

## Review

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

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Received 12 June, 2015; Accepted 15 October, 2015

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-5 $\alpha$ -2,4-dihydroxy-4'-metoxidihydrochalcona (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  $\mu$  mL<sup>-1</sup> to *Prevotella intermedia*, *Porphyromonas gingivalis* and *Fusobacterium nucleatum*, and 8000  $\mu$ g mL<sup>-1</sup> 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	<p><b>Respiratory problems:</b> asthma, bronchitis, expectorant, flu, respiratory infection, catarrhal infections, cough.</p> <p><b>Gastrointestinal problems:</b> heartburn, colic, diarrhea, dysentery, flatulence, gastritis, indigestion, stomach pain, stomach problems.</p> <p><b>Problems of the circulatory system:</b> hemostatic,</p> <p><b>Undefined symptoms:</b> inflammation, fever.</p> <p><b>Recreation:</b> Aphrodisiac.</p> <p><b>Lesions:</b> Cicatrizant, injuries, bruises.</p> <p><b>Endocrine problems:</b> Diabetes.</p>	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	<p><b>Respiratory problems:</b> asthma, bronchitis, expectorant, flu, respiratory infection, catarrhal infections, cough.</p> <p><b>Gastrointestinal problems:</b> heartburn, colic, diarrhea, dysentery, flatulence, gastritis, indigestion, stomach pain, stomach problems.</p> <p><b>Problems of the circulatory system:</b> hemostatic,</p> <p><b>Undefined symptoms:</b> fever. <b>Recreation:</b> Aphrodisiac. <b>Lesions:</b> Cicatrizant, injuries, bruises.</p> <p><b>Endocrine problems:</b> Diabetes.</p>	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	<p><b>Respiratory problems:</b> asthma, bronchitis, expectorant, flu, respiratory infection, catarrhal infections, cough.</p> <p><b>Gastrointestinal problems:</b> colic, diarrhea, dysentery, flatulence, gastritis, stomach pain, indigestion.</p> <p><b>Fungicide:</b> candidiasis.</p> <p><b>Lesions:</b> Cicatrizant, injuries, bruises.</p> <p><b>Endocrine problems:</b> Diabetes.</p> <p><b>Other:</b> Diuretic.</p>	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	<p><b>Respiratory problems:</b> asthma, bronchitis, expectorant, respiratory infection, flu, cough.</p> <p><b>Gastrointestinal problems:</b> heartburn, colic, diarrhea, stomach pain, flatulence, gastritis.</p> <p><b>Undefined symptoms:</b> fever.</p> <p><b>Lesions:</b> wounds, bruises.</p> <p><b>Endocrine problems:</b> Diabetes.</p>	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 ( $MIC \leq 1000 \mu\text{g mL}^{-1}$ ) 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* ( $MIC = 125 \mu\text{g mL}^{-1}$ ), and the ethyl

acetate extract of the root against *E. coli* and *S. aureus* were  $500$  and  $250 \mu\text{g mL}^{-1}$ , respectively; and the methanol extract of the leaves against *E. coli* was  $250 \mu\text{g mL}^{-1}$ . 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-dimetoxyumaric	Phenylpropanoid	Oliveira, 2010
6	Root	7-hydroxy-4'-metoxyflavone-5 $\alpha$ -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- $\beta$ -glucopiranosyloxy-Z-7-hydroxycinnamic	Fenilpropanoid	Mendes et al., 2000
13	Leaf	Acid 4-O- $\beta$ -D-glucopyranosyloxy-8-Z-hydroxycinnamic	Fenilpropanoid	Mendes et al., 2000
14	Root	7-hydroxy-4'-methoxyflavone-5 $\alpha$ -2,4-dihydroxy-4'-metoxidihydrochalcone	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  $\mu\text{g mL}^{-1}$ ), *Candida guilliermondii* (MIC = 25  $\mu\text{g mL}^{-1}$ ), *Candida albicans* (MIC = 12.5  $\mu\text{g mL}^{-1}$ ),

$\text{mL}^{-1}$ ), *Cryptococcus neoformans* (MIC = 12.5  $\mu\text{g mL}^{-1}$ ) and *Fonsecaea pedrosoi* (MIC = 200  $\mu\text{g mL}^{-1}$ ).

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  $\text{mg mL}^{-1}$ . 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  $\mu\text{g mL}^{-1}$ , of MIC and

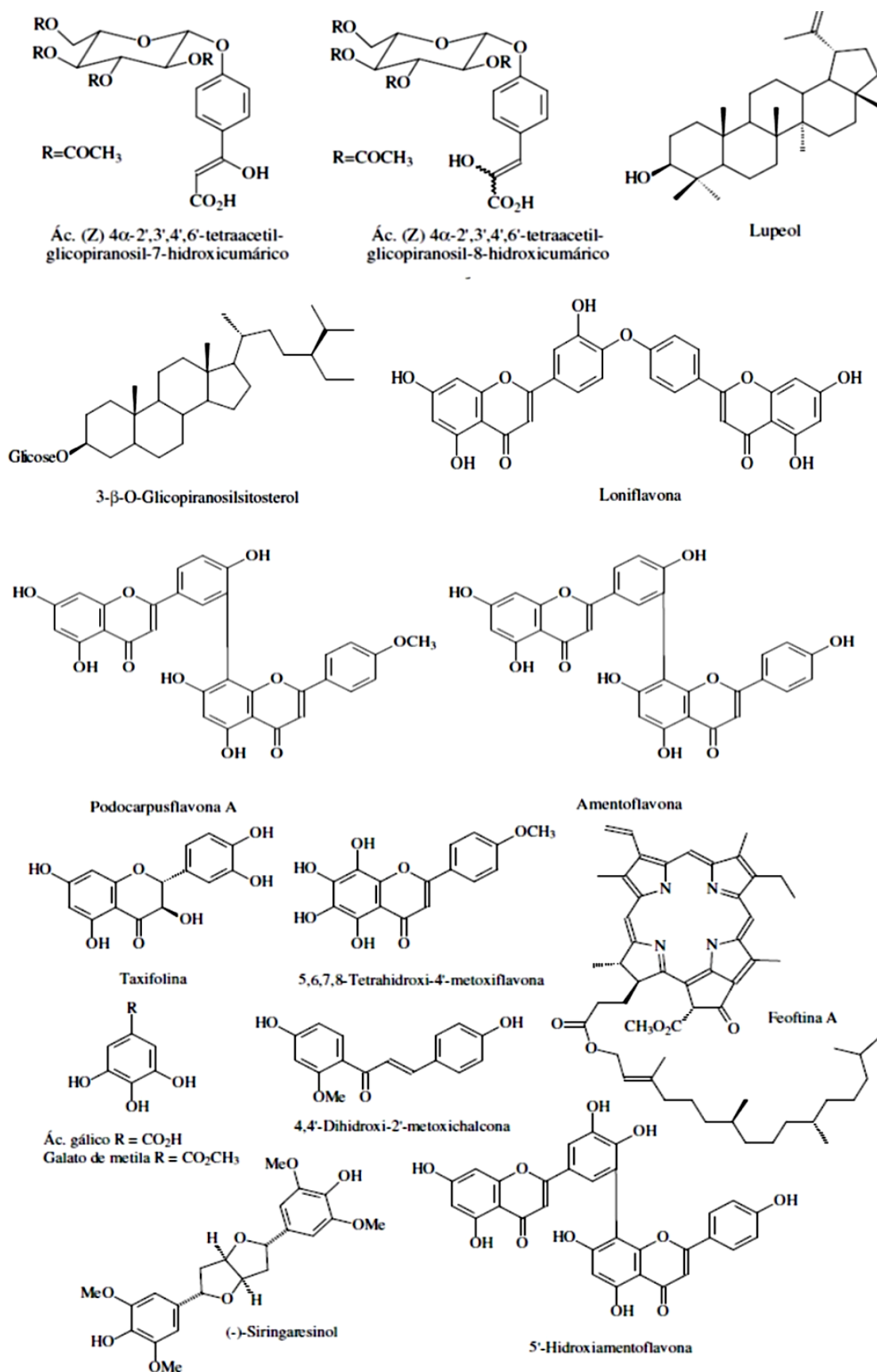


Figure 1. Isolated molecules from *P. pyramidalis*.

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  $\mu\text{g mL}^{-1}$ ) 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 ( $\text{EC}_{50} = 15.2 \pm 1.0 \text{ mg L}^{-1}$ ), and was better than the synthetic antioxidant BHT ( $\text{EC}_{50} = 86 \text{ }\mu\text{g mL}^{-1}$ ). 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 ( $\text{IC}_{50} = 16.98 \pm 1.34 \text{ }\mu\text{g mL}^{-1}$ ) compared to standards rutin and ascorbic acid ( $\text{IC}_{50} = 22.96 \pm 1.99$  and  $16.12 \pm 0.01 \text{ }\mu\text{g mL}^{-1}$ , respectively). Moreover, the extract of leaves was more effective in chelating ferrous ions ( $\text{IC}_{50} = 62.49 \pm 10.77 \text{ }\mu\text{g mL}^{-1}$ ), with  $\text{IC}_{50}$  values closer to EDTA control ( $\text{IC}_{50} = 15.26 \pm 0.58 \text{ }\mu\text{g mL}^{-1}$ ).

Melo et al. (2010) evaluated the antioxidant activity of 14 medicinal plants of the Brazilian semi-arid region; *P. pyramidalis* presented lower  $\text{IC}_{50}$  value ( $42.95 \pm 1.77 \text{ }\mu\text{g mL}^{-1}$ ) 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  $\text{mg kg}^{-1}$ , 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  $0.92 \pm 0.40$ ,  $0.93 \pm 0.46 \text{ mm}^2$ ,  $0.16 \pm 0.08\%$ , 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  $\text{mg kg}^{-1}$ ) and positive control (Cimetidine 100  $\text{mg kg}^{-1}$ ) 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 =  $1.00 \pm 0.13 \text{ mg L}^{-1}$ ; extract 300  $\text{mg kg}^{-1} = 1.61 \pm 0.09 \text{ mg L}^{-1}$ ).

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 H<sub>2</sub>S 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  $\text{mg Kg}^{-1}$ ) 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  $\text{mg kg}^{-1}$ ) 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  $4.5 \pm 0.5 \text{ mg UMPO}^{-1}$  and the vehicle group had  $7.1 \pm 0.9 \text{ mg UMPO}^{-1}$ . In addition, the activity of this extract was against carrageenan-induced peritonitis in mice. The extract (400  $\text{mg kg}^{-1}$ ) significantly inhibited the migration of leukocytes into the peritoneal cavity ( $2.63 \pm 0.23 \times 10^6 \text{ mL}^{-1}$  of leukocytes / 80.2% inhibition) compared to the vehicle group ( $7.22 \pm 0.99 \times 10^6 \text{ mL}^{-1}$  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  $\text{mg kg}^{-1}$ ) showed a significant reduction of cyclophosphamide-induced MPO. 100  $\text{mg kg}^{-1}$  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<sup>-1</sup>) 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<sup>-1</sup>) 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<sup>-1</sup>) 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<sup>-1</sup>) 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<sup>-1</sup>) after receiving a nitric oxide synthase inhibitor L-NOARG (75 mg Kg<sup>-1</sup>) or extract (30 mg Kg<sup>-1</sup>). 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<sup>-1</sup>. 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<sub>50</sub>**, 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**, Nw-nitro L-arginine.

### Conflict of interests

The authors have not declared any conflict of interests.

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