Scientia Amazonia owns the copyright and has the approval and permission of authors for publication this article electronically.

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