Quim. Nova, Vol. 45, No. 8, 977-993, 2022 http://dx.doi.org/10.21577/0100-4042.20170897

Revisão

***Pavonia* Cav. SPECIES (MALVACEAE *SENSU LATO*) AS SOURCE OF NEW DRUGS: A REVIEW**

Janderson Barbosa Leite de Albuquerque[a], Camila Macaúbas da Silva[a], Diégina Araújo Fernandes[a], Pedro Isaac Vanderlei de Souza[b] and Maria de Fátima Vanderlei de Souza[a,*]

[a]Departamento de Ciências Farmacêuticas, Universidade Federal da Paraíba, 58051-900 João Pessoa – PB, Brasil
[b]Instituto de Biociências, Universidade Federal do Mato Grosso do Sul, 79070-900 Campo Grande – MS, Brasil

Recebido em 17/12/2021; aceito em 17/03/2022; publicado na web em 19/04/2022

Pavonia Cav., is a genus in the Malvaceae *sensu lato* family, containing 271 species with worldwide distribution, although with a higher diversity in America and Asia. Species from this genus are traditionally used in folk medicine with several biological activities, arousing scientific interest on the search for the substances responsible for such activities. This review aimed to provide and expand the scientific interest through phytochemical and pharmacological studies and the utilization of those plants in folk medicine. Species *P. odorata* and *P. zeylanica* are described in literature, specially at India, following the traditional medicine system Ayuverda, while the other species are studied mostly at Africa and America. There have been around 169 compounds isolated and characterized for such genus, most of them from the metabolic classes fat acids, terpenoids, flavonoids and phenolic compounds. Those species have shown *in vivo*, *in vitro* and *in silico* significant pharmacological activities, which include anti-inflammatory, analgesic, antimicrobial, cytotoxic, antitumoral, antidiabetic and antioxidant properties. Based on those informations, the search for new sources of plant based biologic prototypes with potential for the treatment of several diseases is of major scientific, economical and medicinal interest.

Keywords: *Pavonia* Cav.; ethnopharmacological relevance; natural products; biological studies.

INTRODUCTION

Medicinal plants constitute the main therapeutic source of folk medicine. Traditional knowledges are passed through generations due to the stark believes that come since primitive folks and healers. Previous ethno-pharmaceutical-botanical studies form the foundation to the development of new drugs from medicinal herbs.[1]

Plants provide an essential economic role as they are used as a drug source.[2] This fact rises in developing countries due to lesser side effects and easy access that low-income populations have to those plants, making them an almost inexhaustible source of remedies for those people.[3]

Several chemical compounds that act as potential therapeutic agents have been isolated from plant species.[4] Studies about those compounds are based on ethnobotanical, chemical and pharmacological knowledges, aiming to find out new bioactive molecules. On this context, species from Malvaceae *sensu lato* family arouse major interests of the scientific community due to the fact that those species are important economic sources in agriculture, decorations, manufacturing, food and medicine.[5]

Among several genus belonging to Malvaceae *sensu lato*, we highlight *Pavonia* Cav., which has several biological and pharmacological activities described in literature about folk medicine. Those activities have been confirmed through the isolation, identification and characterization of secondary metabolites, as well as several pharmacological activities described for those compounds.[6]

The genus *Pavonia* Cav. includes approximately 271 species distributed worldwide, being more diverse in America and Africa, with only two species being recorded for Asia. A lot of chemical and pharmacological studies with species *P. odorata* and *P. zeylanica* are described in literature, mostly for India, due to the traditional medicine system Ayuverda.[7]

Approximately 224 species can be found in America, ranging from USA to Uruguay, including the Antilles and excluding Chile. In Africa, approximately 46 species can be found.[8] In Brazil, 136 species of *Pavonia* can be found, ranging from Amazon rainforest, Caatinga, Cerrado, Atlantic Forest, Pampas and Pantanal wetlands.[9]

Based on presented data, this review aims to accomplish a bibliographical survey about traditional uses of *Pavonia* species and evaluate the chemical and pharmacological potential of this genus in order to drive future researches based on natural products as a source of new drugs.

METHODOLOGY

Information about the use of plants by folk medicine, phytochemical studies, botanic characteristics and pharmacological activities of genus *Pavonia* have been based and collected from scientific data banks such as: *'Web of Science'*, *'Scifinder'*, *'Pubmed'* and *'Scholar Google'*, using papers, books, dissertation and thesis from the year 1918 until April 2021 and searching for the keyword *'Pavonia'*. Following this methodology, we consulted 156 scientific articles, having, as inclusion criteria, the presence of information regarding the use of *Pavonia* genus in traditional medicine, phytochemical studies, pharmacological and/or biological activities. The exclusion criteria of the articles involved repetition of those in different databases, review articles that contained references used in the manuscript, information with the keyword *'Pavonia'* that do not concerns the genus, articles with only botanical data or articles not available for access on the platforms used. A single patent referring to the species *P. schiedeana* (JP 2001181172A (2001)) was found as part of a cosmetic composition.

The development of this revision paper aimed the study of this genus in order to expand the scientific interest through knowledge of isolated compounds with several biological activities, as those are the candidates to new drugs isolated from *Pavonia* species.

The present study and data have been extracted by the author (JBLA) and confirmed by other (DAF, CMS, PIVS, MFVS). All data are resumed in tables and their descriptions have been resumed as updated information.

*e-mail: mfvanderlei@ltf.ufpb.br

RESULTS AND DISCUSSION

Botanical description

Pavonia comprises species of herbs, shrubs and bushes. Its flowers are, generally, solitary, composed by four epicalyxes, several free bracteoles, a tubulous and cupuliform calyx composed by five petals, carpels uniovulate and stigma capitate (Figure 1). The fruits are schizocarp, formed by five mericarps with a nervous-reticulate dorsal face, smooth lateral faces and smooth or striated obovoid or reniform seeds.[10]

Some species of *Pavonia* possess floral nectaries formed by multicellular glandular trichomes, providing a thick area located near the internal base of calyx. This characteristic attracts hummingbirds, which are pollinators of tubulous flowers, such as *P. glazioviana*[11] and *P. multiflora*. Species that possesses flowers with twisted corolla and short staminal tube formed by free stamens, such as *P. malacophylla*, *P. varians*, *P. zeylanica* and *P. distinguenda*, are pollinated by bees.[12]

Ethnopharmacological relevance

Different species of *Pavonia* Cav. are related in folk medicine as a treatment for several diseases. Among the most used parts of those plants used by some tribes in therapeutics are flowers, bark, roots, rhizomes and flowers (Table 1).

Juice of *P. odorata* leaves is used by traditional medicine Ayuverda as a treatment for dysentery, gonorrhea and halitosis, whereas leaves macerate as a paste are used as a treatment for rheumatism, foot infections and antipyretic.[13-18]

Powder from seeds of *P. senegalensis* is used as a contraceptive.[19] Decoct of *P. urens* roots is largely used as a treatment for toothache.[20,21] Brewing of roots and leaves of *P. zeylanica*, as well as decocts, powder and pastes are largely used by eastern communities as a treatment for osteoarthritis, joint pain, bone fractures, cough with discharge and healing of wounds.[22-26] Leaves' juice and the entire plant prepared as infusion are also used for its vermifuge and purgative properties.[27-30]

Several ethnopharmacological studies regarding *Pavonia* species have been described in literature, which give us basis for deepening the chemical and pharmacological knowledge of those herbs, since many of the pharmacological activities are related to traditional use of medicinal plants, therefore providing essential information to the development of new drugs.

Chemical composition

Based on literature data, 29 references in the area of phytochemistry have been find to species of the genus *Pavonia*: 10 papers referred to species *P. odorata* (06) and *P. zeylanica* (04); 9 papers referred to species *P. malacophyla* (03), *P. glazioviana* (03) and *P. sepium* (03), and; 2 papers referred to *P. cancelatta*. Besides, several other papers have been related in this field with the species *P. varians*, *P. xanthogloea*, *P. sepioides*, *P. distinguenda*, *P. multiflora*, *P. hastata*, *P. lasiopetala*, *P. schiedeana* and *P. alnifolia.* 169 compounds have been isolated and/or identified in the genus *Pavonia* (Table 2), comprehending the most diverse classes of secondary metabolites ever related.

Fat acids, terpenoids, steroids, flavonoids, phenolics and other compounds such as pheophytins, hydrocarbons and volatile oils are some of the substances that can be found in the genus *Pavonia*. A broad profile of such compounds within has been detected in a study of the chemical composition of oils in the aerial parts of the species *Pavonia odorata* through hyphenated gas chromatography techniques coupled with mass spectrometry.[105] All compounds and their chemical structures are related in Table 2 and Figure 2, respectively.

Fatty acids

Fatty acids are molecule that consists of the most diverse lipids and, by enzymatic action, become free fatty acids, presenting powerful biological activities.[122]

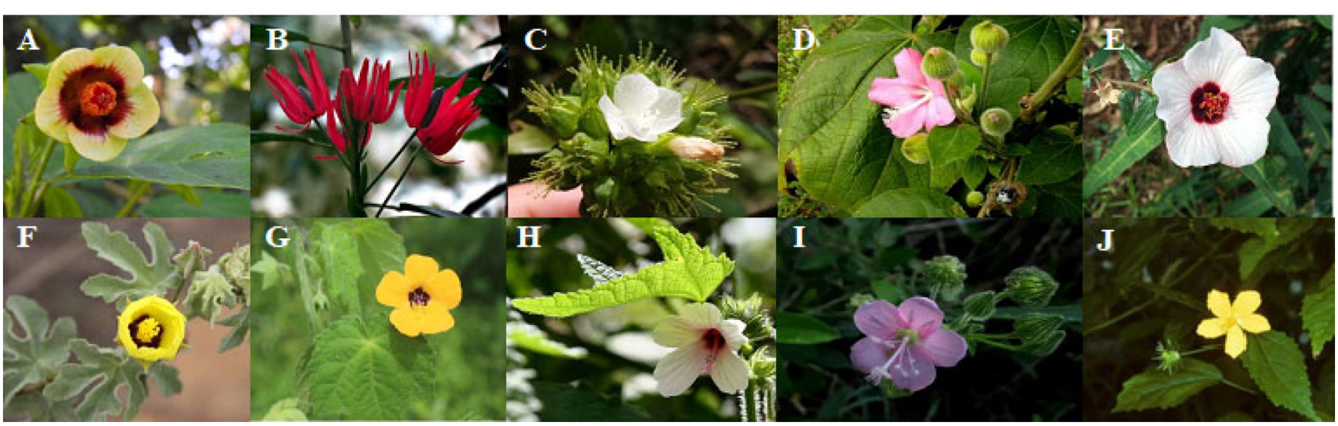


Figure 1. *Pavonia plants. A) P. alnifolia, B) P. multiflora, C) P. fruticosa, D) P. malacophylla, E) P. hastata, F) P. varians, G) P. procumbens, H) P. urens, I) P. odorata, J) P. spinifex*

Table 1. Species of *Pavonia* genus and their uses in folk medicine

Scientific name/ Popular name	**Used plant part**	**Traditional Use**	**Therapeutic Properties**	**References**
Pavonia cancellata/Malva-rasteira	LV	Poultice	Boils	31
Pavonia distinguenda	AP	*	Antitumor and antibacterial	32
Pavonia fruticosa/Anamu	WP	Decoction	Antipyretic and common cold	33
Pavonia lasiopetala/ Pavonia rosa	LV	*	Breaks and disintegrates kidney and urinary stones; Diuretic	34

Table 1. Species of *Pavonia* genus and their uses in folk medicine (cont.)

Pavonia odorata/ Sugandhibala	RH	*	Dysentery, anti-inflammatory, anti-hemorrhagic; Antipyretic, digestive and astringent	35,36
	RH and LV	*	Antipyretic, stomachic, dysentery and antiurolytic	37,38
	WP	*	Antipyretic, stomachic, dysentery; Rheumatism; Antiemetic; Anti-hemorrhagic; Demulcent, carminative, diaphoretic, diuretic, anti-inflammatory, spasmolytic and astringent	29,39-45
	ST and RT	*	Antipyretic	7
	ST	*	Bone fractures	46
	AP	*	Colds, diaphoretic, diuretic, demulcent; Antipyretic, anti-inflammatory and anti-hemorrhagic	47-49
	*	*	Antipyretic, stomachic, dysentery; Anti-hemorrhagic; Skin diseases, anti-inflammatory, spasmolytic; Nervous weakness	3,50-54
	LV	Leaf juice	Dysentery; Gonorrhea; Anti-halitosis	12-15
		Paste	Rheumatism; Foot infection, and antipyretic	16,17
	RT	*	Stomachache, anti-inflammatory, anti-hemorrhagic; Antipyretic, diuretic; Carminative, diaphoretic, polydipsia, burning when urinating, demulcent astringent, stomachic, haemorrhages from intestines; bleeding disorders, dysentery and antiulcerogenic; appetizer	4,29,52,55-58
		Paste	Athlete's foot	1,59
		Powder	Dislocations of bone joints; Osteoarthritis	21,22
		Decoction	Dysentery and carminative	60,61
Pavonia procumbens	*	*	Antiulcerogenic, fumigation, vermifuge, analgesic and skin infections	2,51,62-64
Pavonia schiedeana/ Cadillo	RT	Decoction	Retained placenta and prevention of miscarriage	65
	RT and WP	Poultice	Antipyretic	66
	LV	Infusion	Hypoglycemic; retained placenta and prevention of miscarriage	65,67
Pavonia senegalensis	LV	Aqueous extract	Bone and soft tissue infections	68,69
	RT	Inhalation and infusion	Diarrhea and induce labour	70,71
	SD	Powder	Contraceptive	18
Pavonia spinifex	FL	Infusion	Analgesic and skin problems	72,73
	LV and TW	Infusion	Stomach problems, gallstones and liver pain	
	LV	*	Hepatoprotection, antioxidant, anticancer, antifungal and antibacterial	74
Pavonia urens	AP	Inhalation and decoction	Antipyretic	75
	RT	*	Pneumonia and stomachic	76,77
		Decoction	Toothache	19,20
	LV	*	Boils	78
		Smoke	Repellent for mosquitoes and house flies	79-81
Pavonia varians/ Malva-peluda	*	*	Infections of the digestive system, and anti-inflammatory	82
Pavonia xanthogloea/ Erva-de-ovelha	*	*	Antimicrobial and antitumor	83,84
Pavonia zeylanica/ Citramutti	LV	*	Eczema; Eye diseases; Antipyretic, Anthelmintic, anti-inflammatory, analgesic, toothache; Dysentery, anti-hemorrhagic and emollient	43,85-91
		Decoction	Cough with phlegm	23
		Ground	Constipation in animals	92
		Paste	Bone fractures; Healing of acute and chronic wounds	24,25
	*	*	Skin diseases, anthelmintic, leprosy, scabies, ringworm, dermatitis, acne, wounds and antiulcerogenic; Blood circulation	3,93

Table 1. Species of *Pavonia* genus and their uses in folk medicine (cont.)

Scientific name/ Popular name	Medicinal Parts	Traditional Use	Therapeutic Properties	References
Pavonia zeylanica/ Citramutti	WP	Inhalation	Wound dressing	94
		*	Antipyretic and anthelmintic; Paralysis; Joint pain	4,95,96
		Infusion and leaf juice	Vermifuge and purgative	26-29
	RT	*	Demulcent, carminative, diaphoretic, diuretic, astringent, tonic, anti-hemorrhagic and anti-inflammatory; Antiulcerogenic	88,97
		Powder	Dislocations of bone joints; Osteoarthritis	21,22

* not reported in the literature. **AP**: Aerial Parts; **FL**: Flowers; **FR**: Fruits; **LV**: Leaves; **RH**: Rhizomes; **RT**: Roots; **SD**: Seeds; **ST**: Stems; **TW**: Twigs; **WP**: Whole Plant.

Table 2. Isolated compounds from *Pavonia* genus

Nº	Name	Source	Reference
	Fatty acids		
1	Malvalic acid	SD of *P.sepiu.* and *P.z.*	98-101
2	Sterculic acid		
3	Palmitic acid	SD of *P.z.*, RT and AP of *P.o.*	48,101-105
4	Stearic acid		
5	Oleic acid		
6	Linoleic acid		
7	Dihydrosterculic acid	SD of *P.z.*	101
8	(9Z,12*Z*,15*Z*)-9,12,15-Octadecatrienoic acid 2,3-*bis*(trimethylsilyloxy) propyl-ester	RT of *P.o.*	48,102-104,106
9	Isovaleric acid		
10	Caproic acid		
11	Dodecanoic acid	AP of *P.o.*	105
12	Methyl tetradecanoate		
13	Tetradecanoic acid		
14	Methyl-(2*E*,6*E*)-farnesate		
15	Pentadecanoic acid		
16	Methyl palmitate		
17	Methyl linoleate		
18	Methyl oleate		
	Terpenoids		
19	α-amirine	AP of *P.mal.*	107
20	β-amirine		
21	Lupeol	AP of *P.mal.* and *P.d.*	31,108
22	Blumenol C	LV of *P.mul.*	109
23	Vomifoliol		
24	4,5-dihydroblumenol A		
25	3-oxo-α-ionol		
26	Loliolide		
27	Taraxerol *p*-methoxybenzoate		
28	Cycloart-23*Z*-en-3β, 25-diol	AP of *P.g.*	110
29	Cycloart-25*Z*-en-3β, 24-diol		
30	Taraxerol	AP of *P.d.*	31
31	Germanicol		
32	Cedran-diol,8S,13	RT of *P.o.*	48,102-104,106
33	Cedrol		
34	S-guaiazulene		
35	Pinocarveol		
36	α-terpinene		
37	Pavonenol*		
38	β-pinene		
39	*p*-cymene		
40	1,8-cineole	AP of *P.o.*	105
41	(*Z*)-linalooloxide		
42	(*E*)-linalooloxide		
43	Linalool		
44	(*E*)-pinocarveol		
45	Borneol		
46	Menthol		
47	Terpinen-4-ol		
48	*p*-cymen-8-ol		
49	α-terpineol		
50	Carvone		
51	Geraniol		
52	Thymol		
53	Eugenol		
54	β-damascenone		
55	β-caryophyllene		
56	β-eudesmol		
57	Muurolane		
58	Farnesyl acetone		
59	Phytol		
60	β-caryophyllene oxide		
61	Guaiol		
62	γ-eudesmol		
63	α-eudesmol	RT and AP of *P.o.*	48,102-105
64	α-pinene		
	Steroids		
65	Sitosterol-3-*O*-β-D-glucopyranoside	AP of *P.c.*, *P.mal.* and *P.g.*	107,110-112
66	Stigmasterol-3-*O*-β-D-glucopyranoside		

Table 2. Isolated compounds from *Pavonia* genus (cont.)

Nº	Name	Source	Reference
67	β-sitosterol	AP of *P.c.*, *P.mal.* and *P.d.*; RT of *P.o.*	31,106, 107,111, 112
68	Stigmasterol	AP of *P.c.*	111,112
69	Ethyl iso-allocholate	RT of *P.o.*	106
	Flavonoids		
70	Kaempferol 3-*O*-(6''-*O*-*p*-coumaroyl glucoside (Tiliroside)	AP of *P.c.*, *P.x.*, *P.mal.*, *P.v.*, *P.g.*, *P.d.*	11,31,83, 107, 111-114
71	3,7-di-*O*-methylkaempferol	AP of *P.c.*	111,112
72	Quercetin	FL of *P.h.* and *P.l.*; AP of *P.x.*, *P.mal.*, *P.g.*	11,83, 107,115
73	2-(3,4-dihydroxyphenyl) chromane-3,5,7-triol (Cyanidin)		
74	Rutin	AP of *P.a.* and *P.x.*	83,116
75	Quercitrin	AP of *P.x.*	83
76	Kaempferol	AP of *P.mal.*, *P.g.*	11,107
77	5,8-dihydroxy-7,4'-dimethoxyflavone	AP of *P.mal.*	108
78	5,7-dihydroxy-4′-methoxyflavone (Acacetin)	AP of *P.g.*	11,110, 117
79	5,7-dihydroxy-3,8,4'-trimethoxyflavone		
80	5-hydroxy-3,7,8,4'-tetramethoxyflavone		
81	5,7,4'-trihydroxy-3,8-dimethoxyflavone		
82	5,7,4'-trihydroxy-3-methoxyflavone		
83	Kaempferol-3-glucoside (Astragalin)	AP of *P.d.*	31
84	Dihydrokaempferol (Aromadendrin)	RT of *P.o.*	48,102-104
85	Aromadendrene		
	Compounds Phenolics		
86	Gossypol	SD of *P.sch.*	118
87	Gallic acid	AP of *P.x.*	83
88	Catechin		
89	Chlorogenic acid		
90	Caffeic acid	AP of *P.x.*; LV of *P.sepio.*	83,119
91	Vanillic acid	LV of *P.mul.* and *P.sepio.*	109,119
92	Ferulic acid		
93	*p*-Hydroxybenzoic acid		
94	*p*-coumaric acid	LV of *P.mul.*	109
95	Salicylic acid	LV of *P.sepio.*	119
96	Cinnamic acid		
97	*p*-Hydroxyphenylacetic acid		
98	Gentisic acid		
99	4-[(1*E*)-prop-1-en-1-yl] benzoic acid		

Nº	Name	Source	Reference
100	2-[(1*E*)-prop-1-en-1-yl] benzoic acid	LV of *P.sepio.*	119
101	3-[(1*E*)-prop-1-en-1-yl] benzoic acid		
102	Syringic acid		
103	Protocatechuic acid		
	Other compounds		
104	17^3-ethoxy-phaeophorbide *a*	AP of *P.mal.*	107,108
105	Phaeophytin *b*		
106	13^2-*S*-hydroxy-phaeophytin *a*	AP of *P.g.* and *P.mal.*	110
107	13^2-*S*-hydroxy-17^3-ethoxy-phaeophorbide *a*		
108	Triacontanol		
109	*cis*-*p*-coumaric acid ethyl ester		
110	Pavophylline	ST of *P.z.*	26,120
111	Methyl-19-ketotetracosanoate		
112	12-Methyl-tetracosan-9-one	FL of *P.z.*	121
113	Phenyl-alcohol	RT of *P.o.*	48,102-104,106
114	Benzoic acid-2-hydroxy-ethyl-ester		
115	5aH-3a,12-methano-1H-cyclopropa [5',6'] cyclodeca[1',2',1,5] cyclopenta [1,2-d] [1,3] dioxal-13-one		
116	2,7-diphenyl-1,6 dioxopyridazino[4,5,2',3'] pyrrolo[4',5'-d]pyridazine		
117	Bicyclo [4, 3, 0] nonan-7-one,1-(2-methoxyvinyl)		
118	1,5-*bis* (3-cyclopentyl-propoxy)-1, 13,3,5,5-hexa-methyltrisiloxane		
119	Pavonene*		
120	Isovaleraldehyde		
121	Azulene		
122	Hexahydrofarnesyl-acetone	RT and AP of *P.o.*	48,102-105
123	6-methyl-5-hepten-2-one		
124	Isopentyl alcohol	AP of *P.o.*	105
125	Pentanol		
126	Hexanol		
127	Benzyl alcohol		
128	Phenylethyl alcohol		
129	2-methoxy-*p*-cresol		
130	2-methoxy-4-vinylphenol		
131	2,4-*bis*(1,1-dimethyethyl)-phenol		
132	Acetophenone		
133	2-nonanone		
134	Isophorone		
135	4-keto-isophorone		
136	*p*-menth-4-en-3-one		

Table 2. Isolated compounds from *Pavonia* genus (cont.)

Nº	Name	Source	Reference
137	Dihydro-5-pentyl-2-(3H)-furanone		
138	Hexahydropseudoionone		
139	α-ionone		
140	Dihydro-β-ionone		
141	Dihydropseudoionone		
142	β-ionone		
143	4,8,12-trimethyltridecan-4-olide		
144	Phthalic acid		
145	2-pentyl-furan	AP of *P.o.*	105
146	3-butyl-pyridine		
147	*p*-allyl-anisole		
148	3-phenylpyridine		
149	Dihydroactinolide		
150	Ageratochromene		
151	Hexadecanolactone		
152	Hexanal		
153	Benzaldehyde		
154	Phenylacetaldehyde		
155	(2*E*)-nonen-1-al		
156	1,3,4-trimethyl-3-cyclohexene-1-carboxyaldehyde		
157	2-methyl-3-phenyl-propanal		
158	2-hydroxy-4-methoxy-benzaldehyde		
159	Pentadecanal		
160	*p*-ethoxy-ethyl-benzoate		
161	Isobutyl-phthalate		
162	Naphthalene	AP of *P.o.*	105
163	Dodecane		
164	2-methyl-naphthalene		
165	Tetradecane		
166	2,3,6-trimethyl-naphthalene		
167	3-(2-methyl-propenyl)-1H-indene		
168	γ-cadinene		
169	Hexadecane		

P.a.: *P. alnifolia*; ***P.c.***: *P.cancellata*; ***P.d.***: *P.distinguenda*; ***P.g.***: *P.glazioviana*; ***P.h.***: *P.hastata*; ***P.l.***: *P.lasiopetala*; ***P.mal.***: *P.malacophylla.*; ***P.mul.***: *P.multiflora*; ***P.o.***: *P.odorata*; ***P.sch.***: *P.schiedeana*; ***P.sepio.***: *P.sepioides*; ***P.sepiu.***: *P.sepium*; ***P.v.***: *P.varians*; ***P.x.***: *P.xanthogloea*; ***P.z.***: *P.zeylanica*. **AP**: Aerial Parts; **FL**: Flowers; **LV**: Leaves; **SD**: Seeds; **ST**: Stems; **RT**: Roots. *chemical structures not reported in the literature.

Studies described in literature review that activities of those compounds depend on the level of unsaturation and the size of hydrocarbons chain, resulting antibacterial, antifungal and antimycobacterial activities.[123,124] A recent study has shown that *P. malacophylla* and *P. cancellata* have palmitic, oleic and linoleic acids as majoritarian fatty acids.[125]

Eighteen fatty acids have been isolated and identified in species *P. sepium*, *P. odorata* and *P. zeylanica* (Table 2). Palmitic (**3**) and caproic (**10**) fatty acids showed significant activities in preparatory *in silico* studies as having inhibitory properties for the activities of glycerol-kinase enzyme from the fungus *Epidermophyton floccosum*[104] and inhibitory properties for the alcohol-dehydrogenase enzyme from the protozoan *Entamoeba histolytica*.[53]

Terpenoids and steroids

Terpenoids can be find in several groups of organisms. In plants, they are present under distinct aspects such as volatile molecules or adhered to resins. Their oxygenated, hydrogenated and dehydrogenated derivates have hydrocarbons as a base-structure, being widely distributed among plant species.[126]

Forty-six terpenoids have been isolated and identified in *P. odorata*, *P. multiflora*, *P. malacophylla*, *P. glazioviana* and *P. distinguenda*, being the last one of the most common of *Pavonia* species. Terpenoids α-amirine (**19**) and β-amirine (**20**) showed *in vitro* antibacterial activities against *Escherichia coli*.[107] The terpenoid cicloart-23Z-en-3β-25-diol (**28**) also presented *in vitro* antimicrobial activities against *Escherichia coli*, *Pseudomonas aeruginosa*, *Candida tropicalis*, *Candida parapsilopsis* e *Aspergillus fumigatus*.[110]

Compounds loliolide (**26**) and the taraxerol *p*-metoxybenzoate (**27**) have demonstrated significant *in vitro* activities on the inhibition of electrons flux in photosystem II of plants, therefore allowing those molecules to become future candidates to herbicides as they prevent photosynthesis.[127]

Steroids are a minority class in *Pavonia* genus, with only five isolated compounds (**65-69**). Phytosteroids share as common structure ciclopentanoperidrofenaterne as carbonic skeleton, being β-sitosterol and stigmasterol the most common steroids of this genus and commonly encountered attached to sugar monomers.[128]

Flavonoids and phenolic compounds

Flavonoids are the most important and diversified class of phenolic compounds among natural products, being relatively abundant secondary metabolites and responsible for several functions in plants' organisms.[129]

Seventeen flavonoids have been isolated from *Pavonia* species, being sixteen of those members of subclass flavone (**70-84**) and one, to flavanonol subclass (**85**). Many isolated flavonoids have glycosids attached to their structures.

Among the isolated compounds, flavonoid 5,7-dihydroxy-3,8,4'-trimethoxyflavone (**79**) has demonstrated *in vitro* antimicrobial, *in silico* anticancer, *in vitro* antineoplasic, *in vitro* antiprotozoal and *in vito* photoprotective activities.[130,131]

The compound tiliroside (**70**) has demonstrated *in vitro* and *in vivo* antihypertensive activities, leading to reduction of peripheric vascular and vasorelaxant resistances by blocking the Calcium channels dependent of voltage (Ca_V) in cells of vascular smooth muscle (VSMCs);[132] *in vitro* antimicrobial activity;[31,107] *in silico* antidiabetic activity through interaction with human pancreatic α-amylase enzyme;[114] *in vitro* anticancer and anticolinesterasic activities.[31]

Nineteen phenolic compounds (**87-105**) have been identified and isolated from the species *P. xanthogloea*, *P. sepioides*, *P. multiflora* and *P. schiedeana*. Studies demonstrated that those compounds presented different activities. Gross ethanolic extract and fractions of ethyl acetated from extractive process of *P. sepioides* leaves have shown a large quantity of phenolic compounds present on the samples, which

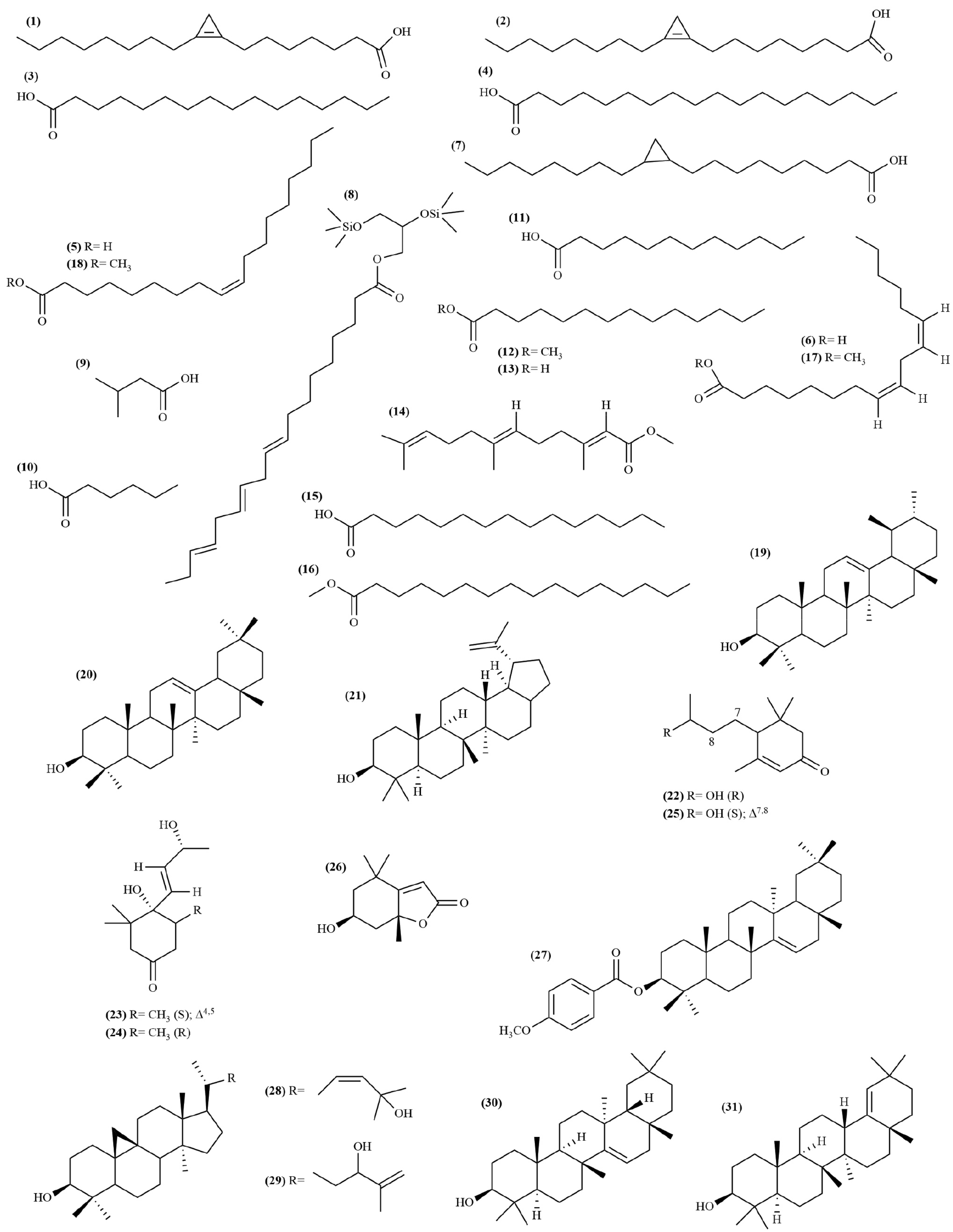


Figure 2. *Compounds isolated from Pavonia species*

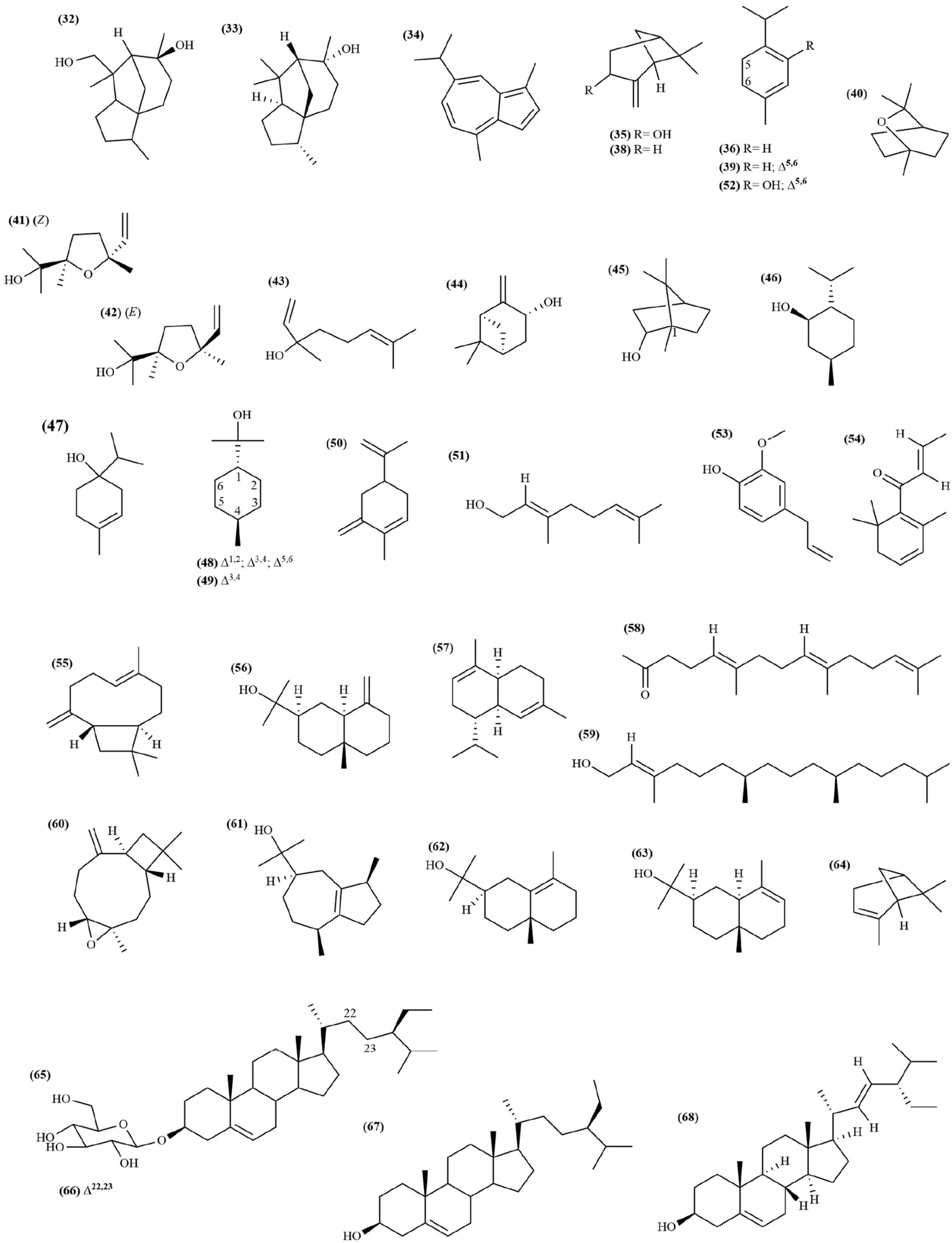
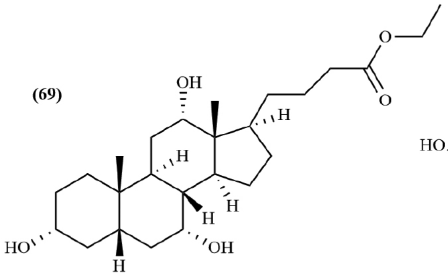
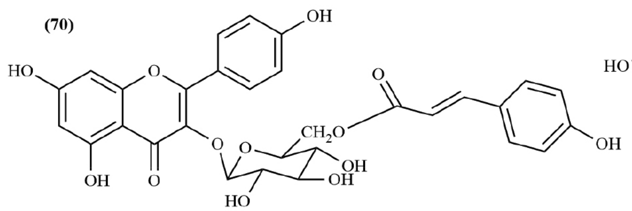


Figure 2. *Compounds isolated from Pavonia species (cont.)*

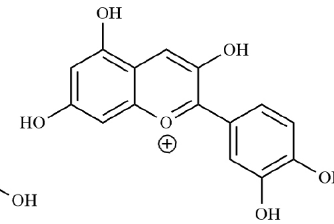
(69)

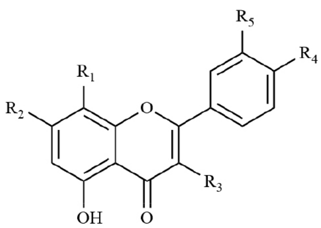


(70)



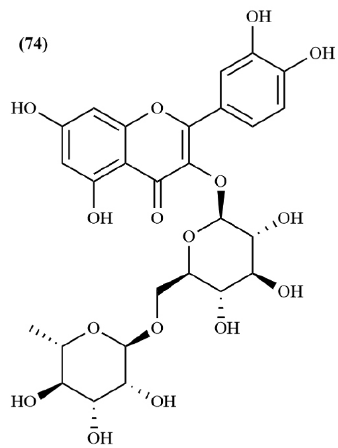
(73)



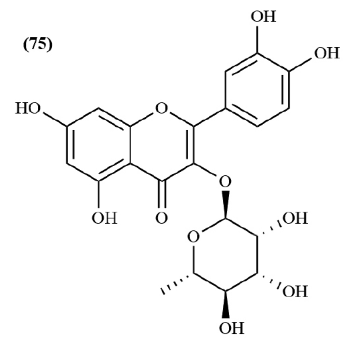


(71) R_1=R_5= H; R_2=R_3= OCH_3; R_4= OH
(72) R_1= H; R_2=R_3=R_4=R_5= OH
(76) R_1=R_5= H; R_2=R_3=R_4= OH
(77) R_1= OH; R_2=R_4= OCH_3; R_3=R_5= H
(78) R_1=R_3=R_5= H; R_2= OH; R_4= OCH_3
(79) R_1=R_3=R_4= OCH_3; R_2= OH; R_5= H
(80) R_1=R_2=R_3=R_4= OCH_3; R_5= H
(81) R_1=R_3= OCH_3; R_2=R_4= OH; R_5= H
(82) R_1=R_5= H; R_2=R_4= OH; R_3= OCH_3

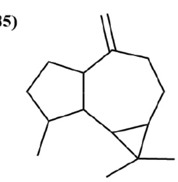
(74)



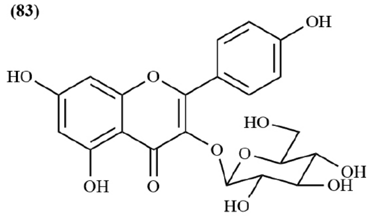
(75)



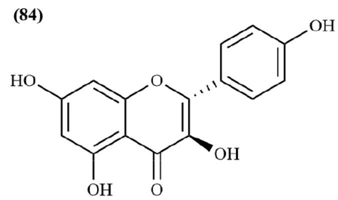
(85)



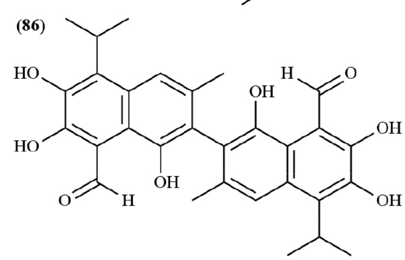
(83)

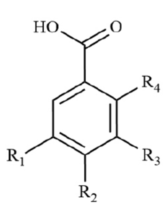


(84)



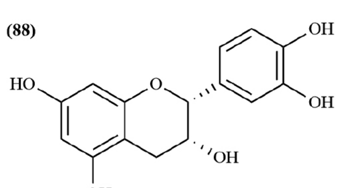
(86)



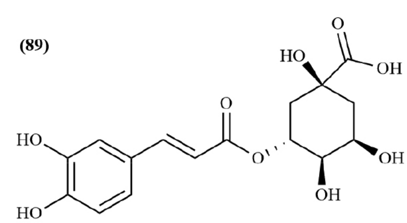


(87) R_1=R_2=R_3= OH; R_4= H
(91) R_1=R_4= H; R_2= OH; R_3=OCH_3
(93) R_1=R_3=R_4= H; R_2= OH
(95) R_1=R_2=R_3= H; R_4= OH
(98) R_1=R_4= OH; R_2=R_3= H
(102) R_1=R_3= OCH_3; R_2= OH; R_4= H
(103) R_1=R_2= OH; R_3=R_4= H

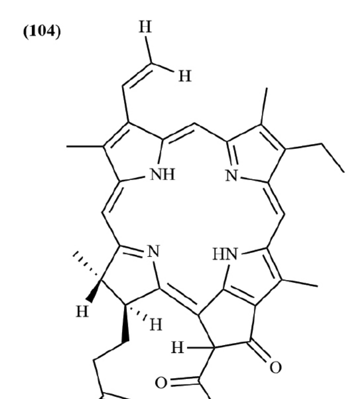
(88)

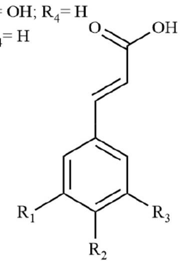


(89)



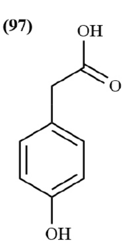
(104)

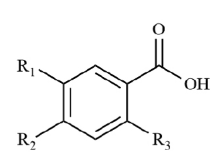




(90) R_1=R_2= OH; R_3= H
(92) R_1= H; R_2= OH; R_3= OCH_3
(94) R_1=R_3= H; R_2= OH
(96) R_1=R_2=R_3= H

(97)

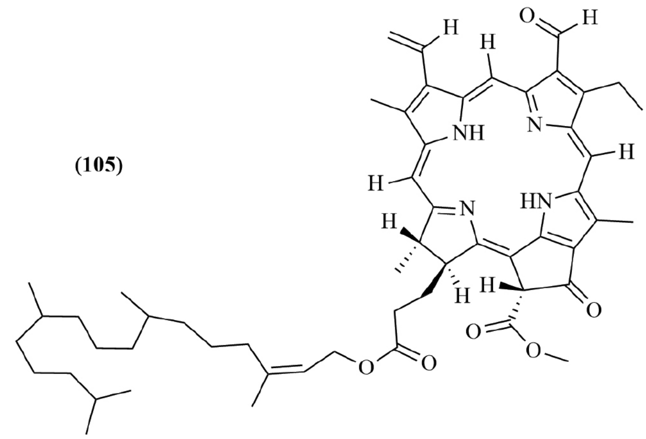


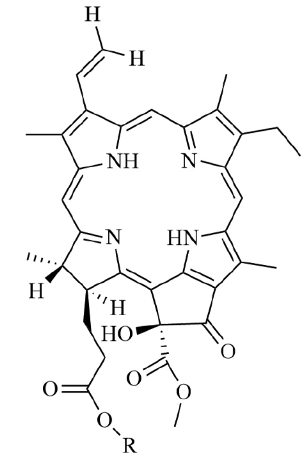


(99) R_1=R_3= H; R_2= $CH_2CH_2CH_3$
(100) R_1=R_2= H; R_3= $CH_2CH_2CH_3$
(101) R_1= $CH_2CH_2CH_3$; R_2=R_3= H

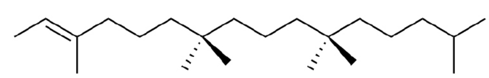
***Figure 2.** Compounds isolated from Pavonia species (cont.)*

(105)



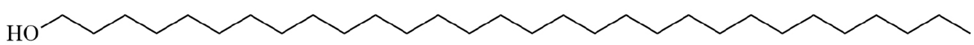


(106) R=

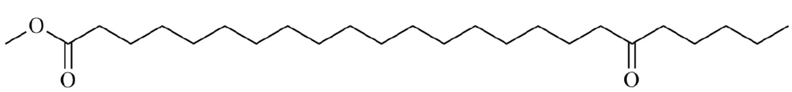


(107) R= CH_2CH_3

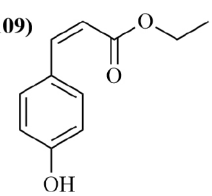
(108)



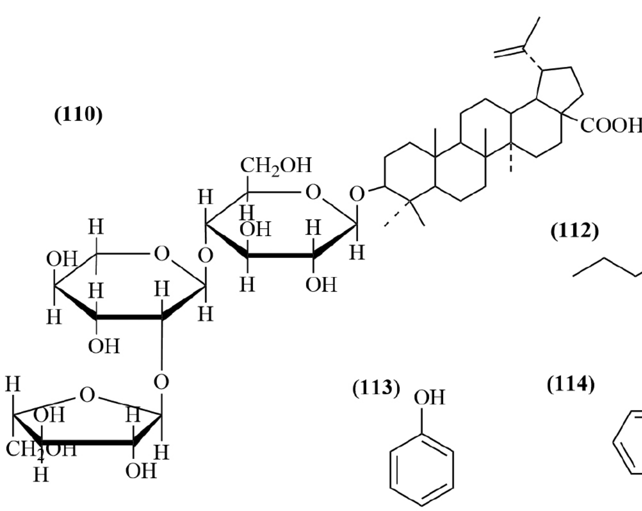
(111)



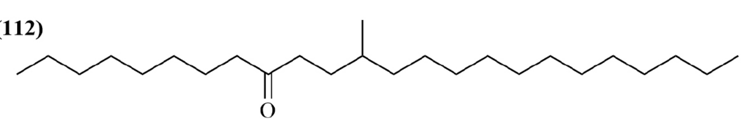
(109)



(110)

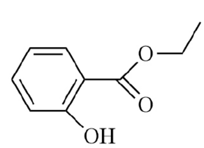


(112)

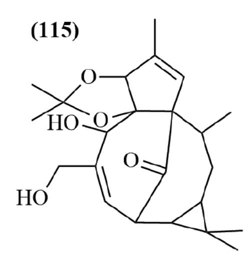


(113)

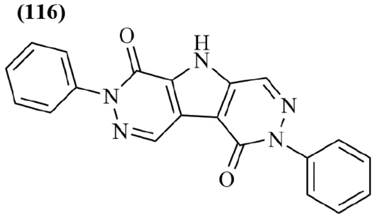
(114)



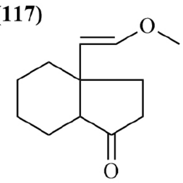
(115)



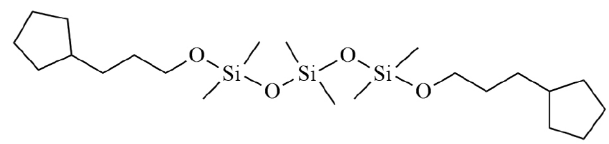
(116)



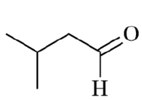
(117)



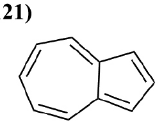
(118)



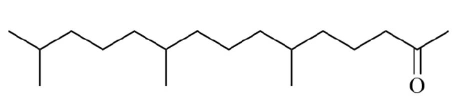
(120)



(121)



(122)



(123)

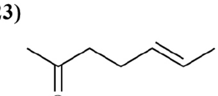


***Figure 2.** Compounds isolated from Pavonia species (cont.)*

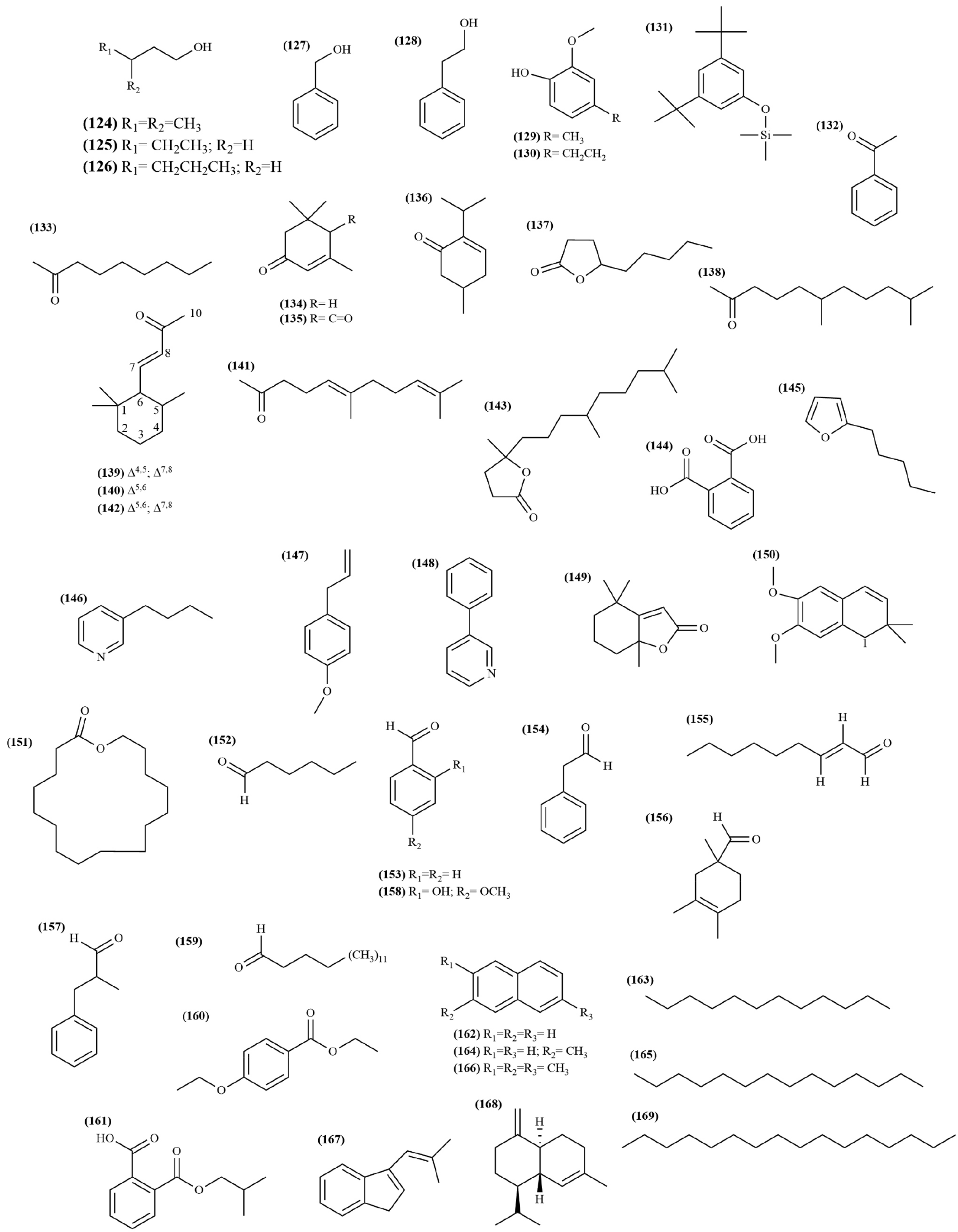


Figure 2. *Compounds isolated from Pavonia species (cont.)*

explains the antioxidant activity of those substances against free radicals inhibitions tests through the methods of DPPH and ABTS.[119]

Besides that species, other studies have shown a large potential of antioxidant activity as a primordial activity of those phenolic compounds such as described for *P. xanthogloea*, *P. zeylanica*, *P. odorata*, *P. distinguenda*, *P. varians*, *P. glazioviana* and *P. procumbens*.[31,44,82,83,90,105,117,133-135]

Other compounds

Differently from previously mentioned compounds, other classes of secondary metabolites have been isolated and identified in a lesser frequency on *Pavonia* species. Among those compounds, we can list alcohols, aldehydes, ketones, pheophytins and hydrocarbons (**106**-**171**) (Table 2, Figure 2).

Chaves[107] has conducted a phytochemical study of *P. malacophylla*, isolating and identifying the compound 17^3-ethoxy-phaeophorbide A (**104**), which has presented *in vitro* antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*.

Pharmacological study

Several pharmacological activities involving *Pavonia* species have been arousing interest of scientific community hence there is a large collection of reports of their use in folk medicine. Researches have been developed to confirm the anti-inflammatory, analgesic, antioxidant, cytotoxic, antitumoral, antidiabetic, antimicrobial and antiviral potential of *Pavonia* species through scientific analysis (Table 3).

Anti-inflammatory and analgesic activities

Plants constitute a vast and precious source of natural products, which are essential to human health as they play several biological roles such as anti-inflammatory and analgesic activities, as it has been demonstrated by some studies over extracts and isolated compounds.[106]

Alcoholic extract of *P. zeylanica* leaves has shown *in vivo* anti-inflammatory activity in rat foot edema induced by carrageenan and

Table 3. *In vitro*, *in vivo*, and *in silico* biological studies reported from *Pavonia* genus

Species	Material used	Experimental model	Reference
		Anti-inflammatory and Analgesic Activity	
P.z.	Leaves alcoholic extract	*In vitro* - anti-inflammatory and antinociceptive by inhibition the arachidonic acid pathway	88
P.z.	Leaves and stems aqueous extract	*In vitro* - anti-inflammatory and analgesic	136
P.z.	Leaves ethanolic extract	*In vitro* – anti-inflammatory activity by inhibition protein denaturation	90
P.o.	Roots extract	Anti-inflammatory activity	137
P.o.	Roots methanolic, chloroform and ethyl acetate extract	*In vitro* - anti-inflammatory	106
		Antioxidant Activity	
P.x.	Aerial parts hexane fractions, dichloro-methane, ethyl acetate, n-butanol, and water ethanolic extract	*In vitro* – inhibition of DPPH, H_2O_2 and sodium nitroprusside radicals (SNP)	83
P.v.	Aerial parts hydroalcoholic extract	*In vitro* - stabilization of radicals free DPPH	82
P.gla.	Aerial parts ethanolic extract	*In vitro* – inhibition of DPPH radicals	117,134
P.pro.	Leaves methanolic extract	*In vitro* – inhibition of ABTS radicals	135
P.d.	Aerial parts methanolic extract and hexane fraction	*In vitro* - inhibition of DPPH radicals	31
P.sep.	Leaves ethanolic extract, hexane fraction, dichloromethane fraction, ethyl acetate fraction and aqueous fraction	*In vitro* – inhibition of DPPH and ABTS radicals	119
P.z.	Leaves ethanolic extract	*In vitro* – inhibition of radicals free	90
P.o.	Whole plant methanolic extract, hydroalco-holic fractions and ethyl acetate	*In vivo* – inhibition of lipoperoxidation	44
P.o.	Aerial parts essencial oils	*In vitro* – inhibition of ORAC radicals	105
P.o.	Leaves aqueous extract	*In vitro* – inhibition of FRAP, NO radicals and reduction of phosphomolybdenum	133
		Antitumor and Cytotoxic Activity	
P.gla.	5,7-dihydroxy-3,8,4'-trimethoxy flavone	*In silico* - uterine and ovarian anticancer; *In vitro* - antineoplastic activity against sar-coma, carcinoma, melanoma and squamous cells	130,131
P.d.	Methanolic extract Hexane fraction Dichloromethane fraction Tiliroside	*In vitro* – anticancer activity against leukemia, ovary, colon, prostate, kidney, breast, resistant breast, lung and melanoma; cytotoxic for *Artemia salina* larvae	31
P.o.	Whole plant methanolic extract, hydroalco-holic and ethyl acetate fractions	*In vitro* – Erlich's ascites carcinoma (EAC) and cytotoxic	44
P.o.	Whole plant methanolic extract	*In vitro* – lung and human breast cancers	138
		Antidiabetic Activity	
P.v.	Tiliroside	*In silico* – interaction by the human pancreatic α-amylase enzyme	114

Table 3. *In vitro*, *in vivo*, and *in silico* biological studies reported from *Pavonia* genus (cont.)

Species	Material used	Experimental model	Reference
P.z.	Leaves aqueous extract Leaves and stems aqueous extract	*In vitro* – reduced blood sugar levels	86,136
P.o.	Roots extract	*In vitro* – reduced blood sugar levels	139
		Antimicrobial and Antiviral Activity	
P.mal.	Mixture of α-amirine and β-amirine 17^3-ethoxy-pheoforbide A Tiliroside Acetate Fraction Hexane:Acetate (9:1) fraction Hexane:Acetate (1:1) fraction Acetate:Methanol (9:1) fraction Acetate:Methanol (1:1) fraction Aerial parts Crude Ethanolic Extract	*In vitro – Staphylococcus aureus, Escherichia coli* and *Candida albicans*	107
P.gla.	5,7-dihydroxy-3,8,4'-trimethoxy flavone Cicloart-23Z-en-3β, 25-diol	*In vitro – Escherichia coli*, *Pseudomonas aeruginosa*, *Candida tropicalis*, *Candida parapsilopsis*, *Aspergillus flavus* and *Aspergillus fumigatus*	131
P.pro.	Leaves methanolic extract	*In vitro – Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli, Klebsiella pneumoniae* and *Proteus mirabilis*	63
P.u.	Roots methanolic extract	*In vitro – Candida albicans*, *Aspergillus fumigatus*, *Fusarium culmorum*, *Staphylococcus aureus*, *Pseudomonas syringae* and *Erwinia amylovora*.	76,77
P.spi.	Whole plant ethanolic extract	*In vitro – Staphylococcus aureus* and *Klebsiella pneumoniae*	140
P.d.	Aerial parts methanolic extract, hexane, dichloromethane, ethyl acetate and n-butanolic fractions Tiliroside	*In vitro – Staphylococcus aureus, Staphylococcus epidermidis, Bacillus subtillis, Klebsiela pneumoniae, Pseudomonas aeruginosa, Escherichia coli* and *Salmonella setubal*	31
P.z.	Leaves dichloromethane extract	*In vitro – Escherichia coli* and *Klebsiella aerogenes*	85
	Leaves ethyl acetate extract	*In vitro – Escherichia coli*	
	Leaves diethyl ether extract	*In vitro – Staphylococcus aureus*	
	Leaves methanolic extract	*In vitro – Bacillus subtilis*, *Escherichia coli* and *Klebsiella aerogenes*	
P.o.	Rhizomes essential oil	*In vitro – Staphylococcus aureus, Bacillus subtilis, Bacillus mycoides, Diplococcus pneumonia,Salmonella typhi H, Salmonella paratyphi A., Shigella flexneri, Vibrio cholerae Ogawa,Escherichia coli, Klebsiella sp.*; *Helminthosporium sp., Fusarium solani, Aspergillus flavus, Aspergillus niger, Aspergillus nidulans, Aspergillus fumigatus, Botrydiplodia sp., Alternaria sp., Rhizophus nodosus, Colletotrichum capsici, Trichophyton mentagrophytes, Chrysosporium indicum* and *Rhizoctonia sp.*	35,141-143
P.o.	Roots methanolic, chloroform and ethyl acetate extracts	*In vitro – Staphylococcus aureus* and *Candida albicans*	106
P.o.	Caproic and palmitic acids	*In silico* – inhibition of the activity of the glycerol kinase enzyme of *Epidermophyton floccosum*	104
		Other Activities	
P.c.	Tiliroside	*In vitro* e *in vivo* – antihypertensive activity by reducing resistance peripheral vascular and vasorelaxing by blocking voltage-gated calcium channels (CaV) in vascular smooth muscle cells (VSMCs)	132
P.gle.	Leaves aqueous extract	*In vitro* – phytopesticidal activity against termites	144
P.l.	Leaves aqueous extract	*In vitro* - antiurolytic activity (inhibition of calcium oxalate nucleation by disintegrating into smaller particles with increasing fraction concentrations)	34
P.pra.	Leaves ethanolic extract	*In vitro* – inhibition of tyrosinase enzyme	145
P.sch.	Aerial parts methanolic extract	*In vitro* - Antiretroviral activity (reverse transcriptase inhibition)	146,147
P.sch.	Aqueous extract	Promoter of peripheral vascular blood flow; improves dryness and roughness of the skin and stimulates hair growth	148
P.sen.	Leaves aqueous ethanolic extracts	It does not present acute toxicity, however after 28 days the extract becomes nephrotoxic and slightly hepatotoxic	68
P.a.	Stems hydroethanolic extract	*In vivo* e *in vitro* - dose-dependent hypotensive and ACE inhibitor	116
P.a.	Stems ethanolic extract	*In vivo* - gastroprotective activity	149
P.mul.	Leaves ethanolic extract	*In vitro* - inhibitor of cathepsins K and V	109

Table 3. *In vitro*, *in vivo*, and *in silico* biological studies reported from *Pavonia* genus (cont.)

Species	Material used	Experimental model	Reference
P.mul.	Loliolide	*In vitro* - inhibition of electron flow in photosystem II	127
	Taraxerol *p*-methoxybenzoate		
P.gla.	5,7-dihydroxy-3,8,4'-trimethoxy flavone	*In vitro* – antiprotozoan (*Trichomonas vaginalis*) *In vitro* - photoprotective activity with a high level of protection (25.01 FPS)	130,131
P.d.	Tiliroside	*In vitro* - inhibition of acetylcholinesterase (AChE) activity	31
P.z.	Leaves methanolic extract	*In vitro* - larvicide against *Culex quinquefasciatus*	150
P.z.	Leaves methanolic, hexanic, chloroformic, ethyl acetate and acetonic	*In vitro* - larvicide against *Anopheles stephensi* and *Culex quinquefasciatus*	151
P.z.	Leaves and stems ethanolic extract	*In vitro* – laxative activity	136
P.z.	Leaves ethanolic extract	*In vitro* - inhibition of denaturation of albumin, stabilization of the erythrocyte membrane and protection against hemolysis	90
P.o.	Rhizomes essential oil	*In vitro* – anthelmintic against tapeworms and roundworms	35,141-143
P.o.	Rhizomes essential oil	*In vitro* - Hypotensive, antispasmogenic and intestinal relaxant	36
P.o.	Whole plant extract	Antirheumatic, antiasthmatic/antibronchial activities	137
P.o.	Roots aqueous and alcoholic extracts	*In vitro* – anthelmintic against *Pheretima postuma*	152
P.o.	Leaves methanolic extract	*In vitro* – larvicidal and repellent activity against *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus*	153
P.o.	Caproic, palmitic acids and hexahydro-pharnesyl-acetone	*In silico* – inhibition of the activity of the enzyme alcohol dehydrogenase of *Entamoeba histolytica*	53
P.o.	Whole plant aqueous extract	*In vitro* – inhibits the formation of minerals in urine samples	154
P.o.	Whole plant aqueous extract	*In vitro* – controls human urinary calculogenesis	155
P.o.	Whole plant extract	Antiparasitic activity against *Entamoeba histolytica*	29

P.a.: *P. alnifolia*; ***P.c.***: *P.cancellata*; ***P.d.***: *P.distinguenda*; ***P.gla.***: *P.glazioviana*; ***P.gle.***: *P.glechomifolia* ***P.l.***: *P.lasiopetala*; ***P.mal.***: *P.malacophylla*; ***P.mul.***: *P. multiflora*; ***P.o.***: *P.odorata*; ***P.pra.***: *P.praemorsa*; ***P.pro.***: *P.procumbens*; ***P.sch.***: *P.schiedeana*; ***P.sen.***: *P.senegalensis*; ***P.sep.***: *P.sepioides*; ***P.spi.***: *P.spinifex*; ***P.u.***: *P.urens*; ***P.v.***: *P.varians*; ***P.x.***: *P.xanthogloea*; ***P.z.***: *P.zeylanica*.

in vivo antinociceptive activity by inhibition of arachidonic acid formation.[88] Methanolic, chloroformic and ethyl acetate extracts of *P. odorata* roots have also demonstrated *in vivo* anti-inflammatory activity in albino rat foot edema induced by carrageenan.[106] (Table 3).

Antioxidant activity

Antioxidants are substances that control the action of free radicals, minimizing the risk of diseases, specially those related to oxidative damage on nervous system. Naturally, some enzymes are responsible for the protection of harmful effects of free radicals, such as catalasis and dismutasis superoxide, as well as natural products with antioxidant action such as ascorbic acid, tocopherol, phenolics and flavonoids.[133]

The evaluation of antioxidant activity of extracts from the aerial parts of *Pavonia* species has shown the presence of phenolics and flavonoids as its constituents, having those compounds demonstrated a huge antioxidant potential in tests through the methods DPPH (1,1-diphenil-2-picril-hidrazil), H_2O_2 (hydrogen peroxide), NO (nitric oxide), ABTS (2,2'-azino-*bis*(3-etilbenzotiazoline-6-sulphonic) acid), FRAP (Ferric Reduction Antioxidant Power), SNP (Sodium Nitroprussiate radicals), phosphomolybdenium reduction, ORAC (Oxygen Radical Absorbance Capacity) and TBARS (Thiobarbituric Acid Reactive Substances) (Table 3).

Cytotoxic and anticancer activities

Cancer is one of the most lethal diseases that affects humankind. Some phytochemical studies have demonstrated anticancer potentials in several plants due to their chemoprotective and antioxidant properties, which make plants an option to minimize the adverse effects of conventional cancer treatments.[156]

Extracts and isolated compounds from *P. glazioviana*, *P. distinguenda* and *P. odorata* have demonstrated anticancer activities. The tiliroside flavonoid isolated from *P. distinguenda* has shown *in vitro* anticancer activity against leukemic, ovarian, colon, prostate, kidney, breast, resistant breast and melanoma cells, besides being cytotoxic to *Artemia salina* larvae.[31]

Other flavonoid isolated from *P. glazioviana* (5,7-dihydroxy-3,8,4'-trimethoxyflavone) (**79**) has shown *in silico* anticancer activity against carcinogen uterine and ovarian cells, while having *in vitro* antineoplastic activity against sarcoma, carcinoma, melanoma and squamous cell carcinoma.[130,131]

Extracts from the whole plant of *P. odorata* has shown *in vitro* anticancer activity against Ehrlich Ascites Carcinoma (EAC), lung and breast cancer.[44,138]

Antidiabetics activity

Several plants are used by folk medicine worldwide against diabetes.[86] Some of the species quoted in literature are *P. zeylanica* and *P. odorata.* Extracts from their leaves, stems and roots have been evaluated regarding their *in vitro* antidiabetic activity, being constated a significant reduction of glycose levels in bloodstream.[86,136,139]

In silico hypoglycemic activity of the tiliroside flavonoid isolated from *P. varians* through the interaction of this compound with human pancreatic α-amylase enzyme presented a lesser linking energy of -9.4 kcal/mol, being more stable in its active site when compared to the standard drug acarbose, that presented an energy of -7.6 kcal/mol.[114]

Antimicrobial activity

Bacterial resistance has been increasing significatively in the last years, which leads to high mortalities caused by generalized infections. This fact is a consequence of ungovernable use of antibiotics. For those reasons, the search for new natural compounds with antimicrobial activity and new action mechanisms if necessary for the control of such micro-organisms.[140]

Extracts, fractions and compounds isolated from *Pavonia* species have shown a great antimicrobial potential that has already been described in literature. Among the compounds that were tested against several fungal and bacterial lineages, we have α-amirine (**19**), β-amirine (**20**), 17^3-ethoxy-phaeophorbide A (**104**)[107] isolated from *P. malacophylla*, cycloart-23*Z*-en-3β,25-diol (**28**), 5,7-dihydroxy-3,8,4'-trimethoxyflavone (**79**)[110] isolated from *P. glazioviana*, tiliroside (**70**)[31,107] isolated from *P. malacophylla* e *P. distinguenda* and caproic (**10**) and palmitic (**3**)[104] acids identified in *P. odorata* (Table 3).

Other activities

Other activities have been related for *Pavonia* species. Methanolic extract from *P. odorata* leaves has shown *in vitro* larvicide and repellent activities against *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus*.[153] Researches have shown anti-hypertensive,[36,116,132] anti-helminthic,[35,141-143,152] anti-urolithic,[34] gastroprotective,[149] laxative,[136] photoprotective,[131] antiretroviral[146,147] and several other kinds of activities.

Furthermore, a study on *P. senegalensis* has showed that fresh liquid ethanolic extract of leaves has not a very strong toxicity, becoming nephrotoxic and slightly hepatotoxic after 28 days.[68]

CONCLUSIONS

Pavonia Cav. is one of the largest genus on Malvaceae *sensu lato* family and has showed different biologic activities amongst its species, which have already been mentioned in literature and scientific proved. Studies have shown that fatty acids, terpenoids, flavonoids and phenolics are the most common classes of secondary metabolites on this genus. Pharmacological *in vivo*, *in vitro* and *in silico* tests have given the researches promissory results due to the presence of those compounds, both isolated and present on the extracts, corroborating the reports of use of those herbs in folk medicine.

Nonetheless, there is a major need of keep exploring chemical and biological potentials of *Pavonia* species, both already and never studied, since medicinal plants are almost inexhaustible sources of bioactive molecules that can help the treatment and cure of several diseases that affect human populations worldwide.

This paper is a database with very relevant information from both phytochemical and biological studies of *Pavonia* species that can be further explored, aiming to understand the use of *Pavonia* by traditional medicine in various diseases, becoming alternatives for therapies by the use of these natural products with emphasis on the benefit of the world population.

ACKNOWLEDGMENTS

We thank Coordenação de Aperfeiçoamento do Ensino Superior (CAPES) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for all the support to our researches.

REFERENCES

1. Mohammed, F.; Shifa, S. P.; *J. Pharmacogn. Phytochem.* **2019**, *8*, 1887.
2. Vijayashalini, P.; Jayanthi, G.; Abirami, P.; *Journal of Medicinal Plants Studies* **2017**, *5*, 331.
3. Reddy, A. M.; Suresh Babu, M. V.; Rao, R. R.; *Herba Pol.*, **2019**; *65*, 40 [Crossref].
4. Sterlin Raj, T.; Edal Kuvin, J.; Asha, K. R. T.; Mohammed, A. A.; Puspharaj, A.; Raubbin, R. S.; *World J. Pharm. Sci.* **2016**, *4*, 518.
5. Vadivel, V.; Sriram, S.; Brindha, P.; *Int. J. Green Pharm.* **2016**, *10*, 33 [Crossref].
6. Fernandes, D. A.; Assis, E. B.; Souza, M. S. R.; Souza, P. I. V.; Souza, M. F. V.; *Quim. Nova* **2020***, 43*, 787 [Crossref].
7. Johnson, M.; Maharajan, M.; Janakiraman, N.; *Journal of Medicinal Herbs and Ethnomedicine* **2015**, *1*, 125 [Crossref].
8. Grings, M.; Boldrini, I. I.; *Revista Brasileira de Biociências* **2013**, *11*, 352.
9. http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB9118, acessada em abril 2022.
10. Esteves, G. L.; Krapovickas, A.; Boletim de Botânica da Universidade de São Paulo, **2009**, *27*, 63 [Crossref].
11. Mazzotti, M. R. R. M.; *Dissertação de Mestrado*, Universidade do Estado da Bahia, Brasil, 2015.
12. Pando, A. M. S. C.; *Dissertação de Mestrado*, Instituto de Botânica da Secretaria do Meio Ambiente, Brasil, 2009.
13. Behera, K. K.; Mandal, P.; Mahapatra, D.; *Ethnobotanical Leaflets* **2006**, *10*, 305.
14. Madhu, V.; Naik, D. S. R.; *Ethnobotanical Leaflets*, **2009**, *13*, 1337.
15. Mishra, R. K.; Patel, S. P.; Srivastava, A.; Vashistha, R. K.; Singh, A.; Puskar, A. K.; *Nature and Science* **2012**; *10*, 22.
16. Singh, P. S.; Kumar, P. P.; Srinivasulu, D.; *Nat. Oral Care Dent. Ther.* **2020**, 407 [Crossref].
17. Kingston, C.; Nisha, B. S.; Kiruba, S.; Jeeva, S.; *Ethnobotanical Leaflets* **2007**, *11*, 32.
18. Ranjithkumar, A.; Chittibabu, C. V.; Renu. G.; *Indian Journal of Medicine and Healthcare* **2014**, *3*, 322.
19. Adebisi, I. M.; Alebiosu, O. C.; *Int. J. Curr. Res. Chem. Pharm. Sci.* **2014**, *1*, 81.
20. Tadesse, M.; Hunde, D.; Getachew, Y.; *Ethiopian Journal of Health Sciences* **2005**, *15*, 89.
21. Megersa, M.; Jima, T. T.; Goro, K. K.; *J. Evidence-Based Complementary Altern. Med.* **2019**, 1 [Crossref].
22. Babu, N. V. J.; Murty, P. P.; Rao, G. M. N.; *International Journal of Botany and Research* **2020**, *10*, 55.
23. Babu, N. V. J.; Murty, P. P.; Rao, G. M. N.; *IOSR J. Pharm. Biol. Sci.* **2020**, *15*, 44 [Crossref]
24. Kumar, R. B.; Suryanarayana, B.; *Ethnobotanical Leaflets* **2008**, *12*, 896.
25. Somashekhara Achar, K. G.; Boosanur, V.; Shivanna, M. B.; *Indian Journal of Traditional Knowledge* **2015**, 1, 147.
26. Kannan, M.; Kumar, T. S.; Rao, M. V.; *Global Journal Research Medicinal Plants & Indigenous Medicine* **2016**, *5*, 203.
27. Tiwari, K. P.; Minocha, P. K.; *Phytochemistry* **1980**, *19*, 701 [Crossref].
28. Anand, R. M.; Nandakumar, N.; Karunakaran, L.; Ragunathan, M.; Murugan, V.; *Natural Product Radiance* **2005**, *5*, 139.
29. Daddam, J. R.; Kotha, P.; Katike, U.; Basha, S.; Dowlathabad, M. R.; *Research Square* **2020**, 1 [Crossref].
30. Khare, C. P.; *Indian Medicinal Plants – An Illustrated Dictionary*, New Delhi, 2007.
31. Agra, M. F.; Freitas, P. F.; Barbosa-Filho, J. M.; *Rev. Bras. Farmacogn.* **2007**, *17*, 114 [Crossref].
32. Garcia, C. M.; *Tese de Doutorado*, Universidade de Santa Maria, Brasil, 2007.
33. Caballero-George, C.; Gupta, M. P.; *Planta Med.* **2011**, *77*, 1189 [Crossref].
34. Ramprasad, R.; Anil, N.; Hameed, S. S.; Shifama, J. M. R.; Venkateshan, N.; *J. Drug Delivery Ther.* **2019**, *9*, 102 [Crossref].
35. Nakhare, S.; Garg, S. C.; *Ancient Science of Life* **1992**, *12*, 227.
36. Nakhare, S.; Garg, S. C.; Bhagwat, A. W.; *Ancient Science of* Life **1997**, *17*, 23.
37. Waghmare, S. D.; *International Research Journal on Advanced Science Hub* **2020**, *2*, 268 [Crossref].

38. Jamil, M.; Mansoor, M.; Latif, N.; Muhammad, S.; Gull, J.; Shoab, M.; Khan, A.; *Pak. J. Sci. Ind. Res., Ser. B* **2019**, *62*, 61 [Crossref].
39. Chitme, H. R.; Alok, S.; Jain, S. K.; Sabharwal, M.; *Int. J. Pharm. Sci. Res.*, **2010**, *1*, 24 [Crossref].
40. Panda, S. P.; Sahoo, H. K.; Subudhi, H. N.; Sahu, A. K.; *American Journal of Ethnomedicine* **2014**, *1*, 260.
41. Ahmed, S.; Hasan, M. M.; Ahmed, S. W.; Mahmood, Z. A.; Azhar, I.; Habtemariam, S.; *Phytopharmacology* **2013**, *4*, 390.
42. Ahmed, S.; Hasan, M. M.; Ahmed, S. W.; *Pak. J. Pharm. Sci.* **2014**, *27*, 1583.
43. Premamalini, P.; Sharmila, S.; *International Journal of Advanced Herbal Science and Technology* **2017**, *3*, 67 [Crossref].
44. Selvan, V. T.; Kakoti, B. B.; Gomathi, P.; Kumar, D. A.; Islam, A.; Gupta, M.; Mazumder, U. K.; *Pharmacologyonline* **2007**, *2*, 453.
45. Murty, P. P.; Rao, G. M. N.; Rao, D. S.; *Journal of Science* **2015**, *5*, 385.
46. Jenifer, S. P.; Lekha, K.; *Journal of Medicinal Plants Studies* **2019**, *7*, 196.
47. Shukla, V. S.; Nigam, I. C.; *Proc. Inst. Chem. (India)* **1961**, *33*, 229.
48. Baslas, K. K.; *Perfum. Essent. Oil Rec*. **1959**, *50*, 896.
49. Kirtikar, K. R.; Basu, B. D.; Pâninî office, Bahadurganj, 1918.
50. Gritto, M. J.; Nanadagopalan, V.; Doss, A.; *Adv. Appl. Sci. Res.* **2015**, *6*, 157.
51. Nandagopalan, V.; Doss, A.; Anand, S. P.; *The International Journal Of Science & Technoledge* **2014**, *2*, 1.
52. Bensy, D.; Gamble, A; Kaptchuk, T.; *Chinese Herbal Medicine – Materia medica*, **1993**, 331.
53. Nayak, J. K.; Sahu, S. K.; Barik, E.; Bhattacharyay, D.; Pandey, M.; *Plant Cell Biotechnol. Mol. Biol.* **2020**, *21*, 166 [Crossref].
54. Lakshmanan, R.; Thiruvalluvar, M.; Subramanian, M. P. S.; Ganthi, A. S.; *Eur. J. Biomed. Pharm. Sci.* **2018**, *5*, 294.
55. Randive, K. R.; Hatekar, S.; *Eastern Geographer* **2010**, *15*, 79.
56. Sharma, J. P.; Srivastava, A.; Thakur, S. P.; Barpete, P. K.; Singh, S.; *Int. J. Pharm. Life Sci.* **2010**, *1*, 18.
57. Iswarya, P.; Lakshmikantham, T.; Mohan, S.; International Journal *of* Ayurveda *and* Pharma Research **2019**, *7*, 45.
58. Jayaprasad, B.; Thamayandhi, D.; Sharavanan, P. S.; *International Journal of Research in Pharmaceutical and Biosciences* **2012**, *2*, 1.
59. Deepthy, R.; Remashree, A. B.; *International Journal of Herbal Medicine* **2014**, *2*, 92.
60. Soudahmini, E.; Ganesh, M. S.; Panayappan, L.; Madhu, C. D.; *Natural Product Radiance* **2005**, *4*, 492.
61. Shanmugam, S.; Annadurai, M.; Rajendran, K.; *J. Appl. Pharm. Sci.* **2011**, *1*, 94.
62. Karthiyayini, R.; *Int. J. Pharm. Sci. Res.* **2012**, *3*, 1829 [Crossref].
63. Manoranjitham, M.; Premalatha, S.; *Int. J. Adv. Res. Biol. Sci.*, **2015**, *2*, 256.
64. Kumar, P. P.; Ayannar, M.; Ignacimuthu, S.; *Indian Journal of Traditional Knowledge* **2007**, *6*, 579.
65. Ticktin, T.; Dalle, S. P.; *J. Ethnopharmacol.*, **2005**, *96*, 233. [10.1016/j.jep.2004.09.015]
66. Suryanarayana, S. N.; Seetharami, R. T. V. V.; *Medicinal Plant Research* **2017**, *7*, 1. [Crossref].
67. Andrade-Cetto, A.; Heinrich, M.; *J. Ethnopharmacol.* **2005**, *99*, 325. [Crossref].
68. Shehu, U. F.; Aliyu, I. M.; Ilyas, N.; Ibrahim, G.; *Trop. J. Nat. Prod. Res.* **2020**, *4*, 21. [Crossref].
69. Abdulhamid, Z.; *Interviewer*, Kaduna, 2016.
70. Neuwinger, H.; *Medpharm Scientific*, Stuttgart, 2000.
71. Burkill, H. M.; *Royal Botanic Gardens Kew*, United Kingdom, 1997.
72. Francis, J. K.; *Gen. Tech. Rep. IITF-GTR-26*, San Juan, 2004.
73. Liogier, H. A.; *Iberoamericana de Ediciones, Inc.*, San Juan, 1990.
74. Michael, M.; *Dissertação de Mestrado*, Universidade do Cairo, Egito, 2018.
75. Rasoanaivo, P.; Petitjean, A.; Ratsimamanga-Urverg, S.; Rakoto-Ratsimamanga, A.; *J. Ethnopharmacol.* **1992**, *37*, 117 [Crossref].
76. De Boer, H. J.; Kool, A.; Broberg, A.; Mziray, W. R.; Hedberg, I.; Levenfors, J. J.; *J. Ethnopharmacol.*, **2005**, *96*, 461 [Crossref].
77. Dayal, B.; Purohit, R. M.; *Flavour Industry* **1971**, *2*, 484.
78. Rabearivony, A. D.; Kuhlman, A. R.; Razafiarison, Z. L.; Raharimalala, F.; Rakotoarivony, F.; Randrianarivony, T.; Rakotoarivelo, N.; Randrianasolo, A.; Bussmann, R. W.; *Ethnobotany Research & Applications* **2015**, *14*, 123 [Crossref].
79. Pavela, R.; Benelli, G.; *Exp. Parasitol.* **2016**, *167*, 103. [Crossref].
80. Karunamoorthi, K.; Hailu, T.; *Journal of Ethnobiology and Ethnomedicine* **2014**, *10*, 1 [Crossref].
81. Degu, S.; Berihun, A.; Muluye, R.; Gemeda, H.; Debebe, E.; Amano, A.; Abebe, A.; Woldkidan, S.; Tadele, A.; *Pharmacy & Pharmacology International Journal* **2020**, *8*, 274 [Crossref].
82. Leal, R. S.; Maciel, M. A. M.; Dantas, T. N. C.; Melo, M. D.; Pissinate, K.; Echevarria, A.; *Rev. Fitos* **2007**, *3*, 26.
83. Mostardeiro, C. P.; Mostardeiro, M. A.; Morel, A. F.; Oliveira, R. M.; Machado, A. K.; Ledur, P.; Cadoná, F. C.; Silva, U. F.; Cruz, I. B. M.; *Pharmacognosy Magazine* **2014**, *10*, 630 [Crossref].
84. Grochowski, D. M.; Locatelli, M.; Granica, S.; Cacciagrano, F.; Tomczyk, M.; *Compr. Rev. Food Sci. Food Saf.* **2018**, *17*, 1395 [Crossref].
85. Samy, R. P.; Ignacimuthu, S.; *J. Ethnopharmacol.* **2000**, *69*, 63 [Crossref].
86. Kalarani, D. H.; Venkatesh, P.; Dinakar, A.; *Res. J. Pharm. Technol.* **2009**, *2*, 789.
87. Basu, S. K.; Rupeshkumar, M.; Kavitha, K.; *Pharmacologyonline* **2009**, *1*, 1144.
88. Kumari, A.; Lalitha, K. G.; Venkatachalam, T.; Kalaiselvi, P.; Sethuraman, M. G.; *Asian Journal of Research in Pharmaceutical Science* **2011**, *1*, 113.
89. Chavan, S.; Singh, A.; Daniel, M.; *International Journal of Pharmaceutical Development & Technology* **2014**, *4*, 157.
90. Kumar, M. P.; Sivasankar; Senthilvel, G.; Prabhu, L. R.; *World J. Pharm. Pharm. Sci.* **2018**, *7*, 644 [Crossref].
91. Sathishkumar; Anbarasu; *Int. J. Plant, Anim. Environ. Sci.* **2019**, *9*, 6.
92. Bhuvaneswari, R.; Ramanathan, R.; Mathumathi, T. K.; Madheswaran, A.; Dhandapani, R.; *Journal of Medicinal Plants Studies* **2015**, *3*, 33.
93. Muthuraja, R.; Nandagopalan, V.; Thomas, B.; Marimuthu, C.; *European Journal of Environmental Ecology* **2014**, *1*, 33.
94. Murty, P. P.; Rao, G. M. N.; *J. Phytol.* **2010**, *2*, 17.
95. Madhava, C. K.; Sivaji, K.; Tulasi, R.; *Students offset printers*, Tirupati, 2008.
96. Wilson, E.; Rajamanickam, G. V.; Vyas, N.; Agarwal, A.; Dubey, G. P.; *Indian Journal of Traditional Knowledge* **2007**, *6*, 678.
97. Rao, D. M.; Rao, U. V. U. B.; Sudharshanam, G.; *Ethnobotanical Leaflets* **2006**, *10*, 198.
98. Madrigal, R. V.; Smith Jr., C. R.; *Lipids* **1973**, *8*, 407.
99. Bohannon, M. B.; Kleiman, R.; *Lipids* **1977**, *13*, 270.
100. Harwood, J. L. In *The Biochemistry of Plants*; Stumpf, P. K., ed.; Davis, 1980, cap. 1.
101. Rao, K. S.; Lakshminarayana, G.; *J. Am. Oil Chem. Soc.* **1985**, *62*, 714.
102. Rayar, A.; Aeganathan, R.; Ilayaraja, S.; Prabakaran, K.; Manivannan, R.; *Am. J. Phytomed. Clin. Ther.* **2015**, *3*, 79.
103. Kumar, A.; Pande, C. S.; Kaul, R. K.; *Indian J. Appl. Chem.* **1965**, *28*, 190.
104. Dube, P.; Purohit, R. M.; *Riechst., Aromen, Koerperpflegem.* **1973**, *23*, 149.
105. Sahu, S. K.; Nayak, J. K.; Prakash, K. V. D.; Bhattacharyay, D.; *Plant Cell Biotechnol. Mol. Biol.* **2020**, *21*, 149.
106. Kashima, Y.; Nakaya, S.; Miyazawa, M.; *J. Oleo Sci.* **2014**, *63*, 149 [Crossref].

107. Chaves, O. S.; *Tese de Doutorado*, Universidade Federal da Paraíba, Brasil, 2016.
108. Albuquerque, J. B. L.; trabalho não publicado.
109. Lopes, L. G.; *Dissertação de Mestrado*, Universidade Federal do Espírito Santo, Brasil, 2014.
110. Oliveira, M. S.; *Tese de Doutorado*, Universidade Federal da Paraíba, Brasil, 2019.
111. Casimiro-Júnior, F.; Chaves, O. S.; Fernandes, M. M. M. S.; Agra, M. F.; Teles, Y. C. F.; Souza, M. F. V.; *36ª Reunião Anual da Sociedade Brasileira de Química*, São Paulo, Brasil, 2013.
112. Fernandes, M. M. M. S.; *Dissertação de Mestrado*, Universidade Federal da Paraíba, Brasil, 2013.
113. Gualberto, F. T. A.; *Trabalho de Conclusão de Curso*, Universidade Federal da Paraíba, Brasil, 2013.
114. Fernando, L. M.; Lima, A. A.; Dias, W. S.; Moura-Júnior, R. T.; Teles, Y. C. F.; Souza, M. F. V. In *Processos Químicos e Biotecnológicos*; Andrade, D. F., Souza, A. A., Andrade, D. E., Oliveira, E. J., Santos, F., Lopes, J. E. F., Neves, O. F.,Lima, L. C., Ferreira Filho, N., Oliveira, V. A., eds.; Editora Poisson: Belo Horizonte, 2020, cap. 3.
115. Puckhaber, L. S.; Stipanovic, R. D.; Bost, G. A.; *Herbs, Medicinals, and Aromatics* **2002**, 556.
116. Andrade, T. U.; Ewald, B. T.; Freitas, P. R.; Lenz, D.; Endringer, D. C.; *Int. J. Pharm. Pharm. Sci.* **2012**, *4*, 124.
117. Silva, C. M.; *Trabalho de Conclusão de Curso*, Universidade Federal da Paraíba, Brasil, 2018.
118. Sotelo, A.; Villavicencio, H.; Montalvo, I.; Gonzalez-Garza, M. T.; *Afr. J. Tradit., Complementary Altern. Med.* **2005**, *1*, 4 [Crossref].
119. Gasca, C. A.; Cabezas, F. A.; Torras, L.; Bastida, J.; Codina, C.; *Free Radicals and Antioxidants*, **2013**, *3*, 55 [Crossref].
120. Tiwari, K. P.; Minocha, P. K.; Masood, M., *Proc. Natl. Acad. Sci., India, Sect. A* **1978**, *48*, 158.
121. Tiwari, K. P.; Choudhary, R. N.; *Acta Cienc. Indica, Chem.* **1980**, *6*, 36.
122. Desbois, A. P.; Smith, V. J.; *Appl. Microbiol. Biotechnol.*, **2010**, *85*, 1629 [Crossref].
123. Mandey, J. S.; Wolayan, F. R.; Pontoh, C. J.; Kowel, Y. H. S.; *Scientific Papers, Series D, Animal Science* **2020**, *63*, 214.
124. Seidel, V.; Taylor, P. W.; *Int. J. Antimicrob. Agents* **2004**, *23*, 613 [Crossref].
125. Fernandes, D. A.; Chaves, O. S.; Teles, Y. C. F.; Agra, M. F.; Vieira, M. A. R.; Silva, P. S. S.; Marques, M. O. M.; Souza, M. F. V.; *Quim. Nova* **2021**, *44*, 137 [Crossref].
126. Yadav, N.; Yadav, R.; Goyal, A.; *Int. J. Pharm. Sci. Rev. Res.* **2014**, *27*, 272.
127. Lopes, L. G.; Tavares, G. L.; Thomaz, L. D.; Sabino, J. R.; Borges, K. B.; Vieira, P. C.; Veiga, T. A. M.; Borges, W. S.; *Chem. Biodiversity* **2016**, *13*, 284 [Crossref].
128. Santos, R. A. F.; *Dissertação de Mestrado*, Universidade Federal da Bahia, Brasil, 2010.
129. Santos, D. S.; Rodrigues, M. M. F.; *Estação Científica (UNIFAP)* **2017**, *7*, 29 [Crossref].
130. Sousa, A. P.; Oliveira, M. S.; Fernandes, D. A.; Ferreira, M. D. L.; Cordeiro, L. V.; Souza, H. D. S.; Souza, M. F. V.; Pessoa, H. L. F.; Oliveira-Filho, A. A.; Silveira e Sá, R. C.; *Scientific Electronic Archives* **2021**, *13*, 120 [Crossref].
131. Sousa, A. P.; Nunes, M. K. S.; Oliveira, M. S.; Fernandes, D. A.; Ferreira, M. D. L.; Cordeiro, L. V.; Souza, H. D. S.; Souza, M. F. V.; Pessoa, H. L. F.; Oliveira Filho, A. A.; Silveira e Sá, R. C.; *Sci. Plena* **2020**, *16*, 1 [Crossref].
132. Silva, G. C.; Pereira, A. C.; Rezende, B. A.; Silva, J. F. P.; Cruz, J. S.; Souza, M. F. V.; Gomes, R. A.; Teles, Y. C. F.; Cortes, S. F.; Lemos, V. S.; *Planta Med.* **2013**, *79*, 1003. [Crossref].
133. Rajalakshmi, P.; Vadivel, V.; Subashini, G.; Pugalenthi, M.; *Int. J. Adv. Res.* **2016**, *4*, 1751 [Crossref].
134. Silva, C. M.; Félix, M. D.; Aquino, A. K.; Oliveira, M. S.; Teles, Y. C. F.; Souza, M. F. V.; *Mol2Net* **2016**, *2*, 1 [Crossref].
135. Badami, S.; Channabasavaraj, K. P.; *Pharm. Biol.* **2007**, *45*, 392 [Crossref].
136. Kalarani, D. H.; Dinakar, A.; Senthilkumar, N.; *Int. J. Drug Dev. Res.* **2012**, *4*, 298.
137. Kirtikar, K. R.; Basu, B. D.; *Indian Medicinal Plants*, International Book Distributors Book Sellers and Publishers: Deheradun, 1999.
138. Girish, H. V.; Vinod, A. B.; Dhananjaya, B. L. Satish Kumar, D.; Duraisamy, S.; *Pharmacogn. J.* **2016**, *8*, 28 [Crossref].
139. Rayar, A.; Manivannan, R.; *Int. J. Pharm. Sci. Invent.* **2015**, *4*, 46 [Crossref].
140. Lozano, C. M.; Vasquez-Tineo, M. A.; Ramirez, M.; Infante, M. I.; *Pharmacogn. Commun.* **2021**, *11*, 52 [Crossref].
141. Garg, S. C.; *Anthelmintic activity of some medicinal plant products*, Research Periodicals and Book Publishing House, Houston, 2003, 207.
142. Garg, S. C.; *Natural Product Radiance* **2005**, *4*, 18.
143. Bhavani, S.; *J. Pharm. Sci. Res.* **2015**, *7*, 812.
144. Singh, D.; Singh, B.; Dutta, B. K.; *International Journal of Science* **2012**, *4*, 3 [Crossref].
145. Mapunya, M. B.; *Dissertação de Mestrado*, Universidade de Pretória, África do Sul, 2009.
146. Matsuse, I. T.; Lim, Y. A.; Hattori, M.; Correa, M.; Gupta, M. P.; *J. Ethnopharmacol.* **1999**, *64*, 15 [Crossref].
147. Dan, G.; Castellar, A.; *Alumni – Revista Discente da UNIABEU* **2015**, *3*, 8.
148. Shaku, M.; Yamamoto, T.; Shishido, M.; Takashi, T.; Yoshitani, S.; Yoshimi, F., *Jpn. Kokai Tokkyo Koho* **2001**. (JP 2001181172).
149. Ewald, B. T.; Loyolla, C. M.; Pereira, A. C. H.; Lenz, D.; Medeiros, A. R. S; Andrade, T. U.; Nogueira, B. V.; Pereira, T. M. C.; Endringer, D. C.; *Rev. Bras. Plantas Med.* **2015**, *17*, 392 [Crossref].
150. Vahitha, R.; Venkatachalam, M. R.; Murugan, K.; Jebanesan, A.; *Bioresour. Technol.* **2002**, *82*, 2 [Crossref].
151. Kamaraj, C.; Abdul Rahuman, A.; Bagavan, A.; Abduz Zahir, A.; Elango, G.; Kandan, P.; Rajakumar, G.; Marimuthu, S.; Santhoshkumar, T.; *Tropical Biomedicine* **2010**, *27*, 211.
152. Singhai, A.; Singour, P. K.; Garg, G.; Pawar, R. S.; Patil, U. K.; *Research Journal of Pharmacology and Pharmacodynamics* **2009**, *1*, 82.
153. Selvakumar, B.; Gokulakrishnan, J.; Elanchezhiyan, K.; Deepa, J.; *International Journal of Current Advanced Research* **2015**, *4*, 221.
154. Mago, N.; Sofat, I. B.; Jethi, R. K.; *Indian J. Med. Res.* **1989**, *90*, 77.
155. Jethi, R. K.; Duggal, B.; Sahota, R. S.; Gupta, M.; Sofat, I. B.; *Indian J. Med. Res.* **1983**, *78*, 422.
156. Jeeva Gladys, R.; Kalai Arasi, R.; Elangovan, S.; Mubarak, H.; *J. Appl. Pharm. Sci.* **2013**, *3*, 176 [Crossref].