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Annona muricata (Graviola) (*Annonaceae*): Phytochemistry, Pharmacology and Future Directions, a Review

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Authors' contributions

This work was carried out in collaboration between all authors. Authors PLM and FBM designed the study, wrote the methodology and wrote the first draft of the manuscript. Authors IZA, JZNN, DMK, ISW, PM, VML, RIK, PSN, RMB, BMWM, JND, FBM, BML, MML, PKM and GKM managed the literature searches. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Aims: Promote *Annona muricata* (Graviola) and provide information on its phytochemistry and bioactivity.
Study Design: Multidisciplinary advanced bibliographic surveys, utilization of ChemBioDraw software package, and dissemination of the resulted knowledge.
Place and Duration of Study: UR73, Development in Pedagogy and Health, Interdisciplinary Research Center of the National Pedagogical University, National Pedagogical University, Kinshasa, the Democratic Republic of the Congo, between June 2021 and July 2022.
Methodology: A bibliographic review was carried out to acquire information on the pharmacognosy and phytochemistry of *A. muricata* from various electronic databases (PubMed, PubMed Central, Science Direct and Google Scholar). The terms phytochemistry, pharmacognosy and the scientific name of this plant species were used as keywords for the search. The ChemBioDraw Ultra 15.0 software package was used to draw the chemical structures of natural compounds of *A. muricata*.
Results: From the results obtained, it should be noted that *A. muricata* is traditionally used as an analgesic or stimulant. Various studies inform that this plant has various pharmacological properties such as anti-inflammatory, antimicrobial, antihyperglycemic, antioxidant, antihelminthic, cytotoxic, antipyretic, analgesic, healing and anti-sickling effects. Many natural phytochemicals like tannins, alkaloids, phenols, glycosides, flavonoids and steroids are responsible for its properties.
Conclusion: This review therefore helps to inform future research on the design and development of new relevant drugs from *A. muricata* to improve human health and well-being. Especially drug candidates for the treatment of cancer and tuberculosis.

Keywords: Annona muricata; primary health care; phytoconstituents; pharmacognosy; model system.

1. INTRODUCTION

The African flora constitutes an important reserve of medicinal plants that occupy an important place in the African pharmacopeia [1-3]. Medicinal plants are considered the basis of health preservation and care worldwide. Even today, they play an important role in the treatment of some tropical diseases [4]. “According to the World Health Organization (WHO), more than 80% of the population in Africa in general and in the Democratic Republic of Congo (DRC) in particular, use traditional pharmacopeia to solve the problem of primary health care” [5,6]. The use of medicinal plants for various health problems is not only a choice but is also linked to poverty, high costs, and drug resistance to some modern drugs [7-10]. This use of plants is justified by a strong attachment to endogenous know-how and the availability of plants throughout a large Congolese rainforest, comprising just over 10,000 species of angiosperms, of which about 3,000 are endemic [11].

From the *Annonaceae* family, *Annona muricata* L. is a species that has been widely studied for its therapeutic potential in recent decades. Ethnobotanical and medicinal uses of the Annonaceae family were reported long ago [12] and this species has since attracted the attention of researchers due to its bioactivity and toxicity [13].

Ethnobotanical studies have indicated that *A. muricata* leaves are used for headaches, insomnia, cystitis, liver problems, diabetes, hypertension, and as an anti-inflammatory, antispasmodic, and anti-dysenteric [14, 15]. They are also used as a remedy for the treatment of *diabetes mellitus*, gastrointestinal disorders and as an antitumor agent in Mexico [16]. Various parts of this plant, including the leaves, bark, and roots, have been used to treat diseases such as diabetes [17, 18] and arthritis in the West Indies. Fruit juice and leaf or branch infusions have been used to treat fever [19,20], as sedatives [21], respiratory diseases [22-24], malaria [25,26], gastrointestinal problems [27,28], liver, heart, and kidney ailments [13,29]. Other reported medicinal uses include anticancer [30,31], antibacterial and antifungal actions, and its antinociceptive and anti-inflammatory effects [32].

Annona muricata L. is recognized as an indispensable source of alkaloids [18]. It has been reported that the plant possesses acetogenins as the main phytoconstituents [33] which are responsible for several activities such as antitumor, immunomodulatory, antispasmodic, antimalarial, pesticidal,

antiparasitic, antibacterial, antifungal, and antihelminthic activity [34] and flavonoid glycosides. In recent years, it has become widely used as hypoglycemic [35,36], as hypotonic [28,35,37] and for anticancer treatments [38,39].

In addition, the objective of this study is to review the literature on traditional use, phytochemistry, biological activities, and toxicity. Therefore, this review will help guide future research on the use of *Annona muricata*.

2. METHODOLOGY

In this review, the different data resulting from articles, books, book chapters, and Ph.D. theses retrieved via bibliographic search on the internet with different scientific search engines such as Google Scholar, Pubmed, Sciencedirect, Web of Science, Online Library, Scopus, and Chemical Abstracts. As a search strategy, the scientific name of this plant species was used as a keyword, along with the terms phytochemistry and pharmacology of these scientific engines to obtain the searched data. After the first stage of the search, we proceeded to eliminate duplicates and those that did not provide information about the plant. Then, we proceeded to the full-text filtering. Finally, some articles were retained for the editorial team of our journal. These individual articles were characterized according to the activities of *Annona muricata* as detailed in the search result selections.

3. RESULTS AND DISCUSSION

In this literary review, 148 scientific articles were downloaded and put in a folder. After this first stage of research, we proceeded to eliminate duplicates and documents that did not provide the information we were looking for. Finally, 95 articles were included for full-text filtering. Finally, 75 articles providing information on the traditional use, phytochemical and pharmacological data of the plant were included for the editorial team of our journal. These different articles were characterized according to the activities of *Annona muricata* as detailed in the following selections.

3.1 Botanical Description

Annona muricata is a tropical fruit tree found in the rainforests of Africa, South America, and Southeast Asia. *A. muricata*, commonly called soursop, graviola, guanabana, and other local native names listed in Table 1, has large, dark green, glossy leaves and heart-shaped, edible green fruits [38,39]. Soft, curved thorns cover the leathery skin of the fruits, each of which can contain 55 to 170 black seeds distributed in a creamy-white flesh with a characteristic aroma and flavor [39, 40].

This plant is a species of the genus *Annona*, family *Annonaceae*, order *Magnoliales,* and division *Magnoliophyta* [40]. The genus *Annona* includes more than 70 species among which *A. muricata* is the most cultivated. Its synonyms are *A. bonplandiana* Kunth; *A. cearensis* Barb. Rodr., *A. macrocarpa* Werckle; and *A. muricata* var. borinquensis Morales [40].

Soursop is a tree reaching about 5-10 m in height and 15-83 cm in diameter with low branches [34]. It tends to flower and fruit almost all year round, but there are more defined seasons depending on altitude [40]. The soursop is distributed in tropical regions of Central and South America, West Africa and Southeast Asia [40], at altitudes below 1200 m above sea level. , with temperatures between 25 and 28°C, with relative humidity between 60 and 80%, and annual rainfall above 1500 mm. The soursop fruit is an edible ovoid collective berry of dark green color. Its average weight is 4 kg in some countries [40], but in Mexico [41], Venezuela [42] and Nicaragua [43], it varies between 0.4 and 1.0 kg. Each fruit can contain 55 to 170 black seeds [44] when fresh and turn light brown when dry. The flesh is white and creamy with a characteristic aroma and flavor [40].

3.2 Traditional Medicinal Uses

All parts; leaves [45-49], pericarp [50-52], fruits [38,53,45], seeds [45,54-56], and roots [57] of *Annona muricata* have been used in traditional medicine, but the most commonly used in traditional medical decoction preparations are stem barks, roots, seeds and leaves [58]. Coria-Tellez et al. and Baillon reported 212 bioactive compounds in extracts of *A. muricata* [39,59].

Preparations derived from *A. muricata* have been used to treat many ailments, making this plant an important ethnomedical species. In developing tropical countries, including Africa, different parts of *A. muricata* are used to treat conditions such as diabetes [60], coughs, skin diseases [61], and cancers [62,63,57,64,65]. Furthermore, in Jamaica [66] and Trinidad [67], *A. muricata* is the most widely used herbal remedy in the treatment of most cancers. For example, in Jamaica, a large proportion of cancer patients use herbal medicines for self-medication, with *A. muricata*

being commonly used (along with *Petiveria alliacea*) to treat breast and prostate cancers, respectively [66].

A. muricata has also been used, mainly in developing tropical countries, for the treatment of arthritis [68], hypertension [69], snakebites [70], diarrhea [66], headaches [71], and malaria [72]. Furthermore, it has been mentioned as antimicrobial [73], antidiabetic [74], anti-inflammatory [75], antiprotozoal [76], antioxidant, insecticide [77], larvicide [78] and anticancer. Although these uses of A. muricata strongly imply the presence of bioactive compounds with medical benefits, a comprehensive overview of the potential of *A. muricata* in the treatment of disease will require the identification of specific bioactive compounds and a scientifically rigorous demonstration of their ability to improve health outcomes.

3.3 Phytochemicals

Alkaloids, saponins, terpenoids, flavonoids, steroids, coumarins, lactones, anthraquinones, tannins, cardiac glycosides, phenols, phytosterols and reducing sugars constitute the richness in secondary metabolites of ethanolic extracts and water content of *Annona muricata* (Graviola) leaves after phytochemical analysis. Quantitatively, phenol has been shown to be present in greater amounts [125,126]. In the aqueous extract, total phenols were 683.69 (± 0.09) µg/mL gallic acid equivalents (GAE) while they were 372.92 (± 0.15) µg/ mL of GAE in the ethanolic extract [125].

In *A. muricata*, two hundred and twelve bioactive compounds have been reported. Acetogenins are the predominant compounds followed by alkaloids, phenols and other compounds. The main plant organs studied are the leaves and the seeds, certainly because they are the most traditionally used. Table 2 lists the bioactive compounds, and their structures are shown in Figs. 1–4. The majority of phytochemicals have been identified from organic extracts, but recently attention has shifted to aqueous extracts as well.

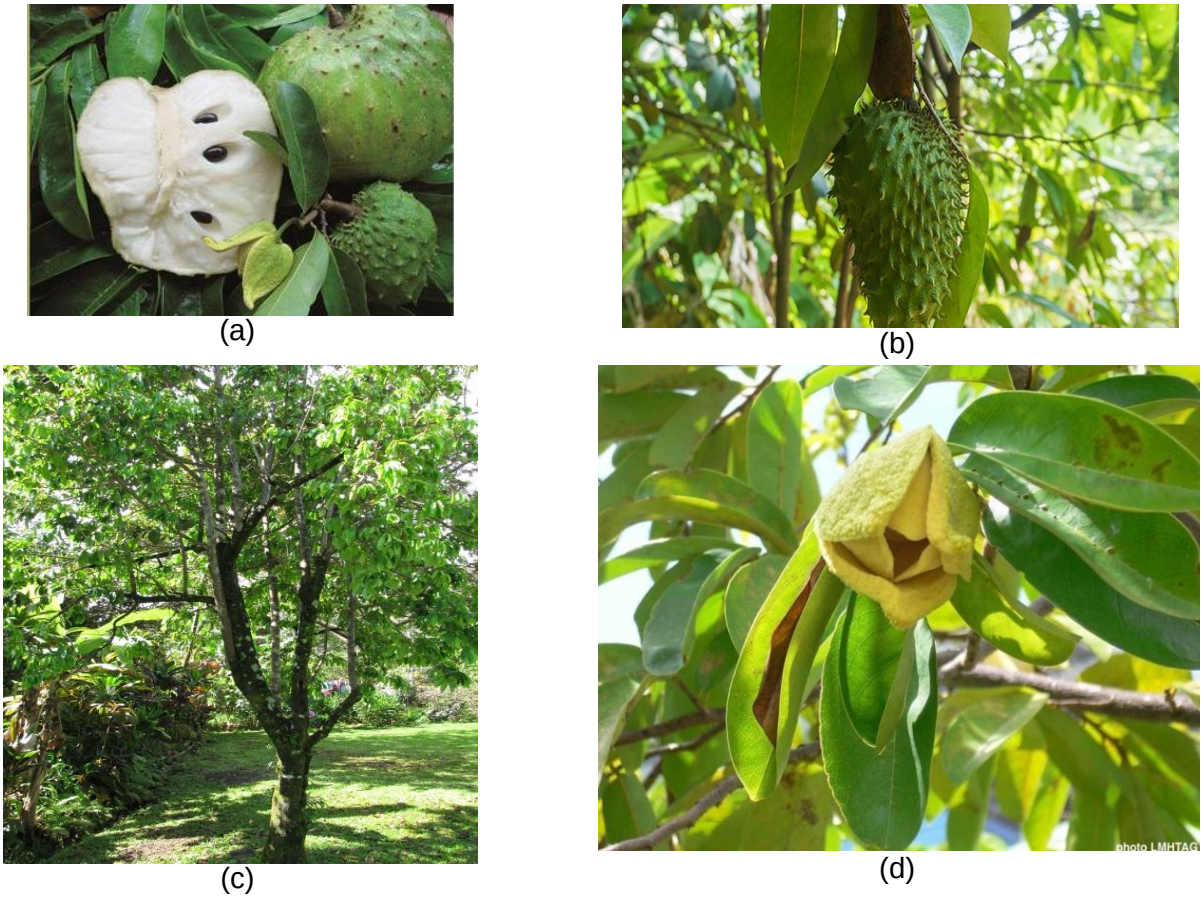


Fig. 1. Fruit and leaves (a, b), Whole plant (c) and Flowers (d) of *Annona muricata* (Graviola

Table 1. *A. muricata:* local names, medicinal uses, plant part used, and type of preparations

Country or Region	Local name	Medicinal uses	Plant part	Preparation/ application	References
Benin	Araticum, araticum-do-grande condessa; graviola; jaca-de-pobre; fruta-do conde, soursop	Insomnia, catarrh, febrifuge	Leaf Bark Root Seed	Decoction/oral	[79]
Bolivia	Sinini	Kidney disorders, Hypertension	Fruit Leaf	Juice/oral Decoction/oral	[69]
Brazil	Araticum, araticum-do-grande, coraçâo-da-rainha, graviola; jaca-do-parâ; jaca-de-pobre;	Snake bite Analgesic Lactagogue, astringent, diarrhea, dysentery Arthritis pain, rheumatism, neuralgia, weight loss	Leaf Fruit Leaf	Macerate/topical Decoction/oral Juice/oral Decoction/oral	[70,80,58,81]
Cameroon	Soursop, sabasaba, Ebom beti	Malaria, anthelmintic, parasites, antimicrobial, anticonvulsant, digestive Typhoid fever	Leaf	Decoction/oral	[76,82,83]
Caribbean	Graviola, Jamaica soursop, prickly custard apple, soursop	Chills, febrifuge, flu, indigestion, nervousness, palpitations, rash, spasms, skin disease, sedative	Leaf Bark	NR	[84,85,86]
Colombia	Guanabana	Febrifuge, inflammation	Fruit, Leaf	Juice/oral Decoction/oral	[87]
Cuba	Guanábana	Diarrhea, abortifacient, lactagogue Catarrh	NR Leaf	NR Decoction in milk or water/oral	[88,89]
Dominican Republic	Guanábana	Respiratory conditions, women in labor Galactagogue	Leaf	NR Infusion/oral	[90,80]
Ecuador	Guanábana	Plague Rheumatism	Fruit Seed Leaf	 NR Heated/topical	[91,92]

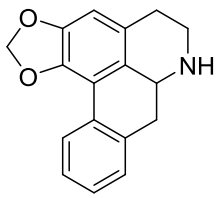
Country or Region	Local name	Medicinal uses	Plant part	Preparation/ application	References
Ghana	Apre	Malaria	Root	Decoction/bath	[72]
Guyana	Cachiman, corossol, Money Apple, sorasaka, kaiedi, zuurzak, soensaka, sroesaka, soeng sakka, sunsaka, corossolier	Sedative, cardiotonic Convulsion	Stem Leaf Seed	Infusion/oral Infusion/oral NR	[93,85]
Haiti	Guanábana, korosol	Flu, heart affectation parasite, pellagra, anxiety, febrifuge, diarrhea, lactagogue	Leaf Fruit		[58]
India	Mamphal, Fófı	Suppurative, febrifuge Pain and pus from ulcers Tonic Spasms, parasites Bechic Insecticidal, astringent, fish-poison	Leaf Bark Root Flower Seed	Decoction/oral Smeared in coconut oil/topical NR	[58,94]
Indonesia	Sirsak; nangka belanda; nangka seberang; Zuurzak Wulanda	Insecticidal Dermatitis	Leaf and other tree parts Leaf	NR Pounding	[95,58,96,97]
Jamaica	Jamaica soursop	Malaria Spasms, anxiety, asthenia, asthma, heart affections, febrifuge, parasites, diarrhea, lactagogue, dewormer, dysentery, pain, diuretic	Branch Leaf Fruit	Decoction/oral	[98,58]
Madagascar	Corossol	Heart palpitation, malaria, liver maladies	Leaf	Decoction	[99]
Malaysia	Durian belanda, durian blanda, durian,	Lice Stomach pain,	Leaf Fruit	Crushed/topical Juice/oral	[58,100]

Country or Region	Local name	Medicinal uses	Plant part	Preparation/ application	References
	benggala, durian maki, durian makkah, seri kaya belanda	hypertension			
Martinique	Kowosol	Skin rashes, sedative Thoracic pain, inflammation, flatulence, liver disease	Leaf	Crushed/Bath Decoction/oral	[61]
Mauritius	Coross ol Corossol	Hypertension Headache	Leaf	Infusion/oral Crushed/topical	[101,71]
Mexico	Takole, pobox, ajpox	Dysentery, diabetes	Fruit	Juice/oral	[102,103-105]
	Cabeza de negro; catuch, chincua, guanábana; guanábano; polvox; tak'ob; tak'op	Gastric cancer, gastrointestinal disorders, stomach pain	Leaf Young leaf	Decoction/oral Infusion/oral	
	caduts-at; xunápill; llama de tehuantepec; zopote de viejas, zapote agrio. Anona, tzon te chkia nion	Febrifuge, diarrhea, dysentery, stomach pain Bronchitis, asthma, leprae	Leaf, stem	Infusion/oral	
Nicaragua	Guanábana, pumo, puntar waithia, saput, sarifa, seremaia, soursap	Ringworm Abdominal and back pain, menstrual hemorrhage, abortions, fever, vaginal infection Renal and skin disorders, diarrhea Insecticidal	Leaf	Plaster/topical Infusion/oral Decoction/oral	[42,80,106]
Nigeria	Soursop, graviola, pawpaw brasileña, Abo, Chop-chop, Sapi sapi	Gastric disorders, Prostate cancer, diabetes, neuralgia, rheumatism, arthritic pain	Seed Leaf Unripe fruit	 Decoction/oral Juice/oral	[40,107,108]
Panama	Guanábana	Dyspepsia, allergy, helminthiasis	Leaf Bark	NR	[109,80]

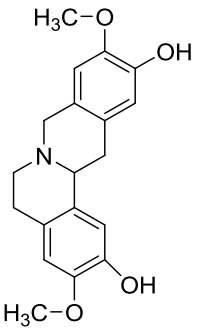
Country or Region	Local name	Medicinal uses	Plant part	Preparation/ application	References
		Diarrhea Stomach ulcer	Pulp	Decoction/oral	
Philippines	Babana	Lice, dandruff	Leaf	NR	[58, 110, 111]
	Babaná , guyabano, gwabana	Cancer, ascariasis, high blood pressure, stomach acidity, urination difficulty, cough Headache Diabetes	Leaf Fruit	Decoction/oral Poultice/topical Pulp/oral	
New Guinea	Saua sap Sow sop, Kahiloko	Stomach pain	Leaf	Heated/compression	[58]
Peru	Guanábano, guanábana, cashacushma	Obesity, gastritis, dyspepsia, diabetes, inflammation, cancer, spasms, sedative, flu, febrifuge, anxiety, kidneys, prostate, urinary tract, infection, inflammation, panacea	Fruit, Leaf	Pulp, juice/oral Infusion/oral	[58,112-116]
South Pacific countries	Durian belanda, soursop, seremaia, sarifa, apele, katara ara tara	Stomach ailments, indigestion Skin diseases Dizziness, fainting spells	Leaf Leaf	Infusion/oral Bath Inhaled	[117] [80]
Thailand	Thu-rian-khack, thurian-thet, thurian khaek	Insecticidal	Seed	NR	[58]
Trinidad Tobago	Soursop	Hypertension	Leaf	NR	[58, 118]
Togo	Anyigli, apele	Hypertension, diabetes, malaria	Leaf	Decoction/oral	[119,80]
Uganda	Ekitafeli	Diabetes	Leaf Fruit	Infusion/oral Pulp/oral	[120]
Vanuatu	Soursop, Karasol, korosol, saosop	Scabies	Leaf	Infusion/Bath	[121]
Venezuela	Catoche, catuche	Liver affectation, stomach	Leaf	Decoction/oral	[85,58]

Country or Region	Local name	Medicinal uses	Plant part	Preparation/ application	References
		pain, insecticidal	Seed	Crushed/topical	
West Africa	Dukumé porto, niom, pinha, sawa sap, alukuntum,	Sedative, nasopharyngeal affectation Diarrhea, dysentery, vermifuge, antidote	Leaf Seed, Bark root	Decoction/oral	[122]
West Indies	Apple leaf, kowoso, soursopl	Asthmas, diarrhea, hypertension, parasites, lactagogue, sedative	Leaf	Decoction/oral	[123,85,80,86]
		Skin ailments		Decoction/bath	
		Galactagogue	Fruit	Poultice/oral	
Vietnam South	Mang câu xiêm	Malaria	Leaf	Infusion/oral	[124]

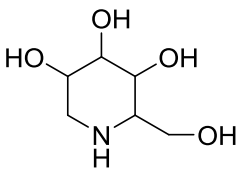
NR, Not reported



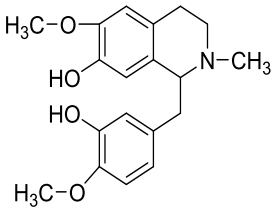
Aporphine type



Protoberberine type

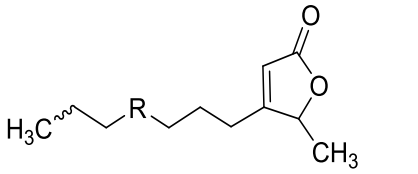


Iminosugar type



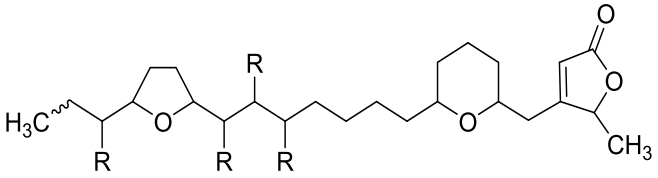
Isoquinone type

Fig. 2. Chemical structure of alkaloids present in *A. muricata*. Representative compounds of alkaloids are found in Table 2 at numbers 2, 11, 12, and 27 respectively



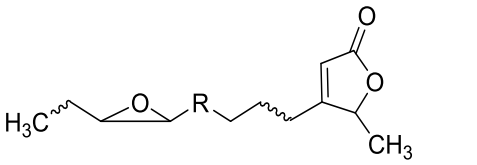
R=(CH_2)—, —CH=CH—, —CH−OH

Chemical structure of linear derivatives corresponding to the acetogenins numbers 31-39 of Table 2



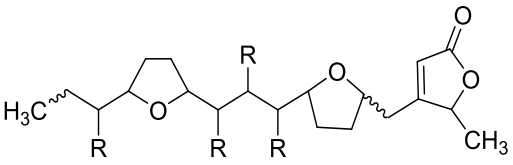
R=H, OH, Carbonyl

Chemical structure of mono THF, mono THP acetogenins corresponding to the acetogenins numbers 155–156 of Table 2.



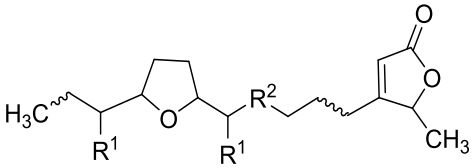
R═(CH_2) —CH=CH—, Epoxy, C=O CH−OH

Chemical structure of epoxy acetogenins corresponding to the acetogenins numbers 40–52 of Table 2.



R=H, OH,

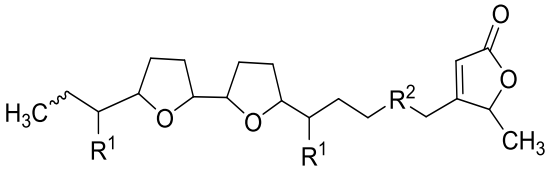
Chemical structure of Bis-THF nonadjacent acetogenins corresponding to the acetogenins numbers 141–144 of Table 2



R^1=H, OH,

R^2=(CH_2)—, CH=CH Carbonyl

Chemical structure of mono THF acetogenins corresponding to the acetogenins numbers 53–140 of Table 2.



R^1=H, OH,

R^2=(CH_2)—, CH=CH Carbonyl

Chemical structure of Bis-THF adjacent acetogenins corresponding to the acetogenins numbers 145–154 of Table 2.

Fig. 3. Chemical structures of six types of acetogenins present in *A. muricata*. (A)

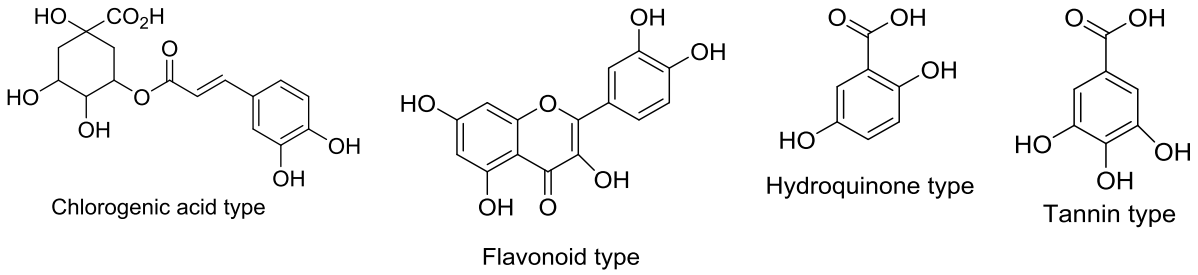


Fig. 4. Chemical structure of some compounds present in *A. muricata*. Representative compounds are found in Table 2 for numbers 194, 205, 198, 204, and 212 respectively

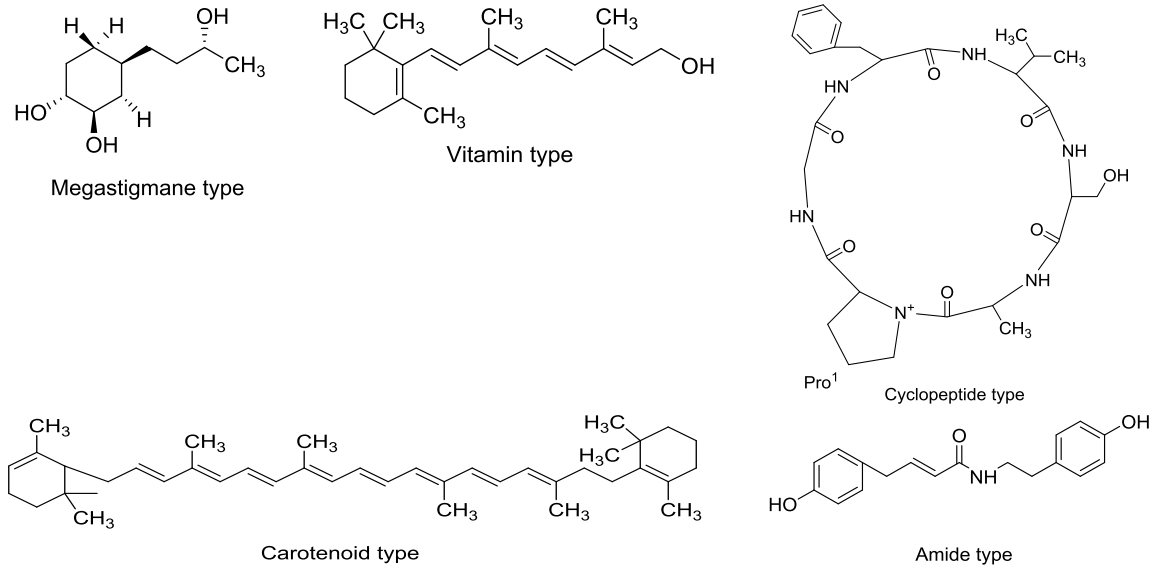


Fig. 5. Some compounds present in *A. muricata*. The representative compounds are found in Table 2 for 194, 205, 198, 204 and 212 respectively

Table 2. Bioactive compounds isolated from *A. muricata*

No	Chemical name	Part of plant	Type	Bioactivity	References
			Alkaloids		
1	Anonaine	Fruit Leaf	Aporphine	Antidepressive Anti-plasmodium, Dopamine Inhibitor Cytotoxic	[127, 128] [129-131]
2	Annonamine	Leaf	Aporphine	Cytotoxic	[131]
3	Anomuricine	Root Bark	Isoquinoline	NR	[132]
4	Anomurine	Root Bark	Isoquinoline	NR	[132]
5	Asimilobine	Fruit Leaf	Aporphine	Antidepressive Cytotoxic	[127, 128] [133]
6	Atherospermine	Stem	Aporphine	NR	[132]
7	Atherosperminine	Root Bark	Aporphine	NR	[132]

No	Chemical name	Part of plant	Type	Bioactivity	References
9	Casuarine	Leaf/Stem	Imino sugar	NR	[134]
10	Coclaurine	Root Bark Leaf	Isoquinoline	NR	[132, 133]
11	Coreximine	Root Bark Leaf	Protoberberine	Neurotoxic	[132, 135]
12	DMDP (2,5-Dihydroxymethyl-3,4, dihydroxypyrrolidine)	Leaf/stem	Imino sugar	NR	[134]
13	DMJ (Deoxymannojirimycin)	Leaf/stem	Imino sugar	NR	[134]
14	DNJ (Deoxynojirmycin)	Leaf/stem	Imino sugar	NR	[134]
15	(R)-O,O-dimethylcoclaurine	Leaf	Isoquinoline	Cytotoxic	[131]
16	Isoboldine	Leaf	Aporphine	Antimalarial	[133]
17	Isolaureline	Leaf	Aporphine	Cytotoxic	[129]
18	Liriodenine	Leaf	Aporphine	NR	[133]
19	(R)-4'O-methylcocaurine	Leaf	Isoquinoline	Cytotoxic	[131]
20	N-methylcoclaurine	Leaf	Isoquinoline	NR	[133]
21	N-methylcoculaurine	Leaf Pulp	Isoquinoline	NR	[136]
22	Muricine	Bark	Isoquinoline	NR	[85]
23	Muricinine	Bark	Isoquinoline	NR	[85]
24	(S)-Narcorydine	Leaf	Aporphine	Cytotoxic	[131]
25	Nornuciferine	Fruit	Isoquinoline	Antidepressive/*in vitro* NIH-3T3	[127¸ 128]
26	Remerine	Leaf	Isoquinoline	NR	[133]
27	Reticuline	Stem Leaf Pulp	Isoquinoline	Neurotoxic	[85,132,135,136]
28	Stepharine	Leaf	Isoquinoline	NR	[132]
29	Swainsonine	Leaf/stem	Imino sugar	Stimulate immune response	[134]
30	Xylopine	Leaf	Isoquinoline	NR	[129]
			Acetogenins		
31, 32	Cohibin A, B	Root Seed	Linear, unsaturated, 2OH	NR	[137,138]
33, 34	Cohibin C, D	Seed	Linear, unsaturated, 2OH	NR	[138]
35	Donhexocin	Seed	Linear, 6OH	NR	[139]
36	Montecristin	Root Pulp Nectar	Linear, unsaturated, 2OH	NR	[137,140]
37	Muricatenol	Seed	Linear,	NR	[141]

No	Chemical name	Part of plant	Type	Bioactivity	References
			unsaturated, 4OH		
38	Murihexol	Seed	Linear, 6OH	NR	[139]
39	Coronin	Root		NR	[85]
40, 41	Epomuricenins A, B or epoxymurin	Seed Root	Mono epoxy unsaturated	NR	[142,143]
42, 43	Epomurinins A, B	Pulp	Mono epoxy	NR	[143]
44, 45	Epomusenins A B	Pulp	Mono epoxy unsaturated	NR	[143]
46	Epoxyrollin-A = Dieporeticanin-1		Mono epoxy	NR	[142]
47	Murin A	Stem	Mono epoxy	NR	[85]
48	Rolin B	Seed	Mono epoxy	NR	[85]
49	Sabadelin	Root Pulp	Mono epoxy, 1 carbonyl	Cytotoxic	[144,145]
50	Corepoxylone	Seed	Diepoxy, 1 carbonyl	NR	[146]
51, 52	Diepomuricanin A, B = Epoxyrollin B	Seed	Diepoxy	NR	[142]
53	Annocatalin	Leaf	Mono THF, 4OH	Cytotoxic	[147]
54	Annoglaxin	Seed	Mono THF 4OH, 1 carbonyl	NR	[148]
55	Annohexocin	Leaf	Mono THF, 6OH	Cytotoxic	[149]
56	Annomontacin	Seed Leaf	Mono THF, 4OH	Cytotoxic Insecticidal	[147,150, 151]
57	Annomontacin, cis	Seed	Mono THF, 4OH	Cytotoxic	[147,150]
58	Annomuricin	Leaf	Mono THF, 5OH	Cytotoxic	[45]
59	Annomuricin A	Leaf Peric	Mono THF, 5OH	Cytotoxic	[46,51]
60	Annomuricin B	Leaf	Mono THF, 5OH	Cytotoxic	[46]
61, 62	Annomuricin C, E	Leaf	Mono THF, 5OH	Cytotoxic	[149,152,153]
63, 64	Cis, trans, Annomuricin-D-one	Leaf	Mono THF, 4OH	Cytotoxic	[137]
65	Annomutacin	Leaf	Mono THF, 4OH	Cytotoxic	[152]
66	Annonacin	Leaf Peric Seed Root Leaf Pulp Nectar	Mono THF, 4OH	Cytotoxic Insecticidal Antimicrobial Antitumor Neurotoxic Neurodegenerative	[51, 140, 147,150-152, 154-156]
67	Annonacin A	Peric Leaf Seed	Mono THF, 4OH	NR	[51,152]
68	Annonacin, cis-	Seed	Mono THF, 4OH	Cytotoxic	[157]
69	Annonacin-10-one, cis-	Seed	Mono THF, 3OH, 1 carbonyl	Cytotoxic	[157]
70	Annonacinone Annonacin 10-one	Leaf Seed Pulp Nectar	Mono THF, 3OH 1 carbonyl	Cytotoxic Antileishmaniasis	[147, 150, 140,158]
71	(2,4-trans)-1OR-annonacin A-one	Leaf	Mono THF, 3OH,	Cytotoxic	[152]

No	Chemical name	Part of plant	Type	Bioactivity	References
			ketolactone		
72, 73, 74	Annopentocin A, B, C	Leaf	Mono THF, 5OH	Cytotoxic	[137]
75	Annoreticuin-9-one	Seed	Mono THF, 3OH, 1 carbonyl	Cytotoxic	[145]
76	Annoreticuin, cis	Pulp	Mono THF, 4OH	Cytotoxic	[145]
77	Arianacin	Seed	Mono THF, 4OH	Cytotoxic	[137]
78	Corossolin	Seed Leaf	Mono THF, 3OH	Cytotoxic	[140,150, 159]
79	Corossolone	Leaf Seed Pulp	Mono THF, 2OH, 1 carbonyl	Cytotoxic	[140,142, 147,150, 159]
80	Cis-corossolone	Leaf	Mono THF, 2OH, 1 carbonyl	Cytotoxic	[147,150]
81	Gigantetrocin A	Seed	Mono THF, 4OH	Cytotoxic Insecticidal	[137]
82	Gigantetrocin B	Seed	Mono THF, 4OH	Cytotoxic	[137]
83, 84	2,4 Cis or trans Gigantetrocinone	Seed	Mono THF, 3OH, ketolactone	NR	[160]
85	Gigantetronenin	Leaf seed	Mono THF, 4OH, 1 double bond	Cytotoxic	[47]
86	Goniothalamicin	Seed Leaf	Mono THF, 4OH	Cytotoxic	[157]
87	Cis-goniothalamicin	Seed	Mono-THF, 4OH	Cytotoxic	[157]
88	Isoannonacin	Leaf	Mono THF, 3OH		[56]
89, 90	2,4-trans; cis-isoannonacin	Leaf seed	Mono THF	NR	[160,161]
91	2,4-trans-isoannonacin-10-one	Seed	Mono THF, 3OH, ketolactone	NR	[161]
92	Javoricin	Seed	Mono THF, 4OH	Cytotoxic	[157]
93	Longifolicin	Seed	Mono THF,3OH	Cytotoxic	[150, 159]
94	Montanacin	Leaf	Mono THF, 5OH	Cytotoxic	[140]
95	Montanacin H	Leaf Nectar	Mono THF, 4OH, 1 carbonyl	Cytotoxic	[140]
96	Muricapentocin	Leaf	Mono THF, 5OH	Cytotoxic	[137]
97	Muricatalicin	Leaf	Mono THF, 5OH	NR	[139]
98	Muricatalin	Leaf	Mono THF, 5OH	NR	[139]
99, 100	Muricatetrocin A,B	Seed	Mono THF, 4OH	Cytotoxic	[150, 159]
101, 102	Muricatin A, B	Seed	Mono THF, 5OH	NR	[142]
103	Muricatin C	Bark Pulp Nectar	Mono THF, 4OH, 1 carbonyl	NR	[142, 140]
104	Muricatin D	Seed	Mono THF, 5OH	NR	[85]
105	Muricatocin A	Leaf Pulp Nectar	Mono THF, 5OH	Cytotoxic	[140, 161]
106, 107	Muricatocin B, C	Leaf	Mono THF, 5OH	Cytotoxic	[161]
108	Muricenin	Pulp	Mono THF, 4OH	Cytotoxic	[162]
109, 110, 111, 112	Muricin A B, C, D	Seed	Mono THF, 4OH	Cytotoxic	[150,159]
114, 115	Muricin F, G	Seed	Mono THF,	Cytotoxic	[159]

No	Chemical name	Part of plant	Type	Bioactivity	References
			4OH, unsaturated		
116	Muricin H	Leaf Seed	Mono THF, 3OH	Cytotoxic	[147,163]
117	Muricin I	Leaf Seed	Mono THF, 3OH, unsaturated	Cytotoxic	[147,164]
118, 119, 120	Muricin J, K, L	Fruit	Mono THF, 4OH	Cytotoxic	[162]
120 121	Muricin M	Pulp	Mono THF, 4OH	Cytotoxic	[162]
122	Muricin N	Pulp	Mono THF, 4OH	Cytotoxic	[162]
123	Muricoreacin	Leaf	Mono THF, 6OH	Cytotoxic	[137]
124, 125	Muricoreacin A, B	Leaf	Mono THF, 5OH	Cytotoxic	[137]
126	Murihexocin	Leaf	Mono THF, 6OH	Cytotoxic	[137]
127	Murihexocin A	Leaf Pulp	Mono THF, 6OH	Cytotoxic	[140,149]
128	Murihexocin B	Leaf	Mono THF, 6OH	Cytotoxic	[149]
129	Murihexocin C	Leaf	Mono THF, 6OH	Cytotoxic	[45]
130	Murisolin	Seed	Mono THF, 3OH	Cytotoxic	[150,148]
131	Cis-panatellin	Root	Mono THF, 2OH	NR	[137]
132	Cis-reticulatacin	Root	Mono THF, 2OH	NR	[137]
133	Cis-reticulatacin-10-one	Root	Mono THF, 2OH, carbonyl	NR	[137]
134	Solamin	Seed Stem Root Leaf	Mono THF, 2OH	Cytotoxic	[142,147,150]
135	Cis-solamin	Root Leaf	Mono THF, 2OH	NR	[137]
136	Cis-solamin A	Leaf Root Seed	Mono THF, 2OH	NR	[165]
137, 138	Cis-uvariamicin I, IV	Root	Mono THF, 2OH	NR	[137]
139	Xylomatenin	Pulp	Mono THF, 4OH, unsaturated		[140]
140	Xylomaticin	Seed	Mono THF, 4OH	Cytotoxic	[147,150]
141	Bullatalicin	Seed	Bis THF nonadjacent, 4OH	Cytotoxic	[137]
142	Gigantecin	Seed Leaf	Bis THF nonadjacent, 4OH	Cytotoxic, Antitumor *in vitro*	[140]
143, 144	Cis-squamostatin A, D	Seed	Bis THF nonadjacent, 4OH, 3OH	Cytotoxic	[148]
145	Annocatacin A	Seed	Bis THF adjacent, 2OH	Cytotoxic	[150,166]
146	Annocatacin B	Leaf	Bis THF adjacent, 2OH	Cytotoxic	[166]
147	Asimicinone-9-oxo	Leaf	Bis THF adjacent, 2OH, 1 carbonyl, keto lactone	Cytotoxic	[140]

No	Chemical name	Part of plant	Type	Bioactivity	References
148	Asiminecin	Seed	Bis THF adjacent, 3OH	Cytotoxic	[148]
149	Bullatacin	Seed	Bis TFH adjacent, 3OH	Cytotoxic Antitumor Neurotoxic	[148,150, 167,168]
150	Desacetyluvaricin	Seed	Bis THF adjacent, 2OH	NR	[148]
151	Isodesacetyluvaricin	Seed	Bis THF adjacent, 2OH	NR	[148]
152	Robustocin	Seed	Bis THF adjacent, 1OH	NR	[169]
153	Rolliniastatin 1, 2	Seed	Bis THF adjacent, 3OH	Cytotoxic	[170]
154	Squamocin	Seed	Bis THF adjacent, 3OH	Cytotoxic Insecticide	[154] [150]
155, 156	Montanacin D, E	Leaf Pulp	Mono THF, Mono THP, 2OH, 1 carbonyl	NR	[140]
			Phenols		
157	Emodin	Leaf	Anthraquinone	NR	[171]
158	Caffeoylquinic acid	Leaf Pulp	Chlorogenic acid	NR	[172] [173]
159	Chlorogenic acid	Leaf	Chlorogenic acid	NR	[174]
160	Dicaffeoylquinic acid	Leaf Pulp	Chlorogenic acid	NR	[172] [173]
161	Feruloylquinic acid	Leaf	Chlorogenic acid	NR	[172]
162	Cinnamic acid	Leaf Pulp	Cinnamic acid	NR	[171] [173]
163	Apigenin-6-C-glucoside	Leaf	Flavonoid	Antioxidant	[175]
164	Argentinine	Leaf	Flavonoid	Antioxidant	[174]
165	Catechin	Leaf	Flavonoid	Antioxidant	[174]
166	Coumarid acid	Leaf Pulp	Flavonoid Flavonoid	NR	[171] [173]
167	Daidzein	Leaf	Flavonoid	NR	[171]
168	Dihydrokaempferol-hexoside	Pulp	Flavonoid	NR	[173]
169	Epicatechin	Leaf	Flavonoid	Antioxidant	[174]
170	Fisetin	Pulp	Flavonoid	NR	[176]
171	Gallocatechin	Leaf	Flavonoid	NR	[171]
172	Genistein	Leaf	Flavonoid	NR	[171]
173	Glycitein	Leaf	Flavonoid	NR	[171]
174	Homoorientin	Leaf	Flavonoid	Antioxidant	[171]
175	Isoferulic acid	Leaf	Flavonoid	NR	[171]
176	Kaempferol	Leaf Pulp	Flavonoid	Antioxidant	[174,177]
177	Kaempferol 3-O-rutinoside	Leaf Pulp	Flavonoid	Antioxidant	[174] [177]
178	Luteolin 3'7-di-O-glucoside	Leaf Pulp	Flavonoid	Antioxidant	[175,177]
179	Morin	Pulp	Flavonoid	Antioxidant	[176]
180	Myricetin	Pulp	Flavonoid	Antioxidant	[176]
181	Quercetin	Leaf	Flavonoid	Antioxidant	[174,175]
182	Quercetin 3-O-glucoside	Leaf	Flavonoid	Antioxidant	[174]

No	Chemical name	Part of plant	Type	Bioactivity	References
183	Quercetin 3-O-neohesperidoside	Leaf	Flavonoid	Antioxidant	[174]
184	Quercetin 3-O-robinoside	Leaf	Flavonoid	Antioxidant	[174]
185	Quercetin -O-rutinoside	Leaf	Flavonoid	Antioxidant	[174]
186	Quercetin 3-O-α-rhamnosyl	Leaf	Flavonoid	Antioxidant	[174]
187	Robinetin	Leaf	Flavonoid	Antioxidant	[175]
188	Tangeretin	Leaf	Flavonoid	NR	[171]
189	Taxifolin (+)	Leaf	Flavonoid	NR	
190	Vitexin	Leaf	Flavonoid		[175]
191	Caffeic acid	Leaf	Hydroxycinnamic acid	Antioxidant	[173]
192	Gentisic acid	Leaf	Hydroquinone	Antimicrobial Inhibitor	[85]
193	Gallic acid	Leaf	Tannin		[175], 174]
			Other compounds		
194, 195, 196	Annoionol A, B, C	Leaf	Megastigmane	NR	[178]
197	Annoionoside	Leaf	Megastigmane	NR	[178]
198, 199	Annomuricatin A, B	Seed	Cyclopeptides	Insecticide	[179]
200	Annomuricatin C	Seed	Cyclopeptides	Cytotoxic	[180]
201	Vitamin A	Leaf	Vitamin	Antioxidant	Non published
202	Vitamin C	Pulp leaf	Vitamin, organic acid	Antioxidant	[181]
203	Vitamin E (Tocopherols)	Leaf Seed Pulp	Vitamin	Antioxidant	[176,181]
204, 205	Carotenes α, β	Pulp	Carotenoid	Antioxidant	[176]
206	Cryptoxanthin β	Pulp	Carotenoid	Antioxidant	[176]
207	Lycopene	Pulp	Carotenoid	Antioxidant	[176];
208	Lutein	Pulp	Carotenoid	Antioxidant	[176]
209	Tocopherol α	Pulp	Carotenoid	Antioxidant	[176]
210, 211	Tocotrienol α, ϒ	Pulp	Carotenoid	Antioxidant	[176]
212	N-p-coumaroyl tyramine	Leaf	Amide	Antitumoral	[152]

NR, Not reported.

Table 3. Mineral analysis in *Annona muricata* [182]

Metals	*Annona muricata* (mg/kg)
Sodium	694.86±10.65
Potassium	363.05±3.46
Magnesium	9619±801
Calcium	11183±10
Zinc	8.34±0.56
Manganese	8.25±1.25
Iron	139.50±32
Copper	14.25±0.7
Chromium	3.75±0.2
Cadmium	5.49±0.07

Values are means ± SD for 2 determinations

Table 4. Pharmacological activities of *A. muricata* extract evaluated *In vitro*

Activity	Plant part	Solvent	Test model	Effect	References
Cytotoxic	Leaf	H_2O:EtOH 40%	K562 ECV-304	MIC =7 mg/ml MIC =2 mg/ml	[183]
	Peri	MeOH Hex EtOAc	U-937	MEC > 1 mg/ml MEC =1 mg/ml MEC = 0.1 mg/ml	[51]
	Dried fruit	H_2O:Cet 50%	MCF-10A BC MDA-MB-468 MDA-MB-231 MCF-7	IC_{50} >200 μg/ml IC_{50} = 4.8 μg/ml IC_{50} >200 μg/ml IC_{50} >200 μg/ml	[184]
	Leaf	EtOAc	U-937	LC_{50} = 7.8 μg/ml	[185]
	Stem	EtOAc MeOH Hex EtOAc MeOH Hex		IC_{50} =10.5 μg/ml IC_{50} =60.9 μg/ml IC_{50} =18.2 μg/ml IC_{50} =28.1 μg/ml IC_{50} =38.5 μg/ml IC_{50} =15.7 μg/ml	[186]
	Leaf	EtOH	VERO H460 C-678	IC_{50} <0.00022 mg/ml IC_{50} <0.00022 mg/ml IC_{50} <0.00022 mg/ml	[163]
	Leaf/stem	DMSO	PC FG/COLO357 PC CD18/HPAF	IC_{50} =200 μg/ml IC_{50} =73 μg/ml	[187]
	Leaf	*n*-But	MDA-MB-435S HaCaT WRL-68	IC_{50} =29.2 μg/ml IC_{50} =30.1 μg/ml IC50 =52.4 μg/ml	[175]
		H_2O:EtOH	HaCat	1.6 to 50 μg/ml increase cellular activity 100 μg/ml does not change cell behavior	[174]
		H_2O EtOH Pen	A375	IC_{50} > 500 μg/ml IC_{50} =320 μg/ml IC_{50} =140 μg/ml	[188]
		EtOH	MCF-7 H-460 SF-268	ED_{50} = 6.2 μg/ml ED_{50} = 4.0 μg/ml ED_{50} = 8.5 μg/ml	[189]
	Leaf Seed	EtOH	MDBK	CC_{50} = 20x10-4 μg/ml CC_{50} = 24x10^{-5} μg/ml	[87]
	Leaf	EtOAc EtOH + H_2O Chl	HeLa	15.62 μg/ml = 11.37% inh 15.62 μg/ml = 3.97% inh 15.62 μg/ml = 18.42% inh	[190]

Activity	Plant part	Solvent	Test model	Effect	References
		n-Hex		15.62 μg/ml = 21.41% inh	
		n-Hex	HT-29	IC_{50} =14.93 μg/ml	[191]
		EtOAc		IC_{50} =4.29 μg/ml	
		MeOH		IC_{50} >100 μg/ml	
		n-Hex	HCT-116	IC_{50} =12.26 μg/ml	
		EtOAc		IC_{50} =3.91 μg/ml	
		MeOH		IC_{50} >100 μg/ml	
		n-Hex	CCD841	IC_{50} =42.19 μg/ml	
		EtOAc		IC_{50} =34.24 μg/ml	
		MeOH		IC_{50} >100 μg/ml	
		EtOH	Spleen cell	IC_{50} >750 μg/ml	[125]
			EACC	IC_{50} =335.85 μg/ml	
			MDA	IC_{50} =248.77 μg/ml	
			SKBR3	IC_{50} =202.33 μg/ml	
			T47D	IC_{50} =17.15 μg/ml	[192]
	Leaf	EtOH	HL-60	IC_{50} =14 μg/ml	[57]
	Twigs			IC_{50} =49 μg/ml	
	Roots			IC_{50} =9 μg/ml	
	Leaf	Hex	Capan-1	IC_{25} =7.8 μg/ml	[193]
	Com leaf	DMSO		IC_{25} =0.9 μg/ml	
Antiprotozoal	Leaf	H_2O	*Plasmodium*	IC_{50} =240 μg/ml	[124,188]
		EtOH	*falciparum*	IC_{50} =52 μg/ml	
		Pen	(Chloroquine-sensitive strain)	IC_{50} =18 μg/ml	
		H_2O	*Plasmodium*	IC_{50} =230 μg/ml	
		EtOH	*falciparum* FcM29	IC_{50} =49 μg/ml	
		Pen		IC_{50} = 16 μg/ml	
		EtOH	*Plasmodium*	IC_{50} = 7.43 μg/ml	[76]
		MeOH	*falciparum* strain W2	IC_{50} = 3.55 μg/ml	
		Ip		IC_{50} > 10 μg/ml	
		Hex		IC_{50} = 2.03 μg/ml	
		H_2O		IC_{50} > 10 μg/ml	
	Twig	EtOH		IC_{50} = 8.56 μg/ml	
		MeOH		IC_{50} = 4.11 μg/ml	
		Hex		IC_{50} > 10 μg/ml	
		H_2O		IC_{50} > 10 μg/ml	
	Flow	EtOH		IC_{50} = 5.12 μg/ml	
		MeOH		IC_{50} = 2.92 μg/ml	
		H_2O		IC_{50} > 10 μg/ml	
	Peric	EtOH		IC_{50} = 6.87 μg/ml	
		MeOH		IC_{50} = 4.3 μg/ml	
		Ip		IC_{50} > 10 μg/ml	
		H_2O		IC_{50} > 10 μg/ml	
	Pulp	EtOH		IC_{50} = 6.01 μg/ml	
		MeOH		IC_{50} = 5.17 μg/ml	
		Pp		IC_{50} = 4.42 μg/ml	
		H_2O		IC_{50} > 10 μg/ml	
	Seed	EtOH		IC_{50} = 3.02 μg/ml	
		MeOH		IC_{50} = 2.42 μg/ml	
		Pp		IC_{50} > 10 μg/ml	

Activity	Plant part	Solvent	Test model	Effect	References
		H_2O		IC_{50} > 10 μg/ml	
	Leaf	Hex	*Plasmodium falciparum* F32/W2	IC_{50} =7 μg/ml/38 μg/ml	[194]
		EtOAc		IC_{50} = 8 μg/ml/10 μg/ml	
		MeOH		IC_{50} = 9 μg/ml	
	Stem	Hex		IC_{50} = 11 μg/ml /38 μg/ml	
		EtOAc		IC_{50} = 40 μg/ml /34 μg/ml	
		MeOH		IC_{50} = 32 μg/ml /26 μg/ml	
	Leaf	MeOH	*Plasmodium falciparum* 3D7	IC_{50} = 0.715 μg/ml	[195]
	Peri	EtOH	*Plasmodium falciparum* strain W2	IC_{50} =1.01 μg/ml	[76]
	Root			IC_{50} = 0.79 μg/ml	
	Steam			IC_{50} = 1.45 μg/ml	
	Peri	MeOH	*Leishmania braziliensis*	MEC > 1 mg/ml	[51]
		Hex		MEC > 1 mg/ml	
		EtOAc		MEC = 0.1 mg/ml	
	Leaf	Hex	*Leishmania sp.*	IC_{50} > 100 μg/ml	[185]
		EtOAc		IC_{50} = 25 μg/ml	
		MeOH		IC_{50} > 100 μg/ml	
	Stem	Hex		IC_{50} = 76.3 μg/ml	
		EtOAc		IC_{50} = 63.2 μg/ml	
		MeOH		IC_{50} = 98.6 μg/ml	
	Leaf	EtOH	*Biomphalaria glabrata*	500 ppm, 100% mort	[196]
	Leaf	EtOAc	*Trypanosoma cruzi*	IC_{50} = 40.2 μg/ml	[186]
		MeOH		IC_{50} > 200 μg/ml	
		Hex		IC_{50} > 200 μg/ml	
	Stem	Hex		IC_{50} = 91 μg/ml	
		EtOAc		IC_{50} = 93.5 μg/ml	
		MeOH	*Entamoeba histolytica*	IC_{50} > 200 μg/ml	
	Bark	EtOH		MIC = 63 mcg/ml	[80]
	Leaf	H_2O	*Haemonchus contortus*	12.5% extract 90% of larvae mort	[197]
Insecticidal	Seed	EtOH	*Spodoptera litura* larvae	5% extract, 18-96% inh	[95]
		PE	*A. aegypti*	18.75 ppm, 15% mort	[198]
			An. albimanus	4.7 ppm, 85% mort	
			A. aegypti	37.5 ppm, 3% mort	
			An. albimanus	9.4 ppm/, 2.5% mort	
	Leaf and Bark	H_2O	*A. aegypti*	5% extract, 99% mort	[199]
	Flow	EtOH	*A. aegypti*	CL_{50} = 3.33 mg/ml	[200]
	Seed	H_2O		CL_{50} = 0.02 mg/ml	

Activity	Plant part	Solvent	Test model	Effect	References
	Leaf			CL_{50} = 8.25 mg/ml	
	Stem			CL_{50} = 19.21 mg/ml	
	Root			CL_{50} > 50 mg/ml	
	Leaf	EtOH	*Plutella xylostella*	5 mg/ml by 12 days : 100% larvae mort	[201]
		EtOH	*Callosobruchus maculatus Fabricius*	1 g/l, 40.8% mort	[202]
	Seed	EtOH/*n*-Hex	*A. aegypti*	LC_{50} = 73.77 ppm	[203]
		EtOH	*Cx. Quinquefascia-tus*	1 ml extract, 22% mort	[204]
		DicMet		1 ml extract, 22% mort	
		H_2O		20% extract, 11.5% mort	
		DicMe	*Ae. albopictus*	1 ml extract, 25% mort	
Repellent	Seed	EtOH	*C. gestroi* Wasmann	20% extract, 15.75% mort	[205]
Antioxidant	Juice	NR	ABTS	6.09 μM of Tr/g	[206]
			DPPH	1.36 μM M of Tr/g	
	Pulp	NR	FRAP	503 μmol/l/g	[176]
			ORAC	14.51 μmol of Tr/g	
			ABTS	287.67 μmol of Tr/g	
			DPPH	2.88 μmol of Tr/g	
			Lipid peroxidation	3.5% with 10 μM GAE	
	Leaf	MeOH	DPPH	IC_{50} = 221 μg/ml	
		EtOH	DPPH	IC_{50} = 70 μg/ml	
			ABTS	IC_{50} = 305 μg/ml	
			Lipid peroxidation	IC_{50} = 455 μg/ml	
			Follow nitric oxide radical	IC_{50} = 350 μg/ml	
			Follow superoxide radical	IC_{50} = 155 μg/ml	
	Leaf	H_2O:EtOH(3:1)	ORAC assay	14269537.4 μM Tr/g	[174]
	Fresh leaf	H_2O	DPPH	SC_{50} = 10.1 mg/l	[207]
	Leaf	*n*-But	DPPH	400 μg of extract, 60% inh	[175]
	Fresh-leaf	EtOH	ABTS	219.2 μmol of Tr/100 g	[208]
	Dried-leaf	MeOH		182.3 μmol of Tr/100 g	
	Pulp	EtOH		280.2 μmol of Tr/100 g	
		MeOH		160.8 μmol of Tr/100 g	
	Seed	EtOH		306 μmol of Tr/100 g	

Activity	Plant part	Solvent	Test model	Effect	References
		MeOH		193.4 μmol of Tr/100 g	
		EtOH		131.2 μmol of Tr/100 g	
		MeOH		86.6 μmol of Tr/100 g	
	Pulp	MeOH	DPPH	5 mg of pulp, 75.39% inh	[209]
Antibacterial	Peel	H_2O	*S. aureus*	50 μL/dish, DIH = 14 mm	[210]
			V. cholera	50 μL/dish, DIH = 17 mm	
			E. coli (river)	50 μL/dish, DIH = 18 mm	
	Leaf	EtOH	*S. aureus*	MIC = 128 mg/ml	[113, 211]
		H_2O:EtOH	*E. coli* EC27	MIC > 1024 μg/ml	
		H_2O/ MeOH	*B. subtilis*	400 mg/ml, DIH = 8.5/19.5m	[212]
			S. aureus	400 mg/ml, DIH = 7.7/20.5m	
			K. pneumonia	400 mg/ml, DIH = 6.0/18.0m	
			S. typhimurium	400 mg/ml, DIH = 6.5/16.5m	
		E. coli		400 mg/ml, DIH =17.5/16.5m	
		S. pyogenes		400 mg/ml, DIH = 0/17.2 m	
	Seed, stem	MeOH	*E. coli* C600	MIC > 1024 μg/ml	[104]
			S. aureus 209P	MIC > 1024 μg/ml	
	Leaf	H_2O	*M. tuberculosis* H37Rv	5 mg/ml of extract, 82% inh	[213]
			M. tuberculosis MDR	5 mg/ml of extract, 50% inh	
		EtOH	*S. thypimurium*	MIC = 4096 μg/ml	[83]
			S. thypimurium A	MIC = 2048 μg/ml	
			S. thypimurium B	MIC = 4046 μg/ml	
	Stem	EtOH	*Herpes simplex* HSV-1 strain #753166	MIC =1 mg/ml	[214]
	Leaf	EtOH	Spleen cell	IC_{50} >750 μg/ml	[125]
			EACC	IC_{50} =335.85 μg/ml	
			MDA	IC_{50} =248.77 μg/ml	
			SKBR3	IC_{50} =202.33 μg/ml	
		EtOH	T47D	IC_{50} =17.15 μg/ml	[192]
	Leaf	EtOH	HL-60	IC_{50} =14 μg/ml	[57]
	Twigs			IC_{50} = 49 μg/ml	
	Roots			IC_{50} = 9 μg/ml	
	Leaf	Hex	Capan-1	IC_{25} = 7.8 μg/ml	[193]
		DMSO		IC_{25} = 0.9 μg/ml	
	Leaf	H_2O	BPH-I	IC_{50} = 1.36 mg/ml	[215]

3.4 Mineral Analysis on *Annona muricata*

A study by Usunomena & Paulinus [182] also showed a great of mineral elements found in the powdered leave of *Annona muricata* shown in Table 3 are as follows:

3.5 Pharmacological Activities of *Annona muricata*

3.5.1 *Annona muricata* in combating cancer

With each passing year the incidence of cancer increases, raising concerns about the effectiveness of the various current treatment options. This leads patients to resort to alternatives to supplement or replace radiotherapy, surgery and chemotherapy. *Annona muricata* and other medicinal plant species have been shown to contain promising compounds that can be used for the treatment of cancer. *A. muricata* is a species native to tropical and subtropical regions, whose extracts contain compounds that are particularly effective against cancer cells" [125]. All the extracts tested inhibited the proliferation of HL-60 cells in a concentration-dependent manner with an IC_{50} varying from 6 to 49 µg/mL. Inhibition of cell growth by the extracts was associated with disruption of MMP, generation of reactive oxygen species (ROS), and arrest of G0/G1 cells.

The chemopreventive effect of ethanolic extracts of leaves of A. muricata was studied on cell proliferation induced by DMBA (7,12-dimethylbenzene[a]anthracene) in the mammary tissues of female albino mice. DNA smears obtained by agarose gel electrophoresis suggested that DMBA-induced damage was significantly prevented due to the effect of leaf extract of *A. muricata*. The presence of DMBA-induced lobular alveolar hyperplasia, adenomatoid hyperplasia, fibro-adipose stroma and sebaceous gland proliferation were revealed in histological sections of mouse mammary tissue. However, these changes have been found to vary in their occurrence among different groups of treated animals [126].

The major bioactive components that have been extracted from various *A. muricata*'s parts are known as annonaceous acetogenins (AGEs). These are derivatives of long-chain (C32 or C34) fatty acids derived from the polyketide pathway, reviewed in Liaw [29]. Many of these derivatives are reported to be selectively toxic to cancer cells, including multidrug-resistant cancer cell lines [63]. Annonaceous acetogenins induce cytotoxicity, at least in part, by inhibiting mitochondrial complex I, which is involved in oxidative phosphorylation and ATP synthesis [216]. As cancer cells have a higher demand for ATP than normal cells, mitochondrial complex I inhibitors have potential in cancer therapy [217].

3.5.2 Cytotoxicity activity and acute toxicity

The ethanolic extract of *Annona muricata* leaves was found to be selectively cytotoxic *in vitro* for tumor cell lines (EACC, MDA, and SKBR3) with IC_{50} values of 335.85 µg/mL, 248.77 µg /mL, 202.33 µg/mL respectively, while it had no cytotoxic effect on normal spleen cells [125].

At low doses (5-100 mg/kg), the ethanolic extract plant did not induce neurological deficits. However, at higher doses (300 and 1000 mg/kg), side effects including reduced exploratory behavior and abdominal constriction were observed in 20% and 60% of animals, respectively. No mortality was recorded 24 hours after administration of the plant extract. Based on the acute toxicity test, only four doses (5; 50; 100; and 300 mg/kg) of the extract were tested [218].

3.5.3 Healing activity

The healing activity of the alcoholic extract of the stem bark of *Annona muricata* was evaluated in albino rats by the open wound method for 12 days. The extract showed a marked reduction in wound area compared to that of the control group from day 4; suggesting its possible use in wound healing [219].

3.5.4 Convulsive seizures in mice

The effects of ethanolic extract of mature leaves of *Annona muricata* were studied on pentylenetetrazol (PTZ)-induced clonic-tonic seizures in mice. The latency of PTZ clonic seizures and the incidence of clonic and tonic episodes of PTZ seizures were analyzed. The results showed that the plant extract significantly reduced the incidence of tonic PTZ seizures and mortality, and prolonged the time to onset of PTZ clonic seizures. This study indicates that the extract of *A. muricata* leaves contains at least one or more active substances that preferentially suppress the tonic phase of PTZ-induced clonic seizures [218].

3.5.5 Histomorphological and morphometric studies of the pancreatic islet cells of diabetic rats

Adeyemi et al. [220] demonstrated that histomorphological and morphometric examination of stained pancreatic sections showed a significant increase in the number, diameter, and volume of pancreatic islet b-cells of the *A. muricata*-treated group (5.67 ± 0.184 N/1000 μm^2, 5.38 ± 0.093 µm, and 85.12 ± 4.24 μm^3, respectively) compared with those of the untreated diabetic rat group (2.85 ± 0.361 N/1000 μm^2, 2.85 ± 0.362 µm, and 69.56 ± 5.216 μm^3, respectively). The results revealed the regeneration of pancreatic islet b cells from rats treated with *A. muricata* extract.

3.5.6 Diabetic

Rats treated with *A. muricata* showed a significant decrease ($p < 0.05$) in the elevation of blood glucose, MDA, and NO. In addition, treatment with *A. muricata* significantly ($p<0.05$) increased antioxidant enzyme activities, as well as pancreatic/serum insulin levels. In conclusion, the results of the present study indicate that *A. muricata* treatment has beneficial effects on pancreatic tissues under STZ-induced oxidative stress by directly quenching lipid peroxides and indirectly enhancing endogenous antioxidant production. *Annona muricata* protected and preserved the integrity of pancreatic β cells [221].

4. CONCLUSION

Plant essences with pharmaceutical potential are rich in secondary metabolites. The advantages of their therapeutic uses in various conditions are their safety, inexpensiveness, effectiveness, and availability. Revue, if not current, has been taken to the point of providing protruding and updating information on medical and scientific evidence supporting the multiple uses of *Annona muricata* (Graviola) in traditional medicine. Chemically, this plant contains a wide range of secondary metabolites as well as minerals that could be responsible for various reported therapeutic activities. Consequently, *Annona muricata* could be of considerable interest in the development of new anti-cancer drugs based on plants for human health and well-being according to the wealth of annonaceous acetogenin. Vegetable species of the genus Annon are also good candidates for external use such as wound healing drugs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mukeba FB, Mukoko JB, Mayangi MM, Ngondo MM, Ngelinkoto PM, Bamba JV, et al. Microscopic features, mineral contents, anti-sickling, antioxidant and antibacterial activities of stem bark of Harungana madagascariensis Lam. Ex Poiret (Hypericaceae). Eur J Med Plants. 2020; 31:33-47.
   DOI: 10.9734/ejmp/2020/v31i2030355
2. Divengi JPN, Idrissa AZ, Kabasele DM, Mbuyi PL, Walle IS, Lesse VM, Za N, Mukeba FB, Mbenza BL, Mutwale PK, Mesia GK, Tona GL, et al. Costus afer ker gawl (Costaceae): A review on its medicinal uses with focus on potential anti-inflammatory effect. 2022;34:6–23.
   Available:https://doi.org/10.9734/JPRI/2022/v34i41A36269
3. Mukeba FB. Phytochemical study and bioactivities of *Harungana madagascariensis* Lam. ex Poiret and Zanthoxylum gilletii (De Wild) PG Waterman. Master of science, Biology. University of Kinshasa; 2022.
4. Clement YN, Mahase V, Jagroop A, Kissoon K, Maharaj A, Mathura P, et al. Herbal remedies and functional foods used by cancer patients attending specialty oncology clinics in Trinidad. BMC Complement Altern Med. 2016;16(1):399.
   DOI: 10.1186/s12906-016-1380-x, PMID 27769229.
5. Foster K, Younger N, Aiken W, Brady-West D, Delgoda R. Reliance on medicinal plant therapy among cancer patients in Jamaica. Cancer Causes Control. 2017; 28(11):1349-56.
   DOI: 10.1007/s10552-017-0924-9, PMID 28712058.
6. Inkoto CL, Kayembe J-PK, Mpiana PT, Ngbolua KN. A review on the Phytochemistry and Pharmacological properties of Picralima nitida Durand and H. (Apocynaceae family): A potential antiCovid-19 medicinal plant species. Emergent Life Sci Res. 2020;6(1): 64-75.
7. Inkoto CL, Masengo CA, Falanga CM, Mbembo BW-B, Amogu J-JD, Mahendra ISM, et al. A mini-review on the

phytochemistry and pharmacology of the plant Carica papaya L. (Caricaceae). Br Int Exact Sci (Bioex). 2020;2(3):663-75.

8. Inkoto CL, Ngbolua KN, Kilembe JT, Masengo CA, Lukoki FL, Tshilanda DD, et al. A Mini Review on the Phytochemistry and Pharmacology of Aframomum alboviolaceum (Zingiberaceae). S Asian Res J Nat Prod. 2021;4(3):24-35.
9. Ipona EN, Inkoto CL, Bongo GN, Mulenga CM, Ilinga BL, Shetonde OM et al. Ethno-botanical survey and ecological study of medicinal plants traditionally used against erectile dysfunction in Democratic Republic of the Congo. J Biosci Bioeng. 2018; 4(4):85-91.
10. Kabena N, Ngombe KN, Ngbolua KN, Kikufi BA, Lassa L, Mboloko EJ, et al. Etudes ethnobotanique et écologique des plantes d'hygiène intime féminine utilisées à Kinshasa (République Démocratique du Congo). Int J Bio Chem Sci. 2014; 8(6):2626-42.
DOI: 10.4314/ijbcs.v8i6.23
11. Masengo CA, Lengbiye EM, Inkoto CL, Gbolo BZ, Tshilanda DD, Tshibangu DS-T, et al. Literature review on the phytochemistry and pharmaco-biological, nutritional and cosmetic properties of Lippia multiflora and new Research Perspectives. S Asian Res J Nat Prod. 2021;4(4):35-48.
12. Masunda AT, Inkoto CL, Bongo GN, Oloko OW, Ngbolua KN, Tshibangu DST, et al. Ethnobotanical and ecological studies of plants used in the treatment of diabetes in Kwango, Kongo central and Kinshasa in the Democratic Republic of the Congo. Int J Diabetes Endocrinol. 2019;4(1):18-25.
DOI: 10.11648/j.ijde.20190401.14
13. Kalombo ASK, Mukeba FB, Idrissa AZ, Divengi JN, Mbuyi PL, Kayembe JK, Divengi JPN, Mbuyi PL, Kayembe JPK, et al. N'Da review on the ethnobotany, phytochemical and pharmacological profile of *Senna occidentalis* L. (Fabaceae): Potential application as remedy in the treatment of dysmenorrhea. EJMP. 2022;33(6):44-62.
DOI: 10.9734/ejmp/2022/v33i630472. ISSN: 2231-0894.
14. Panzu NN, Inkoto CL, Ngbolua K, Mukeba FB, Kitadi JM, Taba K, K, Mpiana PT, et al. Review on the phytochemistry, toxicology and bioactivities of *Euphorbia hirta* L.: A potential antisickling medicinal plant species. JMPHTR. 2020;7 8-18.
DOI: 10.33500/jmphtr.2020.07.002. ISSN: 2053-1826.
15. Mukeba B, Ngbolua KN, Ngombe K, Mpiana T, Mukoko B, Mutwale K, et al. Review on ethnobotany, phytochemistry and bioactivity of the Tropical medicinal plant species Harungana madagascariensis Lam. ex Poiret. (Hypericaceae). Discovery Phytomedicine. 2020;7(3):138-44.
DOI: 10.15562/phytomedicine.2020.140. ISSN: 2368-4798.
16. Idrissa AZ, Ndombe RT, Mukeba FB, Mulonda AB, Mokekola BE, Muanda FN, et al. Endogenous knowledge of traditional healers on plants used against hepatitis in Mbandaka/DR Congo. OARJ Life Sci. 2022;04(01):001-10.
DOI: 10.53022/oarjls.2022.4.1.0049
17. Cakupewa MF, Mukeba FB, Mulonda AB, Mokoso J-DM, Idrissa AZ. Antibacterial activities of 13 medicinal plants used against infectious and parasitic diseases in Kinshasa and its surroundings, D.R. Congo. IJBPSA. 2022;03(02):039-47.
DOI: 10.53771/ijbpsa.2022.3.2.0045
18. Ngunde ST-N, Inkoto CL, Kowozogono RK, Zua TG, Mayundo BK, Iteku JB. Etude ethnobotanique des plantes utilisées en médecine traditionnelle à Gini (Yakoma, Nord-Ubangi, République Démocratique du Congo). Int J Appl Res. 2021;7(1): 36-43.
19. Pieme C, Kumar S, Dongmo M, oukette M, B., Boyoum F, Ngogang J, Saxena A. BMC complement altern med. Antiproliferative activity and induction of apoptosis by *Annona muricata* (Annonaceae) extract on human cancer cells. 2014;14(1):514-6.
20. Adeyemi DO, Komolafe OA, Adewole OS, Obuotor EM, Adenowo TK. Anti-hyperglycemic activities of *Annona muricata* (Linn). Afr J Tradit Complement Altern Med. 2008;6(1):62-9. PMID 20162043.
21. ATIBT. Synthèse sur les forêts équatoriales-Volet faune sauvage ATIBT, editor. 2006;50.
22. Billön H. Histoire des plantes. Paris: Librairie de L. Hachette. 1869;275-6.
23. Calderon Al, Va´ zquez Y, Solı´ s, PN, Caballero-George C, Zacchino S, Gimenez A, Pinzon R, Caceres A, Tamayo G, Correa M, Gupta MP. Screening of Latin American plants for cytotoxic activity. Pharm. Biol. 2006;44:1–11.

24. Conabio. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, www; 2019. *Annona muricata* [cited Apr 8 2019]. Available from: conabio.gob.mx.
25. de Sousa OV, Vieira GD, de Jesus R G de Pinho J, Yamamoto CH, Alves MS. Antinociceptive and anti-inflammatory activities of the ethanol extract of *Annona muricata* L. leaves in animal models. Int J Mol Sci. 2010;11(5):2067-78. DOI: 10.3390/ijms11052067, PMID 20559502.
26. Di Stasi LC, Hiruma-Lima CA. Plantas medicinais na Amazônia e na mata atlântica. 2nd ed. Editora UNESP. São Paulo, Brazil. 2002;87-112.
27. Kim GS, Zeng L, Alali F, Rogers LL, Wu FE, Sastrodihardjo S. et al. Muricoreacin and murihexocin C, monotetrahydrofuran acetogenins, from the leaves of *Annona muricata*. Phytochemistry. 1998a;49(2): 565-71. DOI:10.1016/s0031-9422(98)00172-1, PMID 9747542.
28. Liaw CC, Liou JR, Wu TY, Chang FR, Wu YC. Acetogenins from annonaceae. prog chem org nat prod. 2016;101:113-230. DOI: 10.1007/978-3-319-22692-7_2, PMID 26659109.
29. Morton JF. The soursop, or guanabana (*Annona muricata* Linn.). Proc Fla State Hortic Soc. 1966;79:355-66.
30. Syed Najmuddin SUF, Romli MF, Hamid M, Alitheen NB, Nik Abd Rahman NMA. Anticancer effect of *Annona muricata* Linn leaves crude extract (AMCE) on breast cancer cell line. BMC Complement Altern Med. 2016;16(1):311. DOI: 10.1186/s12906-016-1290-y, PMID 27558166.
31. Ngbolua KN, Mihigo SO, Liyongo CL, Masengo CA, Tshibangu DT, Zoawe BG, et al. Ethno-botanical survey of plant species used in traditional medicine in Kinshasa city (DR of the Congo). Trop Plant Res. 2016;3(2):413-27.
32. Oberlies NH, Chang CJ, McLaughlin JL. Structure-activity relationships of diverse Annonaceous acetogenins against multidrug resistant human mammary adenocarcinoma (MCF-7/ Adr) cells. J Med Chem. 1997;40(13):2102-6. DOI: 10.1021/jm9700169, PMID 9207950.
33. Orwa C, Mutua A, Kindt R, Jamnadass R, Athony S. Agroforestree database: A tree reference and selection guide version 4.0; 2009. Available:http://www.worldagroforestry.org/resources/databases/agroforestree.
34. Paul J, Gnanam R, Jayadeepa R, Arul L. Anticancer activity on Graviola, an exciting medicinal plant extract vs various cancer cell lines and a detailed computational study on its potent anticancerous leads. Curr Top Med Chem. 1666;13(14):1673, 2013.
35. Sousa MP, Matos MEO, Matos FJA, Machados MIL, Craveiro AA. Constituintes químicos ativos e propriedades biológicas de plantas medicinais brasileiras. 2nd ed.Editora UFC, Fortaleza, Brazil. 2004; 281-283.
36. Tisott G, Molin D, Colet CD. The use of medicinal plants and herbal medicines for patients in chemotherapy in an oncology center of Ijuı´/RS. O M undo da Sau'de. 2013;39(3):287-98.
37. Moghadamtousi SZ, Fadaeinasab M, Nikzad S, Mohan G, Ali HM, Kadir HA. *Annona muricata* (Annonaceae): a review of its traditional uses, isolated acetogenins and biological activities. Int J Mol Sci. 2015a;16(7):15625-58. DOI: 10.3390/ijms160715625, PMID 26184167.
38. Coria-Téllez AV, Montalvo-Gónzalez E, Yahia EM, Obledo-Vázquez EN. *Annona muricata*: a comprehensive review on its traditional medicinal uses, phytochemicals, pharmacological activities, mechanisms of action and toxicity. Arab J Chem. 2016;30.
39. Pinto AC, de Q, Cordeiro MCR, De Andrade SRM, Ferreira FR, Filgueiras HA, et al. *Annona muricata*. In: Williams JT, editor, Annona species, taxonomy and botany inter-national centre underutilised crops. Southampton, UK: University of Southampton. 2005;3-16.
40. Evangelista-Lozano S, Cruz-Castillo JG, Perez-Gonzalez S, Mercado-Silva E, Davila-Ortiz G, Produccion y calidad frutı cola de guanabanos (*A. muricata* L.) provenientes de semilla de Jiutepec, Morelos, Mexico. Rev Chap. Ser. Hortic. 2003;9:69-79.
41. Ojeda G, Coronado J, Nava R, Sulbaran B, Araujo D, Cabrera L. Caracterizacion fisicoquı mica de la pulpa de la guanabana (*Annona muricata*) cultivada en el occidente de Venezuela. Bol. Cen. Investig Biol. 2007;1:151-60.
42. Benavides A. Caracterizacion numérica de germoplasma de guanabana (*Annona*

muricata L.) muestreado in situ en el pacıfico y norte de Nicaragua; 2003.

43. Awan JA, Kar A, Udoudoh PJ. Preliminar studies on the seeds of *Annona muricata* Linn. Plant Food Hum Nutr. 1980; 30(2):163-8.
DOI: 10.1007/BF01099054
44. Kim GS, Zeng L, Alali F, Rogers LL, Wu FE, McLaughlin JL, et al. Two new monotetrahydrofuran ring acetogenins, annomuricin E and muricapentocin, from the leaves of *Annona muricata*. J Nat Prod. 1998;61(4):432-6.
DOI: 10.1021/np970534m, PMID 9584396
45. Wu FE, Gu ZM, Zeng L, Zhao GX, Zhang Y, McLaughlin JL, et al. Two new cytotoxic monotetrahydrofuran Annonaceous acetogenins, annomuricins A and B, from the leaves of *Annona muricata*. J Nat Prod. 1995a;58(6):830-6.
DOI: 10.1021/np50120a002, PMID 7673926.
46. Wu FE, Zeng L, Gu ZM, Zhao GX, Zhang Y, Schwedler JT, et al. New bioactive monotetrahydrofuran Annonaceous acetogenins, annomuricin C and muricatocin C, from the leaves of *Annona muricata*. J Nat Prod. 1995b;58(6): 909-15.
DOI: 10.1021/np50120a014, PMID 7673936.
47. Wu FE, Zeng L, Gu ZM, Zhao GX, Zhang Y, Schwedler JT, et al. New bioactive monotetrahydrofuran annonaceous acetogenins, annomuricin C and muricatocin C, from the leaves of *Annona muricata*. J Nat Prod. 1995c;58(6): 909-15.
DOI: 10.1021/np50120a014, PMID 7673936.
48. Ge HL, Zhang DW, Li L, Xie D, Zou JH, Si YK, et al. Two new terpenoids from endophytic fungus Periconia sp. F-31. Chem Pharm Bull (Tokyo). 2011;59(12):1541-4.
DOI: 10.1248/cpb.59.1541, PMID 22130377.
49. Kuete V, Dzotam JK, Voukeng IK, Fankam AG, Efferth T. Cytotoxicity of methanol extracts of *Annona muricata*, Passiflora edulis and nine other Cameroonian medicinal plants towards multi-factorial drug-resistant cancer cell lines. Springerplus. 2016;5(1):article 1666.
DOI: 10.1186/s40064-016-3361-4
50. Jaramillo MC, Arango GJ, González MC, Robledo SM, Velez ID. Cytotoxicity and antileishmanial activity of *Annona muricata* pericarp. Fitoterapia. 2000;71(2):183-6.
DOI: 10.1016/s0367-326x(99)00138-0, PMID 10727816.
51. Calderón ÁI, Vázquez Y, Solís PN, Caballero-George C, Zacchino S, Gimenez A, et al. Screening of Latin American plants for cytotoxic activity. Pharm Biol. 2006;44(2):130-40.
DOI: 10.1080/13880200600592285
52. Sun S, Liu J, Zhou N, Zhu W, Dou QP, Zhou K. Isolation of three new annonaceous acetogenins from graviola fruit (*Annona muricata*) and their antiproliferation on human prostate cancer cell PC-3. Bioorg Med Chem Lett. 2016; 26(17):4382-5.
DOI: 10.1016/j.bmcl.2015.06.038, PMID 27499453.
53. Rieser MJ, Fang XP, Anderson JE, Miesbauer LR, Smith DL, McLaughlin JL. Erratum. Helv Chim Acta. 1994;77(3):882.
DOI: 10.1002/hlca.19940770327.
54. Rieser MJ, Kozlowski JF, Wood KV, McLaughlin JL. Muricatacin: A simple biologically active acetogenin derivative from the seeds of *Annona muricata* (Annonaceae). Tetrahedron Lett. 1991; 32(9):1137-40.
DOI: 10.1016/S0040-4039(00)92027-6
55. Rieser MJ, Fang XP, Rupprecht JK, Hui YH, Smith DL, McLaughlin JL. Bioactive single-ring acetogenins from seed extracts of *Annona muricata*. Planta Med. 1993; 59(1):91-2.
DOI: 10.1055/s-2006-959614, PMID 8441787.
56. Pieme CA, Kumar SG, Dongmo MS, Moukette BM, Boyoum FF, Ngogang JY, et al. Antiproliferative activity and induction of apoptosis by *Annona muricata* (Annonaceae) extract on human cancer cells. BMC Complement Altern Med. 2014;14(1):516.
DOI: 10.1186/1472-6882-14-516, PMID 25539720.
57. Badrie N, Schauss AG. Soursop (*Annona muricata* L.): composition, nutritional value, medicinal uses, and toxicology. In: Watson RR, Preedy VR, editors, Bioactive foods in promoting health. Oxford; 2009.
58. Baillon H. History of plants. Paris: Library of LH Hachette; 1869.
59. Karou SD, Tchacondo T, Djikpo Tchibozo MA, Abdoul-Rahaman S, Anani K, Koudouvo K, et al. Ethnobotanical study of medicinal plants used in the management

of diabetes mellitus and hypertension in the Central Region of Togo. Pharm Biol. 2011;49(12):1286-97.
DOI: 10.3109/13880209.2011.621959, PMID 22077164.

60. Longuefosse JL, Nossin E. Medical ethnobotany survey in Martinique. J Ethnopharmacol. 1996;53(3):117-42.
DOI: 10.1016/0378-8741(96)01425-0, PMID 8887020.
61. Zorofchian Moghadamtousi SZ, Karimian H, Rouhollahi E, Paydar M, Fadaeinasab M, Abdul Kadir H. *Annona muricata* leaves induce G1 cell cycle arrest and apoptosis through mitochondria-mediated pathway in human HCT-116 and HT-29 colon cancer cells. J Ethnopharmacol. 2014a;156:277-89.
DOI: 10.1016/j.jep.2014.08.011, PMID 25195082.
62. Moghadamtousi SZ, Rouhollahi E, Karimian H et al. The chemopotential effect of *Annona muricata* leaves against azoxymethane-induced colonic aberrant crypt foci in rats and the apoptotic effect of acetogenin annomuricin E in HT-29 cells: A bioassay-guided approach. PLOS ONE. 2015b;10(4):article e0122288.
63. Liu N, Yang HL, Wang P, Lu YC, Yang YJ, Wang L et al. Functional proteomic analysis revels that the ethanol extract of *Annona muricata* L. induces liver cancer cell apoptosis through endoplasmic reticulum stress pathway. J Ethnopharmacol. 2016;189:210-7.
DOI: 10.1016/j.jep.2016.05.045, PMID 27224241
64. Yang C, Gundala SR, Mukkavilli R, Vangala S, Reid MD, Aneja R. Synergistic interactions among flavonoids and acetogenins in Graviola (*Annona muricata*) leaves confer protection against prostate cancer. Carcinogenesis. 2015;36(6): 656-65.
DOI: 10.1093/carcin/bgv046, PMID 25863125.
65. Foster K, Younger N, Aiken W, Brady-West D, Delgoda R. Reliance on medicinal plant therapy among cancer patients in Jamaica. Cancer Causes Control. 2017;28(11):1349-56.
DOI: 10.1007/s10552-017-0924-9, PMID 28712058.
66. Clement YN, Mahase V, Jagroop A, Kissoon K, Maharaj A, Mathura P, et al. Herbal remedies and functional foods used by cancer patients attending specialty oncology clinics in Trinidad. BMC Complement Altern Med. 2016;16(1):399.
DOI: 10.1186/s12906-016-1380-x, PMID 27769229.
67. Prabhakaran K, Ramasamy G, Doraisamy U, Mannu J, K R, Murugesan JR. Polyketide natural products, acetogenins from graviola (*Annona muricata* L), its biochemical, cytotoxic activity and various analyses through computational and bio-programming methods. Curr Pharm Des. 2016;22(34):5204-10.
DOI:10.2174/1381612822666160531163144, PMID 27262333.
68. Hajdu Z, Hohmann J. An ethnopharmacological survey of the traditional medicine utilized in the community of Porvenir, Bajo Paraguay Indian Reservation, Bolivia. J Ethnopharmacol. 2012;139(3):838-57.
DOI: 10.1016/j.jep.2011.12.029, PMID 22222280.
69. Ritter RA, Monteiro MV, Monteiro FO, Rodrigues ST, Soares ML, Silva JC, et al. Ethnoveterinary knowledge and practices at Colares island, Para´state, Eastern Amazon, Brazil. J Ethnopharmacol. 2012; 144(2):346-52.
DOI: 10.1016/j.jep.2012.09.018, PMID 23000170.
70. Sreekeesoon DP, Mahomoodally MF. Ethnopharmacological analysis of medicinal plants and animals used in the treatment and management of pain in Mauritius. J Ethnopharmacol. 2014;157: 181-200.
DOI: 10.1016/j.jep.2014.09.030, PMID 25261690.
71. Asase A, Hesse DN, Simmonds MSJ. Uses of multiple plants prescriptions for treatment of malaria by some communities in southern Ghana. J Ethnopharmacol. 2012;144(2):448-52.
DOI: 10.1016/j.jep.2012.09.028, PMID 23022690.
72. Mithun Pai BH, Rajesh G, Shenoy R, Rao A. Antimicrobial efficacy of soursop leaf extract (*Annona muricata*) on oral pathogens: an in-vitro study. J Clin Diagn Res. 2016;10(11):ZC01–ZC04.
73. Florence NT, Benoit MZ, Jonas K, Alexandra T, Désiré DD, Pierre K, et al. Antidiabetic and antioxidant effects of *Annona muricata* (Annonaceae), aqueous extract on streptozotocin-induced diabetic rats. J Ethnopharmacol. 2014;151(2): 784-90.

DOI: 10.1016/j.jep.2013.09.021, PMID 24076471.

74. Oliveira AP, Sá I, Pereira DM, Gonçalves RF, Andrade PB, Valentão P. Exploratory studies on the in vitro anti-inflammatory potential of two herbal teas (*Annona muricata* L. and *Jasminum grandiflorum* L.), and relation with their phenolic composition. Chem Biodiversity. 2017; 14(6):article e1700002.
DOI: 10.1002/cbdv.201700002
75. Boyom FF, Fokou PV, Yamthe LR, Mfopa AN, Kemgne EM, Mbacham WF, Tsamo, Zollo PH, Gut, Rosenthal PJ. Potent antiplasmodial extracts from Cameroonian Annonaceae. J Ethnopharmacol. 2011;134(3):717-24.
DOI: 10.1016/j.jep.2011.01.020, PMID 21256952.
76. Santhosh SB, Ragavendran C, Natarajan D. Spectral and HRTEM analyses of *Annona muricata* leaf extract mediated silver nanoparticles and its larvicidal efficacy against three mosquito vectors Anopheles stephensi, Culex quinquefasciatus, and Aedes aegypti. J Photochem Photobiol B Biol. 2015a;153:184-90.
DOI: 10.1016/j.jphotobiol.2015.09.018
77. Santhosh SB, Yuvarajan R, Natarajan D. *Annona muricata* leaf extract-mediated silver nanoparticles synthesis and its larvicidal potential against dengue, malaria and filariasis vector. Parasitol Res. 2015b;114(8):3087-96.
DOI: 10.1007/s00436-015-4511-2, PMID 26002825.
78. Kossouoh C, Moudachirou M, Adjakidje V, Chalchat JC, Figuérédo G. Essential oil chemical composition of *Annona muricata* L. leaves from Benin. J Essent Oil Res. 2007;19(4):307-9.
DOI: 10.1080/10412905.2007.9699288
79. Ross IA. Medicinal plants of the world. 2nd ed. Chemical Constituents, Traditional and Modern Medicinal. Totowa: Humana Press. 2010;1:133-42.
80. Cercato LM, White PAS, Nampo FK, Santos MRV, Camargo EA. A systematic review of medicinal plants used for weight loss in Brazil: is there potential for obesity treatment? J Ethnopharmacol. 2015; 176:286-96.
DOI: 10.1016/j.jep.2015.10.038, PMID 26520790.
81. Tsabang N, Fokou PV, Tchokouaha LR, Noguem B, Bakarnga-Via I, Nguepi MS, et al. Ethnopharmacological survey of Annonaceae medicinal plants used to treat malaria in four areas of Cameroon. J Ethnopharmacol. 2012;139(1):171-80.
DOI: 10.1016/j.jep.2011.10.035, PMID 22079831.
82. Roger T, Pierre-Marie M, Igor V, Patrick V. Phytochemical screening and antibacterial activity of medicinal plants used to treat typhoid fever in Bamboutos division, West Cameroon. J App Pharm Sci. 2015; 5(06):034-49.
DOI: 10.7324/JAPS.2015.50606
83. Joyeux M, Mortier F, Fleurentin J. Screening of antiradical, antilipoperoxidant and hepatoprotective effects of nine plant extracts used in Caribbean folk medicine. Phytother Res. 1995;9(3):228-30.
DOI: 10.1002/ptr.2650090316
84. TDRG. (Technical Data Report on graviola). *Annona muricata*. Austin: SAGE Press Inc. 2002;52.
85. Boulogne I, Germose´ n-Robineau L, Ozier-Lafontaine H, Fleury M, Loranger Merciris G. TRAMIL ethnopharmalogical survey in les Saintes (Guadeloupe, French West Indies): a comparative study. J. Ethnopharmacol. 2011;133(3):1039–1050.
86. Betancur-Galvis LA, Saez J, Granados H, Salazar A, Ossa JE. Antitumor and antiviral activity of Colombian medicinal plant extracts. Mem Inst Oswaldo Cruz. 1999;94(4):531-5.
DOI: 10.1590/S0074-02761999000400019
87. Gomez-Estrada H, Dıaz-Castillo F, Franco-Ospina L, Mercado-Camargo J, Guzman-Ledezma J, Domingo Medina J. Gaita´ n-Ibarra, R. J Ethnobiol Ethnomed. Folk medicine in the northern coast of Colombia: an overview. 2011;7:1-10.
88. Beyra A. Leo´ n MC, Iglesias E, Ferra´ ndiz D, Herrera R Volpato G, Guimarais M. Estudios etnobota´ nicos sobre plantas medicinales. Jard A. Bot. Madrid. 2004; 61:185-204.
89. Vandebroek I, Balick MJ, Ososki A, Kronenberg F, Yukes J, Wade C et al. The importance of botellas and other plant mixtures in Dominican traditional medicine. J Ethnopharmacol. 2010;128(1):20-41. doi: 10.1016/j.jep.2009.12.013, PMID 20006697.
90. Brechelt A. El manejo ecologico de plagas y enfermedades. 1st ed RAP-AL, Santiago de Chile. 2004;25.
91. Tene V, Malago´ n O, Finzi PV, Vidari G, Armijos C, Zaragoza T. An ethnobotanical

survey of medicinal plants used in Loja and Zamora-Chinchipe. Ecuador. J. Ethnopharmacol. 2007;111:63–81.
92. Defilippis RA, Maina SL, Crepin J. Medicinal plants of the Guianas (Guyana, Surinam, French Guiana). Washington: Museum of History; 2004. Available:http://botany.si.edu/BDG/medicinal/index.html.
93. Dagar HS, Dagar JC. Plant folk medicines among the Nicobarese of Katchal Island, India. Econ Bot. 1991;45(1):114-9. DOI: 10.1007/BF02860056
94. Leatemia JA, Isman MB. Insecticidal activity of crude seed extracts of Annona spp., Lansium domesticum and Sandoricum koetjape against Lepidopteran Larvae. Phytoparasitica. 2004;32(1):30-7. DOI: 10.1007/BF02980856
95. Roosita K, Kusharto CM, Sekiyama M, Fachrurozi Y, Ohtsuka R. Medicinal plants used by the villagers of a Sundanese community in west Java, Indonesia. J Ethnopharmacol. 2008;115(1):72-81. DOI: 10.1016/j.jep.2007.09.010, PMID 17961941.
96. Abdillah S, Tambunan RM, Farida Y, Sandhiutami NMD, Dewi RM. Phytochemical screening and antimalarial activity of some plants traditionally used in Indonesia. Asian Pac J Trop Dis. 2015; 5(6):454-7. DOI: 10.1016/S2222-1808(15)60814-3
97. Asprey GF, Thornton PT. Medicinal plants of Jamaica. III. West Indian Med J. 1955;4(2):69-82. PMID 13257077.
98. Novy JW. Medicinal plants of the eastern region of Madagascar. J Ethnopharmacol. 1997;55(2):119-26. DOI: 10.1016/s0378-8741(96)01489-4, PMID 9032624.
99. Samuel AJSJ, Kalusalingam A, Chellappan DK, Gopinath R, Radhamani S, Husain Hj A, et al. Ethnomedical survey of plants used by the Orang Asli in Kampung Bawong. Perak: West Malaysia. J. Ethnobiol. Eth- nomed. 2010;6:1-6.
100. Mootoosamy A, Fawzi Mahomoodally M. Ethnomedicinal application of native remedies used against diabetes and related complications in Mauritius. J Ethnopharmacol. 2014;151(1):413-44. DOI: 10.1016/j.jep.2013.10.069, PMID 24231070.
101. Alonso-Castro AJ, Villarreal ML, Salazar-Olivo LA, Gomez-Sanchez M, Dominguez F, Garcia-Carranca A. Mexican medicinal plants used for cancer treatment: Pharmacological, phytochemical and ethnobotanical studies. J Ethnopharmacol. 2011;133(3):945-72. DOI: 10.1016/j.jep.2010.11.055, PMID 21146599.
102. Maganä MA, Gama LM, Mariaca R. The use of medicinal plants in the Mayachon communities of Nacajuca. Mexico: Tabasco. Polibo´tanica. 2010;29:213-62.
103. Yasunaka K, Abe F, Nagayama A, Okabe H, Lozada-Pérez L, López-Villafranco E, et al. Antibacterial activity of crude extracts from Mexican medicinal plants and purified coumarins and xanthones. J Ethnopharmacol. 2005;97(2):293-9. DOI: 10.1016/j.jep.2004.11.014
104. Waizel HS, Waizel BJ. Some plants used in Mexico for the treatment of asthma. Annals Mex Orl. 2009;54:145-71.
105. Coe FG. Rama midwifery in Eastern Nicaragua. J Ethnopharmacol. 2008; 117(1):136-57. DOI: 10.1016/j.jep.2008.01.027, PMID 18337033.
106. Atawodi SE. Nigerian foodstuffs with prostate cancer chemopreventive polyphenols. Infect Agents Cancer. 2011;6;Suppl 2:S9. DOI: 10.1186/1750-9378-6-S2-S9, PMID 21992488.
107. Ezuruike UF, Prieto JM. The use of plants in the traditional management of diabetes in Nigeria: pharmacological and toxicological considerations. J Ethnopharmacol. 2014;155(2):857-924. DOI: 10.1016/j.jep.2014.05.055, PMID 24929108.
108. Gupta MP, Arias TD, Correa M, Lamba SS. Ethnopharmacognostic observations on Panamamanian medicinal plants. Part I. Q J Crude Drug Res. 1979;17(3-4): 115-30. DOI: 10.3109/13880207909065163.
109. Langenberger G, Prigge V, Martin K, Belonias B, Sauerborn J. Ethnobotanical knowledge of Philippine lowland farmers and its application in agroforestry. Agrofor Syst. 2009;76(1):173-94. DOI: 10.1007/s10457-008-9189-3
110. Ong HG, Kim YD. Quantitative ethnobotanical study of the medicinal plants used by the Ati negrito indigenous group in Guimaras Island, Philippines. J Ethnopharmacol. 2014;157:228-42. DOI: 10.1016/j.jep.2014.09.015, PMID 25240586.

111. Bussmann RW, Malca-García G, Glenn A, Sharon D, Chait G, Díaz D, et al. Minimum inhibitory concentrations of medicinal plants used in Northern Peru as antibacterial remedies. J Ethnopharmacol. 2010;132(1):101-8.
DOI: 10.1016/j.jep.2010.07.048, PMID 20678568.

112. Bussmann RW, Malca-García G, Glenn A, Sharon D, Chait G, Díaz D, et al. Minimum inhibitory concentra- tions of medicinal plants used in Northern Peru as antibacterial remedies. J Ethnopharmacol. 2010;132(1):101-8.
DOI: 10.1016/j.jep.2010.07.048, PMID 20678568.

113. Rodrıguez MP, Management of medicinal plants in the northeastern Peruvian Amazon. ECIPERU´8. 2011;150-7.

114. Poma E, Requis ER, Gordillo G, Fuertes C. Phytochemical study and anti-inflammatory activity of *Annona muricata* L. (Soursop) from Cuzco. Sci Res. 2011; 14:29-33.

115. Monigatti M, Bussmann RW, Weckerle CS. Medicinal plant use in two Andean communities located at different altitudes in the Bolívar Province, Peru. J Ethnopharmacol. 2013;145(2):450-64.
DOI: 10.1016/j.jep.2012.10.066, PMID 23159468.

116. WHO (Worl Health Organization). Medicinal plants in the South Pacific. Western Pacific Series. 19. Manila, Philippines. 1998;17.

117. Lans CA. Ethnomedicines used in Trinidad and Tobago for urinary problems and diabetes mellitus. J Ethnobiol Ethnomed. 2006;2:45.
DOI: 10.1186/1746-4269-2-45, PMID 17040567.

118. Karou SD, Tchacondo T, Djikpo Tchibozo MA, Abdoul-Rahaman S, Anani K, Koudouvo K, et al. Ethnobotanical study of medicinal plants used in the management of diabetes mellitus and hypertension in the Central Region of Togo. Pharm Biol. 2011;49(12):1286-97.
DOI: 10.3109/13880209.2011.621959, PMID 22077164.

119. Ssenyange CW, Namulindwa A, Oyik B, Ssebuliba J. Plants used to manage type II diabetes mellitus in selected districts of central Uganda. Afr Health Sci. 2015; 15(2):496-502.
DOI: 10.4314/ahs.v15i2.24, PMID 26124796.

120. Bradacs G, Heilmann J, Weckerle CS. Medicinal plant use in Vanautu: a comparative ethnobotanical study of three islands. J Ethnopharmacol. 2011;137(1): 434-48.
DOI: 10.1016/j.jep.2011.05.050, PMID 21679762.

121. Burkill HM. In: Botanic R, editor. The useful plants of west tropical Africa. 2nd ed. Kew, UK. 1985;1:960.

122. Feng PC, Haynes LJ, Magnus KE, Plimmer JR, Sherratt HS. Pharmacological screening of some West Indian medicinal plants. J Pharm Pharmacol. 1962;14: 556-61.
DOI: 10.1111/j.2042-7158.1962.tb11139.x, PMID 13892272.

123. Nguyen-Pouplin J, Tran H, Tran H, Phan TA, Dolecek C, Farrar J, et al. Antimalarial and cytotoxic activities of ethnopharmacologically selected medicinal plants from South Vietnam. J Ethnopharmacol. 2007;109(3):417-27.
DOI: 10.1016/j.jep.2006.08.011, PMID 17010546.

124. Gavamukulya Y, Abou-Elella F, Wamunyokoli F, AEl-Shemy H. Phytochemical screening, anti-oxidant activity and in vitro anticancer potential of ethanolic and water leaves extracts of *Annona muricata* (Graviola). Asian Pac J Trop Med. 2014;7S1;Suppl 1:S355-63.
DOI: 10.1016/S1995-7645(14)60258-3, PMID 25312150.

125. Minari JB, Okeke U. Chemopreventive effect of *Annona muricata* on DMBA-induced cell proliferation in the breast tissues of female albino mice. Egypt J Med Hum Genet. 2014;15(4):327-34.
Available:https://doi.org/10.1016/S1995-7645(14)60258-3

126. Hasrat JA, De Bruyne T, De Backer JP, Vauquelin G, Vlietinck AJ. Isoquinoline derivatives isolated from the fruit of *Annona muricata* as 5-HTergic 5-HT1A receptor agonists in rats: unexploited antidepressive (lead) products. J Pharm Pharmacol. 1997a;49(11):1145-9.
Available:https://doi.org/10.1016/j.ejmhg.2014.05.001

127. Hasrat JA, Pieters L, De Backer JP, Vauquelin G, Vlietinck AJ. Screening of medicinal plants from Suriname for 5-HT 1A ligands: bioactive isoquinoline alkaloids from fruit of *Annona muricata*. Phytomedicine. 1997b;4(2):133-40.

DOI: 10.1016/S0944-7113(97)80059-1, PMID 23195401.

128. Fofana S, Ziyaev R, Abdusamatov A, Zakirov SK. Alkaloids from *Annona muricata* leaves. Chem Nat Compd. 2011; 47(2):321.
DOI: 10.1007/s10600-011-9921-5
129. Ocampo DM, Ocampo R. Bioactividad de la familia Annonaceae. Rev Univ Caldas. 2006:135-55.
130. Matsushige A, Kotake Y, Matsunami K, Otsuka H, Ohta S, Takeda Y. Annonamine, a new aporphine alkaloid from the leaves of *Annona muricata*. Chem Pharm Bull (Tokyo). 2012;60(2):257-9.
DOI: 10.1248/cpb.60.257, PMID 22293487.
131. Leboeuf M, Legueut C, Cave A, Desconclois JF, Fargacs P, Jacquemin H. Alkaloids of Annonaceae XXIX. Alkaloids of *Annona muricata*. J. Med. Plants Res. 1981;42:37–44.
132. Fofana S, Keita A, Balde S, Ziyaev R, Aripova SF. Alkaloids from leaves of *Annona muricata*. Chem Nat Compd. 2012;48(4):714.
DOI: 10.1007/s10600-012-0363-5
133. Mohanty S, Hollinshead J, Jones L, Jones PW, Thomas D, Watson AA, et al. *Annona muricata* (Graviola): toxic or therapeutic. Nat Prod Commun. 2008;3(1):31-3.
DOI: 10.1177/1934578X0800300107
134. Lannuzel A, Michel PP, Caparros-Lefebvre D, Abaul J, Hocquemiller R, Ruberg M. Toxicity of Annonaceae for dopaminergic neurons: potential role in atypical Parkinsonism in Guadeloupe. Mov Disord. 2002;17(1):84-90.
DOI: 10.1002/mds.1246, PMID 11835443.
135. Kotake Y, Okuda K, Kamizono M, Matsumoto N, Tanahashi T, Hara H, et al. Detection and determination of reticuline and N-methylcoculaurine in the Annonaceae family using liquid chromatography-tandem mass spectroscopy. J Chromatogr B Analyt Technol Biomed Life Sci. 2004;806(1): 75-8.
DOI: 10.1016/j.jchromb.2004.03.017, PMID 15149614.
136. Alali FQ, Liu XX, McLaughlin JL. Annonaceous acetogenins: recent progress. J Nat Prod. 1999;62(3):504-40.
DOI: 10.1021/np980406d, PMID 10096871.
137. Gleye C, Raynaud S, Fourneau C, Laurens A, Lapre´ vote O, Serani L, Fournet A, Hocquemiller R. Cohibins C and D, two important metabolites in the biogenesis of acetogenins from *Annona muricata* and Annona nutans. J. Nat. Prod. 2000a; 63:1192–1196.
138. Yu JG, Gui HQ, Luo XZ, Sun L, Zhu P, Yu ZL. Studies on the chemical constituents of *Annona muricata*. Acta Pharmacol Sin. 1997;3:431-7.
139. Champy P, Guérineau V, Laprévote O. MALDI-TOF MS profiling of annonaceous acetogenins in *Annona muricata* products for human consumption. Molecules. 2009;14(12):5235-46.
DOI: 10.3390/molecules14125235, PMID 20032889.
140. Li DY, Yu JG, Luo XZ, Sun L, Yang SL. Muricatenol, a linear acetogenin from *Annona muricata* (Annonaceae). Chin Chem Lett. 2000; 11:239-42.
141. Zafra-Polo MC, Gonza´ lez C, Estornell E., Sahpaz S, Cortes D. Acetogenins from Annonaceae, inhibitors of mitochondrial complex. Phytochemistry. 1996;42:253–271.
142. Melot A, Fall D, Gleye C, Champy P. Apolar annonaceous acetogenins from the fruit pulp of *Annona muricata*. Molecules. 2009;14(11):4387-95.
DOI: 10.3390/molecules14114387, PMID 19924072.
143. Gleye C, Laurens A. Lapre´ vote, O. Serani, L. Hocquemiller, R. Isolation Struct Elucidation Sabadelin Acetogenin Roots *Annona Muricata* Phytochem. 1999;52: 1403-8.
144. Ragasa AY, Soriano G, Torres GB, Don M, Shen C. Acetogenins from *Annona muricata*. Pharmacogn J. 2012;32: 32-7.
145. Gromek D, Figadère B, Hocquemiller R, Cavé A, Cortes D. Corepoxylone, a possible precursor of mono-tetrahydrofuran γ-lactone acetogenins: biomimetic synthesis of corossolone. Tetrahedron. 1993;49(24):5247-52.
DOI: 10.1016/S0040-4020(01)82374-7
146. Liaw CC, Chang FR, Lin CY, Chou CJ, Chiu HF, Wu MJ, et al. New cytotoxic monotetrahydrofuran annonaceous acetogenins from *Annona muricata*. J Nat Prod. 2002;65(4):470-5.
DOI: 10.1021/np0105578, PMID 11975482.
147. Yang H, Zhang N, Zeng Q, Yu Q, Ke S, Li X. HPLC method for the simultaneous

determination of ten annonaceous acetogenins after supercritical fluid CO2 extraction. Int J Biomed Sci. 2010; 6(3):202-7. PMID 23675194.

148. Zeng L, Ye Q, Oberlies NH, Shi G, Gu ZM, He K, et al. Recent advances in Annonaceous acetogenins. Nat Prod Rep. 1996;13(4):275-306.
DOI: 10.1039/np9961300275, PMID 8760865.
149. Nakanishi Y, Chang FR, Liaw CC, Wu YC, Bastow KF, Lee KH. Acetogenins as selective inhibitors of the human ovarian 1A9 tumor cell line. J Med Chem. 2003;46(15):3185-8.
DOI: 10.1021/jm020548b, PMID 12852747.
150. Castillo-Sanchez LE, Jiménez-Osornio JJ, Delgado-Herrera M. Secondary metabolites of the Annonaceae, Solanaceae and Meliaceae families used as biological control of insects. Trop Subtrop Agroecosyst. 2010;12:445-62.
151. Wu FE, Zhao GX, Zeng L, Zhang Y, Schwedler JT, McLaughlin JL, et al. Additional bioactive acetogenins, annomutacin and (2,4-trans and cis)-10R-annonacin-A-ones, from the leaves of *Annona muricata*. J Nat Prod. 1995; 58(9):1430-7.
DOI: 10.1021/np50123a015, PMID 7494150.
152. Moghadamtousi SZ, Rouhollahi E, Hajrezaie M, Karimian H, Abdulla MA, Kadir HA. *Annona muricata* leaves accelerate wound healing in rats via involvement of Hsp70 and antioxidant defence. Int J Surg. 2015c;18:110-7.
DOI: 10.1016/j.ijsu.2015.03.026, PMID 25899210.
153. Guadaño A, Gutiérrez C, de La Peña E, Cortes D, González-Coloma A. Insecticidal and mutagenic evaluation of two annonaceous acetogenins. J Nat Prod. 2000;63(6):773-6.
DOI: 10.1021/np990328+, PMID 10869199.
154. Ko YM, Wu TY, Wu YC, Chang FR, Guh JY, Chuang LY. Annonacin induces cell cycle-dependent growth arrest and apoptosis in estrogen receptor-alfa-related pathways in MCF-7 cells. J Ethnopharmacol. 2011;137(3):1283-90.
DOI: 10.1016/j.jep.2011.07.056, PMID 21840388.
155. Champy P, Ho¨ Glinger GU, Fe´ ger J, Gleye C, Hocquemiller R, Laurens A, Ruberg M. Annonacin, a lipophilic inhibitor of mitochondrial complex I, induces nigral and striatal neurodegeneration in rats: possible relevance for atypical Parkinsonism in Guadeloupe. J. Neurochem. 2004;88, 63–69.
156. Rieser MJ, Gu ZM, Fang XP, Zeng L, Wood KV, McLaughlin JL. Five novel mono-tetrahydrofuran ring acetogenin from the seed of *Annona muricata*. J Nat Prod. 1996;59(2):100-8.
DOI: 10.1021/np960037q, PMID 8991944.
157. Vila-Nova NS, de Morais SM, Falcão MJ, Alcantara TT, Ferreira PA, Cavalcanti ES, et al. Different susceptibilities of Leishmania spp. Promastigotes to the *Annona muricata* acetogenins annonacinone and corossolone, and the Platymiscium floribundum coumarin scoparone. Exp Parasitol. 2013;133(3): 334-8.
DOI: 10.1016/j.exppara.2012.11.025, PMID 23232251.
158. Chang FR, Wu YC. Novel cytotoxic Annonaceous acetogenins from *Annona muricata*. J Nat Prod. 2001;64(7): 925-31.
DOI: 10.1021/np010035s, PMID 11473425.
159. Li DY, Yu JG, Zhu JX, Yu DL, Luo XZ, Sun L et al. Annonaceous acetogenins of the seeds from *Annona muricata*. J Asian Nat Prod Res. 2001;3(4):267-76.
DOI: 10.1080/10286020108040366, PMID 11783580.
160. Wu FE, Zeng L, Gu ZM, Zhao GX, Zhang Y, Schwedler JT, et al. Muricatocins A and B, two new bioactive monotetrahydrofuran annonaceous acetogenins from the leaves of *Annona muricata*. J Nat Prod. 1995d;58(6):902-8.
DOI: 10.1021/np50120a013, PMID 7673935.
161. Sun S, Liu J, Kadouh H, Sun X, Zhou K. Three new anti-proliferative Annonaceous acetogenins with mono-tetrahydrofuran ring from graviola fruit (*Annona muricata*). Bioorg Med Chem Lett. 2014;24(12): 2773-6.
DOI: 10.1016/j.bmcl.2014.03.099, PMID 24780120.
162. Quispe A, Zavala D, Rojas J, Posso M, Vaisberg A. Efecto citoto´ xico selectivo in vitro de muricin H (acetogenina de *Annona muricata*) en cultivos celulares de cancer de pulmon. Rev Peru Exp Salud Publ. 2006;23:265-9.

163. Lannuzel A, Hôglinger GU, Champy P, Michel PP, Hirsch EC, Ruberg M. Is atypical Parkinsonism in the Caribbean caused by the consumption of Annonacae? J Neural Transm Suppl. 2006;70(70):153-7.
DOI: 10.1007/978-3-211-45295-0_24, PMID 17017523.

164. Konno H, Okuno Y, Makabe H, Nosaka K, Onishi A, Abe Y, et al. Total synthesis of cis-solamin A, a mono-tetrahydrofuran acetogenin isolated from *Annona muricata*. Tetrahedron Lett. 2008;49(5):782-5.
DOI: 10.1016/j.tetlet.2007.11.190.

165. Chang FR, Liaw CC, Lin CY, Chou CJ, Chiu HF, Wu YC. New adjacent bis-tetrahydrofuran Annonaceous acetogenins from *Annona muricata*. Planta Med. 2003;69(3):241-6.
DOI: 10.1055/s-2003-38485, PMID 12677528.

166. Landolt JL, Ahammadsahib KI, Hollingworth RM, Barr R, Crane FL, Buerck NL, et al. Determination of structure-activity relationships of Annonaceous acetogenins by inhibition of oxygen uptake in rat liver mitochondria. Chem Biol Interact. 1995;98(1):1-13.
DOI: 10.1016/0009-2797(95)03628-y, PMID 7586047.

167. Wang AQ, Min BS, Nakamura N, Qin G, Li CJ, Hattori M. Annonaceous acetogenins from the leaves of Annona montana. Bioorg Med Chem Lett. 2002;10:561-5.

168. Gleye C, Rafidiarison N, Duret P, Laurens A, Hocquemiller R. Robustocin, a new acetogenin from the seed of *Annona muricata*. Nat Prod Lett. 2000a;14(4):239-45.
DOI: 10.1080/10575630008041238

169. Gromek D, Hocquemiller R, Cavé A. Qualitative and quantitative evaluation of annonaceous acetogenins by high performance liquid chromatography. Phytochem Anal. 1994;5(3):133-40.
DOI: 10.1002/pca.2800050309.

170. George VC, Kumar DR, Suresh PK, Kumar RA. Antioxidant, DNA protective efficacy and HPLC analysis of *Annona muricata* (soursop) extracts. J Food Sci Technol. 2015;52(4):2328-35.
DOI: 10.1007/s13197-014-1289-7, PMID 25829616.

171. Marques V, Farah A. Chlorogenic acids and related compounds in medicinal plants and infusions. Food Chem. 2009; 113(4):1370-6.
DOI: 10.1016/j.foodchem.2008.08.086.

172. Jiménez VM, Gruschwitz M, Schweiggert RM, Carle R, Esquivel P. Identification of phenolic compounds in soursop (*Annona muricata*) pulp by high-performance liquid chromatography with diode array and electrospray ionization mass spectrometric detection. Food Res Int. 2014;65:42-6.
DOI: 10.1016/j.foodres.2014.05.051.

173. Nawwar M, Ayoub N, Hussein S, Hashim A, El-Sharawy R, Wende K, et al. A flavonol Triglycoside and investigation of the antioxidant and cell stimulating activities of *Annona muricata* Linn. Arch Pharm Res. 2012;35(5):761-7.
DOI: 10.1007/s12272-012-0501-4, PMID 22644843.

174. George VC, Kumar DR, Rajkumar V, Suresh PK, Kumar RA. Quantitative assessment of the relative antineoplastic potential of the n-butanolic leaf extract of *Annona muricata* Linn. In normal and immortalized human cell lines. Asian Pac J Cancer Prev. 2012;13(2):699-704.
DOI: 10.7314/apjcp.2012.13.2.699, PMID 22524847.

175. Correa-Gordillo J, Ortiz J, Sanchez-Mejıa M, Pachon H. Antioxidant activity in soursop (*Annona muricata* L.) a literature review. Bol. Latinoam. Carib Plant Aromat. 2012;11:111-26.

176. Sandoval L, Ettiene G, Fuenmayor M. HPLC determination of flavonoids in fruits of soursop (*Annona muricata* L.) from different plants. Rev Fac Agron. 2014;1:785-800.

177. Matsushige A, Matsunami K, Kotake Y, Otsuka H, Ohta A. Three new megastigmanes from the leaves of *Annona muricata*. J Nat Med. 2011;66:284-91.

178. Li CM, Tan N, Lu Y, Liang H, Mu Q, Zheng H et al. Annomuricatin A, a new cyclopeptide from the seeds of *Annona muricata*. Acta Bot Yunnan. 1995;17: 459-62.

179. Li Chao-Ming, Tan Ning-Hua, Zheng Hui-Lan, Mu Qing, Hao Xiao-Jiang, He Yi-Neng et al. Cyclopeptide from the seeds of *Annona muricata*. Phytochemistry. 1998;48(3):555-6.
DOI: 10.1016/S0031-9422(98)00002-8

180. Welé A, Ndoye I, Badiane M. Fatty acid and essential oil composition of the seed oil of five Annona species. Niger J Nat Prod Med. 2004;8:62-5.

181. Vijayameena C, Sabhashini G, Loganayagi M, Ramesh B. Phytochemical screening and assessment of antibacterial activity for the bioactive compounds in *Annona muricata*. Int J Curr Microbiol Appl Sci. 2013;2:1-8.

182. Usunomena U, Paulinus ON. Phytochemical Analysis and Mineral Composition of *Annona muricata* leaves. Int J Res Dev. 2015;1(1):38-42.

183. Oviedo V, Garcıa M, Dıaz C, Marder M, Costa M, Rincon J, et al. Extract and alkaloidal fraction of *Annona muricata* with anxiolytic-type activity in mice. Rev Colomb Sci What? Pharma. 2009;38: 105-20.

184. Dai Y, Hogan S, Schmelz EM, Ju YH, Canning C, Zhou K. Selective growth inhibition of human breast cancer cells by graviola fruit extract in vitro and in vivo involving downregulation of EGFR expression. Nutr Cancer. 2011;63(5):795-801.

DOI: 10.1080/01635581.2011.563027, PMID 21767082.

185. Osorio E, Arango GJ, Jimenez N, Alzate F, Ruiz G, Gutierrez D, et al. Antiprotozoal and cytotoxic activities in vitro of Colombian Annonaceae. J Ethnopharcol. 2007;111:630-5.

186. Valencia L, Munoz DL, Robledo SM, Echeverri F, Arango GJ. Ve´ lez. Biomedica 31. Trypanocidal and cytotoxic activity of Colombian plant extracts;I(D)., Triana, O. 2011;552-9.

187. Torres MP, Rachagani S, Purohit V, Pandey P, Joshi S, Moore ED et al. Graviola: A novel promising natural derived drug that inhibits tumorigenicity and metastasis of pancreatic cancer cells in vitro and in vivo through altering cell metabolism. Cancer Lett. 2012;323(1): 29-40.

DOI: 10.1016/j.canlet.2012.03.031, PMID 22475682.

188. Ménan H, Banzouzi JT, Hocquette A, Pélissier Y, Blache Y, Koné M, et al. Antiplasmodial activity and cytotoxic of plants used in West African traditional medicine for treatment of malaria. J Ethnopharmacol. 2006;105(1-2): 131-6.

DOI: 10.1016/j.jep.2005.10.027, PMID 16368205.

189. Calderon AI, Vazquez Y, Solı´ s, PN, Caballero-George C, Zacchino S, Gimenez A, Pinzo´ n, R, Caceres A, Tamayo G, Correa M, Gupta MP. Screening of Latin American plants for cytotoxic activity. Pharm. Biol. 2006;44, 1–11.

190. Astirin OP, Artanti AN, Fitria MS, Perwitasari EA, Prayitno A. *Annona muricata* Linn leaf induce apoptosis in cancer cause virus. J Cancer Ther. 2013; 4:1244-50.

191. Zorofchian Moghadamtousi SZ, Rouhollahi E, Karimian H, Fadaeinasab M, Firoozinia M, Ameen Abdulla M, et al. The chemopotential effect of *Annona muricata* leaves against azoxymethane-induced colonic aberrant crypt foci in rats and the apoptotic effect of acetogenin annomuricin E in HT-29 cells: A bioassay-guided approach. PLOS ONE. 2015c;10(4):e0122288.

DOI: 10.1371/journal.pone.0122288, PMID 25860620.

192. Rachmani N, Prasasti E, Suhesti TS, Widiastut R. The breast of anticancer from leaf extract of *Annona muricata* against cell line T47D. Int J Appl Sci Technol. 2012;2(1):157-64.

193. Mohamad M, Daud N, Zulkifli R, Yaakob H. Cytotoxic effect of *Annona muricata* Linn leaves extract on Capan-1 cells. J Appl Pharm Sci. 2015;5(05):045-8.

194. Osorio E, Arango G, Garcıa E, Munoz K, Ruiz G, Gutierrez D, et al. *In vitro* antiplasmodic activity and inhibition of b-hematin formation in Colombian plants of the Annonaceae family. Buenos Aires Farm Act. 2005;24:527-32.

195. Yamthe LRT, Fokou PVT, Mbouna CDJ, Keumoe R, Ndjakou BL, Djouonzo PT, et al. Extracts from *Annona muricata* L. and Annona reticulata L. (Annonaceae) potently and selectively inhibit Plasmodium falciparum. Medicines (Basel). 2015;2(2): 55-66.

DOI: 10.3390/medicines2020055, PMID 28930201.

196. de S Luna JS, Dos Santos AF, De Lima MRF, De Omena MC, de Mendonça FA, Bieber LW, et al. A study of the larvicidal

and molluscicidal activities of some medicinal plants from northeast Brazil. J Ethnopharmacol. 2005;97(2):199-206.

DOI: 10.1016/j.jep.2004.10.004, PMID 15707752.

197. Ferreira LE, Castro PM, Chagas AC, França SC, Beleboni RO. *In vitro* anthelmintic activity of aqueous leaf extract of *Annona muricata* L. (Annonaceae) against Haemonchus contortus from sheep. Exp Parasitol. 2013;134(3):327-32.

DOI: 10.1016/j.exppara.2013.03.032, PMID 23583362.

198. Morales CA, González R, Aragón R. Evaluación de la actividad larvicida de extractos polares y no polares de acetogeninas de *Annona muricata* sobre larvas de Aedes aegypti y Anopheles albimanus (Diptera: Culicidae). Rev Colomb Entomol. 2004;30(2):187-92.

DOI: 10.25100/socolen.v30i2.9552

199. Sanabria L, Segovia EA, González N, Alcaraz P, Vera NB. Health. Larvicidal activity of aqueous plant extracts on Aedes aegypti larvae (first trials). Mem. Inst. Invest. Science. 2009;27(2):26-31.

200. Bobadilla M, Zavala F, Sisniegas M, Zavaleta G, Mostacero J, Taramona L. Larvicidal evaluation of aqueous suspensions of *Annona muricata* Linnaeus << soursop>> on Aedes aegypti Linnaeus (Diptera: Culicidae). Rev Peru Biol. 2005;12:145-52.

201. Prédes-trindade RC, De Souza-luna J, Ferreira De Lima MR, Da Silva PP, Goulart-sant'ana AE. Larvicidal activity and seasonal variation of *Annona muricata* (Annonaceae) extract on plutella xylostella (Lepidoptera: Plutellidae). Rev Colomb Entomol. 2011;37(2):223-7.

DOI: 10.25100/socolen.v37i2.9078.

202. Adeoye OT, Ewete FK. Potentials of *Annona muricata* Linnaeus (Annonaceae) as a botanical insecticide against Callosobruchus maculatus Fabricius (Coleoptera: Bruchidae). J Agric Forest. 2010;8:147-51.

203. Komansilan A, Abadi AL, Yanuwiadi B, Kaligis DA. Soursop (*Annona muricata* Linn) seed to mosquito (Aedes aegypti) larvae. Int J Eng Technol. 2012;12: 28-32.

204. Ravaomanarivo LHR, Razafindraleva HA, Raharimalala FN, Rasoahantaveloniaina B, Ravelonandro PH, Mavingui P. Efficacy of seed extracts of Annona squamosa and *Annona muricata* (Annonaceae) for the control of Aedes albopictus and Culex quinquefasciatus (Culicidae). Asian Pac J Trop Biomed. 2014;4(10):798-806.

DOI: 10.12980/APJTB.4.2014C1264.

205. Acda MN. Repellent effects of Annona crude seed extract on the Asian subterranean termite Coptotermes gestroi Wasmann (Isoptera: Rhinotermitidae). Sociobiology. 2014;61(3):332-7.

206. Almeida MMB, De Sousa PHM, Arriaga ÂMC, Do Prado GM, Magalhães CEdC, Maia GA et al. Bioactive compounds and antioxidant activity of fresh exotic fruits from northeastern Brazil. Food Res Int. 2011;44(7):2155-9.

DOI: 10.1016/j.foodres.2011.03.051

207. Alitonou GA, Tchobo FP, Sessou P, Avlessi F, Menut C, Sohounhloue DCK. Chemical composition, antiradical and anti-inflammatory activities of four Annonaceae from Benin. Int J Pharm Chem Biol Sci. 2013;3:914-23.

208. Vit P, Santiago B. Chemical composition and antioxidant activity of pulp, leaf and seed of soursop *Annona muricata* L. Interciencia. 2014;39(5):350-3.

209. Boakye AA, Wireko-Manu FD, Agbenorhevi JK, Oduro I. Antioxidant activity, total phenols and phytochemical constituents of four underutilised tropical fruits. Int Food Res J. 2015;22(1): 262-8.

210. Viera GH, Mourão JA, Angelo AM, Costa RA, Vieira RH. Antibacterial effect (*In vitro*) of Moringa oleifera and *Annona muricata* against gram positive and gram negative bacteria. Rev Inst Med Trop Sao Paulo. 2010;52(3):129-32.

DOI: 10.1590/s0036-46652010000300003, PMID 20602021.

211. Bento EB, Matias EFF, Brito FE, Oliveira DR, Coutinho HDM, Costa JGM, et al. Association between food and drugs: antimicrobial and synergistic activity of *Annona muricata* L. Int J Food Prop. 2013;16(4):738-44.

DOI: 10.1080/10942912.2011.565905.

212. Solomon-Wisdom GO, Ugoh SC, Mohammed B. Phytochemical screening and antimicrobial activities of *Annona muricata* (L.) leaf extract. Am J Biol Chem PharmSci. 2014;2:1-7.

213. Radji M, Kurniati M, Kiranasari A. Comparative antimycobacterial activity of some Indonesian medicinal plants against multi-drug resistant Mycobacterium tuberculosis. JAPS. 2015;5(01):19-22.
214. Padma P, Pramod NP, Thyagarajan SP, Khosa RL. Effect of the extract of *Annona muricata* and Petunia nyctaginiflora on herpes simplex virus. J Ethnopharmacol. 1998;61(1):81-3.
DOI: 10.1016/s0378-8741(98)00013-0, PMID 9687085.
215. Asase A, Hesse DN, Simmonds MSJ. Uses of multiple plants prescriptions for treatment of malaria by some communities in southern Ghana. J Ethnopharmacol. 2012;144(2):448-52.
DOI: 10.1016/j.jep.2012.09.028, PMID 23022690.
216. McLaughlin JL. Paw paw and cancer: annonaceous acetogenins from discovery to commercial products. J Nat Prod. 2008;71(7):1311-21.
DOI: 10.1021/np800191t, PMID 18598079.
217. Deep G, Kumar R, Jain AK, Dhar D, Panigrahi GK, Hussain A, et al. Graviola inhibits hypoxia-induced NADPH oxidase activity in prostate cancer cells reducing their proliferation and clonogenicity. Sci Rep. 2016;6(1):article 23135.
DOI: 10.1038/srep23135, PMID 26979487.
218. N'Gouemo P, Koudogbo B, Tchivounda HP, Akono-Nguema C, Etoua MM. Effects of ethanol extract of *Annona muricata* on pentylenetetrazol-induced convulsive seizures in mice. Phytother Res. 1997; 11(3):243-5.
DOI:10.1002/(SICI)1099-1573(199705)11:3<243::AID-PTR66>3.0.CO;2-A.
219. Paarakh P, Chansouria J, Khosa R. Wound healing activity of *Annona muricata* extract. J Pharm Res. 2009;2(3):404-6.
220. Adeyemi DO, Komolafe OA, Adewole OS, Obuotor EM, Abiodun AA, Adenowo TK. Histomorphological and morphometric studies of the pancreatic islet cells of diabetic rats treated with extracts of *Annona muricata*. Folia Morphol. 2010; 69(2):92-100. PMID 20512759.
221. Adewole S, Caxton-Martins E. Morphological changes and hypoglycemic effects of *Annona muricata* linn. (annonaceae) leaf aqueous extract on pancreatic β-cells of streptozotocin-treated diabetic rats. Afr J Biomed Res. 2009;9(3):173-87.
DOI: 10.4314/ajbr.v9i3.48903.

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