



BOTANICAL CONSIDERATIONS AND BIOLOGICAL POTENTIAL OF THE SPECIES *Croton heliotropiifolius* Kunth (EUPHOBIACEAE): A LITERATURE REVIEW

Considerações botânicas e potencial biológico da espécie *Croton heliotropiifolius* Kunth (Euphobiaceae): Uma revisão de literatura

*Jéssica de Andrade Gomes Silva¹, Rayane Siqueira de Sousa², Elizabeth
Fernanda de Oliveira Borba³, Katharina Rodrigues de Lima Porto Ramos², Marília
Grasielly de Farias Silva¹, Teresinha Gonçalves da Silva⁴*

¹Programa de Pós-Graduação em Inovação Terapêutica, Universidade Federal de Pernambuco (UFPE).

²Programa de Pós-Graduação em Ciências Farmacêuticas, Universidade Federal de Pernambuco (UFPE).

³Programa de Pós-Graduação em Ciências Biológicas, Universidade Federal de Pernambuco (UFPE).

⁴Departamento de Antibióticos, Universidade Federal de Pernambuco (UFPE).

*Autor para Correspondência: jessica.andrade.gs@gmail.com

ABSTRACT

The species *Croton heliotropiifolius* Kunth, popularly known as "velamen", constitutes an important representative of the genus *Croton* and the Family Euphorbiaceae. In this way, this review aimed to elucidate the geographic distribution, morphological characteristics, ethnomedicinal value, phytochemical composition and biological activities of the species. For that, consultations were carried out in the Lilacs, Pubmed, Scielo and Science direct databases, in the period from 2000 to 2021, where national and international articles were analyzed. With



this consultation, it was possible to verify the neotropical distribution of the species, having in Brazil occurring predominantly in the vegetation of the caatinga. Morphologically, *C. heliotropiifolius* presents itself as a sub-shrub to shrub up to two meters high. As for its ethnomedicinal value, it has been used mainly to relieve pain, gastric and intestinal problems and inflammation. The biological activities attributed to the species are related to the ability to inhibit acetylcholinesterase, antifungal, antibacterial activity, larvicidal capacity, insecticide and repellent, based on its chemical composition, which comprises several biologically active compounds. However, despite the population's use and knowledge about the species, many of its activities have not yet been investigated, thus motivating further studies. In this way, works like ours are an important tool for understanding the potential of the species, developing new research and using this plant resource in a more targeted and compatible way with its already recognized properties, which helps the planning of public policies and the insertion species in the arsenal of medicinal plants applied to health.

Keywords: velamen; caatinga; phytochemistry; ethnomedician.

RESUMO

A espécie *Croton heliotropiifolius* Kunth, popularmente conhecida como “velame”, “velaminho” e “velame-de-cheiro”, constitui um importante representante do gênero *Croton* e da Família Euphorbiaceae. Deste modo, esta revisão teve o objetivo de elucidar a distribuição geográfica, características morfológicas, valor etnomedicinal, composição fitoquímica e atividades biológicas da espécie. Para isto, foram realizadas consultas nas bases de dados *Lilacs*, *Pubmed*, *Scielo* e *Science direct*, no período de 2000 a 2021, onde foram analisados artigos nacionais e internacionais. Com esta consulta, foi possível constatar a distribuição neotropical da espécie, tendo no Brasil ocorrência predominante na vegetação da caatinga.



morfologicamente, o *C. heliotropiifolius* apresenta-se como subarbusto a arbusto com até dois metros de altura. Quanto ao seu valor etnomedicinal, tem sido usado principalmente no alívio da dor, em problemas gástricos, intestinais e na inflamação. As atividades biológicas atribuídas a espécie estão relacionadas à capacidade de inibição da acetilcolinesterase, atividade antifúngica, antibacteriana, capacidade larvicida, inseticida e repelente, fundamentadas em sua composição química, que compreende diversos compostos biologicamente ativos. Contudo, apesar do uso e conhecimento da população acerca da espécie, muitas de suas atividades ainda não foram investigadas, motivando assim novos estudos. Desta forma, trabalhos como o nosso constituem ferramenta importante para o entendimento das potencialidades da espécie, desenvolvimento de novas pesquisas e uso deste recurso vegetal de forma mais direcionada e compatível com suas propriedades já reconhecidas, o que auxilia o planejamento de políticas públicas e a inserção da espécie no arsenal de plantas medicinais aplicadas à saúde.

Palavras-chave: velame; caatinga; fitoquímica; etnomedicinal.

INTRODUCTION

The genus *Croton* is the second largest genus belonging to the Euphorbiaceae family. It has a predominantly pantropical distribution in America and comprises about 1,200 species, of which approximately 350 occur in Brazil (BERRY *et al.*, 2005). Numerous biological assays have been performed to verify the properties claimed by the popular use of this species, such as anti-inflammatory (RAMOS *et al.*, 2013), gastroprotective (COELHO-DE-SOUZA *et al.*, 2013), wound healing (CAVALCANTI *et al.*, 2012) and anticancer activities (SYLVESTRE *et al.*, 2006).

Croton heliotropiifolius Kunth is a species endemic to the Brazilian Northeast region. It is popularly known as "velamen", "velaminho" and "velame-de-cheiro" due



to its tiny trichomes. It can be found frequently in the Caatinga, but it also occurs in marshes, Restingas and Cerrado (COMPAGNONE *et al.*, 2010).

Studies focusing on *Croton heliotropiifolius* have reported a predominant presence of alkaloids, polyphenols and reducing compounds (SOUZA *et al.*, 2017). This species is reported as useful in relieving stomach pain and dysentery and as an antipyretic (RANDAU, 2001).

The species blossoms in May, June, July and November. The fruiting occurs in May and June (SILVA *et al.*, 2010). It differs from *C. campestris* by its concolorous leaves, inflorescences, glandular trichomes, smooth seeds and branches with dendritic trichomes (SÁTIRO *et al.*, 2008). The nomenclature of this species was *C. rhamnifolius*. Its name was changed to *C. heliotropiifolius* Kunth (GOVAERT *et al.*, 2000).

The objective of this literature review was to elucidate the geographic distribution, the morphological characteristics, the ethnomedicinal value, the phytochemical composition and the biologic activities of the species *C. heliotropiifolius* to contribute to the understanding of this species' potentialities and help to develop new studies using this plant resource in a more targeted way taking into account the already recognized properties of this plant.

METHODOLOGY

This study was elaborated from an integrative literature review in the digital databases Lilacs, Pubmed, Scielo and Science direct, in the period from 2000 to 2021, using the keywords "*Croton heliotropiifolius*" and "*Croton heliotropiifolius* Kunth". 42 national and international articles were found, of which 25 were selected after checking the content. The other works were excluded because they portray studies of other species, because they are review articles, or because they are outside the context of this work.



RESULTS AND DISCUSSION

Geographic distribution

The species *Croton heliotropiifolius* has a wide distribution in neotropical regions. It can be found from Panama to Brazil (GOVAERTS *et al.*, 2000). In Brazil, it extends from the state of Minas Gerais to the Northeast region (LUCENA, 2000). It occurs predominantly in the Caatinga, Brejos, Restingas and the Cerrado (RANDAU *et al.*, 2004).

In the northwestern part of the state of Bahia, the so-called dunes of the middle course of São Francisco river form a sandy corridor along which the Caatinga vegetation appear and where species belonging to the Euphorbiaceae family are found, including *Croton heliotropiifolius* (SÁTIRO *et al.*, 2008).

In Pernambuco, the species can be found in vacant lots, high Brejo areas, in the Mata Atlântica, Zona da Mata and the Caatinga (SILVA *et al.*, 2010). The presence of this species in the Rio Grande do Norte (ROQUE *et al.*, 2010), Paraíba (TOLKE *et al.*, 2011) and Goiás (SODRÉ *et al.*, 2014) states was also described.

Morphological characteristics

C. heliotropiifolius is a sub-shrub or shrub up to two meters high with a colorless, creamy to reddish latex. Its branches are cylindrical, green to grayish. There are small lanceolate stipules (1 mm). The leaves are alternate and slightly subopposite at the apex, sessile to petiolate, and greenish. The limbus has an ovoid membranaceous or charcoal consistency with an acute apex, a reentrant base, a serrated border. There are peni-nervous trichomes on both sides. The main vein protrudes on the dorsal surface. There is a marginal insertion of the petiole, which is slightly biconvex in the cross section. The flowers are arranged in terminal inflorescences; they are racemiform and congesta. The fruit is a capsule oblong to sub-globous. Seeds are elliptic to oblong, with a brown to black tegument (RANDAU *et al.*, 2004; SODRÉ *et al.*, 2014).



The species has dense stellate-porrect trichomes in vegetative and reproductive structures, providing a tomentose appearance. In general, it does not present nectaries on the petiole or, when present, they are inconspicuous, globose and often covered by trichomes (SÁTIRO *et al.*, 2008; SODRÉ *et al.*, 2014).

Ethnomedicinal properties

Biodiversity associated with cultural diversity leads populations to use plants differently (CREPALDI *et al.*, 2016). Ethnobotanical studies focus on the Euphorbiacea family due to its different uses (ALBUQUERQUE *et al.*, 2007; NASCIMENTO *et al.*, 2009; MELO *et al.*, 2009; CARTAXO *et al.*, 2010), including several species used in different situations. Particularly, the medicinal uses have been deemed the most significant for the genus *Croton* (CREPALDI *et al.*, 2016). The species *C. heliotropiifolius* has been used in several medicinal treatments as shown in Table 1.

Table 1. Popular uses of the species *Croton heliotropiifolius*.

Popular use	Reference
Stomachache	RANDAU, 2001
Vomiting	RANDAU, 2001
Dysentery	RANDAU, 2001
Antipyretic	RANDAU, 2001
Flu	SARAIVA <i>et al.</i> , 2015
Pains	SARAIVA <i>et al.</i> , 2015
Inflammation	SARAIVA <i>et al.</i> , 2015
Skin diseases	SARAIVA <i>et al.</i> , 2015
Wound healing	CREPALDI <i>et al.</i> , 2016
Aphrodisiac	LONGHINI <i>et al.</i> , 2016



The use of *C. heliotropiifolius* in popular medicine is related to a medicinal potential attributed to the genus. In general, species belonging to this genus are often used as infusions or teas for pain relief (ABREU *et al.*, 2001), to treat intestinal dysfunctions, diarrhea, digestive disorders and infections, and wound healing (SALATINO *et al.*, 2007). This species has also been reported for the treatment of common health problems, such as influenza, inflammation, dermatitis and cysts (SARAIVA *et al.*, 2015).

The extract of *C. heliotropiifolius* associated with extracts of *Trichilia catiguá* and *Paullinia cupana* Kunth comprises the most recent formulation of Catuama, a psychoanaleptic or stimulant medicine recorded at the National Sanitary Surveillance Agency as a herbal medicine and marketed by the Catarinense Laboratory in the form of capsules or as an oral solution (LONGHINI *et al.*, 2016).

Phytochemistry

The phytochemical profile of *C. heliotropiifolius* shows the main classes of compounds present in species of the genus *Croton* and the family Euphorbiaceae.

Based on the methanolic extract of leaves of this species, there was the presence of flavonoids and the absence of alkaloids, coumarins, saponins and condensed tannins (SILVA *et al.*, 2016). Polyphenols such as coumarins are rare substances in the Euphorbiaceae family. In the genus *Croton*, there is only scopoletin in *C. sonderianus* (CRAVEIRO; SILVEIRA, 1982). The absence of saponins is also reported for *Croton linearifolius* (SILVA *et al.*, 2014).

A phytochemical analysis of the ethanolic extract of the stem bark identified the alkaloid taspine and the diterpene acetate of velamolone (QUEIROZ *et al.*, 2014), a compound also described for *Croton campestris* A. St.-Hil. (EI BABILI *et al.*, 2006).

Studies on the chemical composition of the essential oil extracted from the leaves of *C. heliotropiifolius* showed α -pinene, sabinene, linalool, bornyl acetate, β -



caryophyllene, germacrene D, δ -cadinene, α -humulene, bicyclogermacrene, espatulenol and eucalyptol as a main component. However, Silva Brito *et al.* (2018), in his study with the essential oil of the species, found Limonene, α -pinene, cariofilene, as major compounds. In the thallus of this species, there were *p*-cymene, α -pinene, eucalyptol, linalool, β -caryophyllene and germacrene D similar to those identified in its leaves (SILVA, 2008; ANGÉLICO *et al.*, 2012).

Biological activities

Due to the richness of the biologically active compounds present in *C. heliotropiifolius*, its biological potential has been evaluated. Some of the described biological activities are shown in Table 2.

Table 2. Biological Activities of the species *Croton heliotropiifolius*.

Activity	Material	Reference
Larvicide	Essential oil	DÓRIA <i>et al.</i> , 2010.
Antifungal	Ethanollic extract	QUEIROZ <i>et al.</i> , 2014.
Inhibition of Acetylcholinesterase	Ethanollic extract	QUEIROZ <i>et al.</i> , 2014.
Insecticide	Essential oil	MAGALHÃES <i>et al.</i> , 2015.
Repellent	Essential oil	MAGALHÃES <i>et al.</i> , 2015.
Antibacterial	Essential oil	ALENCAR FILHO <i>et al.</i> , 2017.
Nematocidal	Aqueous extract	LIMA <i>et al.</i> , 2019.

The essential oil of *C. heliotropiifolius* presented a relevant larvicidal effect against *Aedes aegypti*, which may represent a contribution to alternative methods of mosquito control (DÓRIA *et al.*, 2010).

The antifungal potential against *Candida albicans* and the



acetylcholinesterase inhibitory activity of the *C. heliotropiifolius* ethanolic extract from the stem bark was described by Queiroz *et al.* (2014). In their study, the alkaloid taspine was identified, a compound reported as a strong acetylcholinesterase inhibitor (ROLLINGER *et al.*, 2006). The antifungal capacity against *Candida albicans* strains has also been described by Silva Brito *et al.* (2018). The identification of acetylcholinesterase inhibitor compounds may explain the insecticidal activity of the essential oil of this plant (MAGALHÃES *et al.*, 2015).

Magalhães *et al.* (2015) also reported a repellent activity of the essential oil against *Tribolium castaneum*. This activity is an important property for pest control: the higher the repellency, the lower the infestations (COITINHO *et al.*, 2006).

The antimicrobial potential of *C. heliotropiifolius* against strains of *Shigella flexneri* and *Escherichia coli* was described by Alencar Filho *et al.* (2017) and may justify the popular use of this species to treat disorders of the gastrointestinal tract. The species was also referred to as nematocidal against *Scutellonema bradys* in a study with the aqueous extract of leaves and stem (LIMA *et al.*, 2019).

CONCLUSION

The species *C. heliotropiifolius* has a wide medicinal value based on its chemical composition, which comprises several biologically active compounds. However, when compared to popular knowledge, many of its activities have not yet been studied. This motivates new studies. Studies such as this are important tools to understand the potential of the properties of this species. New studies should be conducted using this vegetal resource in a more targeted way taking into account its already recognized properties. This helps to plan public policies and establish this species among the arsenal of medicinal plants applied to health.



REFERENCES

ABREU, A. D. S.; BARBOSA, P. S.; MÜLLER, A. H.; GUILHON, G. M. S. P. Constituintes químicos do caule e das cascas do caule de *Croton pullei* var *Glabor* (Euphorbiaceae). **Rev Virt Iniciação Científica**, v. 1, p. 1-9, 2001.

ALBUQUERQUE, U.P.; OLIVEIRA, R.F. Is the use-impact on native caatinga species in Brazil reduced by the high species richness of medicinal plants?. **Journal of ethnopharmacology**, v. 113, n. 1, p. 156-170, 2007.

ALENCAR FILHO, J. M.; ARAÚJO, L. D. C.; OLIVEIRA, A. P.; GUIMARÃES, A. L.; PACHECO, A. G.; SILVA, F. S.; ARAÚJO, E. C. D. C. Chemical composition and antibacterial activity of essential oil from leaves of *Croton heliotropiifolius* in different seasons of the year. **Revista Brasileira de Farmacognosia**. V. 27, P. 440-444, 2017.

ANGÉLICO, E. C.; DA COSTA, J. G. M.; RODRIGUES, F. F. Composição química do óleo essencial das folhas de *Croton heliotropiifolius* Kant (sinônimo *C. rhamnifolius*): resultados preliminares. **BioFar**, v. 7, p. 57-61, 2012.

BERRY, P. E.; HIPPEL, A. L.; WURDACK, K. J.; VAN EEL, B.; RIINA, R. Molecular phylogenetics of the giant genus *Croton* and tribe *Crotoneae* (Euphorbiaceae sensu stricto) using ITS and trnL-trnF DNA sequence data. **American Journal of Botany**, v. 92, n. 9, p. 1520-1534, 2005.

CARTAXO S.L.; SOUZA M.M.A.; ALBUQUERQUE U.P. Medicinal plants with bioprospecting potential used in semi-arid northeastern Brazil. **Journal of ethnopharmacology**, v. 131, n. 2, p. 326-342, 2010.

CAVALCANTI, J. M.; LEAL-CARDOSO, J. H.; DINIZ, L. R. L.; PORTELLA, V. G.; COSTA, C. O.; LINARD, C. F. B. M.; COELHO-DE-SOUZA, A. N. The essential oil of *Croton zehntneri* and trans-anethole improves cutaneous wound healing. **Journal of ethnopharmacology**, v. 144, n. 2, p. 240-247, 2012.

COELHO-DE-SOUZA, A. N.; LAHLOU, S.; BARRETO, J. E.; YUM, M. E.; OLIVEIRA, A. C.; OLIVEIRA, H. D.; DE ALBUQUERQUE, A. A. Essential oil of *Croton zehntneri* and its major constituent anethole display gastroprotective effect by increasing the surface mucous layer. **Fundamental & clinical pharmacology**, v. 27, n. 3, p. 288-298, 2013.

COITINHO, R. L. B. C. Atividade inseticida de óleos essenciais sobre *Sitophilus zeamais* Mots. (Coleoptera: Curculionidae). **Recife: Universidade Federal Rural de Pernambuco**, 2009.



COMPAGNONE, R. S.; CHAVEZ, K.; MATEU, E.; ORSINI, G.; ARVELO, F.; SUÁREZ, A. I. Composition and cytotoxic activity of essential oils from *Croton matourensis* and *Croton micans* from Venezuela. **Records of Natural Products**, v. 4, n. 2, 2010.

CRAVEIRO, A. A.; SILVEIRA, E. R. Two cleistanthane type diterpenes from *Croton sonderianus*. **Phytochemistry**, v. 21, n. 10, p. 2571-2574, 1982.

CREPALDI, C. G.; CAMPOS, J. L. A.; ALBUQUERQUE, U. P.; SALES, M. F. Richness and ethnobotany of the family Euphorbiaceae in a tropical semiarid landscape of Northeastern Brazil. **South African Journal of Botany**, v. 102, p. 157-165, 2016.

DA SILVA BRITO, S. S., SILVA, F., MALHEIRO, R., BAPTISTA, P., PEREIRA, J. A. *Croton argyrophyllus* Kunth and *Croton heliotropiifolius* Kunth: Phytochemical characterization and bioactive properties. **Industrial crops and products**, v. 113, p. 308-315, 2018.

DÓRIA, G. A.; SILVA, W. J.; CARVALHO, G. A.; ALVES, P. B.; CAVALCANTI, S. C. A study of the larvicidal activity of two *Croton* species from northeastern Brazil against *Aedes aegypti*. **Pharmaceutical biology**, v. 48, n. 6, p. 615-620, 2010.

EL BABILI, F.; FABRE, N.; MOULIS, C.; FOURASTE, I. Molluscicidal activity against *Bulinus truncatus* of *Croton campestris*. **Fitoterapia**, v. 77, n. 5, p. 384-387, 2006.

GOVAERTS, R.; FRODIN, D. G.; RADCLIFFE-SMITH, A. **World checklist and bibliography of Euphorbiaceae (with Pandaceae)**. Royal Botanic Gardens, Kew, 2000.

LIMA, R. D. S., MUNIZ, M. D. F. S., COSTA, J. G. D., SILVA, K. B. D., BEHLING, A. Extratos aquosos de *Annona* spp. e *Croton heliotropiifolius* sobre *Scutellonema bradys* e prospecção química dos compostos. **Summa Phytopathologica**, v. 45, p. 223-224, 2019.

LONGHINI, R.; LONNI, A. A.; SEREIA, A. L.; KRZYZANIAK, L. M.; LOPES, G. C.; DE MELLO, J. C. P. *Trichilia catigua*: therapeutic and cosmetic values. **Revista Brasileira de Farmacognosia**, v. 27, p. 254-271, 2017.

LUCENA, M. F. A. Estudos taxonômicos do gênero *Croton* L. (Crotonoideae – Euphorbiaceae) nas zonas do Litoral e da Mata do estado de Pernambuco – Brasil. 2000.



MAGALHÃES, C.; OLIVEIRA, C.; MATOS, C.; BRITO, S.; MAGALHÃES, T.; FERRAZ, M. Potencial inseticida de óleos essenciais sobre *Tribolium castaneum* em milho armazenado. **Revista Brasileira de Plantas Mediciniais**, v. 17, p. 1150-1158, 2015.

MELO, J. W. D. S.; DOMINGOS, C. A.; GONDIM JR, M. G.; DE MORAES, G. J. Can *Euseius alatus* DeLeon (Acari: Phytoseiidae) Prey on *Aceria guerreronis* Keifer (Acari: Eriophyidae) in Coconut Palm?. **Neotropical entomology**, v. 38, n. 1, p. 885-889, 2009.

NASCIMENTO, I. L.; ALVES, E. U.; BRUNO, R. D. L. A.; PEREIRA, E.; GONÇALVES, P. N. Q. C.; DE MEDEIROS, M. S. Superação da dormência em sementes de faveira (*Parkia platycephala* Benth). **Revista Árvore**, v. 33, p. 33-45, 2009.

QUEIROZ, M. M. F.; QUEIROZ, E. F. D.; ZERAIK, M. L.; MARTI, G.; FAVRE-GODAL, Q.; SIMÕES-PIRES, C.; BOLZANI, V. D. S. Antifungals and acetylcholinesterase inhibitors from the stem bark of *Croton heliotropiifolius*. **Phytochemistry Letters**, v. 10, p. lxxxviii-xciii, 2014.

RAMOS, J. M. D. O. Identificação dos constituintes químicos e estudo farmacológico do óleo essencial das folhas da *Croton argyrophyllus* kunth. 2013.

RANDAU, K. P.; FLORÊNCIO, D. C.; FERREIRA, C. P.; XAVIER, H. S. Estudo farmacognóstico de *Croton rhamnifolius* HBK e *Croton rhamnifolioides* Pax & Hoffm. (EUPHORBIACEAE). **Revista Brasileira de Farmacognosia**, v. 14, p. 89-96, 2004.

RANDAU, K.P. Estudo farmacognóstico (farmacobotânico e farmacoquímico) e atividade biológica do *Croton rhamnifolius* H.B.K. e *Croton rhamnifolioides* Pax & Hoffm. (Euphorbiaceae). 2001.

ROLLINGER, J. M.; LANGER, T.; STUPPNER, H. Strategies for efficient lead structure discovery from natural products. **Current medicinal chemistry**, v. 13, n. 13, p. 1491-1507, 2006.

ROQUE, A. D. A.; ROCHA, R. D. M.; LOIOLA, M. I. B. Uso e diversidade de plantas medicinais da Caatinga na comunidade rural de Laginhas, município de Caicó, Rio Grande do Norte (nordeste do Brasil). **Revista Brasileira de Plantas Mediciniais**, v. 12, p. 31-42, 2010.

SALATINO, A.; SALATINO, M. L. F.; NEGRI, G. Traditional uses, chemistry and pharmacology of *Croton* species (Euphorbiaceae). **Journal of the Brazilian chemical society**, v. 18, p. 11-33, 2007.



SARAIVA, M. E.; DE ALENCAR ULISSES, A. V. R.; RIBEIRO, D. A.; DE OLIVEIRA, L. G. S.; DE MACÊDO, D. G.; DE SOUSA, F. D. F. S.; DE ALMEIDA SOUZA, M. M. Plant species as a therapeutic resource in areas of the savanna in the state of Pernambuco, Northeast Brazil. **Journal of Ethnopharmacology**, v. 171, p. 141-153, 2015.

SÁTIRO, L. N.; ROQUE, N. A família Euphorbiaceae nas caatingas arenosas do médio rio São Francisco, BA, Brasil. **Acta Botanica Brasilica**, v. 22, p. 99-118, 2008.

SILVA, F. K. S. Contribuição ao estudo fitoquímico de *Cróton rhamnifolius* (Euphorbiaceae). 2008.

SILVA, G. A.; DE BRITO, N. J. N.; DOS SANTOS, E. C. G.; LÓPES, J. A.; DAS GRAÇAS ALMEIDA, M. Gênero *Spondias*: aspectos botânicos, composição química e potencial farmacológico. **Journal of Biology & Pharmacy and Agricultural Management**, v. 10, n. 1, 2014.

SILVA, J. A. G.; SILVA, G. C.; SILVA, T. M. S.; RANGEL, I. Estudo Fitoquímico das Folhas de *Croton heliotropiifolius* Kunth (Euphorbiaceae). **Anais I Conbracis**. v. 1, 2016.

SILVA, J. S.; SALES, M. F. D.; GOMES, A. P. D. S.; CARNEIRO-TORRES, D. S. Sinopse das espécies de *Croton* L. (Euphorbiaceae) no estado de Pernambuco, Brasil. **Acta Botanica Brasilica**, v. 24, p. 441-453, 2010.

SODRÉ, R. C.; SILVA, M.; SALES, M. *Croton* L. (Euphorbiaceae) no Parque Estadual da Serra Dourada, Goiás, Brasil. **Rodriguésia**, v. 65, p. 221-234, 2014.

SYLVESTRE, M.; PICHETTE, A.; LONGTIN, A.; NAGAU, F.; LEGAULT, J. Essential oil analysis and anticancer activity of leaf essential oil of *Croton flavens* L. from Guadeloupe. **Journal of Ethnopharmacology**, v. 103, n. 1, p. 99-102, 2006.

SOUZA, G. S. D.; BONILLA, O. H.; LUCENA, E. M. P. D.; BARBOSA, Y. P. Chemical composition and yield of essential oil from three *Croton* species. **Ciência Rural**, v. 47, 2017.

TOLKE, E.; SILVA, J. B.; PEREIRA, A. R. L.; DE MELO, J. I. M. Flora vascular de um inselbergue no estado da Paraíba, Nordeste do Brasil. **Biotemas**, v. 24, n. 4, p. 39-48, 2011.