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Review

Traditional use, phytochemistry and biological activities of *Poincianella pyramidalys* (Tul.) LP Queiroz

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The vegetation of Northeastern Brazil is an important source of income for the local population. *Poincianella pyramidalis* is a very important species in the semiarid and is inserted in various categories of ethnobotanical use, as foraging, construction and technology uses. However, the most important use is medicinal. Several preparations obtained from the root, bark, leaves and flowers of *P. pyramidalis* are used to treat various ailments, especially infections, pain and inflammation. This paper discusses the medical use, chemical constituents and pharmacological potential of *P. pyramidalis.* This revision was based on studies published in scientific journals, books, and search sites such as Science Direct, PubMed and American Chemical Society (ACS). *P. pyramidalis* features a wealth of secondary metabolites, belonging to the most diverse classes as flavonoids, terpenoids, tannins and others. Of these, 22 compounds were included in this review. The species showed significant ability to perform biological activities such as antimicrobial, anti-inflammatory, gastroprotective, radioprotective and anticancer, as well as being both a molluscicide and larvicide. On the other hand, the species showed relative toxicity. Numerous compounds in *P. pyramidalis* were identified with recognized action on the body, where anti-inflammatory and antimicrobial activities were the most pronounced. All parts of the plant stem, flower, root and leaf showed pharmacological action validating many traditional uses. However, the identification of the chemical constituents or group responsible for producing these therapeutic actions, as well as carrying out of further test *in vivo* to determine the mechanisms of action related to biological activities is required.

Key words: *Poincianella pyramidalis,* folk medicine, bioactive compounds, phytochemistry, biological activities.

INTRODUCTION

Poincianella pyramidalis (Tul.) LP Queiroz is an arboreal species of the Fabaceae family, popularly known as

catingueira, pau-de-rato or catinga-de-porco. Until recently, this species was known as *Caesalpinia pyramidalis* Tul., and, as a result of a taxonomic reformulation, it belongs to the genus *Poincianella* (Queiroz, 2009). *P. pyramidalis* is a small unarmed tree that can reach 4 m and greater heights in certain environments. It has bipinnate leaves with 5 to 11 leaflets that are sessile, alternate, leathery, oblong and obtuse. It has yellow flowers arranged in racemes with similar length to the leaves. The fruit is a pod that is sessile, leathery, flat, dark in color and can be up to 11 cm long (Corrêa, 1926; Braga, 1960). This species is a native pioneer and endemic of the Caatinga, broadly distributed in Northeastern Brazil, occurring in the states of Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe and Bahia (Valladares et al., 2007; Santana et al., 2011). It adapts to xeric and degraded environments and can be found in several plant associations, inhabiting stony ground and growing well in humid lowlands (Lima, 1996; Oliveira, 2010). These features ensure its successful cultivation throughout the Brazilian semiarid climate (Fabricante et al., 2009).

P. pyramidalis is considered as one of the most useful species for the people of that area because of its multiplicity of uses (Lucena et al., 2012). Among these uses is that of folk medicine, in which its flowers, leaves, and barks are used primarily in the treatment of infectious diseases and as an anti-inflammatory and analgesic (Braga, 1960; Maia, 2004; Santos et al., 2008). Its popular medicinal uses have attracted the attention of researchers from different areas. In recent years, studies have been developed to evaluate the chemical composition and biological activities of *P. pyramidalis*, including its antimicrobial, antioxidant, gastroprotective, anti-inflammatory, antinociceptive, radioprotective, and anthelmintic properties, apart from toxicity. This review aims to highlight the traditional medicinal use and main biological and phytochemical properties of *P. pyramidalis*, targeting future studies on this plant.

MEDICINAL USE

P. pyramidalis is a perpetual contributor to the various health problems of the Brazilian semiarid population. The uses of the stem bark, leaves, flowers and roots of this plant in folk medicine are described in Table 1.

PHYTOCHEMISTRY

The presence of diterpenes, flavonoids, and other phenolic compounds is characteristic of this genre and family. Lignans, gallic acid, steroids, phenylpropanoid, and tannins, flavonoids and especially biflavonoids are isolated in the leaves and stem of *P. pyramidalis* (Mendes et al., 2000; Bahia et al., 2005; Bahia et al., 2010; Oliveira, 2010). Monteiro (2005) quantified the greater abundance of metabolites in the methanol extract from the bark of catingueira, where he obtained 29.60 and 24.72 mg for total phenol and tannins, respectively. The chloroform extract of the leaves provides biflavonoids and phenolic compounds called caesalflavona, podocarpusflavona A, agathisflavona, apigenin, kaempferol, sitosterol and lupeol. Phenylpropanoid glycoside acid, 4-Ob-glucopyranosyloxy-7-Z-hydroxycinnamic acid and 4-Ob-glucopiranosiloxi Z-8-hydroxycinnamic acid were also isolated from the leaves. The chloroform extract gave the stem 4, 4'-dihydroxy-2'-methoxy-chalcone, (-) - Methyl gallate and syringaresinol (Table 2) (Mendes et al., 2000; Bahia et al., 2005; Borges-dos-Santos et al., 2012). The hexane phase of the root was the isolation of lupeol, acacetina, phenylpropanoid, and a mixture of sitosterol and stigmasterol. From the methanolic phase one biflavonoid was isolated, and also 7-hydroxy-4'-methoxyflavone-5α-2,4-dihydroxy-4'-metoxidihidrochalcona (Oliveira, 2010). The chemical structure of some of these molecules is shown in Figure 1.

BIOLOGICAL ACTIVITIES

Antimicrobial activity

There is a concern in global public health about bacteria resistant to most known antibiotics and their prevalence in causing morbidity and mortality. *Staphylococcus aureus* is one of the main actors in this scenario, commonly occurring in strains resistant to methicillin (MRSA), and recently, vancomycin (VRSA). So, with the discovery of new antibacterial agents with different mechanisms of action, new research is vital (Luna et al., 2010). Novais et al. (2003) observed a good microbiological activity in the ethyl acetate extract obtained from the bark and leaves of *P. pyramidalis* against *S. aureus*, by disk diffusion method. Alviano et al. (2008) also noted antibacterial activity against oral pathogens in the bark and leaves of this plant. The MIC values observed in this study were 1000 µ mL^{-1} to *Prevotella intermedia, Porphyromonas gingivalis* and *Fusobacterium nucleatum*, and 8000 µg mL^{-1} to *Streptococcus mutans* and *Lactobacillus casei*, microorganisms related to dental caries.

In their study, Saraiva et al. (2012a) evaluated the activity of the methanol extracts, ethyl acetate and n-

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Table 1. *Poincianella pyramidalis* uses in traditional medicine.

Part used	Form of use	Therapeutic indication	Authors
Stem bark	Maceration, decoction, syrup, juice	**Respiratory problems:** asthma, bronchitis, expectorant, flu, respiratory infection, catarrhal infections, cough. **Gastrointestinal problems:** heartburn, colic, diarrhea, dysentery, flatulence, gastritis, indigestion, stomach pain, stomach problems. **Problems of the circulatory system:** hemostatic, **Undefined symptoms:** inflammation, fever. **Recreation:** Aphrodisiac. **Lesions:** Cicatrizant, injuries, bruises. **Endocrine problems:** Diabetes.	Lima, 1996; Agra et al., 2007a; 2007b; 2008; Cartaxo et al., 2010; Albuquerque et al, 2007; Albuquerque et al., 2006; Oliveira et al., 2010; Marinho et al., 2011; Silva and Albuquerque, 2005; Albuquerque and Andrade 2002a,b; Albuquerque 2006; Silva and Freire, 2010; Silva et al., 2011b; Pereira Jr et al., 2014; Silva et al., 2015;
Flower	Infusion, syrup	**Respiratory problems:** asthma, bronchitis, expectorant, flu, respiratory infection, catarrhal infections, cough. **Gastrointestinal problems:** heartburn, colic, diarrhea, dysentery, flatulence, gastritis, indigestion, stomach pain, stomach problems. **Problems of the circulatory system:** hemostatic, **Undefined symptoms:** fever. **Recreation:** Aphrodisiac. **Lesions:** Cicatrizant, injuries, bruises. **Endocrine problems:** Diabetes.	Cartaxo et al., 2010; Lima, 1996; Albuquerque et al, 2007; Almeida et al., 2006; Souza et al., 2011; Pereira Jr et al., 2014.
Leaves	Infusion	**Respiratory problems:** asthma, bronchitis, expectorant, flu, respiratory infection, catarrhal infections, cough. **Gastrointestinal problems:** colic, diarrhea, dysentery, flatulence, gastritis, stomach pain, indigestion. **Fungicide:** candidiasis. **Lesions:** Cicatrizant, injuries, bruises. **Endocrine problems:** Diabetes. **Other**: Diuretic.	Almeida et al., 2005, 2006; Bahia et al., 2010; Cruz et al., 2007; Lima, 1996; Albuquerque et al., 2007; Ribeiro et al., 2014.
Root	Decoction	**Respiratory problems**: asthma, bronchitis, expectorant, respiratory infection, flu, cough. **Gastrointestinal problems**: heartburn, colic, diarrhea, stomach pain, flatulence, gastritis. **Undefined symptoms**: fever. **Lesions**: wounds, bruises. **Endocrine problems**: Diabetes.	Albuquerque et al., 2007

hexane against 17 isolates multiresistant MRSA, 2 MSSA and 2 standard strains of *S. aureus*. A good activity to the methanol extracts of the leaves, flowers, bark, roots, fruits and seeds, and to the ethyl acetate extract of the bark, roots and fruits (MIC ≤ 1000 µg mL^{-1}) was observed. The antimicrobial efficacy of these extracts against *Escherichia coli*, *Enterococcus faecalis*, *Klebsiella pneumoniae*, *Salmonella* spp., *S. aureus* and *Pseudomonas aeruginosa* (Saraiva et al., 2012b) was observed. MIC values of methanol extract of the leaves against *P. aeruginosa* (MIC = 125 µg ml^{-1}), and the ethyl acetate extract of the root against *E. coli* and *S. aureus* were 500 and 250 µg ml^{-1}, respectively; and the methanol extract of the leaves against *E. coli* was 250 µg ml^{-1}. In another study, it was found that the ethanolic extracts of the leaves of *P. pyramidalis* against strains of MRSA and *S. aureus* with NorA efflux pump protein overexpression. It was observed that the bacterial growth of *S. aureus* resistant NorA was 10-fold less than the negative control (DMSO 1%); and there was no observed growth of the MRSA strain after 24 h of incubation (Lima et al., 2006). *P. pyramidalis* also presented significant antifungal

Table 2. Chemical constituents of *Poincianella pyramidalis.*

S/N	Part of plant	Substance	Group	References
1	Leaf, root	Lupeol	Triterpene	Mendes et al., 2000. Oliveira, 2010; Bahia et al., 2005
2	Leaf, root	Sitosterol	Steroid	Bahia et al., 2005; Oliveira, 2010
3	Root	Estigmasterol	Steroid	Oliveira, 2010; Bahia et al., 2010
4	Root	Acacetina	Flavonoid	Oliveira, 2010;
5	Root	Acid (E)-8-hydroxy-3,5-dimetoxycumaric	Phenylpropanoid	Oliveira, 2010
6	Root	7-hydroxy-4'-metoxyflavone-5α-2,4-dihydroxy-4'-metoxydihydrochalcone.	Biflavonoid	Oliveira, 2010
7	Leaf	Caesalflavone	Biflavonoid	Bahia et al., 2005
8	Leaf	Podocarpusflavone A	Biflavonoid	Bahia et al, 2005
9	Leaf	Agathisflavone	Biflavonoid	Bahia et al., 2005; Borges-dos-Santos, 2012; Mendes et al., 2000
10	Leaf	Kaempferol	Flavonol	Bahia et al., 2005
11	Leaf	Apigenin	Flavone	Bahia et al., 2005
12	Leaf	4-O-β-glucopiranosyloxy-Z-7-hydroxycinnamic	Fenilpropanoid	Mendes et al., 2000
13	Leaf	Acid 4-O-β-D-glucopyranosyloxy-8-Z-hydroxycinnamic	Fenilpropanoid	Mendes et al., 2000
14	Root	7-hydroxy-4'-methoxyflavone-5α-2,4-dihydroxy-4'-metoxidihidrochalcone	Biflavonoid	Oliveira, 2010
15	Leaf	Amentoflavone	Biflavonoid	Bahia et al., 2010
16	Leaf	Sequoiaflavone	Biflavonoid	Bahia et al., 2010
17	Stem bark	Methyl gallate	Phenolic ester	Bahia et al., 2005
18	Stem bark	4, 4'-dihydroxy-2'-methoxy-chalcone	Chalcone	Bahia et al., 2005
19	Leaf	Taxifolin	Flavonone	Bahia et al., 2010
20	Leaf	Loniflavone	Biflavonoid	Bahia et al., 2010
21	Leaf	5-hidroxiamentoflavone	Biflavonoid	Bahia et al., 2010
22	Stem bark	(-)-syringaresinol	Lignan	Bahia et al., 2005

properties. Cruz et al. (2007) evaluated the antifungal activity of four Brazilian medicinal plants used in folk medicine for the treatment of fungal infections. *P. pyramidalis* presented the best results of aqueous extract of the leaves; it had significant activity against standard strains ATCC and clinical isolates of *Trichophyton rubrum* (MIC = 6.25 µg mL^{-1}), *Candida guilliermondii* (MIC = 25 µg mL^{-1}), *Candida albicans* (MIC = 12.5 µg mL^{-1}), *Cryptococcus neoformans* (MIC = 12.5 µg mL^{-1}) and *Fonsecaea pedrosoi* (MIC = 200 µg mL^{-1}).

Barbosa et al. (2015) evaluated the susceptibility of clinical isolates of *Cryptococcus neoformans* resistant to azole antifungal and ATCC strain using plant extracts obtained from medicinal plants in the semiarid region of the State of Sergipe, Brazil. The researchers used the disk diffusion method and the aqueous extract of leaves of *P. pyramidalis* at a concentration of 4, 40 and 100 mg mL^{-1}. The extracts showed good activity against 5 of the 10 strains tested, with zones of inhibition ranging between 7 and 14 mm. The activity of ethanolic extract of the bark of *P. pyramidalis* against standard ATCC strain of *Helicobacter pylori* evaluated by Ribeiro et al. (2013) had 625 and 10,000 µg mL^{-1}, of MIC and

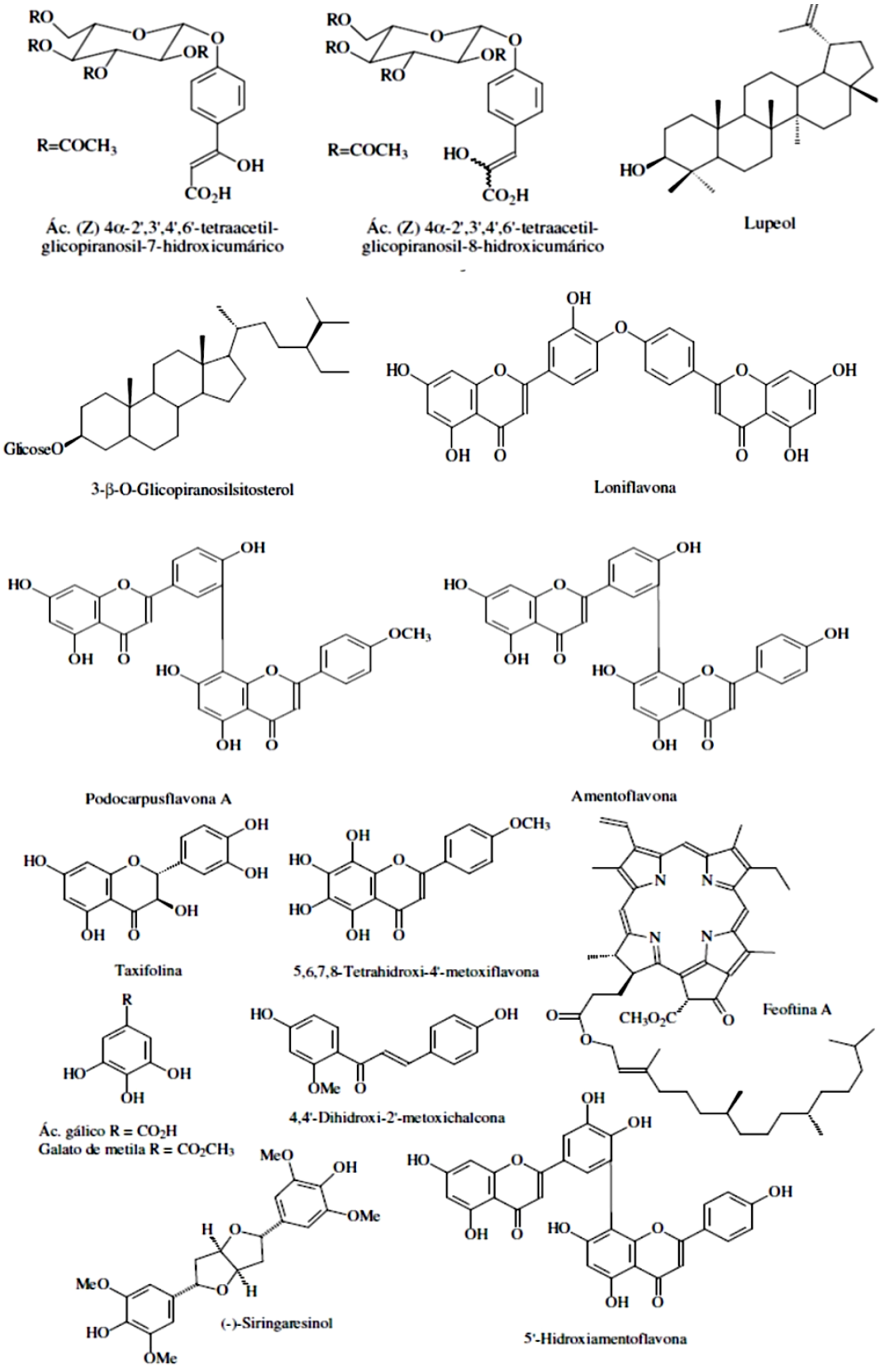

Figure 1. Isolated molecules from *P. pyramidalis*.

MBC respectively; they were obtained by broth microdilution method.

Antioxidant activity

The production of free radicals in the body causes numerous problems that manifest as degenerative diseases, cardiovascular diseases, aging, and immune problems; therefore, this creates a need to discover new antioxidants. In plants, phenolic substances act as free radical scavengers and metal chelators, which may be used as antioxidants in various pathologies (Haslam, 1998). Santos (2010) determined the antioxidant activity of ethanolic extract of the bark of *P. pyramidalis*, by method of thiobarbituric acid reactive substances (TBARS). This indicates the lipid peroxidation. The extract (concentrations of 100 and 1000 µg mL^{-1}) showed antioxidant activity reducing significantly ($P < 0.001$) lipid peroxidation compared to the control (77.66 and 82.41%, respectively). This was achieved by the reduction of TBARS production. The antioxidant potential of Brazilian medicinal plants was evaluated by Alviano et al. (2008) using photometric test DPPH. The aqueous extract of leaves of *P. pyramidalis* presented a great elimination activities of DPPH (EC_{50} = 15.2 ± 1.0 mg L^{-1}), and was better than the synthetic antioxidant BHT (EC_{50} = 86 µg mL^{-1}). While in another study by Silva et al. (2011a), the antioxidant activity of ethanolic extract of the bark and leaves was evaluated by DPPH and FIC assays. The extract from the bark showed high antioxidant activity (IC 50 = 16.98 ± 1.34 µg mL^{-1}) compared to standards rutin and ascorbic acid (IC 50 = 22.96 ± 1.99 and 16.12 ± 0 01 µg mL^{-1}, respectively). Moreover, the extract of leaves was more effective in chelating ferrous ions (IC_{50} = 62.49 ± 10.77 µg mL^{-1}), with IC_{50} values closer to EDTA control (IC_{50} = 15.26 ± 0.58 µg mL^{-1}).

Melo et al. (2010) evaluated the antioxidant activity of 14 medicinal plants of the Brazilian semi-arid region; *P. pyramidalis* presented lower IC_{50} value (42.95 ± 1.77 µg mL^{-1}) and good antioxidant activity. The authors attributed this to the antioxidant activity, that the high concentration of phenolic compounds is mainly tannins.

Gastroprotective activity

Ribeiro et al. (2013) evaluated the antiulcerogenic activity and gastric mucosal protection factors of ethanolic extract of the bark of *P. pyramidalis* through several *in vivo* models using Wistar rats. In the ethanol-induced ulcer model, the animals were treated with doses of extracts of 30, 100 and 300 mg kg^{-1}, and the results showed inhibition of the parameters with higher concentration. The values of ulcer lesion index, total lesion area, and percentage of lesion to extract were 0.92±0.40, 0.93±0.46 mm^2, 0.16±0.08%, respectively. Histopathological analysis showed that the animals pretreated with the extract showed less mucosal damage compared to the control group. In the indomethacin-induced ulcers model, the extract (100 mg kg^{-1}) and positive control (Cimetidine 100 mg kg^{-1}) significantly reduced the ulcer, exhibiting the same ulcer inhibition rate (86.97%). In the model gastric secretion, using ligation of pylorus in groups treated with the extract of *P. pyramidalis, there was* a volume of discharge and acid secretion was not reduced compared to the vehicle. However, when these groups were compared to the model determination mucus there was a significant increase in mucus production (vehicle = 1.00 ± 0.13 mg L^{-1}; extract 300 mg kg^{-1} = 1.61 ± 0.09 mg L^{-1}).

Diniz et al. (2015) investigated the possible mechanisms of the action of ethanolic extract of the bark of *P. pyramidalis* against ethanol-induced gastric damage. To evaluate the possible involvement of gaseous mediators (nitric oxide and hydrogen sulfide) in the protective extract, pretreated groups of rats with L-NAME or PAG were used. The protective effect of the extract was significantly attenuated by pretreatment with PAG, suggesting possible involvement of H2S in the gastro protector extract. The authors believe that another mechanism of action would be an anti-inflammatory effect on gastric mucosa caused by attenuation of expression of the inflammatory mediator gene and increased expression of the anti-inflammatory mediator gene.

Anti-inflammatory activity

The anti-inflammatory activity of ethanolic extract (90%) of *P. pyramidalis* was evaluated by *in vivo* models with Wistar rats. In the model of carrageenan-induced edema and MPO activity in rat paws, the extract (400 mg Kg^{-1}) was able to reduce the edema at 2, 3 and 4 h after the injection of carrageenan. The group treated with the extract has inhibition of edema (41.2%), while dexamethasone (2 mg kg^{-1}) unleashed an inhibition of 54.4% compared to the group treated with carrageenan. The extract at the same concentration was also able to reduce the action of MPO. The group treated with the extract showed 4.5 ± 0.5 mg $UMPO^{-1}$ and the vehicle group had 7.1 ± 0.9 mg $UMPO^{-1}$. In addition, the activity of this extract was against carrageenan-induced peritonitis in mice. The extract (400 mg kg^{-1}) significantly inhibited the migration of leukocytes into the peritoneal cavity (2.63 ± 0.23 × 106 mL^{-1} of leukocytes / 80.2% inhibition) compared to the vehicle group (7 22 ± 0.99 × 106 mL^{-1} of leukocytes) (Santos et al., 2011). Another study was conducted with 90% ethanolic extract of *P. pyramidalis* to assess the anti-inflammatory activity using Wistar rats with hemorrhagic cystitis. The groups treated with the extract (100 and 400 mg kg^{-1}) showed a significant reduction of cyclophosphamide-induced MPO. 100 mg kg^{-1} concentration was significantly decreased in leukocyte infiltration in the urinary bladder and basal

concentration of MDA (Moraes et al., 2013).

Santana et al. (2012) evaluated the anti-inflammatory activity of ethanolic extract of *P. pyramidalis* in acute pancreatitis model in rats. The authors investigated the levels of pancreatic enzymes in the blood, pancreas neutrophil infiltration, lipid peroxidation and abdominal hyperalgesia. The extract (400 mg kg^{-1}) was able to reduce the levels of amylase and lipase in serum after 6 or 24 h of induction; it also reduced MPO activity in pancreatic tissue, leading to a decrease in infiltration neutrophils and promoting anti-inflammatory effect. The extract also promoted protective effect against the lipoperoxidation caused by CBDO. MDA formation decreased after 6 h of pancreatitis induction, and was maintained for 24 h. In the hyperalgesia test was reported that the groups treated with the extract (100, 200 or 400 mg kg^{-1}) had a reduction in abdominal hyperalgesia after 6 h of induction. This effect was maintained for 24 h for the highest concentration. These results demonstrate the anti-inflammatory activity of the extract.

Antinociceptive activity

The ethanolic extract of the bark of *P. pyramidalis* (100, 200 and 400 mg kg^{-1}) reduced significantly the contortion acetic acid-induced compared to the control group. Inhibition of nociceptive behavior occurred; it was induced by formalin at neurogenic and inflammatory phases. In the hot-plate reaction time, the extract (400 mg kg^{-1}) increased the pain latency time of mice exposed to the hot plate. The group treated with the extracts did not show any significant effects in the rotarod test (Santos et al., 2011). The possible mechanism of action of ethanol (90%) extract in the nociceptive behavior was investigated by Santos et al. (2013a). In the analysis of possible involvement of L-arginine–nitric oxide (NO), groups of mice were pre-treated intraperitoneally with nitric oxide precursor L-arginine (600 mg Kg^{-1}) after receiving a nitric oxide synthase inhibitor L-NOARG (75 mg Kg^{-1}) or extract (30 mg Kg^{-1}). The previous treatment with L-arginine reversed the antinociceptive effect of L-NOARG and extract, suggesting the participation of L-arginine/nitric oxide pathway in the antinociceptive activity of *P. pyramidalis* extract. We also observed antinociceptive effect on the glutamate induced nociception at 10, 30, and 100 mg Kg^{-1}. The authors suggest the participation of NMDA receptors in this antinociceptive effect.

Radioprotective activity

Ionizing radiation interaction with biological environment may have various effects such as death or mutation in cells, chromosomes and even DNA. Santos et al. (2013b) reported the effect of methanolic extracts of *P. pyramidalis* opposite to the damage caused by irradiation on *Biomphalaria glabrata* embryos. The bark extract (250 ppm) showed radioprotective activity in the groups irradiated with doses of 2.5 and 4.0 Gy, while the extract of the leaves at the same concentration showed activity in the groups irradiated with doses between 2.5 and 100 Gy, demonstrating potential radioprotective activity.

Anthelmintic activity

Borges-dos-Santos et al. (2012) evaluated the potential benefits of the aqueous extract of *P. pyramidalis* on goats naturally infected with gastrointestinal nematodes. *In vivo* studies demonstrated a significant reduction in the count of eggs in the feces throughout the trial period; which, according to the authors, can be related to the direct activity of the extract reducing the fertility of female parasites. The extract also led to increased concentration of IgA, which can be involved with the generation of protective immunity.

Toxicity

The toxicity of plant species is one of the most important parameters in evaluating its timely use by the population. The bioassay with *Artemia salina* is commonly used to speculate toxicity of plant extracts. In the work of Luna et al. (2005), the ethanol extract of the stem bark (1000 ppm) showed high toxicity, with 100% mortality forwarded to *A. salina*. Oliveira (2010), performing the same test, described the toxicity according to the polarity of the extracts, fractions with ethyl acetate and the more toxic methanol, followed by butanol. The hexane fraction was considered nontoxic, while the other showed moderate toxicity.

CONCLUSION

P. pyramidalis is a natural resource used extensively in the Brazilian semiarid region. This study has identified numerous compounds, largely with recognized action on the body. The species showed therapeutic potential; anti-inflammatory, antioxidant and antimicrobial properties were the most pronounced and they validate its traditional use. All parts of the plant, including the stem, flower, root and leaf had pharmacological action and a wealth of compounds. But, it is necessary to identify and isolate the chemical constituents, and all those responsible for producing the therapeutic action, as well as conducting *in vivo* tests to determine the mechanisms involved in the biological activities.

Abbreviations

ACS, American chemical society; **MRSA,** methicillin-

resistant *Staphylococcus aureus*; **MSSA,** methicillin sensitive *Staphylococcus aureus*; **VRSA,** vancomycin-resistant *Staphylococcus aureus*; **ATCC,** American Type Culture Collection; **MIC,** minimum inhibitory concentration; **NorA,** gene that encodes a membrane-associated protein mediating active efflux of fluoroquinolones; **DPPH,** 2, 2-diphenyl-1-picrylhydrazyl; **FIC,** ferrous ion chelating; **EDTA,** ethylenediaminetetraacetic acid; **IC_{50},** amount of extract needed for 50% inhibition; **BHT,** butylated hydroxytoluene; **L-NAME,** Nw-nitro-L-arginine methyl ester Hydrochloride; **PAG,** DL-propargylglycine; **MPO,** myeloperoxidase; **UMPO,** units of MPO; **CBDO,** common bile duct obstruction; **MDA,** malondialdehyde; **NO,** nitric oxide; **L-NOARG,** Nω-nitro L-arginine.

Conflict of interests

The authors have not declared any conflict of interests.

REFERENCES

Agra MF, Baracho GS, Nurit K, Basílio IJLD, Coelho VPM (2007b). Medicinal and poisonous diversity of the flora of "Cariri Paraibano", Brazil. J. Ethnopharmacol. 111(2):383-395.

Agra MF, Freitas PF, Barbosa-Filho JM (2007a). Synopsis of the plants known as medicinal and poisonous in Northeast of Brazil. Braz. J. Pharmacogn. 17(1):114-140.

Agra MF, Silva KN, Basílio IJLD, Freitas PF, Barbosa-Filho JM (2008). Survey of medicinal plants used in the region northeast of Brazil. Braz. J. Pharmacogn. 18(3):472-508.

Albuquerque UP (2006). Re-examining hypotheses concerning the use and knowledge of medicinal plants: a study in the Caatinga vegetation of NE Brazil. J. Ethnobiol. Ethnomed. 2:30.

Albuquerque UP, Andrade LHC (2002a). Conhecimento botânico tradicional e conservação em uma área de caatinga no Estado de Pernambuco, Nordeste do Brasil. Acta Bot. Bras. 16(3):273-285.

Albuquerque UP, Andrade LHC (2002b). Uso de recursos vegetais da Caatinga: o caso do agreste do Estado de Pernambuco (Nordeste do Brasil). Interciencia 27(7):336-346.

Albuquerque UP, Lucena RFP, Monteiro JM, Florentino ATN, Ramos MA, Almeida CFCBR (2006). Evaluating two quantitative ethnobotanical techniques. Ethnobot. Res. Appl. 4:51-60.

Albuquerque UP, Medeiros PM, Almeida ALS, Monteiro JM, Lins Neto EMF, Melo JG, Santos JP (2007). Medicinal plants of the *caatinga* (semi-arid) vegetation of NE Brazil: A quantitative approach. J. Ethnopharmacol. 114(3):325-354.

Almeida CFCBR, Amorim ELC, Albuquerque UP, Maia MBS (2006). Medicinal plants popularly used in the Xingó region – a semi-arid location in Northeastern Brazil. J. Ethnobiol. Ethnomed. 2:15.

Almeida CFCBR, Silva TCL, Amorim ELC, Maia MBS, Albuquerque UP (2005). Life strategy and chemical composition as predictors of the selection of medicinal plants from the caatinga (Northeast Brazil). J. Arid Environ. 62(1):127-142.

Alviano WS, Alviano DS, Diniz CG, Antoniolli AR, Alviano C, Farias LM, Carvalho MAR, Souza MMG, Bolognese AM (2008). *In vitro* antioxidant potential of medicinal plant extracts and their activities against oral bacteria based on Brazilian folk medicine. Arch. Oral Biol. 53(6):545-552.

Bahia MV, David JP, David JM (2010). Occurrence of biflavones in leaves of *Caesalpinia pyramidalis* specimens. Quim. Nova. 33(6):1297-300.

Bahia MV, Santos JB, David JP, David JM (2005). Biflavonoids and other phenolics of *Caesalpinia pyramidalis* (Fabaceae). J. Braz. Chem. Soc. 16(6b):1402-1405.

Barbosa Jr AM, Mélo DLFM, Almeida FTC, Trindade RC (2015). Estudo comparativo da susceptibilidade de isolados clínicos de *Cryptococcus neoformans* (Sanfelice, 1895) frente a alguns antifúngicos de uso hospitalar e extratos vegetais obtidos de plantas medicinais da região semiárida sergipana. Rev. Bras. Plantas Med. 17(1):120-132.

Borges-dos-Santos RR, Santos JLL, Farouk Z, David JM, David JP, Lima JWM (2012). Biological Effect of Leaf Aqueous Extract of *Caesalpinia pyramidalis* in Goats Naturally Infected with Gastrointestinal Nematodes. Evid. Based Complement. Altern. Med. 17:1.

Braga R (1960). Plantas do Nordeste, especialmente do Ceara. 2ª edição. Fortaleza: Imprensa Oficial do Ceará. 540.

Cartaxo SL, Souza MMA, Albuquerque UP (2010). Medicinal plants with bioprospecting potential used in semi-arid northeastern Brazil. J. Ethnopharmacol. 131(2):326-342.

Corrêa MP (1926). Dicionário das plantas úteis do Brasil e das exóticas cultivadas. Rio de Janeiro: Imprensa Nacional.

Cruz MCS, Santos PO, Barbosa JRAM, Melo DLFM, Alviano CS, Antoniolli AR, Alviano DS, Trindade RC (2007). Antifungal activity of Brazilian medicinal plants involved in popular treatment of mycoses. J. Ethnopharmacol. 111(2):409-412.

Diniz PBF, Ribeiro ARS, Estevam CS, Bani CC, Thomazzi SM (2015). Possible mechanisms of action of *Caesalpinia pyramidalis* against ethanol-induced gastric damage. J. Ethnopharmacol. 168(20): 79-86.

Fabricante JR, Feitosa SS, Bezerra FTC, Feitosa RC, Xavier KRF (2009). Análise populacional de *Caesalpinia pyramidalis* Tul. (Fabaceae) na caatinga da região do Seridó nordestino. Rev. Bras. Bioci. 7(3): 285-90.

Haslam E (1998) Pratical Polyphenolics from structure to molecular recognition and physiological action, Cambridge University Press: 103 p.

Lima JLS (1996). Plantas forrageiras da caatinga usos e potencialidades. Embrapa. Petrolina- PE. 44 p.

Lima MRF, Luna JS, Santos AF, Andrade MCC, Santana AEG, Genet JP, Marquez B, Neuville L, Moreau N (2006). Anti-bacterial activity of some Brazilian medicinal plants. J. Ethnopharmacol. 105(1-2): 137–147.

Lucena RFP, Medeiros PM, Araújo EL, Alves AGS, Albuquerque UP (2012). The ecological apparency hypothesis and the importance of useful plants in rural communities from Northeastern Brazil: An assessment based on use value. J. Environ. Manage. 96(1): 106-15.

Luna CM, Rodriguez-Noriega E, Bavestrello L, Gotuzzo E (2010). Treatment of methicillin-resistant *Staphylococcus aureus* in Latin America. Braz J Infect Dis. 14(Suppl. 2): S119-S127.

Luna JS, Santos AF, Lima MRF, Omena MC, Mendonça FAC, Bieber LW, Sant'Ana AEG (2005). A study of the larvicidal and molluscicidal activities of some medicinal plants from northeast Brazil. J. Ethnopharmacol. 97(2):199-206.

Maia GN (2004). Caatinga: árvores e arbustos e suas utilidades. São Paulo: Leitura e Arte, pp.159-169.

Marinho MGV, Silva CC, Andrade LHC (2011). Levantamento etnobotânico de plantas medicinais em área de caatinga no município de São José de Espinharas, Paraíba, Brasil. Rev. Bras. Plantas Med. 13(2):170-182.

Melo JG, Araújo TAS, Castro VTNA, Cabral DLV, Rodrigues MD, Nascimento SC, Amorim ELC, Albuquerque UP (2010). Antiproliferative Activity, Antioxidant Capacity and Tannin Content in Plants of Semi-Arid Northeastern Brazil. Molecules 15(12):8534-8542.

Mendes CC, Bahia MV, David JM, David JP (2000). Constituents of *Caesalpinia pyramidalis.* Fitoterapia 71(2):205-207.

Monteiro JM, Lins Neto EMF, Amorim ELC, Strattmann RR, Araújo EL, Albuquerque UP (2005). Teor de taninos em três espécies medicinais arbóreas simpátricas da caatinga. Rev. Árvore 29(6):999-1005.

Moraes JP, Pereira DS, Matos AS, Santana DG, Santos CA, Estevam CS, Fakhouri R, Lucca Jr W, Camargo EA (2013). The Ethanol Extract of the Inner Bark of *Caesalpinia pyramidalis* (Tul.) Reduces Urinary Bladder Damage during Cyclophosphamide-Induced Cystitis in Rats. Sci. World J. 2013.

Novais TS, Costa JFO, David JPL, David JM, Queiroz LP, França F,

Giulietti AM, Soares MBP, Santos RR (2003). Atividade antibacteriana em alguns extratos de vegetais do semiárido brasileiro. Braz. J. Pharmacogn. 13(supl.2):4-7.
Oliveira FCS, Barros RFM, Moita Neto JM (2010). Plantas medicinais utilizadas em comunidades rurais de Oeiras, semiárido piauiense. Rev. Bras. Plantas. Med. 12(3):282-301.
Oliveira JCS (2010). Estudo químico e avaliação biológica do extrato das cascas das raízes de *Caesalpinia pyramidalis* Tul. (Leguminosae). Dissertação. Universidade Federal da Bahia, Programa de Pós-Graduação em Química. 2010.
Pereira Jr LR, Andrade AP, Araújo KD, Barbosa AS, Barbosa FM (2014). Espécies da Caatinga como Alternativa para o Desenvolvimento de Novos Fitofármacos. Floresta Ambient. 21(4):509-520.
Queiroz LP (2009). Leguminosas da Caatinga. Feira de Santana: Editora Universitária da UEFS.
Ribeiro AR, Diniz PF, Estevam CS, Pinheiro M, Albuquerque-Jr RLC, Thomazzi S (2013). Gastroprotective activity of the ethanol extract from the inner bark of *Caesalpinia pyramidalis* in rats. J. Ethnopharmacol. 147(2):383-388.
Ribeiro DA, Oliveira LGS, Macêdo DG, Menezes IRA, Costa JGM, Silva MAP, Lacerda SR, Souza MMA (2014). Promising medicinal plants for bioprospection in a Cerrado area of Chapada do Araripe, Northeastern Brazil. J. Ethnopharmacol. 155(3):1522-1533.
Santana DG, Santos CA, Santos ADS, Nogueira PCL, Thomazzi SM, Estevam CS, Antoniolli AR, Camargo EA (2012). Beneficial effects of the ethanol extract of *Caesalpinia pyramidalis* on the inflammatory response and abdominal hyperalgesia in rats with acute pancreatitis. J. Ethnopharmacol. 142(2):445-455.
Santana JAS, Vieira FA, Pacheco MV, Oliveira PRS (2011). Padrão de distribuição e estrutura diamétrica de *Caesalpinia pyramidalis* Tul. (Catingueira) na Caatinga do Seridó. Rev. Biol. Ciênc. Terra. 11(1):116-122.
Santos AC, Ailane MPR, Passos FCA, Camargo EA, Estevam CS, Santos MRV, Thomazzi SM (2011). Antinociceptive and anti-inflammatory effects of *Caesalpinia pyramidalis* in rodents. Braz. J. Pharmacogn. 21(6):1077-1083.
Santos AC, Santos DS, Santana DG, Thomazzi SM (2013a). Evaluation of mechanisms involved in the antinociception of the ethanol extract from the inner bark of *Caesalpinia pyramidalis* in mice. J. Ethnopharmacol. 148(1):205-209.
Santos CA (2010). Estudo farmacológico do extrato etanólico da entrecasca da *Caesalpinia pyramidalis* Tul. (Leguminosae). 83f. Dissertação- Mestrado em Ciências da Saúde, Universidade Federal de Sergipe.
Santos JP, Araujo EL, Albuquerque UP (2008). Richness and distribution of useful woody plants in the semi-arid region of northeastern Brazil. J. Arid Environ. 72(5): 652–663.
Santos MLO, Siqueira WN, Sá LJF, Silva LRS, Cabral DLV, Amâncio FF, Melo AMMA (2013b). Estudo do efeito radioprotetor do extrato metanólico de *Caesalpinia pyramidalis* sobre células embrionárias de *Biomphalaria glabatra*. Scientia Plena 9(9): 1-7.
Saraiva AM, Saraiva CL, Gonçalves AM, Soares RR, Mendes FO, Cordeiro RP, Xavier HS, Pisciottano MNC (2012a). Antimicrobial activity and bioautographic study of antistaphylococcal components from *Caesalpinia pyramidalis* Tull. Braz. J. Pharm. Sci. 48(1):147-154.
Saraiva AM, Saraiva MG, Gonçalves AM, Sena Filho JG, Xavier HS, Pisciottano MNC (2012b). Avaliação da atividade antimicrobiana e perfil fitoquímico de *Caesalpinia pyramidalis* Tul. (Fabaceae). Biofar 7(2): 52-60.
Silva ACO, Albuquerque UP (2005). Woody medicinal plants of the Caatinga in the state of Pernambuco (Northeast Brazil). Acta Bot. Bras. 19(1):17-26.
Silva CG, Marinho MGV, Lucena MFA, Costa JGM (2015). Levantamento etnobotânico de plantas medicinais em área de Caatinga na comunidade do Sítio Nazaré, município de Milagres, Ceará, Brasil. Rev. Bras. Plantas Med. 17(1): 133-142.
Silva CHTB, Peixoto Sobrinho TJS, Castro VTNA, Lima DCA, Amorim ELC (2011a). Antioxidant Capacity and Phenolic Content of *Caesalpinia pyramidalis* Tul. and *Sapium glandulosum* (L.) Morong from Northeastern Brazil. Molecules 16(6):4728-4739.
Silva FS, Ramos MA, Hanazaki N, Albuquerque UP (2011b). Dynamics of traditional knowledge of medicinal plants in a rural community in the Brazilian semi-arid region. Braz. J. Pharmacogn. 21(3): 382-391.
Silva TS, Freire EMX (2010). Abordagem etnobotânica sobre plantas medicinais citadas por populações do entorno de uma unidade de conservação da caatinga do Rio Grande do Norte, Brasil. Rev. Bras. Plantas Med. 12(4):427-435.
Souza MZS, Andrade LRS, Fernandes MSM (2011). Levantamento sobre plantas medicinais comercializadas na feira livre da cidade de Esperança – PB. Biofar 5(1): 111-118.
Valladares F, Gianoli E, Gómez JM (2007). Ecological limits to plant phenotypic plasticity. New Phytol. 176(4): 749–763.