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A Review on Traditional uses, Phytochemistry and Pharmacological Potential of Family Malpighiaceae

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Abstract

Herbal medicine has become more popular in recent years. As a result, an effort is being made to document valuable phyto-constituents and pharmacological knowledge as part of the revitalization of herbal remedies. There are still several plants of certain families that haven't been researched. This is the situation with Malpighiaceae; a flowering plant family rich in secondary metabolites including alkaloids, flavonoids, carbohydrate like substance as vitamin C, proanthocyanidins and phenolic compounds, with promising therapeutic effects as anti-inflammatory, anti-ulcer, anti-cancer, anti-diabetic, antioxidant, anti-depressant, anti-HIV, and anti-microbial activities. The goal of this review is to offer an overview of the chemistry of plants belonging to Malpighiaceae, with a focus on their potential biological impact in recent years.

Keywords: Malpighiaceae; *Byrsonima*; *Malpighia*; Phytochemical constituents; Biological study.

1. Introduction

Nature, particularly plants, is an important source of compounds in healthcare. Only about 15% of the world's plant species have been studied for their pharmacological properties [1]. Even though a wide range of medicinal plants have developed novel and diversified chemical identities that might be utilized as drugs, some botanical families remain unstudied. This is the case of the Malpighiaceae family, a large plant family with about 65 genera and 1,250 species which can be located in tropical and subtropical regions in both hemispheres [2]. It is a family of flowering plants, including trees or shrubs usually lianas [3].

The infra-family classification is based on winged or unwinged fruit, even though the family is obviously monophyletic [4, 5]. Malpighiaceae is a family that belongs to Malpighiales order, Rosidae subclass, Magnoliopsida class, Magnoliophyta division, Spermatophyta superdivision, and Tracheobionta subkingdom [6, 7]. This family is difficult to study due to the large number of species, nomenclatural issues, and difficulty in taxonomic identification. For example, glandular calyces are prevalent in the neotropical Malpighiaceae, but glandular calyces can be found in species belonging to the genera *Banisteriopsis*, *Byrsonima*, *Galphimia*, and *Pterandra* [8], making it difficult to discriminate between these genera using this morphological feature. Complications arise regularly because of morphological variety and species synonymies. [2, 9, 10]. Most botanists believe the family is related to the Geraniales; Hutchinson included it in his Malpighiales (along with the Erythroxylaceae) whereas Hallier placed it in the Polygalales [3].

Several secondary metabolites with medicinal effects have been discovered in the Malpighiaceae family. Although a wide range of medicinal plants have offered new and different chemical identities that could be effective as medications, only a few species in this family have been researched in terms of chemistry and biology [11]. The phytochemical

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studies showed most plants belonging to that family contain *β*-carbolines alkaloids, vitamins, carotenoids, nor-secofriedelanes and nor-friedelane terpenoids, hydroxycinnamic acids, flavonoids, proantho-cyanidines, and phenolic compounds.

Malpighiaceae family contains several medicinally significant genera, including the following: *Acridocarpus, Aspidopterys, Banisteriopsis, Bunchosia, Byrsomina, Callaeum, Caucanthus, Camarea, Diplopterys, Echinopterys, Flabellaria, Galphimia, Hiptage, Heteropterys, Hiraea, Malpighia, Stigmaphyllon, Tetrapterys, Tristellateia,* and *Niedenzuella*. Pharmacological investigations have revealed that most genera in this family have significant biological activities such as antioxidant, anti-inflammatory, anti-diabetic, anti-microbial, anti-depressant, and cytotoxic properties

Table 1. Constituents and biological activities of selected genera of the Malpighiaceae family

Plant species	Part used	Phytoconstituents	Chemical Class	Biological activities	Ref.
Acridocarpus orientalis A. Juss	Aerial parts	Morin and morin-3-*O*-*β*-D-glucopyranoside.	Flavonoids	Antifungal, phytotoxic anticancer, anti-lipi peroxidation	[24]
		β-sitosterol, *β*-sitosterol-3-*O*-*β*-D-glucopyranoside, betulinic acid and botulin	Steroids and triterpenoids	NA	[49]
		2,5-dimethoxy-1,4-benzo-quinone, 2,6-dimethoxy-1,4-benzoquinone	Benzoquinone		
		Quercetin, choerospondin, morin, morin-3-*O*-*α*- L-rhamnopyranoside, and morin-3-*O*-*β*-D-gluco-pyranoside.	Flavonoids		
		1-docosanol	Saturated fatty alcohol		
	Leaves and stem	NA	Flavonoids and phenolic compounds	Antioxidant, lipid peroxidation, anticancer, *α*-glucosidase, and urease inhibitory.	[27]
	Leaves	Morin and morin-3-*O*-*β*-D-glucopyranoside	Flavonoids	Anticancer (inhibit 4T1 cells and promotes mesenchymal stem cells (MSCs) proliferation).	[48]
		β-sitosterol, *β*-sitosterol-3-*O*-*β*-d- gluco-pyranoside and betulinic acid.	Steroids and triterpenoids		
		Botulin	Miscellaneous		
		NA	Flavonoids, tannins, carbohydrates	Hepatoprotective	[26]
	Arial parts	NA	NA	Antidiabetic	[103]
	Leaves and stem	Methyl 8-pimaren-18-oate, octacosane, heptacosane, hexacosane, methyl dehydro-abietate, tetracosane, heptacosane, docosane, *α*-pinene, and heneicosane.	Volatile constituents	Urease, *α*-glucosidase, and carbonic anhydrase II (CA-II) enzyme inhibitory.	[41]
Acridocarpus Smeathmannii (DC.) Guill. & Perr.	Roots	Octadecanoic acid ethyl ester, docosenoic acid, Octadecenoic acid ethyl ester, Octadecenoic acid	Fatty acids	A male reproductive enhancer	[21]

Aspidopterys obcordata Hemsl	Vines	Obcordatas A-I	Polyoxypregnane glycosides	Antitumor (against the human cancer cell lines AGS, SW480, HuH-7 and MCF-7).	[17]
		NA	NA	Kidney Stones (Inhibit NOX4 expression).	[18]
		Aspidoptoids A–D, spruceanol and sonderianol.	Diterpenoids.	Cytotoxic and inhibit nitric oxide (NO) production.	[104]
Aspidopterys indica Willd.	Aerial parts	NA	Tannins, phytosterols, flavonoids	Antioxidant	[57]
Banisteriopsis argyrophylla	Leaves	Catechin, isoquercitrin, hyperoside, quercitrin, guaijaverin, and reinutrin	Flavonoids	Antifungal and cytotoxic	[105]
		Catechin, quercetin-hexoside, quercetin-pentoside and quercetin-3-*O*-*α*-L- rhamnopyranoside, kaempferol-3-*O*-*α*-L-rhamnopyrano-side, quercetin-3-*O*-(2"-galloyl)-*α*-L-rhamnopyranoside, Procyanidin dimer, and procyanidin dimer monogallate.	Flavonoids	Antioxidant, and *α*-amylase, *α*-glucosidase, pancreatic lipase, and glycation inhibitors.	[58]
		Macarangioside A, and macarangio-side B	Megastigmane glucosides		
Banisteriopsis Caapi (Syn. *Banisteriopsis inebrians)*	Stem	Harmine, harmaline and caffeine	Alkaloids	CNS stimulants	[106]
	Aerial parts	1-Carbamoyl-7- methoxy *β*-carboline, 1-acetyl-7-methoxy *β*-carboline and l-methoxy- 1,2,3,4-tetrahydro-1-oxo-*β*-carboline.	Alkaloids	NA	[107]
		Banistenoside A, banistenoside B and their acetate	Alkaloidal glycosides	Treatment of Parkinsonism, and other neuro-degenerative disorders.	[53]
		Tetrahydroharmine, harmol, tetrahydro-norharmine harmaline, and harmine.	*β*-carbolines alkaloids		
		Epicatechin, and procyanidin B2	Proantho-cyanidines		
		β-d-fructofuranosyl-(2-->5)-fructo-pyranose, saccharose, and *β*-D-glucose	Monosaccharide, disaccharide		
	Stem bark	Banistenoside A, banistenoside B, harmine, harmaline, and tetra-hydroharmine, and harmol.	*β*-carboline alkaloids	Treatment of neurodegenerative Disorders Relevant to Parkinson's Disease (MAO inhibition and antioxidant effects).	[29]
		Epicatechin, and procyanidine B2	Proantho-cyanidines		
	Aerial parts	Harmine, harmaline, and tetra-hydroharmine	*β*-carboline alkaloids	Antidepressant	[28]
		5-hydroxytryptamine (serotonine), and N, N-dimethyltryptamine (DMT)	Miscellaneous		
	Liana	Harmine, harmaline, and tetra-hydroharmine	*β*-carboline alkaloids	Monoamine oxidase (MAO) inhibitors.	[108]
		N, N-dimethyltryptamine (DMT)	Miscellaneous		

Banisteriopsis campestris	Flowers	Hexadecanoic acid (palmitic acid), nerolidol, myristic acid, linoleic acid, triacontane, heptacosane and linalool.	Volatile constituents and Fatty acids	Antibacterial, and antifungal	[42]
	leaves, stems, and roots	Palmitic acid, palmitoleic acid, phytol, triacontane, linoleic acid, and oleic acid.	Volatile constituents and Fatty acids	Antibacterial, antifungal, antioxidant, antiprotozoal, cytotoxicity on Vero cells, and glycation inhibitors.	[43]
Banisteriopsis cornifolia	Bark, leaf, and stem	NA	NA	Antidote, treat side effects caused by snakebite	[109]

Bunchosia armeniaca	Leaves	Rutin, afzelin, isoquercitrin, kaempferol and quercetin	Flavonoids	Antimicrobial, antioxidant, antiinflammatory	[59]
	Unripe, ripe fruit	Pyran-4-one,2,3-dihydro-3,5-dihydroxy-6-methyl, 1H-Pyrrole-2,5-dione, 1-Nona-decene, 3-Eicosense, 2-Furanmethanol, 9,12,15-Octadecanoic acid, methyl ester and *n*-Hexadecanoic acid	Volatile constituents and Fatty acids	Antioxidant	[44]
	Fleshy Fruit	Vitamin C	Vitamins		[11, 110]
Bunchosia glandulifera	Leaves	NA	NA	Anti- against *Klebsiella pneumonia*.	[74]
	Fruit pulp & seed	Lauric, linolenic, docosadienoic, myristic, cerotic, myristoleic, palmitic, palmitoleic, stearic, oleic, linoleic, arachidonic, and behenic acids.	Fatty acids	NA	[45]
	Ripe fruits	*β*-Carotene, and lycopene Vitamin C	Carotenoids Vitamins	Antioxidant	[111]
	Tree	NA	Vitamins, Carotenoids		[60]
	Fruit pulp	Rutin, vitexin, and quercitrin *β*-Carotene, and lycopene Vitamin C Caffeine	Flavonoids Carotenoids Vitamins Alkaloids		[112-114]
Byrsomina Sericea DC	Stem bark	NA	NA	Fevers, diarrheas, syphilis, and kidney diseases	[115]
	Leaves	NA	Flavonoids, proantho-cyanidins and tannins	Antioxidant, gastro-protective properties	[116]
Byrsomina bucidaefolia	Leaves	Methyl gallate and Methyl *m*-trigallate	Phenolic acids	Antioxidant	[61]
Byrsomina coccolobifolia	Leaves & Stems	Isoquercitrin, catechin, epicatechin, quercitrin, quercetin and kaempferol	Flavonoids	Antileshimina	[98]
Byrsomina crassa Nied.	Leaves & Aerial parts	NA	NA	Antimicrobial (against *Mycobacterium fortuitum*)	[117]
	Leaves	Quercetin, and quercetin-3-*O*-(2”-galloyl)-a-L-arabinopyranoside. Methyl gallate, and epigallocatechin gallate.	Flavonoids Phenolic acids	Antimicrobial	[75]
		Quercetin-3-*O*-*β*-d-galactopyranoside, quercetin-3-O-*α*-l-arabinopyranoside, amentoflavone, catechin and epicatechin.	Flavonoids	Antiulcerogenic	[118]
		Quercetin-3-*O*-*β*-d-galacto-pyranoside, quercetin-3-*O*-*α*-l-arabino-pyranoside, amentoflavone and catechin. Methyl gallate	Flavonoids Phenolic acids	Mutagenic (using *Salmonella* mutagenicity and micronucleus tests).	[119]

Byrsomina crassa Nied.	leaves & bark	*α*-amyrin, *β*-amyrin and their acetates, lupeol, oleanolic acid, ursolic acid, friedelin, and *α*-amyrinone.	Triterpenes	Antitubercular	[120]
	Aerial parts	NA	Polyphenolic compounds, flavonoids, tannins, and terpenoids.	Antimicrobial (Anti *H. pylori*), immune-stimulatory	[121]
Byrsomina crassifolia (L) Kunth (Syn. *Byrsonima fagifolia* Nied.)	Leaves	Betulin aldehyde, betulin, betulinic acid, lupeol, oleanolic acid and ursen-aldehyde	Triterpenes	Spasmogenic activity	[50]
		β-sitosterol and its glucoside	Sterols		
		Catechin, epicatechin, guaijaverin, hyperin, quercetin and its 3-*O*-[6''-galloyl] galactoside	Flavonoids		
		Methyl gallate (an aromatic ester).	Phenolic acid		
		Alanine, aspartic acid, proline, valine, pipecolic acid and 5-hydroxy-pipecolic acid	Protein and non-protein amino acids.		
	leaves & bark	NA	NA	Antidote and treat side effects caused by snakebite	[109]
	Leaves	Gallic acid, and methyl gallate	Phenolic acids	Gastro protective, healing, and antidiarrheal	[94]
		Quercetin and its glycosides	Flavonoids		
	Fruits & Seed	NA	NA	Antihypeglycemic, antihyperlipidemic and antiglycation	[70]
	Aerial parts	Quercetin 3-O-xyloside, quercetin, rutin and hesperidin	Flavonoids	Antidepressant	[88]
	Leaves	Bassic acid, lupeol, *α*- amyrin, *β*-amyrin and their acetates.	Triterpene	Antitubercular	[51]
	Seeds	NA	NA	Diabetic wound healing in rats (by tissue regeneration).	[122]
		labda-17-acetoxi-13E-en-15-palmitate, and abda-8(17),13E-dien-19-carboxy-15-yl palmitate)	Diterpene labdane	Antimicrobial	[123]
		Byrsoninas A and B	Dimeric guaianolides sesquiterpene lactone	Antioxidant, hypoglycemic, and hypolipidemic.	[71]
	Bark	NA	Phenolic compounds, tannins, flavonoids, anthra-quinones, triterpenes, cardiotonic glycosides and reducing sugars.	Antifungal and antioxidant	[124]
	Yellow & red nance fruits	Lutein and its isomers, zeaxanthin, *β*-carotene and its isomers and lutein dimyristate	Carotenoids and xanthophyll esters	High lutein renders nance fruit as a nutritionally (micro-nutrient).	[125]

Byrsomina crassifolia (L) Kunth (Syn. *Byrsonima fagifolia* Nied.)	Leaves	Catechin, epicatechin, and quercetin	Flavonoids	Antioxidant	[126]
		Ferulic acid	Phenolic acids		
	Fruits	NA	Polyphenols and carotenoids	Antioxidant effects and application to aging.	[62]
		NA	Phenolic compound, flavonoids, and vitamin C	Antioxidant	[63]
	Leaves	Gallic acid, ferric acid, ferrulic acid	Phenolic acids	Antimicrobial	[127]
		Myricetin and quercetin, catechin, and epicatechin	Flavonoids		
	Pulp	NA	Phenolic compounds, flavonoids, and fatty acids.	Antioxidant, Cytotoxic and Cytoprotective	[83]
Byrsonima duckeana W. R. Anderson	Leaves	NA	NA	Hemolytic and cytotoxicity (against cell lines a U937 human monocyte, and HT29 tumor colon cell lines).	[84]
		Ethyl gallate, quinic acid, and gallic acid,	Phenolic acids	Analgesic, antiinflammatory, and antioxidant	[64]
		Catechin, epicatechin, quercetrin, and quercetin	Flavonoids		
Byrsonima intermedia A. Juss.	Leaves	Catechin, epicatechin, gallic acid, methyl gallate, amentoflavone, quercetin and its glycosides.	Phenolic compound and flavonoids	Mutagenic (for the strains TA98 and TA100 in the Ames assay).	[128]
	Stem bark	NA	Flavonoids, saponins, tannins, triterpenes, and steroids.	Antiinflammatory and antinociceptive	[129]
	Leaves	Catechin	Flavonoids	Chronic and acute antiinflammatory	[130]
		Gallic acid, 3,4-di-O-galloylquinic acid, methyl gallate, catechin, epicatechin, 1,3,5-tri-O-galloylquinic acid, amento-flavone, quercetin, and its glycosides.	Phenolic acids, oligomeric proanthocyanidins, and flavonoids.	Gastric and duodenal antiulcer, antimicrobial and antidiarrheal	[95]
		Gallic acid, 3,4-di-*O*-galloylquinic acid, methyl gallate, catechin, epicatechin, 1,3,5-tri-*O* galloyl-quinic acid, 1,3,4,5-tetra-*O*-galloylquinic acid, quercetin and its glycosides.	Phenolic acids, oligomeric proanthocyanidins, and flavonoids.	Gastroprotective (against peptic ulcers, improve healing through antioxidant and antiinflammatory).	[96]
		Cinnamic acids, galloyl quinic and shikimic acid.	Phenolic acids	NA	[131]
		Quercetin, epicatechin and their glycosides	Proanthocyanidins, and glycosylated flavonoids		
		Lupane and oleanane, betulinic acid, oleanolic acid, *β*-amyrin and 3-oxo-olean-12-en-28-al.	Triterpenes		

Byrsonima gardneriana (A. Juss.)		NA	NA	Treatment of external ulcers and inflammations.	[115]
	Leaves	Pyroglutamic, Hexadecanoic, heptanoic, and octanoic acids. Eucalyptol Retinal (Vitamin A)	Fatty acids Terpenoids Vitamins	Antifungal against *Candida* spp., antioxidant activity, and cytotoxicity.	[46]
Byrsonima verbascifolia (L.) DC.	Stem bark	NA	NA	Treatment of external ulcers and inflammations	[115]
	Leaves	Quinic acid, gallic acid, proto-catechuic acid, and their glycosides Epicatechin, catechin, rutin, apigenin, quercetin, kaempferol and their glycosides Procyanidins, and Prodelphindin	Phenolic acids Flavonoids Proanthocyanidin	Antiinflammatory (inhibition of tumor necrosis factor alpha, prostaglandin E2 production and polymorphonuclear leucocyte migration).	[132]
		Quercetin, epicatechin, catechin, and amentoflavone Quinic acid, and gallic acid	Flavonoids Phenolic acids	Antiinflammatory	[133]
	Fruit	butanoic acid, ethyl ester; hexanal; 2-heptanone; methyl octanoate; butyl hexanoate; ethyl octanoate; decanoic acid, methyl ester; and hexanoic acid, ethyl ester	Volatile constituents	Antioxidiant	[134]
Byrsomina microphylla A. Juss.	Leaves	24-hydroxy-urs-12-enyl 3b-eicosanate, estearate and palmitate, 24-hydroxy-olean-12-enyl 3b-eicosanate, oleanolic and 3b,24-dihydroxy-urs-12-en-28-oic acids. Quercetin Methyl galic ester	Triterpenes esterified with fatty acid Flavonoids Phenolic acid	NA	[135]
Byrsomina japurensis A. Juss.	Stem bark	NA	NA	Antiinflammatory, antihyperalgesic, antiplatelet and antiulcer	[34]
		NA	Phenolic compounds (anthocyanins/anthocyanidins, aurones, chalcones, flavanones and condensed tannins and steroid compounds (saponins, pentacyclic triterpenes, cardio-active steroids).	Antioxidant (by DPPH and ABTS radical scavenger's tests).	[136]
Callaeum antifebrile (Griseb.)	Stem & leaves	Harmine	Alkaloids	Antifever	[137]
Caucanthus auriculatus (Radlk.) Nied.	Leaves	NA	NA	Nutritive value for animal livestock	[138]
Camarea. ericoides *C. humifusa* *C. affinis* *C. hirsute* *C. elongates* *C. axillaris* *C. sericea*	Leaves	Apigenin, apigenin 7-*O*-glucoside, luteolin 7-*O*-galactoside, chrysoeriol, kaempferol, kaempferol 3-*O*-glucoside, kaempferol 3-*O*-galactoside, kaempferol 3-*O*-rutinoside, Quercetin, Quercetin 3-*O*-glucoside, Quercetin 3-*O*-galactoside, Quercetin 3-*O*-rutinoside (Rutin).	Flavonoids	NA	[139]

Diplopterys pubipetala (A.) Juss.	Leaves &stems	NA	Flavonoids. Alkaloids, terpenes and prenylated xanthones	Antioxidant	[65]
		NA	Phenolic compounds, among them, mainly flavonoids	Antitumor (Melanoma Cell Line)	[54]
		N-*cis*-Feruloyl-tyramine, and Simulansamide	Alkaloids	NA	[140]
		Cucumerin A, Syringetin 3-glucuronide, and Macarangaflavanone A.	Flavonoids		
		3-*β*-*O*-(*cis*-p-coumaroyl) corosolic acid, 25-anidro-alisol F, Phytuberina	Terpenoid		
		Ginsenoside	Saponins		
		S-cucujolide	Lactone		
Echinopterys eglandulosa (A.) Juss.	Flowers	NA	NA	Antibacterial	[141]
Flabellaria paniculata Cav.	Leaves	NA	Saponins, cardenolides, alkaloid and tannins.	Antibacterial (aganist *Staphylococcus. aureus*, *Pseudomonas aerugniosa*, *Eustaricia coli* and *Klabellia pneumoniae)*.	[76]
		NA	Tannins and amino-glycosides	Antiinfective and wound healing	[101]
		NA	NA	*In-vitro* antibacterial and *in-vivo* wound healing activities	[102]
	Whole plant	NA	Saponnins, alkaloids, anthraquinones, flavonoids and tannins	Antimicrobial (against different Candida species)	[142]
	Leaves & roots	NA	Phenolics, flavonoids and proanthocyanidins	Antioxidant	[66]
	Leaves	NA	Terpenoids, tannins, saponin and flavonoids.	Gastric ulcers	[143]
		NA	Tannins, saponins, flavonoids, and of a steroidal nucleus (cardiac glycoside)	Sub-Chronic Oral Toxicity	[144]
		Friedelin and friedelinol	Triterpenoids	Gastroprotective	[52]
		Sitosterol and sitosterol-*β*-d-glucoside)	Steroids		
		Kaempferol-3-*O*-*α*-l-rhamno-pyranosyl-(1→6)-*β*-d-glucopyranoside	Flavonoid glycoside		

	Whole plant	Gallic acid, methyl gallate, and tetragalloylquinc acid	Phenolic acids	Antiasthmatic	[145]
		Quercetin	Flavonoids		
	Aerial parts	Gaiphimine B	Nor-secotriterpenoid	Sedative	[146]
	Whole plant	Galphin A, galphin B, galphin C, and galphimidin.	Nor-secofriedelanes and nor-friedelane terpenoids	Antiprotozoal Activity	[99]
		Quercetin	Flavonoids		
		Stigmasterol and sitosterol 3-O-*β*-d-glucoside.	Sterols		
Galphimia glauca Cav.	Aerial parts	Galphimine B.	Nor-secotriterpene.	Anxiolytic and antidepressant	[89]
		Galphimine-B, galphimine-A, galphimine-E, and galphimine-J	Nor-secotriterpene.	Antiinflammatory	[86]
		α-amyrin, *β*-amyrin	Triterpenoid		
		β-sitosterol, and *β*-sitosteryl-3-O-*β*-D-glucopyranoside	Sterols		
		methyl-gallate, 4-methoxy methyl gallate, and gallic acid.	Phenolic acids		
		Kaempferol, quercetin, kaempferol 3-*O*-*β*-D-glucopyranoside, quercetin 3-*O*-*β*-D-glucopyranoside, kaempferol 3-*O*-*β*-D-(2″-galloyl)-glucopyranoside, kaempferol 3-*O*-*β*-D-(2″-galloyl) galactopyranoside, and quercetin 3-*O*-*β*-D-(2″-galloyl)-galactopyranoside.	Flavonoids		
	Leaves	NA	Amino acids, carbohydrates, proteins, flavonoids, tannins, and phenolic compounds.	CNS Depressant and muscle relaxant	[147]
	Bark & leaves	NA	Phenolic compounds, flavonoids, alkaloids, carbohydrates, steroids, protein & amino acids, anthraquinone, gums & mucilage, glycosides, tannins and saponins.	Antioxidant, antibacterial and anticancer Activities	[67]

Hiptage benghalensis (L.) kurz	Leaves	NA	NA	Anthelmintic	[148]
		NA	Carbohydrate, proteins, amino acids, saponins, tannins, glycosides, phenolic and flavonoids.	Antiinflammatory, and anthelmintic	[149]
		NA	Phenolic compounds	Antioxidant	[150]
	Leaves & stem bark	NA	Alkaloids, anthraquinones, coumarin, flavonoids, phenols, steroids, tannins, terpenoids & xanthoprotein	Antibacterial (against *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginos*a and *Salmonella typhi*).	[151]
	Leaves	NA	Steroids, terpenoids, carbohydrates, phenolics and glycosides.	Hepato-protective (against carbon tetrachloride-induced liver damage in rats).	[92]
	Root bark	NA	NA	Larvicidal, adulticidal, and repellent (against the larvae and adults of *Anopheles barbirostris*, *Culex quinquefasciatus*, and *Aedes albopictus*)	[152]
	Leaves, stem & flower	NA	Flavonoids (free + bound)	NA	[153]
	Stem	NA	Steroids, carbohydrate, flavonoid, alkaloid, tannins, phenol, mangiferin and terpenoids.	Antidiabetic	[154]
	Leaves	NA	Steroid, carbohydrate, flavonoid, alkaloid, tannin, phenol, mangiferin and terpenoids.	Analgesic and antiinflammatory	[87]
		NA	Steroids, terpenoids, carbohydrate, phenolics and glycosides.	Antidiabetic	[72]
	Root	NA	NA	Antiobesity	[100]
	Stem bark	Alnus-5(10)-en-3*β*-yl acetate, oleanan-3-one, 3*β*-acetoxy-9*β*-bauer-7-en-6-one, lupeol, 24-propylcholesterol, alnus-5(10)-en-3*β*-ol, 3*β*-acetoxy-20-hydroxy-lupane and betulonic acid.	Triterpenes and steroid compound	Antiinflammatory	[155]
		NA	NA	Antimicrobial (against *Klebsiela pneumonia*, *Escherichia coli*, *Micrococcus luteus* and *Pseudomonas aeruginosa*).	[77]

Hiptage benghalensis (L.) kurz	Leaves	NA	NA	Anticancer (human cervical carcinoma (HeLa), human breast cancer (MCF-7) and human neuro-blastoma (IMR-32) cells).	[85]
	Leaves	NA	Phenols, tannins, flavonoids, steroids, and triterpenoids	Antidiabetic	[73]
Heteropterys brachiate L. DC.	Aerial parts	Chlorogenic acid and chlorogenic acid methyl ester	Hydroxycinnamic acids	Antidepressant, anxiolytic and anticonvulsive.	[156]
		NA	Mixture of terpene		
		NA	NA	AntiHIV and anti*Candida* effects	[80]
Heteropterys byrsonimifolia A. Juss.	Leaves	Guaijaverin, quercetin 3-*O*-*α*-L-rhamno-pyranoside, quercetin 3-*O*-robinobioside and rutin.	Flavonoids	Antifungal (against *Aspergillus ochraceus*).	[157]
Heteropterys chrysophylla (Lam.) Kunth	Leaves & twigs	Palmitic acid	Fatty acids	Exhibited hormonal effects on prostate cancer cells	[158]
		Dihydroactinolide	Volatile terpene		
		Kaempferol-3-*O*-*α*-L-rhamnoside, kaempferol-3-*O*-*α*-L-rhamnose-(2-1)-*β*-D-xylopyranoside.	Flavonoids		
Heteropterys cotinifolia A. Juss.	Aerial parts	Chlorogenic acid	Hydroxycinnamic acids	Antidepressant	[91]
		Rutin	Flavonoids		
Heteropterys glabra Hook. &Arn. (*Syn. Heteropterys angustifolia* Griseb	Root	Hiptagin (1, 2, 4, 6-tetra-3-nitropropanoyl-*β*-D-gluco-pyranoside)	Aliphatic nitro compound	NA	[159]
	Fruits	NA	NA	Anxiolytic and sedative in DBA/2J mice.	[90]
Heteropterys tomentosa A. Juss. *(Syn. Heteropterys aphrodisiaca* (O.) Mach.	Roots	NA	Flavonoid, cardiac glycosides with steroidal nucleus, or pentagonal lactonic ring, saponins, hydro-lysable and condensed tannins and aliphatic nitro-compounds.	Improves learning and memory deficits in aged rats.	[97]
		2,3,4,6-tetra-*O*-(3-nitropropanoyl)-*O*-*β*-D-glucopyranoside	Aliphatic nitro compound	Antimicrobial (against *staphylo-coccus aureus, Bacillus subtilis, Candida albicans, C. parapsilosis, C. krusei, and C. tropicalis).*	[78]
		Neoastilbin, astilbin and isoastilbin	Flavonoids	NA	[160]
		2,3,4,6-tetra-*O*-(3-nitropropanoyl)-*O*-*β*-D-glucopyranoside	Aliphatic nitro compound	Antiviral (against poliovirus type-1 (PV-1) and bovine herpes virus type-1 (BHV-1) by plaque reduction assay).	[79]
		NA	NA	Stimulant and aphrodisiac (by reduce Cyclosporine A (CsA) induced injuries in the testis.	[161]

Heteropterys tomentosa A. Juss. (Syn. *Heteropterys aphrodisiaca* (O.) Mach.	Roots	NA	NA	Increasing the spermatogenic yield (by increase testosterone production and spermatogonia mitosis).	[162]
		NA	NA	Anabolic effects (Produce more organized collagen bundles and more resistant tendons to support higher loads from intense muscle contraction).	[163]
		Astilbin, isoastilbin and neoastilbin 2, 3, 4, 6-tetra-*O*-(3-nitropropanoyl)-*O*-*β*-D-glucopyranoside.	Flavonoids Aliphatic nitro compound	Memory retrieval improvement in aging rats and antioxidant	[164]
		NA	NA	A protective action against the side effects of Cyclosporin A on the ventral prostate tissue.	[165]
	Roots, branches & Leaves	Catechin, taxifolin, and rutin. Chlorogenic acid	Flavonoids Hydroxy-cinnamic acids	Not show evidence of adaptogenic effect	[166]
	Roots	Caffeoylquinic acids Taxifolin derivatives	Phenolic acids Flavonoids	Decrease the viability of astrocytes.	[167]
		NA	NA	Improves the endurance capacity of skeletal muscles in trained rats	[168]
		NA	NA	Effect on anxiety and male exposure of female mice with advanced age.	[169]
		Taxifolin and taxifolin 3-O-rhamnoside (astilbin).	Flavonoids	Adaptogenic effect.	[170]
Hiraea reclinate Jacq.	Leaves	Kaempferol 3-*O*-(6˝-galloyl) b-D-galactopyranoside, hyperin 6˝-gallate, vitexin 2˝rhamnoside, isovitexin 2˝rhamnoside, orientin 2˝rhamnoside, isoorientin 2˝rhamnoside. 1,3,4,5-tetragalloyl-quinic acid	Flavonoids Phenolic acids	AntiHIV	[81]
Malpighia glabra L. (Syn. *Malpigia punicifolia* L.)	Mature & immature fruit	Acethyl-methyl-carbinol, 2-methyl-propyl-acetate, limonene, E-Z-octenal, ethyl hexanoate, isoprenyl butirate and acetofenone, methyl hexanoate, 3-octen-1-ol and hexyl-butirate, methyl-propyl-ketone, E-Z-hexenyl-acetate and 1-octadecanol.	Volatile components	NA	[47]
	Fruit	Pelargonidin, malvidin 3,5-di-glycoside and cyanidin 3-glycoside Quercetin, and kaempferol *p*-Coumaric, ferulic, chlorogenic, caffeic acids.	Anthocyanins an anthocyanidin Flavonoids Hydroxy-cinnamic acids	NA	[40]

Malpighia glabra L. (Syn. *Malpigia punicifolia* L.)	Fruit	Lutein, *α*-carotene, and *β*-carotene	Carotenes	NA	[171]
		β-cryptoxanthin	Monohydroxy carotenoids		
		Violaxanthin	Dihydroxy carotenoids		
	Unripe & ripe fruit	Ascorbic acid	Vitamins	Antigenotoxic and antioxidant	[12, 172]
		Rutin and quercetin	Flavonoids		
	Fresh Pulp	NA	Ascorbic acid, anthocyanins, carotenoids, phenols, and flavonoids.	Cytotoxic and mutagenic effects of iodine-131 and radioprotection	[173]
	Fruit	NA	Volatile components, vitamins, and phenolic compounds	Antimicrobial (against *Pseudo-monas putida*, *P. fluorescens*, *P. fragi*, and *Brochothrix, thermo-sphacta* by agar well diffusion and agar dilution tests).	[174]
		Tocopherol, and *β*-carotene.	Carotenoids	Antioxidant	[175]
		Gallic acid, and ellagic acid.	Phenolic acids		
		Catechin, epicatechin, rutin, quercitrin, quercetin and kaempferol.	Flavonoids		
		Caffeic acid	Hydroxycinnamic acids		
	Fruit pulp	Kaempferol, myricetin, quercitin, and epicatechin	Flavonoids	Antioxidant	[176]
		Procyanidin B1	Procyanidin		
		Trans-resveratrol	Phenol		
	Leaves	Acacetin, hispertin, quercetrin, hesperidin, rutin, naringin and apigenin 6-glucose 8-rhamnose.	Flavonoids	Anticancer and antimicrobial activities	[82]
		NA	Cardiac glycosides, alkaloids, anthraquinone glycosides, carbohydrates, saponins, sterols and/or triterpenes, tannins, volatile constituents, and vitamins.		
		Caffeic acid, and chlorogenic acid	Hydroxycinnamic acids	Antioxidant	[68]
		Quercetin, and kaempferol	Flavonoids		
		Saponarin, vicenin, apigenin-C-hexoside-C-pentosyl, vitexin-*O*- pentoside, rutin, kaempferol, isorhamnetin-O-rutinoside, isoorientin, fisetin, luteolin, quercitrin, kaempferol−3-*O*-rutinoside, orientin, quercetin and myricetin.	Flavonoids	Hepatoprotective activity	[93]
		Caffeoyl quinic acid, caffeoyl feruloyl-quinic acid, *Trans*-Cinnamate and 4-methoxycinnamic acid.	Phenolic acids		

Malpighia emarginata DC.	Fruit	Vitamin C	Vitamins	Antimicrobial, and cytotoxic	[177]
	Ripe & unripe fruit	Tartaric acid, malic acid, and citric acid	Organic acids	Antioxidant	[178]
		Ascorbic acid	Vitamins		
		Catechin	Flavonoids		
		Caffeic, ferulic, and coumaric acids.	Hydroxycinnamic acids		
		Gallic acid, and syringic acid	Phenolic acid		
	Fruit	Cyanidin-3-*α* -*O*-rhamnoside and pelargonidin-3-*α* -*O*-rhamnoside.	Anthocyanins	Antihyperglycemic	[179]
		Cyanidin 3,5-hexose pentose, Cyanidin 3-glucoside, Cyanidin 3-rutinoside, Pelargonidin 3-glucoside, Peonidin 3-glucoside, Cyanidin 3-rhamnoside and Cyanidin.	Anthocyanins	NA	[180]
		Epigallocatechin gallate, epicatechin and rutin	Flavonoids	Antioxidant (by ABTS, DPPH and ORAC methods).	[181]
		Vitamin C	Vitamins		
		Chlorogenic acid	Hydroxycinnamic acids		
		Procyanidin B1	Procyanidin		
		NA	Vitamin C, phenolic compounds, and flavonoids	Antioxidant and antimicrobial	[182]
	Aerial parts	Acerolanins A, B, C	Tetranor-diterpenes	Cytotoxic	[39]
		Vitamin C	Vitamins		
		NA	Anthocyanins, flavonoids, and phenolics.		
	Ripe & unripe fruit	Vitamin C	Vitamins	Effect on brain energy metabolism of mice fed a cafeteria diet.	[183]
		Rutin	Flavonoids		
	Leaves	Rhinocerotinoic acid, and isotriptophenolide	Diterpene	Antioxidant and anti-fungal	[184]
		Quinic acid, and protocatechuic acid	Phenolic acids		
		Gallocatechin, apigenin-7-O-glucoside, and apigenin-8-O-glucoside	Flavonoids		
		Matricin	Sesquiterpene		
		Ascorbic acid, and vitamin B3	Vitamins	An immune-stimulatory and antiinflammatory.	[185]
		Rutin	Flavonoids		
		Ellagic acid	Phenolic acids		
		Caffeic acid	Hydroxycinnamic acids		
	Fruits	Chlorogenic and isochlororgenic acids	Hydroxycinnamic acids	Antioxidant	[69]
		Cyanidin, delphinidin-3*β*-D-glucoside, phloretin, peonidin	Anthocyanins		
		Genistein, luteolin, kaempferol, apigenin 7-glucoside, quercitrin, astragalin, kaempferol 3-O-*β*-glucoside, vitexin, malonylapiin and isovitexin	Flavonoids		

Niedenzuella multiglandulosa (A. Juss.)	Leaves	Trigonelline	Alkaloids	NA	[186]
		Tryptophan	Amino acids		
		4-hydroxy-cinnamic acid, cinnamic acid.and cis-p-coumaricacid4-O-*β*-D-gluco-pyranoside	Phenolic acids		
		Luteoforol	Flavonoids		
		Integristerone A, icariside F2, epiecdysterone, ecdysterone, calonysterone, and odecdysoneB.	Miscellaneous		
Stigmaphyllon ovatum (Cav.)	Leaves	NA	Alkaloids, steroids, flavonoids, terpenoids, phenolics, and eugenols	Antimalarial in *Plasmodium falciparum* infected mice	[187]
		NA	NA	Anticancer against human cervical carcinoma	[188]
*Stigmaphyllon paralias (*A. Juss.)	Aerial parts	Friedelin, lupenone, 3-oxo-*α*-amirin, 3-oxo-*β*-amirin, mixture of *α*-amirinyl palmitate and stearate, lupeol, *α*-amirine, and 3,4-seco-friedelan-3-oic acid.	Triterpenes	NA	[189]
		Luteolin-7-rutinoside	Flavonoids		
Tetrapterys mucronate Cav.	Bark	Mucronatin B, 5-hydroxy-N, N-dimethyltryptamine (bufotenine), 5-methoxy -N-methyl-tryptamine, 5-methoxy-N, N di-methyl-tryptamine, trans-N feruloyl-tyramine (Moupinamide), and 2-methyl-6-methoxy-1,2,3,4-tetrahydro-*β*-carboline.	Alkaloids	AntiAlzheimer (acetylcholine-esterase inhibition in a TLC bioautography assay).	[55]
		Gentisic acid, gentisic acid 5-O-*β*-xyloside, vanillic acid, and methoxy-4,5-(methylenedioxy) cinnamic acid.	Phenolic acids		
		Catechin	Flavonoids		
		2,6-phenanthrenediol, 7-methyl-2,6-phenan-threnediol, and 6-dihydroxy-9,10 dihydro-phenanthrene.	Phenanthrene derivative		
		Lyoniside, cannabisin F, and smilaside L	Carbohydrate		
		Nudiposide-9′-dihydroxy-benzoic acid	Aromatic acids		
	Stem bark	Bufotenine, 5-methoxy-N-methyl-tryptamine, 5-methoxy-bufotenine, 2-methyl-6-methoxy-1,2,3,4-tetrahydro-carboline.	Alkaloids	NA	[56]
Tristellateia australasiae (A. Rich)	Leaves & stem	Acyclic hexitol, and dulcitol	Alcohol	NA	[190]
		Isorhamnetin	Flavonoids		
		Friedelin, epifriedelinol, *β*-amyrin, lupeol and *β*-sitosterol.	Steroids and triterpenes		
Tristellateia madagascariensis	Leaves	NA	NA	Antimalarial	[191]

NA: Not available

2. Experimental

Different databases are used to collect data conduct research, including SciFinder, PubMed, Science Direct, Scopus, Plos One, Web of Science, and Google Scholar in addition other sources including books, thesis, and official websites. "The Plant List" (www.theplantlist.org) was used to verify the accepted species number and names. All chemical structures were drawn using *ChemDraw* Ultra 7.0 software.

3. Distribution

Tropical and subtropical regions are the primary habitats for the plants of this family. The New World (the Caribbean and the southernmost United States to Argentina) has about 80% of the genera and 90% of the species, whereas the Old World (the remainder of the world including Africa, Madagascar and Indomalaya to New Caledonia and the Philippines) has the rest. Seven species of five genera are native to the warmer parts of the country: *Byrsonima* in southern Florida, *Malpighia* and *Thryallis* in Texas, and *Aspicarpa* and *Janusia* in western Texas and southern Arizona. *Banisteria* is one of the bigger genera in the family, with roughly 16 species native to Mexico [3]. There is no genus or species that is found in both hemispheres. A Caribbean and Atlantic coast species of a huge American genus, *Stigmaphyllon ovatum* (Cav.) Nied., has been collected numerous times in western Africa. *Heteropterys leona* (Cav.) Exell is a well-known species in western Africa, but it's hard to distinguish it from its closest relatives *H. platyptera* DC. and *H. multiflora* (DC.) Hochr., which grow in the Caribbean and along the Atlantic coast of Central and South America [8].

4. Traditional uses

A set of herbal preparations used in the Indian traditional health care system contains a variety of medicinal plants that have been used for thousands of years (Ayurveda). Although the species of Malpighiaceae family may not have a great economic potential, *Malpighia glabra* (Barbados cherry) and *Malpighia emarginata* (Acerola) have a high nutritional value due to their high vitamin C content [12, 13]. The juicy fruits of *Byrsonima* and *Malpighia* are also consumed fresh, prepared, or as canned juices, in jellies, ice cream, and preserves that are popular in Latin American cuisine [14]. *Malpighia* genus has not been widely utilized in traditional medicine, however *Malpighia glabra* is used as a tonic and diuretic [15].

Acridocarpus, *Banisteriopsis*, *Byrsonima*, *Galphimia*, *Heteropterys*, *Malpighia*, *Peixotoa*, and *Stigmaphyllon* species are also grown as ornamental plants [13, 16]. *Aspidopterys obcordate* has a long history in Dai traditional medicine, and it contains some important biochemical compounds with anti-phlogistic and diuretic effects that could be used to treat acute, chronic nephritis, cystitis, rheumatism, bone pain, and to expel stone as well as postpartum weight loss in the form of a health tea and children's digestive diseases [17-20]. *A. andamanica* and *A. cordata*, on the other hand, are utilized as postpartum remedy [15].

Several species of *Acridocarpus* are still used as a folk medicine all over the world, and more specific studies to support this is needed. Some species are reported to have many ecological advantages as well. Stomachaches are traditionally treated with *Acridocarpus alternifolius* roots, whereas diarrhoea and dysentery are treated with *A. excelsus* bark, which is an astringent. The root of *A. longifolius* is used to cure venereal diseases and stomach problems as a laxative. Its leaf sap is used to treat eye infections and as a febrifuge; however, its root and leaf sap are utilized to treat cutaneous and subcutaneous parasite infections. *A. plagiopterus* root is used as a febrifuge, vermifuge, reptile repellent, and for sleep sickness, superstitions, and magic, while *A. spectabilis* roots are used as diuretics, cutaneous and subcutaneous parasitic infection, kidney and nasopharyngeal affections, ceremonial, and superstitions [15].

According to folklore medicine, *A. smeathmannii* roots are used for aphrodisiac, anti-anemia, pain killers, and various cutaneous and subcutaneous parasite infections. Several Ayurvedic preparations containing *A. smeathmannii* root were used as aphrodisiacs and used to enhance fertility and barrenness. The effect of *A. Smeathmannii* (DC.) root on reproductive potentials and biochemical pathways in male Wistar rats was investigated in a pharmacological study to determine its folkloric medicine application [21-23]. In Yemen, *A. socotranus* is widely traditionally used to relieve headaches, paralysis, and muscle discomfort. While *A. orientalis* (AO) is a traditional medicinal plant

used for treatment of inflammatory diseases that may have potential in cancer treatment. *A. orientalis* has primarily been recorded from the border areas of UAE and Oman, where it is used for the treatment of muscle pain, headaches, paralysis, tendon, and joint pains as well as to treat the udder inflammation in cattle [24-27].

However, some Malpighiaceae species are used traditionally as CNS modulators. *Banisteriopsis caapi* distinguishes particularly among them because it is the main ingredient in Ayahuasca, an Amazonian psychoactive beverage used in religious ceremonies that contains 5-HT2A receptor agonist N, N-dimethyltryptamine (DMT), as well as monoamine oxidase inhibitor alkaloids (harmine, harmaline and tetrahydroharmine) [28-30]. The vine *Banisteriopsis caapi* is a primary source of *β*-Carbolines alkaloids in the ayahuasca drink, which is made by mixing its stems with the leaves of *Psychotria viridis*. The monoamine oxidase inhibitory (MAOi) action of the vine has been related to the traditional explanation of the vine's participation in this psychedelic beverage [31]. *Diplopterys cabrerana* (also known as *Banisteriopsis rusbyana*) is a hallucinogenic plant that has been used for religious, medical, and social purposes. Ayahuasca is a psychoactive substance used in religious ceremonies. It is an ingredient in the entheogenic tea, a South American hallucinogenic beverage produced by Amazon Indians from the bark of the Malpighiaceous liana *B. caapi* combined with the leaves of other admixture plants, such as *Psychotria viridis*, *Psychotria carthagenensis*, or *Diplopterys cabrerana* [15].

Some species of genus *Bunchosia* have been used traditionally as natural remedies, among of which *Bunchosia armeniaca* is used to treat endocrine, infectious, inflammatory, nutritional, and metabolic disorders, as well as some types of cancer [32]. Seeds of *Bunchosia nitida* (Jacq.) DC. were reported to be used as purgative and antiemetic. While *Bunchosia swartziana* Griseb. is used for externally for scabies while flower juice is often used in ear pain. The leaves and bark are used in treating fungal diseases. While the leaves, bark and flowers are aromatic in nature, and are commonly used as a refrigerant, expectorant, cardiotonic, anti‑ inflamm-atory and insecticidal. They are used in burning sensation, wounds, ulcers, leprosy, epilepsy, convulsion, magic, ritual, and ceremonial to sweep away evil winds or spirits. Tea made from the roots of *Bunchosia glandulosa* (Cav.) DC. has been used for fertility, ritual, and ceremonial purposes, as well as to ward off evil spirits [15].

A decoction of the dry bark of *Byrsonima crassifolia* is used to treat asthma, bronchitis, colds, coughs, fevers, tonsillitis, and skin infections; an infusion is used to treat diarrhoea, gastrointestinal diseases, chronic colitis, chest colds, pulmonary complaints, wounds, skin diseases, stomachache, and as a snakebite antidote. Pounded bark was applied to wounds as a poultice, while pulverized bark was applied to ulcers. Leaves and bark is used to cure diarrhea, the bark ground in water and applied directly to the skin to treat measles. In the Amazonian savannas, *Byrsonima crassifolia* and *B. coccolobifolia*, sometimes known as mirixis, muricis, mantecos, or nances, are the most frequently used fruit species. Their fruits are used to make juices and other beverages, while the rest of the plant is used for a variety of reasons by some indigenous people. A decoction of bark from *Byrsonima spicata* is an antidote for rattlesnake bites, as well as a purgative and febrifuge [15, 33]. *B. japurensis* A. Juss. is used in folk medicine in rural areas of Amazonas State (Brazil), where it is known as "saratudo" and is used to treat gastrointestinal and genitourinary tract disorders, as well as being a potent anti-inflammatory [34].

Flabellaria paniculata leaves are used for skin infections and wound dressing. Leaves, seeds, and pods of *Heteropterys leona* have traditionally been used as an antiparasitic, febrifuge, analgesic, and as topical application for headaches and fevers [15]. *Hiptage benghalensis* is a plant that is used in traditional medicine. The leaf is considered one of the important plant organs for the treatment of many diseases. In Ayurveda, the leaves and bark are considered vulnerary, and the leaves are highly recommended for treating skin diseases. The leaf juice possesses insecticidal properties and is applied

cardiac debility, rheumatism, and hyperdipsia. The plant is also used in the treatment of chronic rheumatism, cough, and asthma [15, 35-37].

Stigmaphyllon emarginatum bark is used to reduce stress, while the stems and leaves of *Stigmaphyllon sinuatum* are crushed and used for hair cleaning. As a contraceptive, the seed is swallowed.

Tetrapterys mucronata is a plant used in the preparation of ayahuasca in various parts of Brazil. A narcotic drink is made from its bark. *Tristellateia australasiae* is the last species on the list, and its pounded leaves are used to cure inflammation and edoema [15]

5. Phytochemical constituents

Due to the presence of several secondary metabolites, Malpighiaceae is well known for its therapeutic importance. Extensive and in-depth investigations of various genus have resulted in the isolation and characterization of various secondary metabolites belonging to alkaloids, triterpenoids, anthocyanins, steroids, flavonoids, isoflavonoids, volatile constituents, phenols, and phytosterols and tannins [38-40], which are listed in **Table 1** along with their chemical structures **(Fig. 1-6)**.

Volatile constituents and fatty acids (Fig. 1, 2):

The main volatile constituents identified in the essential oil (EO) of *Acridocarpus orientalis* stem were methyl 8-pimaren-18-oate (43.8 %), octacosane (5.8 %), heptacosane (4.6 %) and hexacosane (4.1 %), methyl dehydroabietate (3.9 %) and methyl pimar-8(14)-en-18-oate (3.6 %), while tetracosane (16.6 %), heptacosane (16.4 %), docosane (13.9 %), hentriacontane (13.5 %), heneicosane (10.9 %) and *α*-pinene (7.7 %) were all found in abundance in the EO of leaves [41]. Hexadecanoic acid (39.43%), (E)-nerolidol (10.51%), triacontane (9.08%), heptacosane (5.49%) and linalool (3.23%) were found in the essential oil of *Banisteriopsis campestris* flowers, along with other constituents such as myristic acid, palmitic acid, and linoleic acid, whereas the leaves had palmitic acid (22.98%), phytol (22.98%), and triacontane (14.88%) and the stem contained palmitic (49.79%), linoleic (11.63%), oleic (4.83%), and palmitoleic (4.15%) fatty acids; in the root included palmitic acid (57.39%), linoleic (10.38%), and oleic acids (5.47%) [42, 43].

Phytochemicals such as 4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl, 1H-pyrrole-2,5-dione, 2-furancarboxaldehyde,5-(hydroxymethyl), 1-nonadecene, 3-eicosense, 2-furanmethanol, 9,12,15-octadecanoic acid, methyl ester and *n*-hexadecanoic acid were found in the fruits of *Bunchosia armeniaca* [44]. Lauric acid, linolenic acid, docosadienoic acid, myristic acid, cerotic acid, myristoleic acid, palmitic acid, palmitoleic acid, stearic acid, oleic acid, arachidonic acid, and behenic acid were identified in the pulp and seed of the *Bunchosia glandulifera* fruit. The pulp has higher concentration of fatty acids than the seed. Palmitic acid was the most prevalent. Stearic acid was also present in high concentrations. This acid was found in higher concentration in the seed than in the pulp [45].

A phytochemical analysis of *Byrsonima gardneriana* leaf extract revealed that pyroglutamic acid, octanoic acid, and other acids such as hexadecanoic and heptanoic acids predominated. Pyroglutamic acid (90.77%) and octanoic acid (76.22%) were the most common compounds found in the extract [46]. The volatile fraction acerola (*Malpighia punicifolia*) was studied to identify 31 compounds in the mature (red) fruits, such as acethyl-methyl-carbinol, 2-methyl-propyl-acetate, limonene, E-Z-octenal, ethyl hexanoate, isoprenyl butirate and acetofenone; 23 in the intermediate (yellow), such as, methyl hexanoate, 3-octen-1-ol and hexyl butirate; and 14 in the immature (green) fruit, such as methyl-propyl-ketone, E-Z-hexenyl-acetate and 1-octadecanol [47].

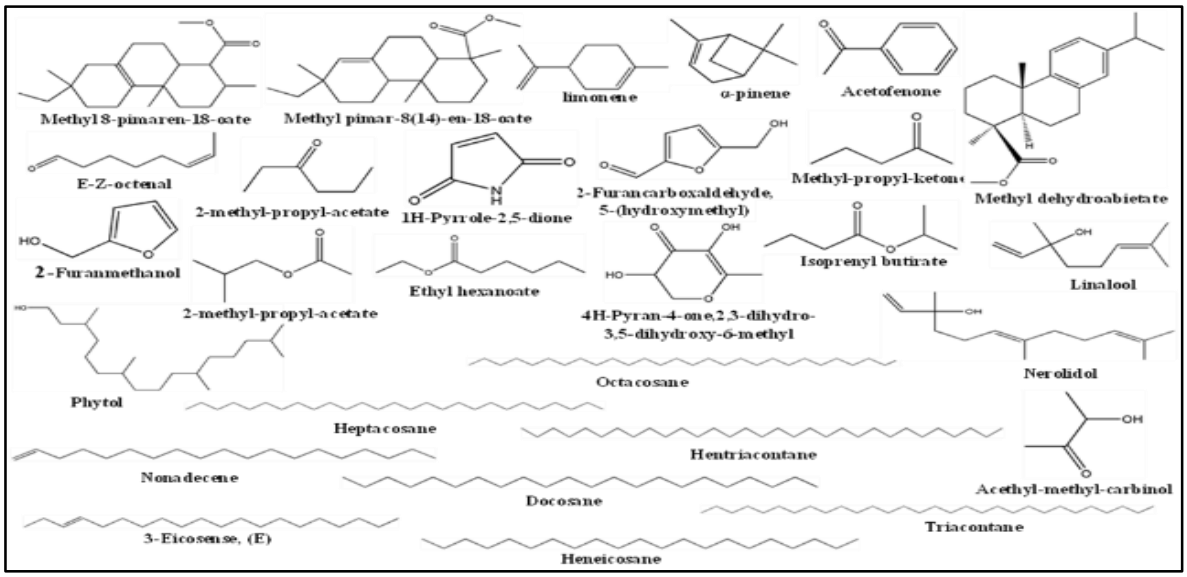


Fig. (1): Chemical structures of some volatile constituents of different genera of family Malpighiaceae

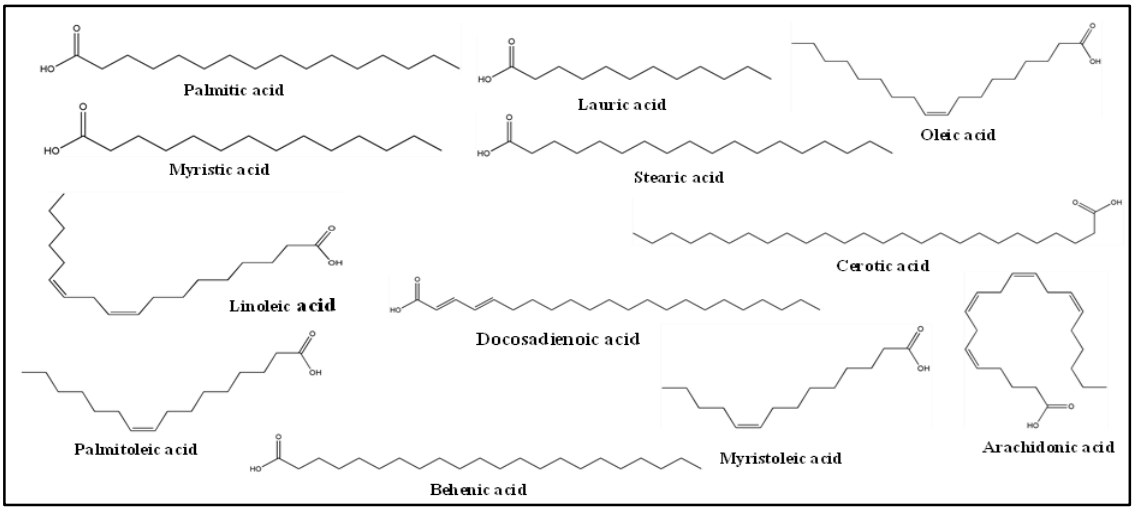


Fig. (2): Chemical structures of some fatty acids of different genera of family Malpighiaceae

Phenolic compounds (Fig. 3, 4):

Morin and morin-3-*O*-D-glucopyranoside were isolated through extraction and separation from leaves and aerial parts of *Acridocarpus orientalis* [24, 48]. The phenolic substances flavonoids and proanthocyanidins were abundant in the ethanolic extract, ethyl acetate fraction (EAF), and butanol fraction (BF) of *Banisteriopsis argyrophylla* leaves. Some of these compounds, such as catechin, quercetin-hexoside, quercetin-pentoside, and quercetin-3-*O*-L-rhamnose, have been identified by ESI-MS/MS in both EAF and BF due to solvent polarity similarities. However, only the EAF yielded kaempferol-3-O-L-rhamnse, quercetin-3-*O*-(2"-galloyl)-L-rhamnose, or quercetin-3-*O*-(3"-galloyl)-L-rhamnose. Only the BF had quinic acid, the procyanidin dimer, the procyanidin dimer monogallate, and dihydroxy benzoic acid pentoside [49, 50]. Epicatechin and procyanidin B2, two known proanthocyanidines, were found in aqueous extracts of stem and stem bark *Banisteriopsis caapi* [29, 51]. By capillary electrophoresis and nuclear magnetic resonance of 1H and 13C, *Bunchosia armeniaca* afforded a mixture of flavonoid constituents, quercetin *α*-L-rhamnopyranosyl-(1→6)-*β*-D-glucopyranose) (rutin), kaempferol 3-O-*α*-L-rhamnopyranoside (afzelin) and quercetin 3-O-*β*-D-glucopyranoside (isoquercitrin) [52]. As shown in the Table (1), many phenolic acids and flavonoids have been extracted from several Malpighiaceae species.

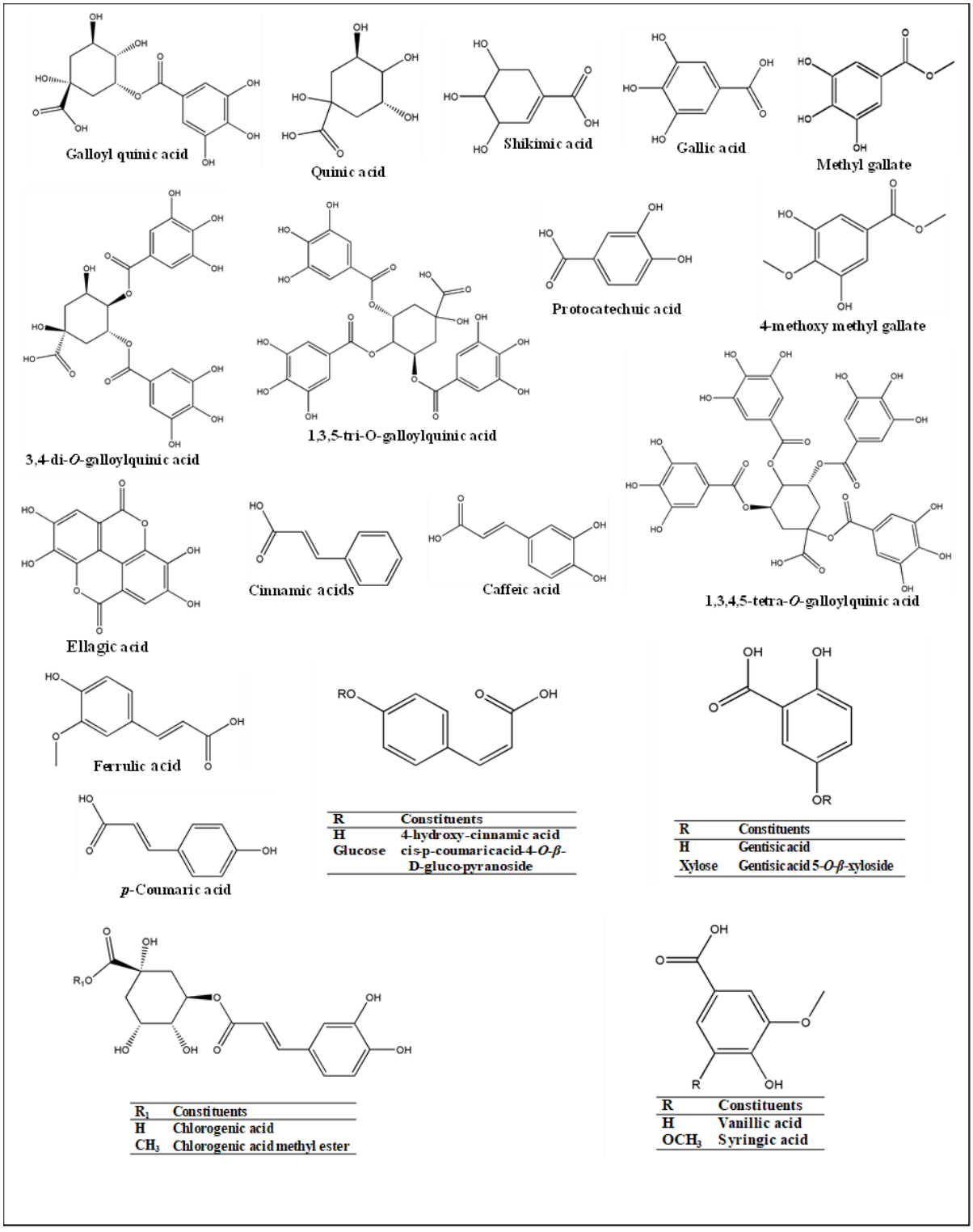
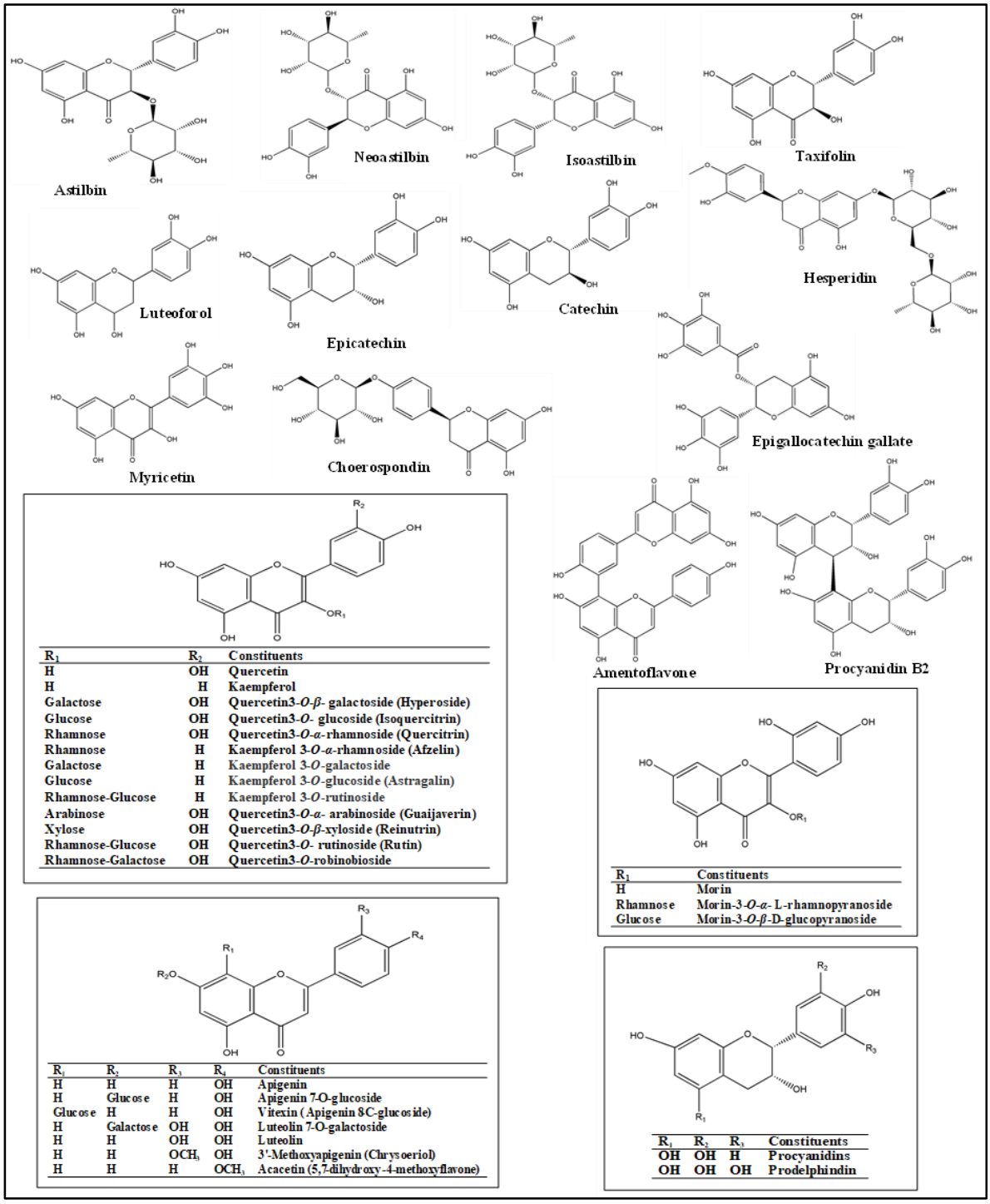


Fig. (3): Chemical structures of some phenolic acids of different genera of family Malpighiaceae



R_1	R_2	Constituents
H	OH	Quercetin
H	H	Kaempferol
Galactose	OH	Quercetin3-*O*-*β*- galactoside (Hyperoside)
Glucose	OH	Quercetin3-*O*- glucoside (Isoquercitrin)
Rhamnose	OH	Quercetin3-*O*-*α*-rhamnoside (Quercitrin)
Rhamnose	H	Kaempferol 3-*O*-*α*-rhamnoside (Afzelin)
Galactose	H	Kaempferol 3-*O*-galactoside
Glucose	H	Kaempferol 3-*O*-glucoside (Astragalin)
Rhamnose-Glucose	H	Kaempferol 3-*O*-rutinoside
Arabinose	OH	Quercetin3-*O*-*α*- arabinoside (Guaijaverin)
Xylose	OH	Quercetin3-*O*-*β*-xyloside (Reinutrin)
Rhamnose-Glucose	OH	Quercetin3-*O*- rutinoside (Rutin)
Rhamnose-Galactose	OH	Quercetin3-*O*-robinobioside

R_1	Constituents
H	Morin
Rhamnose	Morin-3-*O*-*α*- L-rhamnopyranoside
Glucose	Morin-3-*O*-*β*-D-glucopyranoside

R_1	R_2	R_3	R_4	Constituents
H	H	H	OH	Apigenin
H	Glucose	H	OH	Apigenin 7-O-glucoside
Glucose	H	H	OH	Vitexin (Apigenin 8C-glucoside)
H	Galactose	OH	OH	Luteolin 7-O-galactoside
H	H	OH	OH	Luteolin
H	H	OCH_3	OH	3'-Methoxyapigenin (Chrysoeriol)
H	H	H	OCH_3	Acacetin (5,7-dihydroxy-4-methoxyflavone)

R_1	R_2	R_3	Constituents
OH	OH	H	Procyanidins
OH	OH	OH	Prodelphindin

Fig. (4): Chemical structures of some flavonoids of different genera of family Malpighiaceae

Steroids and terpenoids (Fig. 5):

Steroids and lupane-type triterpenoids such as *β*-sitosterol, *β*-sitosterol-3-*O*-*β*-D-glucopyranoside, betulin, betulinic acid isolated from methanolic extract and dichloromethane fraction of *Acridocarpus orientalis* [48, 49]. Spasmogenic bioassay-guided fractionation of methanol extract of *Byrsonima crassifolia* leaves yielded mixtures of identified triterpenes: betulin, betulinic acid, and ursenaldehyde [50]. The potent antitubercular substances alkane dotriacontane, triterpenoids as bassic acid, *α*-amyrin acetate , a mixture of lupeol, *α*- amyrin, *β*-amyrin and a mixture of lupeol, and acetates of *α*- and *β*-amyrin were isolated from the chloroform extract of *Byrsonima fagifolia* leaves using bioassay-guided fractionation [51]. Two

triterpenoids (friedelin and friedelanes), two steroids (*β*-sitosterol and sitosterol-*β*-D-glucoside) were isolated from the ethyl acetate fraction of leaves of *Flabellaria paniculate* [52].

Alkaloids (Fig. 6):

Harmic amide, acetyl norharmine, and keto-tetrahydronorharmine, banistenoside A, banisteno-side B, and their acetate, tetrahydroharmine, harmaline, and harmine were isolated from *Banisteriopsis caapi* [28, 29, 53, 54]. The extraction and purification of bark of *Tetrapterys mucronate* revealed the presence of alkaloid compounds as mucronatine B, 5-hydroxy-N, N-dimethyltryptamine (bufotenine), 5-methoxy -N-methyl-tryptamine, 5-methoxy-N, N di-methyl-tryptamine, trans-N feruloyl-tyramine, and 2-methyl-6-methoxy-1,2,3,4-tetrahydro-*β*-carboline [55, 56].

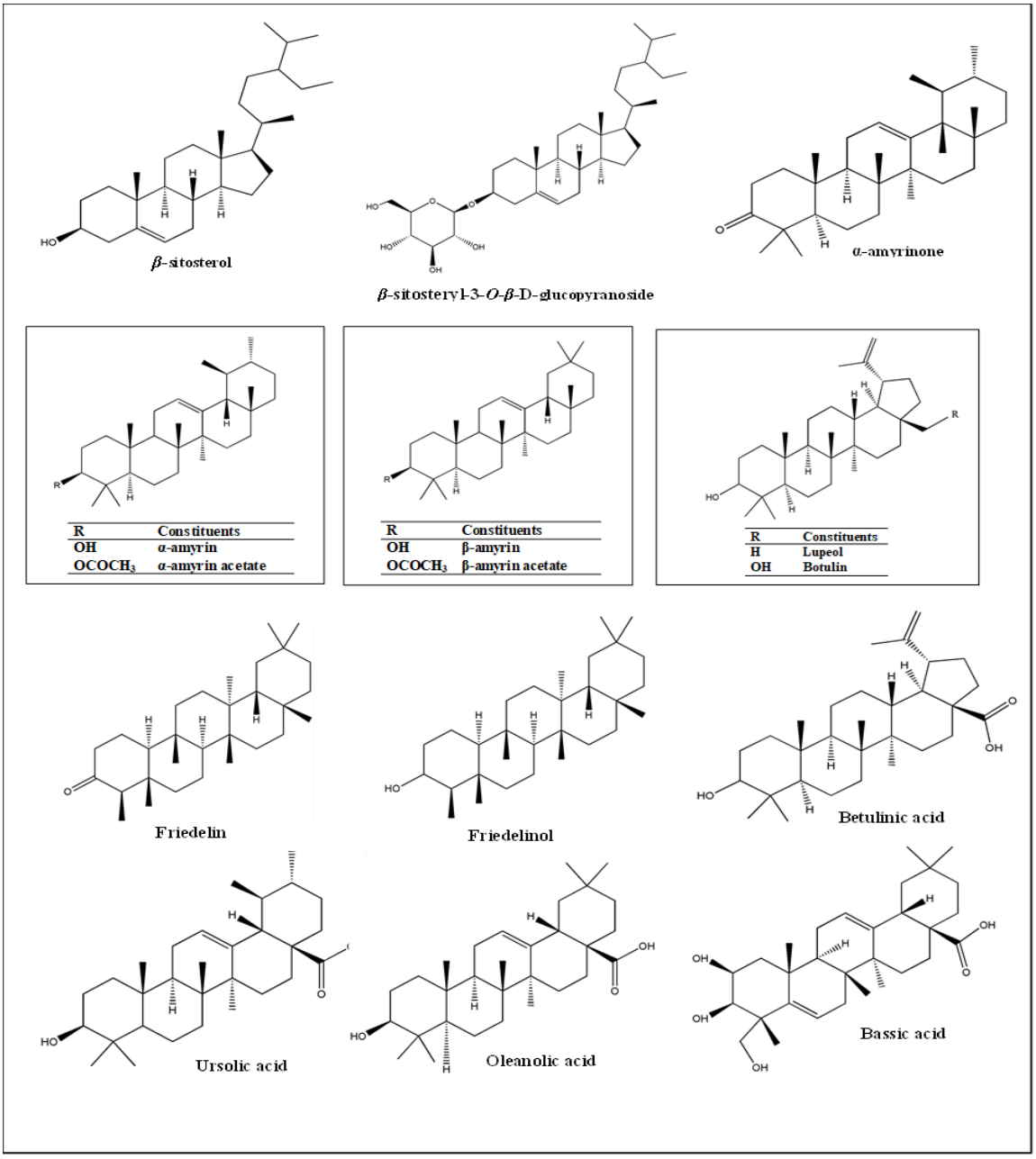


Fig. (5): Chemical structures of some steroids and triterpenoids of different genera of family Malpighiaceae

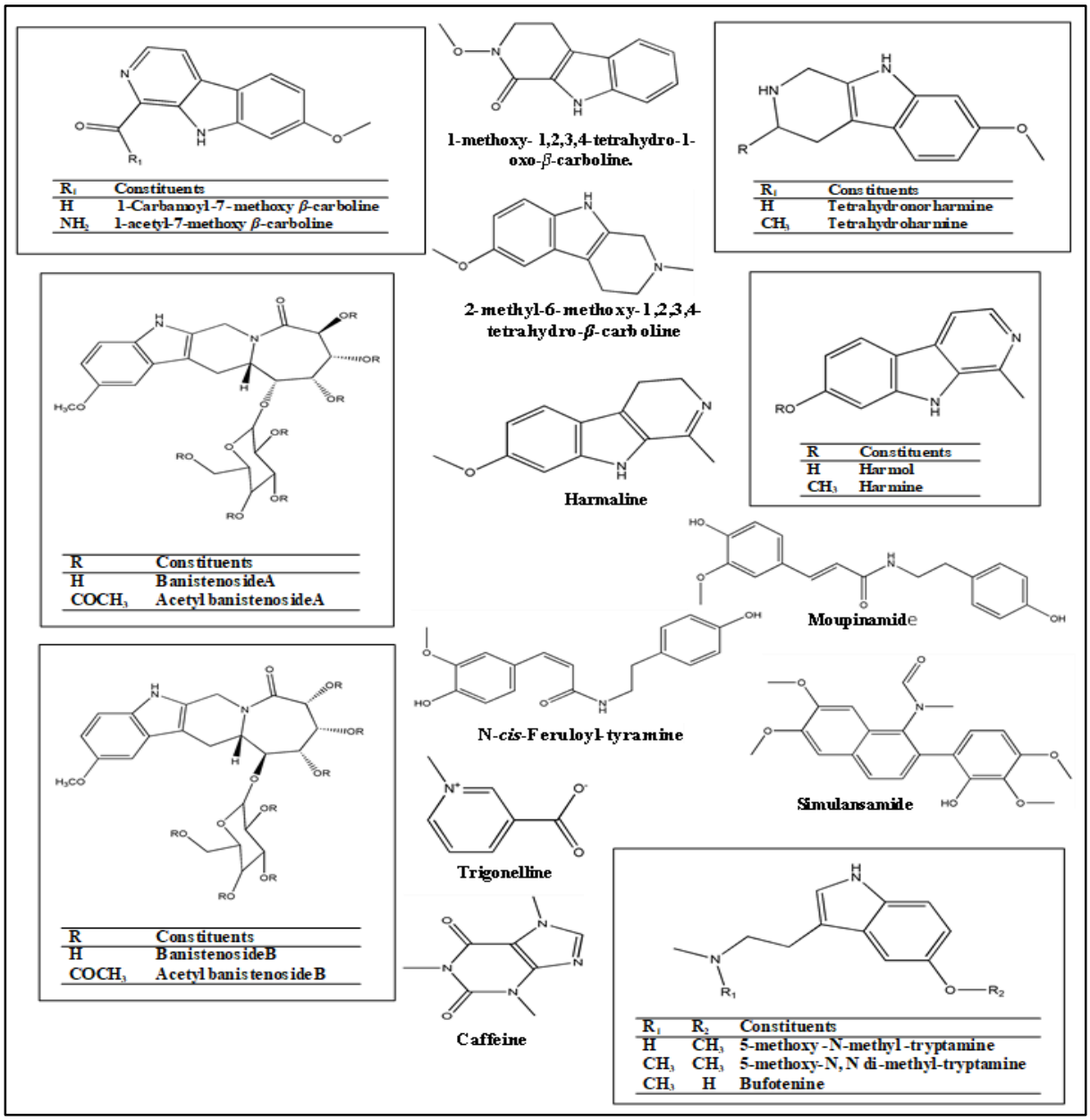


Fig. (6): Chemical structures of some alkaloids of different genera of family Malpighiaceae

5. Pharmacological activities

In various Malpighiaceae species, a diverse range of biological activities has been reported. Malpighiaceae have been discovered to have a wide range of biological actions, including antioxidant, antiinflammatory, antidiabetic, anticancer, antilipid peroxidation, antibacterial, hepatoprotective, neuroprotective, anxiolytic, and antidepressant properties, according to the literature. A summary of the curative activity assessments performed on this family has been represented in Table 1. These findings endorse the traditional uses of plants with respect to the pharmacological actions.

Antioxidant activity

The antioxidant potential of the plants of family Malpighiaceae most probably is attributed to the presence of phenols and flavonoids [57]. The ethyl acetate fraction of *Acridocarpus orientalis* stem had a greater antioxidant effect than the leaves using DPPH (1,1-Diphenyl-2 picrylhydrazyl) radical scavenging activities. This is probably due to the high flavonoid and phenolic content [27]. The methanolic extract of *Aspidopterys indica* (wild.) aerial parts exhibited high DPPH scavenging antioxidant activity, but while aqueous and chloroform extracts showed a moderate effect. The ethanolic extract of *Banisteriopsis argyrophylla*

leaves exhibited the lowest IC_{50} value in the DPPH free-radical sequestration assay, comparable to the positive BHT and ascorbic acid controls. In the ORAC (oxygen radical absorbance capacity test), the EE had a strong antioxidant activity. According to both antioxidant activity techniques (DPPH, and ORAC), the ethyl acetate fraction and *n*-butanol fraction displayed high antioxidants, with similar values to the ethanolic extract and controls [58].

Bunchosia armeniaca leaf ethyl acetate and *n*-butanol fractions displayed strong antioxidant activity. This implies that the scavenging action of free radicals with DPPH is mainly attributed to the presence of flavonoids content [59]. *Bunchosia armeniaca* methanolic fruit extract demonstrated a significant free radical scavenging efficacy comparable to butylated hydroxytoluene (BHT). The antioxidant activity of the fruit extract was higher than BHT on average. As a result of *in-vitro* investigation, *Bunchosia armeniaca* fruit can be considered a substantial source of antioxidant constituents [44]. Ferric ion Reducing Antioxidant Potential **(**FRAP**)**, 2,2′-Azinobis-(3-Ethyl-benzothiazoline-6-Sulfonic Acid (ABTS), DPPH, and electrochemical techniques were used to assess the total antioxidant capacity of *Bunchosia glandulifera* extracts. The antioxidant capacity of root and leaf ethanolic extracts was very high, followed by bark, fruit pulp, and seed extracts, which had lower values. The presence of phenolic compounds is mainly responsible for antioxidant activity [60].

The DPPH reduction assay revealed that methyl gallate and methyl *m*-trigallate fractions of leaf extract of *Byrsonima bucidaefolia* had higher antioxidant activity than vitamin C [61]. The fruit extract of Murici (*muByrsomina crassifolia* can interfere with brain electrophysiological parameters, demonstrating a novel strategy for combating the effects of ageing in the brain. Murici contains significant chemicals that have improved antioxidant actions while also increasing protection from free radicals. It was reported that Murici extract may be useful in preventing aging-related damage, such as reactive species production [62]. The combination of *Byrsonima crassifolia* (L.) Kunth and *Spondias mombin* L. can act synergistically in the improvement of the antioxidant capacity in the beverage's development. In the DPPH, ABTS, and FRAP techniques, *Spondias mombin* L had higher antioxidant capacity than *Byrsonima crassifolia*, however there was no significant difference in ORAC [63]. In the phosphomolybdenum, DPPH, and Thiobarbituric Acid Reactive Substances (TBARS) assays, leaves of *Byrsonima duckeana* revealed high polyphenol content and antioxidant capacity. The ethyl acetate fraction has high antioxidant capability, including free radical scavenging and lipid peroxidation inhibition, which might benefit for pain relief. In addition, chemical analysis of the ethyl acetate fraction revealed that ethyl gallate is a prominent ingredient, which could explain the high antioxidant activity detected [64].

Hydroethanolic extract of *Diplopterys pubipetala* leaves and stems demonstrated antioxidant activity. The stem extract had moderate antioxidant activity, whereas leaves had higher activity. The phytochemical investigation of *D. pubipetala* revealed the presence of flavonoids, alkaloids, and terpenes, as well as prenylated xanthones and glycoside flavonoids, all of which contribute to the medicinal potential of the plant, which is mostly antioxidant [65]. The phosphomolybedum assay was used to evaluate ethanol, aqueous, and chloroform extracts of *Flabellaria paniculata* leaf and root for free radical scavenging against DPPH and hydroxyl radicals, ex vivo lipid peroxidation, ferrous ion chelating activity, reducing power, and total antioxidant capacity. They had high hydroxyl radical scavenging capacity and reduced lipid peroxidation. The leaf and root extracts inhibited lipid peroxidation and scavenged hydroxyl radicals significantly. The extracts also exhibited moderate chelating properties, which could explain their affinity for iron (Fe) and thus their antioxidant properties [66].

The antioxidant activity of methanolic extracts of *Galphimia glauca* bark and leaf was investigated using DPPH Free Radical Scavenging (DFRS), Ferric ion Reducing Antioxidant Potential (FRAP), and Ferric Reducing Power (FRP) assays. Using three assays, methanolic extract of bark had somewhat better antioxidant activity than methanolic leaf extract [67]. The methanolic extract of *Malpighia glabra* .L leaves showed higher antioxidant activity towards DPPH radical with IC_{50} = 49.8(mg/ml) [68]. Immature *Malpighia emarginata* fruit alcoholic extract had stronger DPPH and ABTS scavenging activity than mature fruit one. There were strong relationships between antioxidant potential and its ascorbic acid concentration [69].

Antidiabetic activity

In *α*-glucosidase enzyme inhibition assay, *n*-hexane, chloroform, *n*-butanol, and aqueous fractions obtained from stem of *Acridocarpus orientalis* exhibited significant inhibition. In comparison to the standard inhibitor Acarbose, the leaf aqueous fraction demonstrated modest inhibition. These findings revealed crucial details about the fractions that contain active components,

which are responsible for enzyme inhibition [27]. Along with ethanolic extract, ethyl acetate fraction and *n*-butanol fraction from *Banisteriopsis argyrophylla* leaves had higher inhibitory actions of *α*-amylase, *α*-glucosidase, and pancreatic lipase. The presence of phenolic substances, catechin, procyanidins, and glycosylated flavonoids produced from quercetin, kaempferol, and megastigmane glycosides can explain remarkable actions found [58].

Hexane and chloroform extracts from *Byrsonima crassifolia* fruits and seeds raised superoxide dismutase (SOD), glutathione (GSH), oxidized glutathione (GSSG), and catalase (CAT) levels, as well as hepatic glycogen content, glucose-6-phosphatase (G6Pase), and plasma insulin levels. They also reduced the levels of glucokinase (GK) and TBAR (thio- barbituric acid assay). After four hours of a single oral dose, *Byrsonima crassifolia* has considerable antihyperglycemic effects and can also improve streptozotocin-induced diabetic rats with hyperlipidemia and hyperinsulinemia. Both extracts inhibited the production of AGEs (advanced glycation end products) with IC_{50} values ranging from 94.3 to 138.7 µg/ml. [70]. Sesquiterpene lactone dimeric guaianolides Byrsonina A and Byrsonina B, which were isolated from hexane extracts of *Byrsonima crassifolia* seeds, have antioxidant, hypoglycemic, and hypolipidemic properties, and play a key role in blood glucose control in STZ-induced hyperglycemia by improving pancreatic islet function, increasing glycolysis, and decreasing gluconeogenesis. The mechanism of antidiabetic activity may involve an antioxidant effect, improvement in insulin resistance, and an effect on pancreatic *β*-cells to secret insulin [71].

In alloxan-induced diabetic rats, the methanolic leaves extract of *Hiptage bengalensis* reduced blood glucose levels significantly at doses of 100 and 200 mg $kg^{-1}$and had a positive effect on the lipid profile. These findings revealed that a methanolic extract of *Hiptage bengalensis* provided antihyperglycemic action in rats that was dose dependent [72]. The lipid and lipoprotein levels were significantly improved after administration of the ethanolic extract of *Hiptage bengalensis* and its fractions orally for 21 days. The extracts and fractions restored lipid and lipoprotein levels to normal levels, possibly due to its potent antidiabetic activity. After Streptozotocin (STZ) diabetic rats were treated with ethanolic extract, their urea and creatinine levels were significantly reduced, and serum total protein and albumin levels were significantly higher than normal [73].

Antimicrobial activity

Chaetomium globosum was mildly inhibited by *n*-hexane and aqueous fractions of *Acridocarpus orientalis*, while *Fusarium oxysporum* mold was stimulated by *n*-hexane, chloroform, *n*-butanol, and aqueous fractions. In the case of *Aspergillus niger*, none of the plant fractions impeded the fungal growth [27]. *Bunchosia glandulifera* leaves ethanolic extract had antibacterial efficacy against *Klebsiella pneumonia*. The extract was tested for antimicrobial activity using the agar well diffusion method in Muller Hinton Agar (MHA) plates [74]. *B. armeniaca* crude hydroalcoholic leaves extract showed high antibacterial activity against *S. aureus* and moderate activity against *E. coli* and *P. aeruginosa*. The activity of a flavonoid compound mixture containing rutin, afzelin, and isoquercitrin was also investigated, and it exhibited remarkable activity against all the microorganisms tested [59].

Four components of the methanolic extract of leaves from *Byrsonima crassa*, a Brazilian medicinal plant, quercetin, methyl gallate, epigallocatechin gallate, and quercetin-3-*O*-(2"-galloyl)-*α*-L-arabinopyrano-side, evoked considerable antibacterial activity against tested pathogenic strains of oxacillin-resistant *S. aureus*, coagulase-negative *S. saprophyticus*, *E. coli* (two different strains), *Proteus mirabilis* and *P. aeruginosa* (two different strains) [75]. The pure triterpene bassic acid with potent antitubercular activity was obtained by bioassay-directed separation of the chloroform extract of *Byrsonima fagifolia* leaves. The Microplate Alamar Blue Assay (MABA) was used to test antimycobacterial activity, and spectroscopy was used to determine the structures of interesting compounds [51].

The crude extract of *Flabellaria Paniculata* possesses antimicrobial properties. *S. aureus* > *P. aeruginosa* > *K. pneumoniae* > *E. coli* were the most susceptible to the extract in that order. The chloroform fraction had the highest antibacterial activity, while petroleum ether was absolutely inactive [76]. The antibacterial activity of a methanolic extract of *Hiptage benghalensis* (L) Kurz. was investigated using the disc diffusion method, which measured the zone of inhibition and compared it to a standard antibiotic of 10 µg tetracycline. The extract is efficacious against *K. pneumonia*, *E. coli*, *Micrococcus luteus*, and *P. aeruginosa*. On the four test organisms, the varied concentrations of the extract exhibited a zone of inhibition. The extract gave MIC value 0.625mg/ml on *K. pneumonia*, *M. luteus* and *P. aeruginosa* and 0.3125 mg/ml on *E. coli* [77].

Microdilution techniques were used to determine the antimicrobial activity of 3,4,6-tetra-*O*-(3-nitropropanoyl)-*O*-D-glucopyranoside isolated from

roots of *Heteropteris aphrodisiaca* against Gram-positive and Gram-negative bacteria, as well as Sabouraud dextrose broth for *Candida albicans, C. parapsilosis, C. krusei*, and *C. tropicalis*. The minimal inhibitory concentration (MIC) and minimal bactericidal concentration (MBC) against *Bacillus subtilis* and *Staphylococcus aureus* were 125 and 250 µg/ml and 250 and 500 µg/ml, respectively. The antifungal activity was significantly greater than the antibacterial activity, as seen by the MIC. The latter was 125 µg/ml, while the minimum fungicidal concentration (MFC) against all *Candida* species was 250 µg/ml [78]. Plaque reduction assays in cell culture were used to assess the antiviral activity of the aliphatic nitro compound (NC) isolated from *Heteropteris aphrodisiaca* against poliovirus type 1 (PV-1) and bovine herpes virus type 1 (BHV-1). In HEp-2 (human larynx carcinoma) cells, the NC had moderate antiviral activity against PV-1 and BHV-1, with 50 % inhibitory concentrations (IC_{50}) of 22.01 µg/ml and 21.10 µg/ml, respectively [79].

The antihuman immunodeficiency virus (HIV) activity of a methanolic extract from *Heteropterys brachiata* was investigated using a non-radioactive colorimetric method that targets HIV-1 reverse transcriptase as an enzymatic target. The anticandidal effect of the extract was assessed using a standardized yeast microdilution test methodology employing the *Candida albicans* strain. The methanolic extract of *Heteropterys brachiata* has a high anticandida and moderate antiHIV impact, suggesting that the plant extract could be evaluated as a viable HIV/AIDS therapeutic candidate [80]. 1,3,4,5-tetragalloyl quinic acid was extracted from methanolic extract of *Hiraea reclinata* leaves and demonstrated antiHIV action [81]. Using an agar well diffusion assay, the methanolic extract of *Galphimia glauca* bark (GGB) and leaves (GGL) demonstrated considerable antibacterial activity against clinical and standard methicillin-resistant *Staphylococcus aureus* (ATCC 33591) (MRSA) strains. The antibacterial spectrum of both extracts (GGB and GGL) was assessed using an agar well-diffusion technique to estimate the Zone of Inhibition (ZI) against clinical and standard MRSA. ZI value for the extracts - GGB and GGL against the clinical MRSA strain was 16 ± 2 mm and 15 ± 1.5 mm respectively, while against the standard MRSA strain was 15.3 ± 0.57 mm and 14 ± 1 mm respectively, at 10 mg/ml [67]. *Malpighia glabra* methanolic leaf extract is effective against *Bacillus subtilis*, but have no effect on *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeuroginosa*, *Aspergillus flavus*, and *Candida albicans* [82].

Cytotoxic activity

Morin and morin-3-*O*-D-glucopyranoside were identified in the ethyl acetate fraction of *Acridocarpus orientalis.* When a 100-ppm concentration of morin was administered to the human hepatoma cancer cells (HepG2), colorectal adenocarcinoma (HT29, and HCT116), the viability of the cancer cells was reduced to 63.8 %, 64.5 %, and 45.3 %, respectively. Morin-3-*O*-D-glucopyranoside, on the other hand, reduced the viability of HepG2, HCT116, and HT29 cell lines when compared to control [24]. The treatment of colorectal adenocarcinoma (HT29 and HCT116) cell lines with chloroform and *n*-hexane fractions of *Acridocarpus orientalis* reduced cancer cell viability compared to other extracts at concentrations of 500 and 1000 g/mL. Only the chloroform fraction was found to be effective against proliferating cancer cells in human hepatoma (HepG2) cancer cells when compared to the other fractions [27]. Obcordatas A-I polyoxypregnane glycosides isolated from *Aspidopterys obcordata* Hemsl vines showed significant cytotoxicity against HuH-7 cells, and exhibited moderate cytotoxicity against the AGS and SW480 cell lines [17].

Byrsomina crassifolia oil had a cytoprotective effect in HepG2 cells after 72 hours of treatment, where the longer exposure time encouraged cell proliferation and prevented cell death, effectively reducing the oxidative stress induced by H_2O_2 [83]. At 100 and 1000 µg/mL and 10 to 1000 µg/mL, chloroform, and ethyl acetate fractions of *Byrsonima duckeana* revealed decreased cell viability on the HT29 line respectively. The same fractions displayed hemolytic activity, implying that the ethanol extract's more polar elements are more closely associated to its toxicity [84]. The 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl-2H-tetrazolium bromide (MTT) test was used to evaluate and estimate the IC_{50} value for antiproliferative and cytotoxic effects of methanolic extract of *Galphimia glauca* bark (GGB) and leaf (GGL). At 24 hours, IC_{50} value for the GGB against cancer cell proliferation (A549, SW480), and normal cell line (HEK293) was 157.8 ± 2.44 µg/ml, 136.6 ± 2.73 µg/ml, and 388.67 ± 6 µg/ml, respectively, while IC_{50} value for the GGL against A549, SW480, and HEK293 was 194 ± 4.64 µg/ml 178 ± 3.1 µg/ml, and 317.2 ± 9.4 µg/ml, respectively [67].

The anticancer activity of *Hiptage benghalensis* methanolic leaves extract was assessed against three cancer cell cultures: human cervical carcinoma (HeLa), human breast cancer (MCF-7) and human neuroblastoma (IMR-32) cells using the MTT assay, which is based on the reduction of MTT at

different concentrations (10, 30, 100, 300, and 500 µg/ml). The extract improved the percentage inhibition of MCF7, HeLa, and IMR32 cells. Furthermore, the extract's apoptotic activity increased the production of ROS and caspase-3 activity in all cancer cell lines in a dose-dependent manner [85]. *Malpighia glabra* methanolic leaves extract significantly reduced cell viability in breast (MCF-7) and colon cell lines (HCT-116). *M. glabra* revealed no significant difference from standard doxorubicin (0.1 µg/mL), indicating that it has potent anticancer activity against colon cell line [82].

Analgesic and antiinflammatory activities

The hydroalcoholic extract of *Bunchosia armeniaca* leaves at a dose of 200 mg/kg displayed strong antiinflammatory effect, resulting in a considerable reduction in inflammation as measured by leukocyte count and myeloperoxidase enzyme activity, comparable to dexamethasone standard at 0.5 mg/kg [59]. The presence of ethyl gallate, quinic acid, gallic acid, catechin, epicatechin, quercetrin, and quercetin in the leaves of *Byrsonima duckeana* reduced leukocyte migration in a carrageenan-induced peritonitis by 43% and licking time in a formalin test by 57%. The chloroform (FCL) and ethyl acetate (FEA) fractions were the most active samples in the acetic acid-induced writhing test. The hot plate test was conducted with FEA, and all the dosages tested (5, 50, and 200 mg/kg) exhibited considerable analgesic efficacy [64]. It has been observed that the stem bark of *Byrsonima japurensis* has significant and safe antiinflammatory effect, which is strongly related to its potent antioxidant activity, confirming its widespread use as an antiinflammatory drug in Amazonas State (Brazil). Only the dose of 400 mg/kg of aqueous extract showed antihyperalgesic effect in both phases of the carrageenan-induced inflammatory response, with more activity than the positive control [34].

Galphimines are nor-seco-triterpenoids with anxiolytic activities that are found in the aerial parts of *Galphimia glauca*. Anxiolytic activity of galphimines has been demonstrated in preclinical and clinical studies, and this combined with antiinflammatory activity, suggests that standardized extracts or fractions obtained from this plant could be effective for the treatment of degenerative disorders that have an inflammatory component, such as anxiety and Alzheimer's disease [86]. In Lipopolysaccharide LPS-stimulated RAW 264.7 macrophages, the antiinflammatory activity of triterpenes and steroids derivatives isolated from the chloroform stem bark fraction of *Hiptage benghalensis* was investigated, which resulted in a significant reduction in NO and PGE2 production, as well as protein expressions of iNOS and COX-2. In LPS-stimulated RAW264.7 macrophages, they similarly found that IB protein expression increased while p-p65 protein expression and NF-B transcriptional activity decreased [87].

Anxiolytic and antidepressant activities

Using recombinant human brain MAO-A and B enzymes, aqueous extracts of fresh and dried large branches of *Banisteriopsis caapi* and isolated compounds demonstrated significant inhibitory effects against MAO-A and slight effect against MAO-B. Inhibition of MAO-B activity by *β*-carbolines harmine and harmaline, in addition to potent MAO-A inhibition responsible for antidepressant action, protects against neurodegeneration and could be used to treat Parkinson's disease [53]. When compared to controls, the ayahuasca (decoction of *Psychotria viridis* and *Banisteriopsis caapi* plants) and fluoxetine groups demonstrated a significant decrease in locomotion in the open field and elevated plus-maze tests. The ayahuasca-treated animals swam more than the controls in the forced swimming test, a behaviour that was not observed in the fluoxetine group. All brain regions involved in serotoninergic neurotransmission revealed increased neuronal activity in treated mice. Although there was some brain damage because of this, no permanent impairment was discovered. These findings show that high doses of ayahuasca have antidepressant properties in Wistar females, an effect that should be explored further [28].

In the forced swimming test (FST) in mice, the methanolic extract standardized on flavonoids content of *Byrsonima crassifolia* possesses potential antidepressant-like effects and might be deemed rather safe toxicologically when orally supplied. The flavonoids rutin, hesperidin, and quercetin may be implicated in the antidepressant effects [88]. The elevated plus-maze, light–dark test, and forced swimming paradigm were used to assess the anxiolytic and antidepressant-like effects of *Galphimia glauca* methanolic extract (standardised on galphimine B content) on ICR albino mice. It's impossible to rule out the possibility that the anxiolytic-like effects of *G. glauca*'s methanolic extract are due in part to GB's activity via a mechanism involving ionic channels or the regulation of the GABAA receptor in a different area than that of benzodiazepines [89]. To examine the sleep wakefulness cycle, electroencephalogram (EEG), and visual evoked potentials (VEP) in DBA/2J mice, an ethanolic extract of *Heteropterys glabra* fruits was used. The ethanolic extract reduced motor activity and altered EEG and VEP characteristics, indicating that it may perform as an anxiolytic/sedative agent [90]. In the forced

swimming test in mice, the methanolic extract of *Heteropterys cotinifolia* shows a dose-dependent antidepressant effect at doses range from 31 to 310 mg/kg, with no reduction in mice locomotion [91].

Hepatoprotective activity

The liver marker enzymes serum alanine transaminase (ALT) and aspartate transaminase (AST) were significantly reduced in almost all concentrations after pretreatment with *Acridocarpus orientalis* ethanolic extract. Furthermore, serum reduced glutathione (GSH) levels in *A. orientalis* medicated mice groups were considerably higher. At a dose of 250 mg/kg BW, a reduction in liver weights in pretreated mice with *A. orientalis* indicated substantial weight loss and the histological liver study revealed a near-normal repair of liver architecture [26]. *Hiptage benghalensis* methanolic leaves extract (MEHB) showed hepatoprotective efficacy in rats against carbon tetrachloride-induced liver damage that was comparable to the standard medication silymarin (50 mg/kg). The markers of high serum liver damage enzymes such as aspartate transaminase, alanine transaminase, total bilirubin, and alkaline phosphatase were considerably reduced (p 0.01) after methanolic extract administration (200 mg & 400 mg / kg). MEHB also displayed strong antioxidant effects by increasing glutathione levels, as well as free radical scavenging activities, according to the studies [92]. The dose of 800 mg/kg of *Malpighia glabra* methanolic leaves extract had the greatest hepatoprotective effect, lowering elevated serum levels of ALT, AST, NO, and TNF-α liver content by 26, 24, 23, and 42 %, respectively, while also significantly increasing serum catalase levels by 102 %. When compared to silymarin, all doses tested (200, 400, and 800 mg/kg) demonstrated a greater reduction in serum TNF-α, indicating their significant antiinflammatory activity. The leaves of *M. glabra* were shown to be a rich source of secondary metabolites and to have considerable hepatoprotective properties [93].

Gastroprotective activity

Byrsonima fagifolia methanolic leaf extract effectively reduced stomach lesions generated by ethanol and HCl/ethanol, and endogenous mucosal sulphydryl groups contributed efficaciously to BF gastro-protection. *B. fagifolia* inhibited the progression of the inflammatory process and possesses antidiarrheal properties. With negligible toxicity, this extract expedited the healing of gastric ulcerated mucosa by activating proliferative factors and enhancing gastric mucus production [94]. The methanolic extract of *Byrsonima intermedia* (MBI) leaves completely prevented gastric and duodenal lesions (69%) and completely repaired gastric (49%) and duodenal lesions (45%) on 7 and 14 days. Endogenous sulfhydryl compounds, vanilloid receptors, and an elevation in GSH level are all involved in *B. intermedia*'s gastroprotective action, resulting in effective gastric and duodenal protection. MBI had antidiarrheal effects that were both curative (42%) and preventative (49%) when opiate receptors were involved [95]. *Byrsonima intermedia* ethyl acetate (EtOAc) and water (AcoAq) both reduced gastric lesions, but AcoAq was more effective than EtOAc in terms of antiHelicobacter pylori activity, as well as protecting the gastric mucosa from ethanol, non-steroidal antiinflammatory drugs (NSAIDs), and cysteamine-induced duodenal mucosal damage. After acetic acid damage, both partitions were linked to a considerable increase in gastric and duodenal repair, as well as increased stomach mucosal GSH content. However, after 6 days of treatment, EtOAc was more efficient than AcoAq in reducing stomach damage following the start of the gastric I/R, which was accompanied by a significant decrease in gastric mucosal MPO, IL-1, and TNF-alpha activity, as well as an increase in IL-10 and GSH content [96]. In indomethacin and pylorus ligation-induced ulcer models, the methanolic extract of *Flabellaria paniculata* and the ethyl acetate fraction from this extract showed significant gastroprotective effects [52].

Miscellaneous activities

Anti-Alzheimer activity

In aged rats, treatment with standardized root extract of *Heteropterys aphrodisiaca* for 7 days or longer improves learning and memory deficits. The memory deficits in the passive avoidance test were restored after treatment with standard extract for 7 days (50 mg/kg) or 26 days (100 mg/kg). However, after acute administration of standard extract (100 mg/kg) to aged rats, there was no improvement in memory [97]. The ethanolic extract of the bark of *Tetrapterys mucronate* exhibited *in-vitro* acetylcholinesterase (AChE) inhibition in TLC bioautography assay [55].

Antilipid peroxidation

When assayed with the Thiobarbituric Acid Reactive Substance (TBARS) Test, the crude extract, and fractions of *Acridocarpus orientalis* leaves revealed a higher proportion of oxidative degradation of lipids than the stem extract and other fractions. Aqueous and chloroform fractions of leaves showed higher inhibition of 60.6% and 49.9%, respectively. In case of TBARS bioassay of stem, ethyl acetate (34.5%) and chloroform (34.2%)

fractions revealed higher percentages of lipid peroxidation than the other fractions [27].

Antiprotozoal activity

Using arginase (ARG) from *Leishmania amazonensis* as a molecular target, leishmanicidal compounds from *Byrsonima coccolobifolia* leaf and stem ethanolic extracts were identified as flavonoids. They inhibited the enzyme with IC_{50} values ranging from 0.9 to 4.8 µM and were discovered to be non-competitive ARG inhibitors with dissociation constants (Ki) ranging from 0.24 to 3.8 µM, indicating high affinity. Studies of the structural characteristics of flavonoids linked to ARG action revealed significant commonalities [98]. Quercetin was only substance isolated from methanolic extract of *Galphimia glauca* aerial parts that had antiprotozoal activity, and it was weak. The IC_{50} values were 14 µM against *Plasmodium falciparum* K1, 13.2 µM against *Trypanosoma brucei*, and 63.8 µM against *Leishmania donovanii* [99].

Antiobesity activity

For 40 days, rats were given ethanolic extract of *Hiptage madablota* root orally at doses of 100, 200, and 400 mg/kg, which resulted in a significant decrease in food intake, body weight, lee index, serum lipids, atherogenic index, and coronary risk index, as well as an inverse increase in brain serotonin. As a result of its hypophagic and hypolipidemic actions, *Hiptage madablota* root extract was found to have strong antiobesity efficacy and to increase brain serotonin levels in rats fed a high-fat diet [100].

Wound healing activity

Flabellaria paniculala methanol leaf extract resulted in sic wound contraction and a shorter epithelisation duration. On day 14, which extract, and chloroform fraction achieved 100 % wound contraction in non-infected and *Staphylococcus aureus* groups, whereas on day 18, *Pseudomonas aeruginosa* group obtained 100% wound contraction. The extract had antiinfective and wound-healing properties, justifying the plant's usage in the treatment of skin illnesses and sores on a local level. When compared to the aqueous fraction, the chloroform fraction revealed extremely significant wound healing characteristics in the non-infection group. The proportion of wound contraction of the chloroform fraction in the *Staphylococcus aureus* infected group is like that of the reference drug, as evidenced by epithelization times of 16 days and 17 days for the reference drug and chloroform fraction, respectively. The *Pseudomonas aeruginosa* infected group's data revealed that the chloroform fraction was also significantly more potent than controls [101, 102].

Plants of Malpighiaceae have long been used as ayeuvedic treatment of many illnesses, this article gives collective information concerning the pharmacological activities of these plants, giving scientific evidence for their use in management of various diseases, as well as their phytochemical constituents. Hopefully, these plants will be more profoundly used in medicinal treatments in the future.

Conclusion

As previously stated, the Malpighiaceae family appears to contain a wide range of active constituents, including alkaloids (harmine, harmaline, caffeine, and tetrahydroharmine), Flavonoids (rutin, vitexin, quercitrin, Isoquercitrin, catechin, epicatechin, quercetin and kaempferol), vitamine C, and terpenoids (α-amyrin, β-amyrin and their acetates, lupeol, oleanolic acid, ursolic acid and α-amyrinone). Pharmacologically, Malpighiaceae has the most potent effect on neuro-degenerative disorders including Parkinson's Disease through MAO inhibition and antioxidant actions, as well as cytotoxic and inhibitory effects on NO generation. Also, they are medicinally used as antileshimina, antimicrobial, antiulcerogenic, antitubercular, antioxidant, antidepressant, wound healing, spasmogenic, antidiabetic, CNS stimulants and antiinflammatory properties. As a result, for the first time, this article presents a study of Malpighiaceae plants that contain a variety of active compounds that are effective against a variety of diseases. Hopefully, we will be able to use these plants in medicinal therapies in the future.

Conflict of interest

The author declare no conflict of interest

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