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-inflammatory activity, antispasmodic activity, antioxidant activity, antiparasitic activity, antitumor activity, citalytic activity, trypanocidal activity, antileishmanial activity, anti-Cestodal 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

*Zanthoxylums* 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, flavonoides, 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).

**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 proximity.

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<table>
<thead>
<tr>
<th>Plant species (References)</th>
<th>Distribution</th>
<th>Common uses of different parts of the plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Z. alatum Roxb. [100,101]</td>
<td>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.</td>
<td>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 astaxia. Root: Treat poisonous snake bites and also to treat diseases of the digestive system</td>
</tr>
<tr>
<td>4. Z. americanum Mill. Synonyms: Z. fraxineum [37,102]</td>
<td>Native to central and eastern portions of United States and Canada</td>
<td>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</td>
</tr>
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<td>5. Z. armatum DC. [86,103-105]</td>
<td>Found in India, China, Nepal, Pakistan, Butan, Taiwan, Philippines, Malaysia, and Japan</td>
<td>Fruits and seeds: Piscicide, aromatic tonic in fever, dyspepsia, Skin diseases and for expelling roundworms. Bark, branches and seeds: Carminative, stomachic and antihelminthic. Whole plant: Abdominal colic, asthma, cancer, cholera, diabetes, cough, diarrhea, dysuria, fever, headache, hepatitis, 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, analgetic, anti-inflammatory, pesticide, stomachic and tonic, catching fish (piscicidal).</td>
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<tr>
<td>7. Z. beecheyanum K. Koch [75]</td>
<td>distributed throughout Okinawa, Japan, Taiwan</td>
<td>Leaves: For treat bellyache and skin diseases.</td>
</tr>
<tr>
<td>10. Z. capense (Thunb.) Harv. [17]</td>
<td>Eastern and Northern parts of South Africa</td>
<td>Leaves: Treat fever, stomachache, flatulent colic, toothache and epilepsy.</td>
</tr>
<tr>
<td>12. Z. chalybeum Engl [32,61,113]</td>
<td>Ethiopia and Somalia south to eastern Botswana and Zimbabwe</td>
<td>Fruits and seeds: Piscicide, aromatic tonic in fever, dyspepsia. Bark, branches and seeds: Carminative, stomachic and antihelminthic. Whole plant: Abdominal colic, asthma, cancer, cholera, diabetes, cough, diarrhea, dysuria, fever, headache, hepatitis, 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, analgetic, anti-inflammatory, pesticide, stomachic and tonic, catching fish (piscicidal).</td>
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<td>15. Z. dipetalum H. Mann [115; <a href="http://en.wikipedia.org/wiki/Zanthoxylum_dipetalum">http://en.wikipedia.org/wiki/Zanthoxylum_dipetalum</a>]</td>
<td>Endemic to Hawaii, Z. dipetalum var. tomentosum is known from fewer than 30 individuals on Hualalai volcano on Hawaii. This variety is a federally listed endangered species of the United States.</td>
<td>Leaves and Pericarp: Insecticide-ovicidal.</td>
</tr>
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<td>17. Z. ekmanii, (URB.) ALAIN. [116] <a href="http://zipecodezo.com/Plants/z/Zanthoxylum_ekmanii/#Description">http://zipecodezo.com/Plants/z/Zanthoxylum_ekmanii/#Description</a></td>
<td>Antarctica, Belize, Bolivia, Brazil, Costa Rica, Cuba, Ecuador, French Guiana, Mexico, Panama, Peru</td>
<td>Leaves and roots: For malaria, in vaginal washes and to relieve toothache.</td>
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<td>18. Z. fagara (L.) Sarg. [117;<a href="http://www.ars-grin.gov/cgi-bin/npgs/html">http://www.ars-grin.gov/cgi-bin/npgs/html</a>]</td>
<td>Northern America and Southern America</td>
<td>Leaves, fruits and seeds: Used as sedative and sudorific.</td>
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<td>19.</td>
<td><em>Z. flavum</em> Vahl (<a href="http://en.wikipedia.org/wiki/Zanthoxylum_flavum">http://en.wikipedia.org/wiki/Zanthoxylum_flavum</a>)</td>
<td>Anguilla, Antigua and Barbuda, the Bahamas, Bermuda, Cuba, the Dominican Republic, Guadeloupe, Haiti, Jamaica, Puerto Rico and the Florida Keys, exclusive of Key West where it has been extirpated.</td>
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<td>28.</td>
<td><em>Z. macrophylla</em> Engl. [83,125]</td>
<td>Southern parts of Nigeria</td>
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<td>29.</td>
<td><em>Z. monophyllum</em> (Lam.) P. Wilson [41] USA</td>
<td></td>
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<td>30.</td>
<td><em>Z. myricanthum</em> [126]</td>
<td>Naga hills (Nagaland) and in Assam</td>
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<td>32.</td>
<td><em>Z. nitidum</em> (Roxb.) DC Synonyms: <em>Z. hirtellum</em> [27,127]</td>
<td>South-east Asian countries and in Australia</td>
</tr>
<tr>
<td>33.</td>
<td><em>Z. pipertum</em> DC. [51,52]</td>
<td>Hokkaido to Kyushu in Japan, Southern parts of the Korean peninsula and Chinese mainland.</td>
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<td>34.</td>
<td><em>Z. rhetsa</em> Roxb. [102,128,129]</td>
<td>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.</td>
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<td>35.</td>
<td><em>Z. riedelianum</em> Engl. [130]</td>
<td>Bolivian, Brazil, Colombia, Costa Rica, Ecuador, Panama, Paraguay, Peru</td>
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<td>37.</td>
<td><em>Z. rhoifolium</em> Lam. [48,78,130]</td>
<td>Central and south Brazil</td>
</tr>
<tr>
<td>38.</td>
<td><em>Z. scandens</em> [132]</td>
<td>India, China, the Ryukyus, Sumatra, Java, Borneo and at low altitudes, throughout Taiwan</td>
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<td>39.</td>
<td><em>Z. schinifolium</em> Sieb. &amp; Zucc. [133-135] (Japan) Honshu, Shikoku, Kyushu, Korea, China, Taiwan</td>
<td>Leaves and ripe pericarp: Used as culinary applications and drugs for epigastric pain.</td>
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<td>40.</td>
<td><em>Z. simulans</em> Hance. [75,76]</td>
<td>Native to eastern China and Taiwan, South Korea</td>
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proximity in order for pollination to take place and seed setting. Morphologically, it is the only truly choriparous 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 has 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 xanthoxylne, 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 properties. Studies of analgesic activity have been performed on several species. Methanol and aqueous 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.

A number of antimicrobial activities have been reported in the genus Zanthoxylum. The essential oils of Z. xanthoxyloides and Z. lepriciurei [28], Z. armatum [29], Z. hyemale [30] and Z. tingoaussiba [31] were reported to have antimicrobial properties. Aqueous, hexane and methanol extracts from leaves, roots and stem bark of Z. chalybeum and Z. usambarensis [32], Ethanolic extracts of bark of Z. fagara, Z. elefantiasis and Z. martincense [33], alkaloidal extract of the stem barks of Z. chloropeore [34] were found to have antimicrobial activity. Antimicrobial activity was also recorded for Z. americanus, Z. zanthoxyloides [35] and Z. budrunga [36]. A broad spectrum antifungal activity was also reported for leaf, fruit, stem, bark and root extract of Z. americanus [37] and Canthin isolated from Z. chloropeore [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. guinaeus [41]. Likewise, several compounds have been isolated from Z. tessmannii that possess anti fungal as well as antibacterial activities [42].

Some of the species of the genus Zanthoxylum have been known to be used in traditional medicine for relieving pain. The antinociceptive 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.
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. gilletti [58], Z. guilettii [59,60] Z. rhoifolium [61], Z. limonella [62], Z. chalybeum, Z. syncarpum, Z. xanthoxyloides 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 CCI (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 trypanocidal activity of hexane extract from leaves of Z. narangular [88], antileishmanial activity of alkaloidal extract of Z. chiloporum stem bark [89], antiCestodal property of Z. rhetsa leaves Yadav and Tangpu [90], gastroprotection activity of Z. rhoifolium [91], anti-sickling activity of Z. macrophylla [92], hypnotic activity of Z. budranga [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, Amidex, flavonoids, 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, diarrhea, 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.

References


