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The Genus *Zanthoxylum* - A Stockpile of Biological and Ethnomedicinal Properties

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Abstract

The *genus Zanthoxylum* has been recognised for a number of biological activities like allelopathic activity, analgesic activity, anticonvulsant activity, anthelmintic activity, anti-inflamatory activity, antimicrobial activity, antinociceptive activity, antioxidant activity, antiparasitary activity, antiplatelet activity, citotoxic activity, trypanocidals activity, antileishmanial activity, anti*Cestoda*l property, gastroprotection activity, anti-sickling activity, hypnotic activity etc. A few species of the *genus* has been recommended as dietary supplements to protect against emergent diseases such as cardiovascular problems, cancer and diabetes. Different parts of *Zanthoxylum* have been popularly used traditionally in different ethno medicines for different ailments.

Keywords: *Zanthoxylum*; Ethnomedicine; Antimicrobial; Allelopathy

Introduction

*Zanthoxylum*s are deciduous and evergreen shrubs and trees from the family *Rutaceae* (Figure 1a-1d). They are native to warm temperate and subtropical region of the world. The *genus* is a rich source of various chemicals such as alkaloids, amides, flavanoides, lignans, sterols and terpenes etc. Medicinal plants, which form the backbone of traditional medicine, have in the last few decades been the subject of very intense pharmacological studies. The secondary metabolites, especially the benzophenanthridine alkaloids are considered to be very important in world of medicine. The *genus* is occurring in Eastern and Southeast Asia (India, Bangladesh, Bhutan, China, Myanmar, Cambodia, Vietnam, Thailand, and Malaysia etc.), America (Mexico, Northern South America, Puerto Rico, Brazil, Argentina, Paraguay, Uruguay etc.) and Africa (Ethiopia, Somalia south to eastern Botswana, Kenya, Tanzania and Rwanda, Zimbabwe, etc.) (Table 1).

Figure 1: Photographs of a few Zanthoxylum sp. a) *Z. armatum*, b) *Z. rhetsa*, (c) *Z. nitidum*, (d) *Z. Oxyphyllum*.

Taxonomy of *Zanthoxylum*

Domain: *Eukaryota*
Kingdom: *Plantae*
Subkingdom: *Viridaeplantae*
Phylum: *Tracheophyta*
Subphylum: *Euphyllophytina*
Infraphylum: *Radiatopses*
Class: *Magnoliopsida*
Subclass: *Rosidae*
Superorder: *Rutanae*
Order: *Rutales*
Suborder: *Rutineae*
Family: *Rutaceae*
Genus: *Zanthoxylum*

Morphological characteristics of *Zanthoxylum*: *Genus Zanthoxylum* is typically characterized by sharp thorns on either the stem or foliage, and leaves that are ash-like in appearance. People cut away these plants as they are thorny in nature. Moreover, the *genus* is dioecious, and therefore male and female trees must be in close

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	Plant species (References)	Distribution	Common uses of different parts of the plant
1.	*Z. acanthopodium DC.* [95-97]	Northern India, Tibetan highlands, Bangladesh, Bhutan, China, Myanmar, Cambodia, Vietnam, Thailand, and Malaysia.	**Fruits:** Mainly as spice. **Root:** Used instomachache, toothache and diabetes
2.	*Z. ailanthoides* Siebold. & Zucc. [98,99]	South eastern China, Taiwan, Southeast Asia, and Japan from Honshu southward.	**Bark and Fruits:** Epigastric pain, vomiting, diarrhea, abdominal pain, colds, snake bites. **Tender leaves:** Substitute for the green onion in Chinese dishes. **Stem:** Myocardium disorder attenuation, Cold resistance and bone-injury alleviation.
3.	*Z. alatum* Roxb. [100,101]	Widely distributed in the hot valleys of the subtropical Himalayas, trans-Indus Punjab along the foot of the Himalayas from the Indus eastward, up to an altitude of 5000 ft, Kumaon 5000-7000 ft, eastward up to Bhutan 3500-4000 ft.	**Seed**: Aromatic tonic, stomachic and for fever, dyspepsia, cholera etc. **Fruits, branches and thorns:** Carminative and stomachic, used as a remedy for toothache, skin diseases, abdominal pain, anorexia, warm infestation and ataxia. **Root:** Treat poisonous snake bites and also to treat diseases of the digestive system
4.	*Z. americanum* Mill. Synonyms: *Z. fraxineum* [37,102]	Native to central and eastern portions of United States and Canada	**All parts of the plant:** To treat rheumatic conditions, toothaches, sore throats and burns, and as a tonic for various ailments. Bark: Used in malaria
5.	*Z. armatum DC.* [86,103-105]	Found in India, China, Nepal, Pakistan, Butan, Taiwan, Phillipines, Malaysia, and Japan	**Fruits and seeds:** Piscicide, aromatic tonic in fever, dyspepsia, Skin diseases and for expelling roundworms. **Bark, branches and seeds:** Carminative, stomachic and anthelmintic. **Whole plant:** Abdominal colic, asthma, cancer, cholera, diabetes, cough, diarrhea, dysuria, fever, headache, hepatosis, microbial infections, toothache and worms, as well as being considered useful in improving the blood circulation to affected parts.(vasodilatation), and as a cardio protective, analgesic, anti-inflammatory,pesticide, stomachic and tonic, catching fish (piscicidal).
6.	*Z. avicennae* (Lam.) DC. [106]	Thailand, China, Indonesia and Malayasia	**Branches and stems:** Stomach tonic, to treat snake bites.
7.	*Z. beecheyanum* K. Koch [75]	distributed throughout Okinawa, Japan, Taiwan	**Leaves:** For treat bellyache and skin diseases.
8.	*Z. budrunga* Wall. [36]	Konkan, Deccan Mysore, Malabar, Annamalais and Orissa, Assam and Meghalaya	**Leaves:** Used for treating dyspepsia and some forms of diarrhea. **Stem bark:** Dysentery, coughs and headache.
9.	*Z. bungeanum* Maxim. [107-109]	Native to southwestern China in the provinces Sichuan, Yunnan, Guizhou, Tibet, Guanxi, and Guandong.	**Pericarps:** Food condiment and Seasoning in China. Used to treat vomiting, toothache, stomach ache and abdominal pain owing to roundworm.
10.	*Z. capense* (Thunb.) Harv. [17]	Eastern and Northern parts of South Africa	**Leaves:** Treat fever, stomachache, flatulent colic, toothache and epilepsy.
11.	*Z. caribeum* Lam. [110-112]	Mexico,Northern South America, Puerto Rico	**Leaves and stem bark:** For asthma, spasm, fever, herpes and skin ulcers. **Wood:** Skin diseases.
12.	*Z. chalybeum* Engl [32,61,113]	Ethiopia and Somalia south to eastern Botswana and Zimbabwe	**Leaves**: Treating severe colds and pneumonia. **Bark:** Malaria, colds, coughs, and dizziness. Chewed to alleviate toothaches. The Masai and Sonjo use this for small children by adding its juice to milk to give a better appetite. **Roots:** The decoction is given to sick goats, especially those suffering from diarrhoea. **Fruits:** Malaria, colds, coughs, toothache, sores, wounds and headache.
13.	*Z. chiloperone* var. *angustifolium* Engl. [89,114]	South America, Paraguay	**Root bark:** As antimalaric, emmenagogue and antirheumatic properties.
14.	*Z. davyi* (I.Verd.) Waterm. Hur [28]	South Africa, Eastern Cape, KwaZulu-Natal, Limpopo, Mpumalanga, Western Cape	**Leaves:** To treat snakebite, severe coughs and colds and chest pains. Used for infected wounds. **Spines:** Treat boils, pleurisy and toothache. **Stem bark:** Used for mouth ulcers, sore throats and as aphrodisiac. **Root & Root bark:** Tonic both for man and animals and to treat toothache.
15.	*Z. dipetalum* H. Mann [115; http://en.wikipedia.org/wiki/Zanthoxylum_dipetalum]	Endemic to Hawaii, Z. dipetalum var. dipetalum is present on Kauai, in the mountains of Oahu, on Hawaii in Hawaii Volcanoes, National Park, and possibly on Molokai. Z. dipetalum var. tomentosum is known from fewer than 30 individuals on Hualālai volcano on Hawaii.This variety is a federally listed endangered species of the United States.	**Leaves and Pericap:** Insecticide-ovicidal.
16.	*Z. dugandii* Standl. [110]	Casacoima, Arroyo de Cipacua., Atlántico, Colombia, South America	**Bark:** Diuretic and sudorific.
17.	*Z. ekmanii.* (URB.) ALAIN. [116] http://zipcodezoo.com/Plants/z/Zanthoxylum_ekmanii/#Description]	Antarctica , Belize, Bolivia, Brazil, Costa Rica, Cuba , Ecuador, French Guiana,Mexico, Panama, Peru	**Leaves and roots:** For malaria, in vaginal washes and to relieve toothache.
18.	*Z. fagara* (L.) Sarg. [117.http://www.ars-grin.gov/cgi-bin/npgs/html]	Northern America and Southern America	**Leaves, fruits and seeds:** Used as sedative and sudorific.

19.	*Z. flavum* Vahl (http://en.wikipedia.org/wiki/Zanthoxylum_flavum)	Anguilla, Antigua and Barbuda, the Bahamas, Bermuda, Cuba, the Diminican Republic, Guedeloupe, Haiti, Jamaica, Puerto Rico and the Florida Keys, exclusive of Key West where it has been extirpated.	**Wood:** Fine woodworking.
20.	*Z. gillettii* (Wild) Waterm [118-120]	Guinea and Sierra Leone east to Kenya and south to northern Angola, Zimbabwe and Mozambique	**Leaves:** Anti hypertensive, analgesic and to treat anelling . **Wood:** Used in house and boat-building, decorative panelling, joinery, construction of talking drums and in the paper and Pulp industry.
21.	*Z. hawaiiense* Hbd. [115] http://en.wikipedia.org/wiki/Zanthoxylum_hawaiiense	Grows on lava flows, and mixed mesic forests on the Island of Hawaii, Maui, Molokai, and Lānai.	**Leaves and anellin:** Insecticide-ovicidal.
22.	*Z. hyemale* A. St. Hil. [114] http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?42191	Brazil, Argentina, Paraguay,Uruguay	**Leaves:** As painkiller, sudorific, emetic and to favour the salivation
23.	*Z. integrifoliolum* Merr. [44] http://en.wikipedia.org/wiki/Zanthoxylum_integrifoliolum	Philippines and Taiwan	**Bark:** Folk remedy for snake-bite by Ya-Mei aborigines.
24.	*Z. lemairie* (De Wild) Waterm. [120] http://www.prota4u.org/protav8.asp?h=M4&t=Zanthoxylum, lemairei&p=Zanthoxylum+leimairei	Nigeria, Cameroon, Central African Republic, Gabon, DR Congo and Uganda	**Wood:** House and boat-building, decorative panelling, joinery, construction of talking drums and in the paper and pulp industry.
25.	*Z. leprieurii Guill*. Et Perr. [82,120,121]	Senegal east to Ethiopia and south to Mozambique and eastern South Africa.	**Leaves:** Used for traditional treatment of stomatitis, gingivitis, bilharzia. **Roots:** As antiulcerative, antiseptic, urinary antiseptic, anti-sickler, antibacterial. **Stem bark:** Used as antimicrobial, digestive aid, antidiarrheic, anticancerous, anti-odontologic and parasticide. **Fruits:** Used as spices. **Wood:** Used in house and boat-building, decorative panelling, joinery, construction of talking drums and in the paper and pulp industry.
26.	*Z. liebmanianum* (Engler.) P. Wilson [122,123]	Mexico	**Bark:** Used to treat amebiasis, intestinal. Parasites, and as a local anesthetic.
27.	*Z. limonella* Alston. Synonyms: *Z. budrunga* Wall. Ex DC; Z. *rhetsa* DC [124]	North America, South America, Africa, Asia, and Australia.	**Bark:** Used as febrifugal, sudorific and diuretic.
28.	*Z. macrophylla* Engl. [83,125]	Southern parts of Nigeria	**Bark and seeds:** Used for toothache, colds, fever, malaria, stomachache, rheumatism and urogenital affections, as well as to prepare poisonous arrows.
29.	*Z. monophyllum* (Lam.) P. Wilson [41]	USA	**Bark:** Used as a colorant and to treat of runny nose, jaundice, ophthalmia and as an anesthetic.
30.	*Z. myricanthum* [126]	Naga hills (Nagaland) and in Assam	**Seeds:** The smoke from burning seeds is inhaled for the treatment of incerated nose.
31.	*Z. naranjillo* Griseb. [24,114]	Brazil, Bolivia, Argentina, Paraguay,Uruguay	**Leaves:** Preparations have been used to treat illness associated with inflammatory process.
32.	*Z. nitidum* (Roxb.) DC Synonyms: *Z. hirtellum* [27,127]	South-east Asian countries and in Australia	**Fruits:** Spice and in to treat stomachache, vomiting, diarrhoea, cough, colic, and paresis and as an aromatic, stimulant and piscicide. **Root:** Used in toothache, stomachache, fever, rheumatism, paresis, boils and as an insecticide and piscicide. **Branches, seeds and stem bark:** Used in fever, diarrhoea and cholera.
33.	*Z. piperitum* DC. [51,52]	Hokkaido to Kyushu in Japan, Southern parts of the Korean peninsula and Chinese mainland.	**Pericarp:** Commonly used as a spice in Japan. All parts of the plant: Used to heal vomiting, diarrhoea, and abdominal pain.
34.	*Z. rhetsa* Roxb. [102,128,129]	India and Sri Lanka to Myanmar, Indo-China, Thailand, Peninsular Malaysia, Java, the Lesser Sunda Islands, Moluccas (Wetar), Sulawesi, the Philippines and southern Papua New Guinea.	**Spines:** Applied on the breast to give relief from pain and increase lactation in nursing mothers. **Seeds:** Used as antiseptic, disinfectant, and for treat asthma, toothache and rheumatism. **Fruit:** Treating digestion problems. Urinary complaint and dyspepsia caused by atrabilis (the melancholic “humor”). Also used in some form of diarrhoea. **Bark:** Chewed and applied to snake bites.
35.	*Z. riedelianum* Engl. [130]	Bolivia, Brasil, Colombia, Costa Rica, Ecuador, Panamá, Paraguay, Perú	Used in different types of inflammations, rheumatism and skin stains.
36.	*Z. rigidumHumb*. & Bonpl. Ex Willd. [131,110]	Native to the U.S. (United States)	**Wood:** Used in building houses. **Leaves:** Used for toothache.
37.	*Z. rhoifolium* Lam. [48,78,130]	Central and south Brazil	**Root bark:** Used as a tonic, a febrifuge, against inflammatory and microbial processes, and in the treatment of malaria. **Bark:** Used to treat toothache and earache, also is used as an anti-venom serum, anti-tumor and in the treatment of 8anelling88s.
38.	*Z. scandens* [132]	India, China, the Ryukyus, Sumatra, Java, Borneo and at low altitudes, throughout Taiwan	**Root, stem and leaves:** To treat abdominal pain, toothache, rheumatism, and traumatic injury
39.	*Z. schinifolium* Sieb. & Zucc. [133-135]	(Japan) Honshu, Shikoku, Kyushu, Korea, China, Taiwan	**Leaves and ripe pericarp:** Used as culinary applications and drugs for epigastric pain.
40.	*Z. simulans* Hance. [75,76]	Native to eastern China and Taiwan, South Korea	**Roots:** Used for snake bites and gastrointestinal disorders

41.	*Z. tessmannii* Engl. [42,120]	West African	**Stem bark:** Used for treat tumors, swellings, inflammation and anelling . Root bark: Used as a toothbrush **Wood:** House and boat-building, joinery, decorative anelling and in the paper and pulp industry.
42.	*Z. tetraspermum* Wight and Arn. [136]	Sri Lanka and South India	**Stem bark:** Antispasmodic, muscle relaxant, analgesic, sudorific, antifungal, diuretic, antiplatelet, antiparasitic and antihypertensive.
43.	*Z. usambarense* (Engl.) Kokwaro [137,138]	Ethiopia, Kenya, Tanzania and Rwanda	**Bark:** Used to treat rheumatism. **Young twigs:** Used as toothbrushes. **Seeds:** For respiratory tract infections, malaria and catarrhal fevers.
44.	*Z. xanthoxyloides* Waterm [121,139,140]	West Tropical Africa	**Seeds:** Condiment in Cameroon. **Leaves and bark:** Used against cough, fever, colds, toothache and snake bite. **Leaves:** As scaring and as antiseptic, astringent and laxative. **Roots:** Used as antiseptic, anti-sickler, digestive aid and parasticide. Also are generally used as chewing sticks for teeth cleaning. **Stem bark:** Antirheumatic, anti-odontalgic, diurectic, urinary antiseptic, digestive aid and parasticide.

Table 1: Distribution and various ethnomedicinal use of some *Zanthoxylum* species.

proximity in order for pollination to take place and seed setting. Morphologically, it is the only truly choricarpous *genus* in the family *Rutaceae*, with fully free and stalked carpels [1]. The much unspecialized flower morphology and vascular supply suggest a primitive position of *Zanthoxylum* within the family *Rutaceae* [2,3].

Mode of propagation in *Zanthoxylum*: Conventionally *Zanthoxylum* species are propagated through seeds, stems and root cuttings. Seed production can be particularly low in shaded situations Popp and Reinartz [4]. Seed of numerous *Zanthoxylum* species have been found to have low germination rates [5-8]. Successful micropropagation of *Zanthoxylum* have also been reported in few species like *Z. simulans* as reported by Ducci and Malentacchi [9], *Z. piperitum* reported by Hwang [10] and *Z. zanthoxyloides* [11].

Biological properties

The *genus* has been reported for a number of biological activities. Allelopathy is a biological phenomenon by which an organism produces one or more biochemicals known as allelochemicals that influence the growth, survival, and reproduction of other organism. Allelopathic compounds like xanthoxyline, salicylic acid, p-hydroxybenzoic acid and syringic acid were isolated from *Z. limonella* [12-14].

In the indigenous system of medicine, several plants possess an analgesic property and many investigators screened the plant crude extracts for their analgesic property. Studies of analgesic activity in the *genus Zanthoxylum* have been focused mainly to validate its traditional uses. Some isolated and purified alkaloids of the root bark of *Z. xanthoxyloides* have anti-prostaglandin synthetase activity Prempeh and Mensah-Attipoe [15]. Six lignans (sesamin, methylpluviatolide, dimethylmatairesinol, piperitol-4(‘)-O-(gamma),(gamma)-dimethylallyl ether, kaerophyllin and hinokinin), and a triterpene (lupeol) were also isolated from stem bark crude extract of *Z. riedelianum* and found to be inhibiting cyclooxygenase and its metabolite [16].

Anticonvulsant activity has also been reported in a few *Zanthoxylum* species. Methanol and aqueous extracts from leaves of *Z. capense* showed significant activity as both the extracts on seizures induced by pentylenetetrazole, bicuculline, picrotoxin, N-methyl-DL-aspartic acid and strychnine in mice were effective Amabeoku and Kinyua [17]. The crude extract of *Z. armatum* exhibits spasmolytic effects, mediated probably through Ca^{++} antagonist mechanism which provides pharmacological base for its medicinal use in the gastrointestinal, respiratory and cardiovascular disorders [18].

Anthelmimtic substances generally kill or expel worms. A great effectiveness of *Z. rhoifolium* leaves extract [19], acetone:water (70:30) and ethanol extracts from leaves of *Z. xanthoxyloides*, seed extracts of *Z. armatum* [20] as an active anthelmintic have been reported. The anthelmintic activities of the essential oil (EO) obtained from either *Z. zanthoxyloides* seeds was found to be useful in inhibition of larval migration at a concentrations which were about sevenfold higher than that of the control (thiabendazole) against *Strongyloides ratti* [21].

The anti-inflammatory refers to the property of a substance or treatment that reduces inflammation.

In different studies, ethanolic extracts of bark from *Z. elephantiasis*, *Z. fagara*, *Z. martinicense* and *Z. coriaceum* and *hexane*, *ethyl acetate* and ethanolic extracts of leaf from *Z. chiloperone* have presented promising results of anti-inflammatory activity [22-24]. A dibenzylbutirolactonic lignan (cubebin) from *hexane* extract of *Z. naranjillo* and phenylpropenoids, lignans, coumarins, quinolone and quinoline alkaloids from methanol extract of stem wood of *Z. integrifoliolum* and *Z. avicennae* have been reported the presence of with anti-inflammatory potential [24-26]. Methanol extract of stem wood from *Z. nitidum* was also reported to have anti-inflammatory activity [27].

A number of antimicrobial activities have been reported in the *genus Zanthoxylum*. The essential oils of *Z. xanthoxyloides* and *Z. leprieurii* [28], *Z. armatum* [29], *Z. hyemale* [30] and *Z. tingoassuiba* [31] were reported to have antimicrobial properties. Aqueous, *hexane* and methanol extracts from leaves, roots and stem bark of *Z. chalybeum* and *Z. usambarense* [32], Ethanolic extracts of bark of *Z. fagara*, *Z. elephantiasis* and *Z. martinicense* [33], alkaloidal extract of the stem barks of *Z. chiloperone* [34] were found to have antimicrobial activity. Antimicrobial activity was also recorded for *Z. americanus*, *Z. zanthoxyloides* [35] and *Z. budrunga* [36]. A braod spectrum antifungal activity was also reported for leaf, fruit, stem, bark and root extract of *Z. americanum* [37] and Canthin isolated from *Z. chiloperone* [38]. The toothpaste containing *Z. nitidum* extract decreased the incidence of dental plaque and enhanced gingival health [39]. Broad spectrum antibacterial activities against Gram-positive and Gram-negative bacteria have been reported in *Z. armatum* as described by Panthi and Chaudhary [40] and *Z. quinduense* [41]. Likewise, several compounds have been isolated from Z. tessmannii that possess antifungal as well as antibacterial activities [42]. Four species of the *genus Z. ailanthoides* [43], *Z. integrifoliolum* [44], *Z. scandens* [25] and *Z. davyi* [45] were found to have Anti-HIV activity.

Some of species of the *genus Zanthoxylum* have been known to be used in traditional medicine for relieving pain. The antinociceptive

activity was reported in *Z. rhetsa* Roxb. [46], *Z. chilipirone* [47], *Z. rhoifolium* [48], and *Z. armatum* [49].

Antioxidants activity has been demonstrated in seed [50], fruit [51,52], leaves of *Z. piperitum*. The antioxidant properties of the fruit samples of *Z. acanthopodium* [53], *Z. leprieurii* and *Z. xanthoxyloides* [54], *Z. alatum* [55] and *Z. armatum* [56] were also reported. The essential oil of seeds of *Z. bungeanum* was found to have antioxidant activity [57].

Antimalarial properties has been reported in many species of *Zanthoxylum* like *Z. gilletii* [58], *Z. guilletti* [59,60] *Z. rhoifolium* [61], *Z. limonella* [62], *Z. chalybeum*, *Z. syncarpum*, *Z. zanthoxyloides* and *Z. usambarense* [63].

The essential oil from *Z. armatum* was found to be possessing better leech repellent properties than citronyl due to presence of N-diethyle phenyl acetamide (DEPA), N, N-diethyl-m-toluamide (DEET), dimethyl phthalate (DMP) and N benzoyl piperidine(NBP) [64].

Mosquito repellent activity was exhibited by the *Z. armatum* [65] and *Z. limonella* [66]. The larvicidal potential of the essential oil extracted from the seeds of *Z. armatum* DC [syn. *Z. alatum* Roxb] (*Rutaceae*) was also reported [67].

Anti-plasmodial activity was demonstrated in *Z. syncarpum* [68-70], *Z. rhoifolium* [71], and in *Z. usambarense* [72]. *Zanthoxylum* species that have been found with strong inhibitory activity on platelet aggregation are *Z. schinifolium* [73,74] and *Z. beecheyanum* [75]. A number of cytotoxic compounds were reported in *Z. simulans* [76], *Z. monophyllum* [77], *Z. rhoifolium* [78,79], *Z. ailanthoides* [80], *Z. leprieurii* [81,82]. Moreover, antitumor activity compounds were isolated from *Z. macrophylla* [83] and from species of *Zanthoxylum genus* Tillequin [84]. Chelidonin, a hexahydrobenzophenanthridine alkaloid from the *genus Zanthoxylum* is used in experimental oncology as the main component of Ukrain®, an anti-cancer medicament due to its cytotoxic activity [85]. *Z. armatum* DC possesses significant protective effect against hepatotoxicity induced by CCl (4) which may be attributed to the individual or combined action of phytoconstituents present in it [86,87].

Other biological activities that have been exhibited by the different species of the *genus Zanthoxylum* are trypanocidals activity of *hexane* extract from leaves of *Z. naranjillo* [88], antileishmanial activity of alkaloidal extract of *Z. chiloperone* stem bark [89], anti*Cestoda*l property of *Z. rhesta* leaves Yadav and Tangpu [90], gastroprotection activity of *Z. rhoifolium* [91], anti-sickling activity of *Z. macrophylla* [92], hypnotic activity of *Z. budrunga* [93].

The fruit essential oils of *Z. leprieurii* and *Z. xanthoxyloides* were also suggested as food supplements to protect against emergent diseases such as cardiovascular problems, cancer and diabetes [94].

Ethnomedicinal Properties

The *genus Zanthoxylum* has been widely used in different traditional medicines by different communities according to their local availability for various illnesses. The *genus Zanthoxylum* is a rich source of various phytochemicals such as alkaloids, Amides, flavonoides, lignans, sterols and terpenes, etc. This may be the reason, why people are using the various parts of different *Zanthoxylum* species for curing common illness like vomiting, diarrhoea, abdominal pain, colds, rheumatism, and traumatic injury etc. For these purposes, different parts of the plant like leaves, root, bark, seed, fruit, stems, thorns are used in different ways. In scientific arena, traditional medicines are the source of information for drug discovery. A list including the ethnomedicinal use along with the distribution of different species is given in table 1.

Conclusion

Zanthoxylum has proven to be a very valuable *genus* to the discovery and utilization of medicinal and agrochemical natural products. This is a difficult *genus* with many different, similar and not well-researched species. So, there is a need of research to develop its economic value, its regeneration potentiality and for conservation strategies. This review is trying to create a base line data to explore the hundreds of *Zanthoxylum* species for the various taxonomical, phytochemicals, pharmacologist, entomological and other biological researches by the scientific community.

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