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***Ailanthus excelsa* Roxb. is Really a Plant of Heaven**

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Abstract: Over the past decade, herbal and ayurvedic drugs have become a subject of world importance, with both medicinal and economical implications. A regular and widespread use of herbs throughout the world has increased serious concerns over their quality, safety and efficacy. Thus, a proper scientific evidence or assessment has become the criteria for acceptance of herbal health claims. *Ailanthus excelsa* Roxb. is a tree belonging to family Simaroubaceae, indigenous to Central and Southern India. Commonly it is known as a plant of Heaven. The traditional claims, phytochemical investigations and pharmacological evaluation and some ayurvedic formulations provide the backbone to make this tree as a plant of Heaven. This is not wrong to say that it is largactil because it has number of activities. This review article explores the traditional knowledge or claims along with pharmacognostical, phytochemical, pharmacological and future aspects of this plant. Over many centuries humans have been mining the bounties of nature for discovering new phytoconstituent that have been used for the treatment of number of diseases; many such treatments are useful even today as modern day medicine. Emerging evidence also suggests that search is still continuing for harnessing active compounds from nature in combating human illnesses and it also leads the path to search out new active natural and novel semisynthetic or synthetic compounds.

Key words: Arlu, *Ailanthus excelsa* Roxb., maharukha, Simaroubaceae, quassinoids

INTRODUCTION

During the past decade, the indigenous or traditional system has gained importance in the field of medicine. In most of the developing countries, a large number of populations depend on the traditional practitioners, who are dependent on medicinal plants to meet their primary health care needs. Although, modern medicines are available, herbal medicine retained their image for historical and cultural reasons. Since the usage of these herbal medicines has increased, issues and moto regarding their quality, safety and efficacy in industrialized and developing countries are cropped up (WHO, 1999). Increasing interest has forced researcher to screen scientifically various traditional claims. There is need of screening the traditional claims because this is scientific era and every one wants the scientific support before using the traditional drugs. So presently both common user and health care professionals seek updated, alterative information towards safety and effecy of any recommended medicinal plants as drug prior to its use. The present attempt is to review and compile total information to till date, on various aspects of *Ailanthus excelsa* Roxb. a plant used in the Indian

school/system of medicine for variety of purposes (Kirtikar and Basu, 1995). *Ailanthus* is a genus of tall, leafy trees, widely distributed in Indo-Malay, Japan, China and Australia. The genus is noted for its antidysentric and antidiarrhial properties (Chopra *et al.*, 1958). Different species of the genus are *Ailanthus glandulosa* in China and Malay Peninsula, (leaflets very coarsely toothed at the base and filaments several times exceeding the anther), *Ailanthus malbarica* in Indo-China (leaflets entire and filaments larger than anther) and *Ailanthus excelsa* in India (leaflets very coarsely toothed and filaments shorter than anther) (Lavhale and Mishra, 2007). *Ailanthus excelsa* Roxb. belonging to family Simaroubaceae which is defined in Engler's Syllabus consists of six subfamilies with 32 genera and over 170 arboreous or shrubby species. The largest genus is *Picromnia* with ca 40 species native to the new world tropics. Indeed the entire family is of pantropical occurrence with the exception of the genera *Picrasma* and *Ailanthus* which extend to temperate Asia. The genera of Simaroubaceae are mostly well defined, but the family is only loosely knit. A large botanical literature has accumulated on the question of affinity and the five subfamilies Surianoideae (four genera), Kirkioideae

(monogeneric), Irvingioideae (three genera), Picramnioideae (monogenetic) and Alvaradoideae (monogenetic) have all been removed from the Simaroubaceae at one time or another. This would leave only the Simarouboideae (22 genera) within the Simaroubaceae. This family contain following species which are rich in quassinoids and other important constituents (Anonymous, 1985).

Simaroubeae: *Pierreodendron kerstingi*, *Samadera indica*, *Simarouba amara*, *Simaba cuspidate*, *S. glauca*, *S. versicolor*, *S. multijlora*, *Odyendyea gabonensis*, *Quassia amara*, *Q. Africana*, *Q. indica*, *Hannoa klaineana*, *H. undulate* and *Eurycoma longifolia*.

Picrasmeae: *Castela erecta*, *C. nicholsoni*, *C. texana*, *C. tweedii*, *Holacantha emoryi*, *Brucea guineensis*, *B. antidysenterica*, *B. amarissima*, *B. sumatrana*, *B. javanica*, *Perriera madagascariensis*, *Picrasma crenata*, *P. excelsa*, *P. quassioides*, *Picrolemma pseudocoffea*, *Ailanthus excelsa*, *A. grandis*, *A. integrifolia* sp. *Calycina*, *A. malabarica* and *A. altissima*.

Soulameae: *Soulamea amara*, *S. fraxinifolia*, *S. muelleri*, *S. pancheri*, *S. tomentosa* and *S. soulameoides*.

Ailanthus excelsa Roxb. (Simaroubaceae) is commonly known as Mahanimba due to its resemblance with the neem tree (*Azadirachita indica*) and Maharukha due to its large size. Ailanthus is from ailanto which means tree of heaven and is the name for one of the species in the Moluccas, while in Latin excelsa means tall. The plant is known by different names like tree of heaven in English and others Indian local names are as follow (Database, 2000).

Classical names: Araluka, Aralu, Katvanga, Deerghavrinta, Putiveriksha.

Vernacular names:

Sanskrit : Madala, Katvariga, Dirghavrnta

Assam : Aralu

Hindi : Maharukha, Limbado, Maharuk, Mahanimb, Ghodakaranj

Beng. : Mahanim

Guj. : Moto ardusa, Adusa, Arduri, Arlabo, Moto adusa

Kan. : Doddamaru, Hemaraheera mara, Dodumani

Mal. : Perumaram, Mattipongilyam

Mar. : Mahanimb, Maharukh

Punj : Arua.

Tam : Peruppi, Perumaruttu, Peru, Pee

Tel. : Pedu, Pey, Pedda, Peddamamanu, Putta

Oriya : Mahanim, Mahala, Gorni-Kawat, Palamow-Ghokaram

Kash : Merumaram, Mattipongilyam

Tree of heaven is fast growing extensively cultivated in many parts of India towards the vicinity of villages. The tree is indigenous to Southern and Central India and distributed in Western Peninsula, Rajasthan, Bihar, Orissa, Bundelkhand, through Madhya Pradesh, Broach and Panchamal district of Gujarat, in dry deciduous forests of Maharashtra, scrae in Deccan and Karnataka, N. Circars, forest of Tamilnadu. It is often planted along the roads. It is exotically found in Sudan. The plant is known for its high economical and commercial importance (Anonymous, 1985; Database, 2000).

BOTANICAL DISTRIBUTION

It is a large deciduous tree, 18-25 m tall; trunk straight, 60 to 80 cm in diameter; bark light gray-brown and rough on large trees, aromatic slightly bitter. Leaves alternate, pinnately compound, large, 30-60 cm or more in length; leaflets 8-14 or more pairs, long stalked, ovate or broadly lanceolate shaped from very unequal base, 6-10/90 cm long, 3-5 cm wide, often curved, long pointed, hairy gland; edges coarsely toothed and often lobed. Flower cluster lobed at leaf base, shorter than leaves, much branched; flowers many, mostly male and females on different trees, shorter stalked, greenish-yellow; calyx 5 lobed; 5 narrow petals spreading 6 mm across; stamens 10; on other flowers, 2-5 separate pistils, each with elliptical ovary, 1 ovule and slender type. Fruit a 1 seeded samara, lanceolate shaped, flat, pointed at ends, 5 cm long, 1cm wide, copper red, strongly veined, twisted at the base (Fig. 1a, b and 2). The generic name Ailanthus came from ailaanthos (tree of heaven), the Indonesian for *Ailanthus moluccana* (Anonymous, 1985; Database, 2000; Lavhale and Mishra, 2007).

The leaves are reported to be used as an adulterant for *Adhatoda zeylanica* (*Adhatoda vasica* Nees.). Its bark is good substitute for kutaj (*Holarrhena antidysenterica* Wall.). It is cultivated as an avenue tree for its deep shade and can be used for anti-erosion purposes. It thrives best on porous loamy soil. The tree can be raised from both seeds and stumps. Its quick growth and absolute immunity to grazing gives the species first choice among the soft woods (Anonymous, 1956). The leaves are rated as highly palatable and nutritious fodder for sheep and goats and an average tree yields about 500-700 kg of green leaves twice a year. The wood is sainty, yellowish white and well suited for cabinet making (Bhandari and Gupta, 1972).

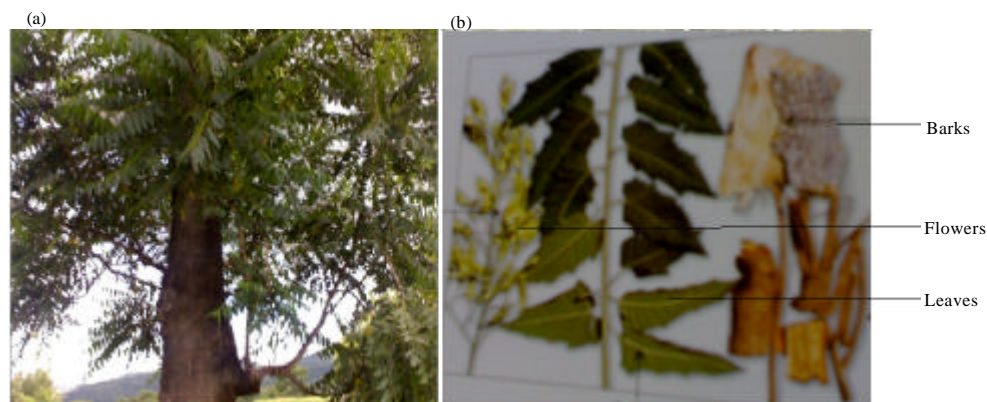


Fig. 1: (a) *Ailanthus excelsa* tree and (b) flowers, leaves and barks of *Ailanthus excelsa*



Fig. 2: *Ailanthus excelsa* with flowering twig, fruits and flower

Vascular occlusions in the stem of *Ailanthus excelsa*

Roxb.: Traumatic gum-resin cavities present or develop in the stem of *Ailanthus excelsa* Roxb. The stem of *Ailanthus excelsa* Roxb. (Simaroubaceae) may develop vascular occlusions and gum-resin cavities in the xylem as a response to injury and infection. Fungal hyphae are observed in the vessel lumen and in the adjacent parenchyma cells. The occlusions appeared in various forms and showed varying chemical composition. The chemical nature of the occluding material differed from that of the exudate formed in the cavities. The majority of occlusions contained lipids, protein, polysaccharides, phenolics, lignin and probably pectin, whereas, the exudate contained lipids, protein and four soluble sugars. All the components of the occlusion except lignin and pectin appear to have been formed in the parenchyma cells adjacent to the vessel and migrated to vessel lumen through the vessel wall pits. The different constituents migrate into the vessel lumen independently where they mix to form occlusions (Shah and Babu, 1986).

Ecology and distribution

History of cultivation: The tree is native to Central, Western and Southern India, but is now being spread to other semi-arid and subtropical areas. It is fairly common in Central Sudan and is found planted on riverine and sandy soils.

Natural habitat: *Ailanthus excelsa* grows well in semi-arid and semi-moist regions and has been found suitable for planting in dry areas with annual rainfall of about 400 mm. It is commonly found in mixed deciduous forests and some sal forests, but is rare in moist areas with high monsoons. Plant associations include *Acacia catechu*, *A. leucophloea* and *Azadirachta indica*. It is a relatively salt-tolerant species.

Geographic distribution

- C Native: India, Sri Lanka
- C Exotic: Sudan

Biophysical limits: Altitude: 0-900 m, Mean annual temperature: 0-45°C, Mean annual rainfall: 500-2500 mm.

Soil type: Grows in a wide variety of soils, but thrives best in porous sandy loams. It avoids clayey soils with poor drainage and waterlogged areas. Its growth is poor on shallow dry soils.

Reproductive biology: The flowers appear in large open clusters among the leaves towards the end of the cold season. Male, female and bisexual flowers are intermingled on the same tree. The fruits ripen just before the onset of the monsoon. The seeds are very light and are dispersed far and wide by the wind propagation and management (Vogt, 1995).

Propagation methods: Natural reproduction occurs through seed and coppice. Seedling regeneration is generally scanty and cannot be relied upon to regenerate natural stands. Natural regeneration through coppice and root suckers is adequate so long as the trees harvested are healthy. Artificial regeneration is through direct seeding or planting pregerminated seed (Hong *et al.*, 1996).

Tree management: *Ailanthus excelsa* has strong light requirements. The recommended spacing is 6×6 m for Agro-forestry and 3×3 m in block plantations. The seedlings are susceptible to frost and are easily suppressed by weeds as a result of shading. Prolonged drought also kills the seedlings, although the poles and trees are drought resistant. Water logging and poor drainage cause high seedling mortality. It coppices well and produces root suckers that should be thinned to reduce competition.

Germplasm management: Seeds are usually picked before maturity since fully mature fruits are liable to lose most of their seeds through wind dispersal as soon as attempts are made to collect them. Seed storage behaviour is probably orthodox; viability is maintained for 1 year in open storage. There are about 9500 seeds kg⁻¹.

Services

Shade or shelter: *Ailanthus excelsa* is grown as a shade and avenue tree throughout most of the hotter parts of India.

Boundary or barrier or support: The trees serve as shelterbelts along borders of fields.

Pests and diseases: *Atteva fabriella*, *A. niveigutta* and *Eligma narsissus* defoliate the tree. Borers include *Batocera rufomaculata*. Among the fungi are leaf spot fungi (*Cercospora glandulosa*) and *Alternaria* sp. (Anonymous, 1986).

Provenance trial on *Ailanthus excelsa* (Project 1: AFRI-40/FGTB/1994-2006)

***Ailanthus excelsa*:** The morphological characters of the seeds of the different Provinces were recorded in terms of seed length, seed width and test weight. The highest test weight recorded in Jodhpur Province was 120 g followed by Jodhpur and Kajipet of 105.8 and 105.1 g, respectively. The lowest test weight 55.5 g was recorded from a Province of Bilaspur. The seed length was highest (6.6±0.5 cm) in the Province from Kajipet. The seed length of other Province varied from 5.60 to 2.52 cm. The maximum seed width was claimed by Bikaner Province, which was 1.46±1.7 cm and minimum was

0.78±0.1 cm of Bilaspur Province. The germination percentage was especially in the hot arid and semi arid region of Balaghat Province, which was 50.7%. The next in order was Jodhpur Province, which had 40.1% germination percentages. The poorest germination performance was displayed by Jaipur Province (0.41%). (India).

Pharmacognosy (Anonymous, 1985; Database, 2000)

Bark: Bark is approximately 1 cm thick, whitish superficially, rough with irregular fissures. Inner surface is yellowish, white and fibrous in nature. Lenticels are vertically elongated with pointed tips, centrally blistered and whitish brown in colour. Taste is bitter. In transverse section phellogen consist of thin walled, tangentially elongated cells. Cork cambium originates as single subepidermal layer. Phelloderm is composed of parenchymatous cells with patches of scleroids and isolated spherocrystals scattered through the tissue. Starch grains are also present. The scleroids are long with narrow lumen and pitted. Primary cortex reduced in mature bark and shows the presence of fibers and scleroids. Phloem consists of phloem parenchyma and fibers traversed by medullary rays. The phloem fibers occur singly or in small groups, arranged in a concentric ring. Fibers are long with tapering ends pointed and margin sometimes serrated or showing peg like projection from the side wall of pitted. Medullary rays are usually multiseriate and sometimes uniseriate, composed of radially elongated cells. Crystal of calcium oxalate (polygonal, prismatic, rhomboidal, small rod shaped) occurs abundantly in Phelloderm and spherocrystals are scattered throughout the secondary phloem of the bark.

Leaf: Leaves are pinnate, grayish green, soft and velvety in texture, margins irregularly toothed pinnae unequal at base and petiole not grooved. In transverse section the leaf is subsentric type with a single row of palisade cells. Cuticle is striated; epidermal cell walls are straight with a tendency for beading. Stomata are anomocytic, trichomes glandular with multicellular head on multicellular stalk. Abundant, solitary and cluster crystals of calcium oxalate are present along the veins. Medullary bundles and isolated phloem groups in the medulla are present. Palisade ratio 6-8-10 and stomatal index 5-9-12.

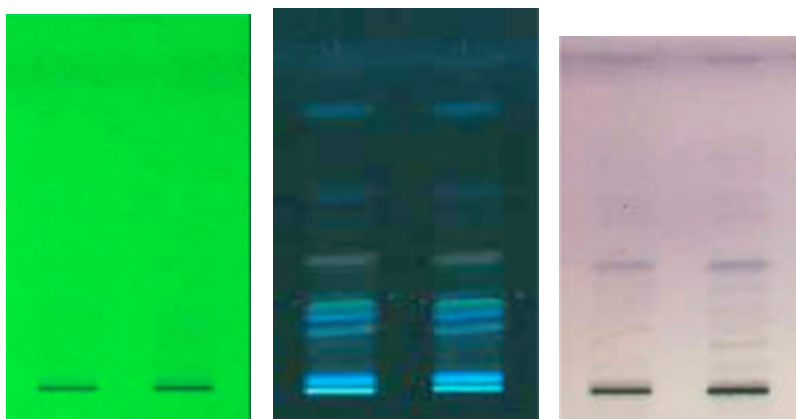
Physical constants:

Bark: Total ash-9.5%, alcohol soluble extractive-1.5%, alcohol soluble extractive-2.40%, water soluble extractive- 12.50%.

C HPTLC (Fig. 3) of *Ailanthus excelsa* Roxb.

C **Botanical name:** *Ailanthus excelsa* Roxb.

C **Family:** Simaroubaceae

Fig. 3: HPTLC profiles of sample of *Ailanthus excelsa*

- C **Part used:** Stem bark
 C **Sanskrit name:** Arlu
 C **Chemical constituents:** β -sitosterol, Quassinoids and Ailantic acid
 C **Area of collection:** Gwalior (Madhya Pradesh)
 C **Month of collection:** September-October, 2007
 C **Mobile phase:** Chloroform: Methanol (9.5:0.5)
 C **Tank saturation:** 20 min
 C **Sample applied:** 7 μ L
 C **Solvent front:** 80 mm
 C **Drying:** For 10 min
 C **Detection/Visualization:** At 254 nm, 366 nm and after derivatization as mentioned below:

Derivatization: Derivatize the plate with anisaldehyde sulphuric acid and heat the plate at 105°C till the band develop. Note the Rf of resolved bands

S. No. of bands	Visualization		After derivatization
	UV 254 nm	UV 366 nm	Under white light
1	---	0.04	0.13
2	---	0.17	0.23
3	---	0.23	0.30
4	---	0.50	0.38
5	---	0.38	0.50
6	---	0.56	0.56
7	---	0.80	---

HPTLC: Fingerprint atlas of ayurvedic single plant drugs mentioned in Ayurvedic Pharmacopoeia Vol- III and IV

Ethnopharmacology: In Chinese system of medicine bark of *A. excelsa* is used to treat diarrhea and dysentery, especially when there is a blood in stool (Chopra *et al.*, 1958; Dash and Padhy, 2006). *Ailanthus excelsa* is a fast growing tree and is extensively cultivated in many parts of India in the vicinity of villages; it is cultivated as an avenue tree for its deep shade and can be used for ant-erosion purposes (Anonymous, 1956). The bark has been used in Asian and Australian medicine to counteract worms, excessive vaginal discharge, malaria and asthma (Kirtikar and Basu, 2003; Chevallier, 1996). It has marked

antispasmodic and cardiac depressant properties (Nadkarni, 1976). The root bark is used to cure epilepsy and heart troubles. In Africa the plant is used to treat cramps, gonorrhea epilepsy, tape worm infestation and high blood pressure (Sharma, 1996). Alcoholic extract of the leaf and stem bark shows anti-implantation and early abortifacient activity. Traditionally the mattress made of leaves is used as bed for children suffering from fever. In Bombay the bark and leaves are of great repute as a tonic especially in debility after child birth. They are used in dyspepsia, bronchitis and asthma. In Konkan the juice of the leaves is usually administered in khir, or the juice of the fresh bark is given with coconut juice and treacle or with aromatics or honey to stop after pains. It is also used to cure wounds and skin eruptions. The plant is used as natural antifertility agent by the Irula women in Mavanahalla region of the Nilgiri district in Tamil Nadu. The fresh juice of stem bark mixed with either honey or sugar is given to pregnant woman during evening for three consecutive days to induce permanent sterility. In Kanakpura taluka in Karnataka, the pest of stem barks along with goat milk and neem oil is used for curing the nose rope wound in ox. The bark is used as bitter, refrigerant, astringent, appetizer, anthelmintic, febrifuge, in dysentery, earache, skin disease, troubles of the rectum and fever due to tridosha and allay thirst. It is also used in gout and rheumatism. In Ayurveda it is used to remove the bad taste of mouth. The bark is a good substitute for kurchi, Holarrhena antidysenterica. *A. excelsa* along with Arjuna myrobalans strengthen the body's natural rejuvenative processes. Fruits are used in diarrhea, polyurea, piles and fever. Leaves along with twigs are found to be suitable fodder for cattle, sheep and goats. The tree yields an inferior quality of bassora or hog gum. The plant serves as one of the host for silk worms. In France the tree is cultivated for its leaves, on which the

caterpillar of the silk spinning *Ailanthus* moth (*Bombyx Cynthia*) is fed yielding a silk of more durable and cheaper than mulberry silk. The wood is short fibered, admixture with long fiber pulp, such as bamboo pulp, used in the manufacture of paper. It is also used for the preparation of pencils (Lavhale and Mishra, 2007). It is avoided by goats and cattle in young stages, but the seedlings are sensitive to frost and drought. The wood is soft white light (sp. g. 0.45, wt. 335-480 kg cuG¹ m) but fairly strong. Because of its light weight, it is used especially for making catamarans and small boat. It is also used for veneers and plywood packing cases, sword handles and spear sheathes toys and poor quality of matchwood (Anonymous, 1985).

In database of medicinal plant used in Ayurveda, the *A. excelsa* has action and uses as follows (Database, 2000).

The bark is bitter, astringent, anthelmintic, febrifuge, appetizer, bitter tonic, taste bud stimulant. It is useful in diarrhea, amoebic dysentery, chronic giardiasis, dyspepsia, abdominal spasm anorectal disease, haemorrhoids, fistula, fissures, ulcerative colitis and worm infection. It is also used as blood purifier in skin diseases, typhoid fevers, blood coagulation disorders, gouty arthritis, boils, carbuncle, scabies and allied skin disease, chronic bronchitis, bronchial asthma, pulmonary kochs, bronchiectasis, polyurea, diabetesmelitus, obesity, uterine disorders like dysmenorrhoea and leucorrhoea. The bark and leaves have great repute as postnatal tonic. Leaf juice is administered along with milk for post labour pains.

Ayurvedic properties

- C Rasa-Tikta, kashaya
- C Guna- Ruksha
- C Veerya-Sheeta
- C Veepaka-Katu

Doshagnata-Kaphapittashamaka, Ragagnata-Kaphapittajaroga, Charmaroga, Dushtavrana, Apasmara, Manasavikara, Balagraha, Pravahika, Atisara, Grahani, Arsha, Bhagandara, Krimi, Raktavikara, Raktavata, Jeernakasa, Urahkshata, Kshaya, Pradara, Yonivyapada, Jeernajwara, Vishamajwara, Medoroga, Madhumeha, Karma-Twagdosahara, Vranshodhana, Deepana, Pachana, Grahi, krimighna, Raktashodhaka, Raktambhana, Kasahara, Sandhaneeya, yonidosahara, Jwaranashaka, Lekhana, Madhuryanashaka, Vishaghna.

Doses: Leaf juice -10-20 mL; Bark powder-1-3 g; Extract-(Ghanasatva)-1 g.

Formulation and preparations: *Ailanthus* is an important ingredient in most of the formulations and preparations

Ailanthus is an important ingredient in most of the ayurvedic preparations like, Pusyanuga churna, a herbo-mineral Ayurvedic preparation of which *Ailanthus excelsa* is one of the constituent, was found effective in vataja and kaphaja pradara. Brahat Gangadhara churna and Aralu putpaka, used in the management of atisara, krimi, arsa, sannipatajwara, brama, tvakroga, chardi, kustha, pravahika, grahani, prameha, gulma, swasa, musaka and visaja roga. Dasmularista, a highly prized ayurvedic formulation for fatigue, is actually a mixture of ten different herbs out of which one is Shyonak/Sonapatha. It aids in cellular regeneration to hasten removal of dead or weak cells and replace them with fresh, vital ones. In ayurvedic literature there happens to be a controversy between the common name used for both *Ailanthus excelsa* and *Oroxylum indicum* mentioned as Shyonak. In the Bhavprakashnighantu also *Ailanthus excelsa*, is described under the name of Aralu and Sonapatha/Shyonak is mentioned as its synonym. In Amarkosh aralu, shyonak and tintuk are the names given to the same plant. In the title some controversial drugs in Indian medicine the Nighantu writers have confounded it with *Oroxylum indicum* (Bignoniaceae). As per the Adarsha Rajniguntakar Nighantu, the description under Shyonakyugal mentioned that in case of two Shyonakas, one should be aralu and other is tintuk, whereas European practitioners consider both *Ailanthus excelsa* and *Oroxylum indicum* as totally different plants; however *Ailanthus excelsa* is said to be a substitute for Shyonak. Pilex, the most popularly used ointments for piles contains bark of *Ailanthus excelsa* and is indicated in hemorrhoids, anal fissures, fistulae, proctitis, venous stasis, varicose veins, thrombophlebitis, varicocele and varicosity. Lukol tablets used in leucorrhoea contains Loh Bhasma, along with extracts of *Withania somnifera*, *Saraca indica*, *Woodfordia floribunda*, *Symplocos racemosa*, *Ailanthus excelsa*, *Leptadenia reticulata* and *Asparagus racemosus* which acts synergistically as uterine tonics, nervine sedatives and have a stimulating action on the endometrium and ovarian tissues. Sports massage oil prepared from the bark of *A. excelsa* is used to keep muscles relaxed. Rain tree's Simarouba extract the preparation of Simarouba amara, contain quassinoids like ailanthinone and glaucarubinone as the main active constituents, which are also present in *Ailanthus excelsa* and are considered to be the main therapeutic constituents for dysentery (amebic and bacterial) and diarrhea; intestinal worms and internal parasites; malaria; as an astringent to stop internal bleeding (stomach ulcers, hemorrhages) and externally for wounds and in viral infections. Katabheyadi taila, asthadashanga kashaya, Hreeberadi kavatha. *Ailanthus excelsa* bark infusion (1 in 20), dose: 1 to 2 ounces. Ailantic acid, dose:

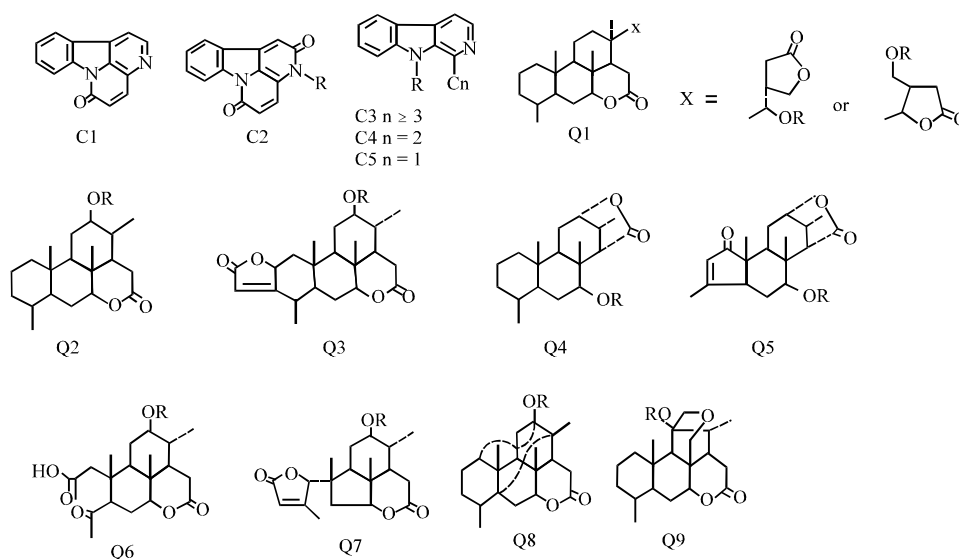


Fig. 4: The canthinones and /L carbolines, classified into structural types C1-C5 and the quassinoids, classified into structural types Q1-Q9

1 to 3 grains; in large doses it causes nausea, vomiting and purging (Anonymous, 1985; Database, 2000; Lavhale and Mishra, 2007).

Phytochemistry: The Simaroubaceae, as defined in Engler's Syllabus (Melchior, 1964) consists of six subfamilies with 32 genera and over 170 arboreal or shrubby species. The largest genus is *Picramnia* with ca 40 species native to the new world tropics. Indeed the entire family is of pan tropical occurrence with the exception of the genera *Picrasma* and *Ailanthus* which extend to temperate Asia (Nooteboom, 1962). The genera of Simaroubaceae are mostly well defined, but the family is only loosely knit (Cronquist, 1981). A large botanical literature has accumulated on the question of affinity and the five subfamilies Surianoideae (four genera), Kirkioideae (monogeneric), Irvingioideae (three genera), Picramnioideae (monogeneric) and Alvaradoideae (monogeneric) have all been removed from the Simaroubaceae at one time or another (Nooteboom, 1962; Iyer and Rangaswami, 1972). This would leave only the Simarouboideae (22 genera) within the Simaroubaceae. Presently known chemical data are consistent with these conclusions based on morphological and anatomical evidence. Only genera of Simarouboideae contain tryptophan- derived alkaloids (/?-carbolines, canthinones) and/ or triterpene-derived quassinoids. Only common flavonoids have so far been isolated from Surianoideae and Irvingioideae (Simao *et al.*, 1991; Mitchell and Geissman, 1971). Nothing seems to be known about Kirkioideae, Picramnioideae and Alvaradoideae (reported to contain one quassinoid, accumulate anthraquinones

not found so far in any other group of Simaroubaceae *sensu late*. Within the Simarou-boideae the genus *Harrisonia* is exceptional: alkaloids and quassinoids seem to be absent while chromones and limonoids suggest affinity with rutaceous genera. *Aeschrion* and *Amaroria* are considered to be synonymous with *Picrasma* and *Soulamea* respectively. *Samadera*, *Simaba* and *Simarouba* have been suggested to constitute sections of *Quassia*. *Hyptiandra*, *Picrella* and *Hebonga* are not quoted in a recent catalogue of genera. Thus the original list of Simarouboideae is reduced to 16 genera. The canthinones and /L carbolines, classified into structural types C1-C5 and the quassinoids, classified into structural types Q1-Q9, reported (Fig. 4) to occur in Simaroubaceae up to 1987.

The American genera of the subtribe castelinae are still very similar with their relatively simple chemistry to the American genera of Simaroubeae. However, the genera of Picrasminae include the two very dissimilar *Brucea* and *Picrasma*. The constituents of the African-Asian *Brucea* are highly specialized: quassinoid. A ring appears, as usual, uniformly oxygenated at C-1 and C-2. In *Brucea*, this situation only prevails for position 2, while it is frequently C-3 and not C-1 which sustains the additional oxygen. Again, quassinoids are usually substituted by 11a-rather than by 11/G OR groups. *Quassia* skeletons Q2 bear both types of substituent's, a feature which recurs in *Pierreodendron*, *Holacantha* and sporadically in a few other genera. In contrast all 42 skeletons of *Brucea* are substituted by 11b-OR groups. Besides, *Brucea* quassinoids bear exclusive double bonds at C-1 and C-4 (Simao *et al.*, 1991).

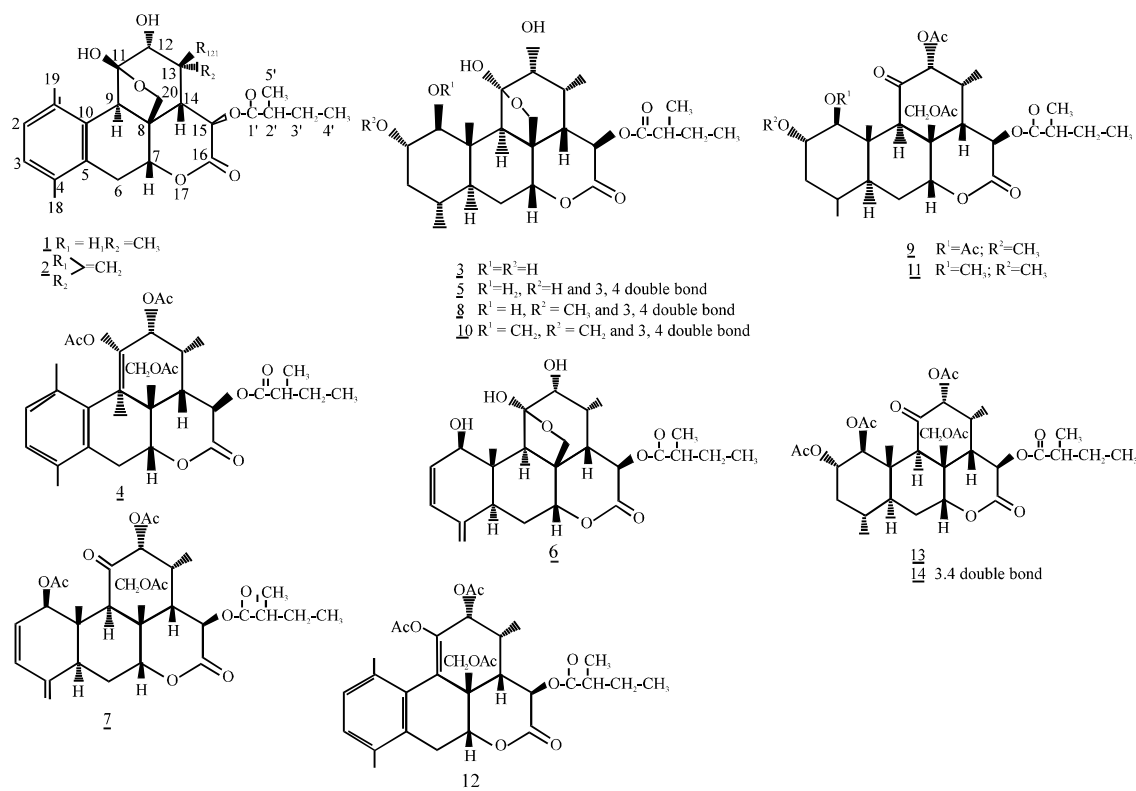


Fig. 5: The structural elucidation is based on the analysis of spectroscopic data

The Simaroubaceae, family contain really a plant of heaven that is *A. excelsa* Roxb.

Quassinoids: Plants from simaroubaceae are known to contain compounds with highly oxygenated triterpenes and bitter taste called as quassinoids. Initially the compounds of such chemical nature were known by the term quassin after the physician Quassi who used the bark of plants from this family for the treatment of fever. Studies on quassinoids have shown their promising role as therapeutic agents as an antitumor, antiviral, anti-inflammatory, antiamoebic, antimalarial, insecticidal, antitubercular, anticancer, amoebicidal, antiulcer, herbicidal and antifeedent, etc. (Lavhale and Mishra, 2007).

The plants of the Simaroubaceae family contain the bitter principles known as quassinoids which are degraded triterpenes and are highly oxygenated. Some of these plants are used in folk medicine for anthelmintic and antiamoebic properties (Polonsky, 1973). In recent years attention has been focused on quassinoids as several of them have shown promising antitumor, antiviral, antimalarial, antileukemic and antifeedant properties (Polonsky, 1985). Chemical examination of

Ailanthus excelsa, a Simaroubaceous plant, has been carried out by several workers resulting in the isolation of quassinoids (Ogura *et al.*, 1977; Khan and Shamsuddin, 1978, 1980; Khan and Zuberi, 1980; Sahai and Bhatia, 1985; Bhatia and Sahai, 1985). Three quassinoids, 1, 2 and 3, 4-dihydro excelsin 3 were isolated from the stem bark of *Ailanthus excelsa*, along with five known quassinoids excelsin, glaucarubine, ailanthinone, glaucarubinone and glaucarubolone. The glaucarubolone has been isolated for the first time from this plant in 2003. The structural elucidation is based on the analysis of spectroscopic data. The structures mentioned (Fig. 5) were listed by Joshi *et al.* (2003).

Five known compounds were identified as excelsin 5 (Khan and Shamsuddin, 1980); glaucarubine (Khan and Shamsuddin, 1980); ailanthinone, glaucarubinone (Ogura *et al.*, 1977) and glaucarubolone (Gaudemer and Polonsky, 1965) by comparing their physical and spectral data with those reported in the literature. Glaucarubolone has been isolated for the first time from this plant.

Stem bark of *A. excelsa* contains quassinoids like excelsin, 1,4-dihydroexcelsin, 2,4-dihydroexcelsin, 3,4-dihydroexcelsin, 13,18 dehydroexcelsin, glaucarubin, glaucarubol, ailanthinone, 1,12-deoxy-13-formylailanthiol,

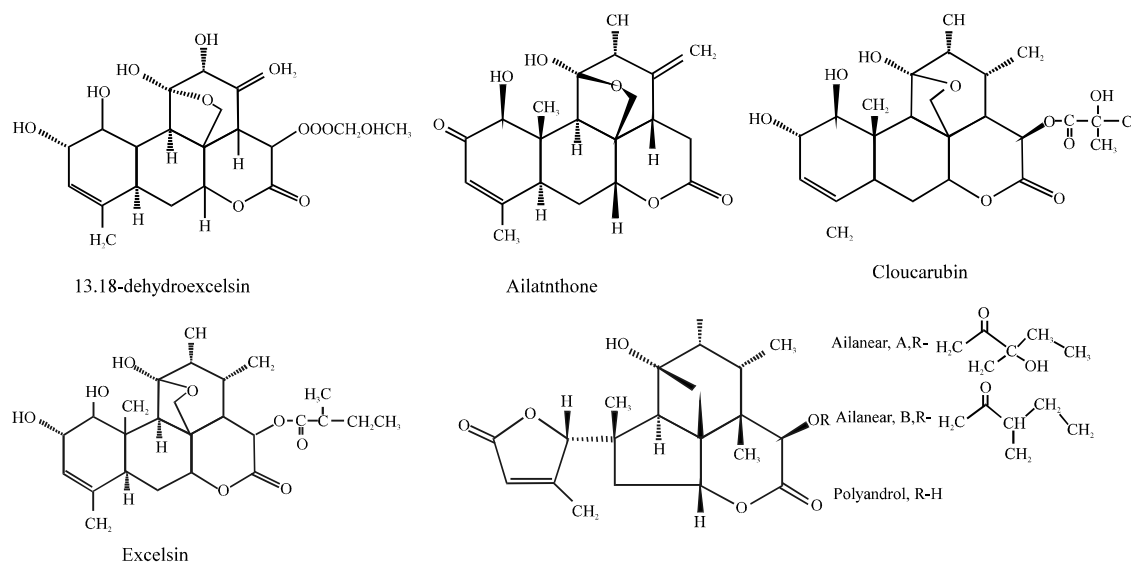


Fig. 6: Structures of quassinoids from *Ailanthus excelsa*

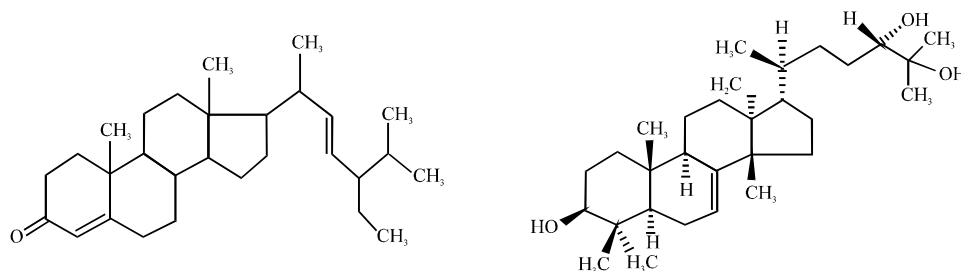


Fig. 7: Structure of steroid and triterpenoid from *Ailanthus excelsa* Roxb.

ailanex A, ailanex B, polyandrol and glaucarubolone while the root bark is reported to contain ailanthinone, glaucarubinone and mixture of glaucarubin-15-isovalerate, 13, 18-dehydroglaucarubol 15-isovalerate (Fig. 6). Ailanthone is toxic to some fungi and may therefore acts to protect plants against fungal pathogens and is associated with the observed toxicity of this species. A total control on *Chenopodium album* and *Amaranthus retroflexus*, the two weeds associated with soybean was observed with excelsin. Quassinoids from *Simarouba amara* were tested *in vitro* against a multi drug resistant strain of *Plasmodium falciparum* and *in vivo* against *Plasmodium berghei* in mice. Although, the *in vitro* studies indicated activity in the region of 23-52 times greater than that for chloroquine, the toxicity was found to be very high. Few quassinoids isolated from *Simana cedron* showed good activity against chloroquine-resistant and chloroquine sensitive strains of *Plasmodium falciparum* and *Plasmodium vinckei petteri* in mice. Quassinoids also play an important role in treating Epstein- Barr virus infection, HIV infection and neoplasms possibly by depolarization of mitochondrial membranes.

2, 6-dimethoxy benzoquinone and malanthin: yellowish green viscous oil was obtained by percolation of air dried powder of trunk bark from an old tree of *A. excelsa*. This oil after refrigeration in minimum amount of benzene and light petroleum gives colorless crystalline malanthin. Saponification of the mother liquor left after malanthin crystallization gives 10% saponifiable matter and 90% unsaponifiable material. The unsaponifiable material upon column chromatography on alumina gives 2, 6 dimethoxy benzoquinone and 'S'-sitosterol (Lavhale and Mishra, 2007).

Steroidal compounds: The petrol extract of stem bark on column chromatography over silica gel gives 'S'-sitosterol and Stigmasta-4, 22-diene-3-one with hexane-ethyl acetate (9:1) (Fig. 7) (Lavhale and Mishra, 2007).

Triterpine: Root bark showed the presence of a new triterpene alcohol, 3S, 24S and 25-trihydroxytirucall-7-ene (Fig. 7). Triacontane and Hexatriacontane: Stem Bark showed the presence of triacontane and hexatriacontane (Lavhale and Mishra, 2007).

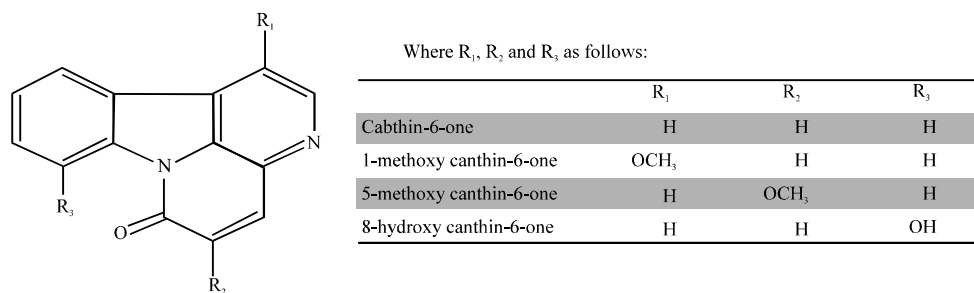
Fig. 8: Structure of alkaloids from *Ailanthus excelsa*

Table 1: Amino acid composition of the fractioned leaf protein concentrate (grams per 16 g of nitrogen) (75-76)

Amino acid	Unfractioned LPC*	Chloroplastic LPC	Chloroplastic LPC	Soyabean protein
Lysine	6.17	5.99	7.75	6.40
Threonine	4.72	4.69	4.85	4.10
Serine	4.87	4.71	4.38	5.60
Glutamic acid	12.27	12.26	12.53	19.10
Glycine	6.57	7.19	6.89	4.20
Alanine	6.67	6.645	6.79	4.30
Valine	7.20	7.08	7.20	5.00
Isoleucine	6.18	6.09	6.16	4.00
Leucine	10.75	11.27	10.10	7.80
Tyrosine	5.98	5.90	6.01	3.80
Phenylalanine	7.87	8.25	7.65	5.20
Methionine	1.79	1.65	2.11	1.40
Cystine	1.00	0.96	1.58	1.80
Aspartic acid	10.80	10.80	11.13	11.60
Arginine	6.37	6.21	8.01	7.70
Histidine	2.43	2.41	2.98	2.80

LPC* - Leaf protein concentration

Alkaloids: Methanol extract from root bark after solvent extraction with chloroform gave four alkaloids viz., canthin- 6-one, 1-methoxy canthin -6-one, 5-methoxy canthin -6-one and 8-hydroxy canthin-6-one (Fig. 8). These alkaloids were studied for nasopharynx carcinoma in Eagles but none of the compounds were sufficiently active to meet the required criteria. On the other hand these alkaloids have shown significant cytotoxicity against 12-O-tetradecanoylphorbol-13- acetate induced Epstein-Barr virus early antigen (EBV-EA). Canthin-6-one and 4-methoxy canthin-6-one showed potent antiulcerogenic activity in gastric lesions induced animals, as well as significant antinociceptive activity in mice (Lavhale and Mishra, 2007).

Proteins: Leaves contain considerable amount of proteins where, cytoplasmic protein fraction can be used for human consumption; while the unfractionated and chloroplastic fractions could be utilized as a nutritious feed for ruminants and nonruminants. Proximate analysis of various fractions of fresh leaves showed 62.71% crude protein in cytoplasmic protein fraction, while whole leaf showed 20.86% protein. The unfractionated and fractions from chloroplastic protein contained more crude fat than the whole leaf and pressed cake. Compared to whole leaf

and pressed cake, protein fractions were low in crude fiber content. The amino acid compositions of protein sample, showed an excellent balance of essential amino acids. The leaf protein fractions were nutritionally superior to the whole leaf, pressed cake as well as soyabean protein (Table 1) (Lavhale and Mishra, 2007).

Fractionation and Some Chemical Studies on *Ailanthus excelsa* Roxb. Seed protein has been carried out (Kundu and Laskar, 2008).

Flavonoids: From a pharmaceutical perspective flavonoids possess a remarkable spectrum of biochemical and pharmacological activities. The leaves were reported to contain different flavonoids like kaempferol (5, 4', 5, 7-Tetrahydroxy flavone), luteolin (3', 4', 5, 7-tetrahydroxy flavone), apigenin (4', 5, 7-trihydroxy flavone) while fruits contains quercetin. These flavonoids were reported to possess many biological activities such as antibacterial, antiinflammatory, antiallergic, antimutagenic, antiviral, antineoplastic, anti-thrombotic and vasodilatory properties. The flavon-C-glycosides like vitexin show antioxidant, analgesic and antithyroid activities, where as quercetin inhibits the growth of leukemic cells, ehrlich ascites tumor cells and other ascites tumor cells. It

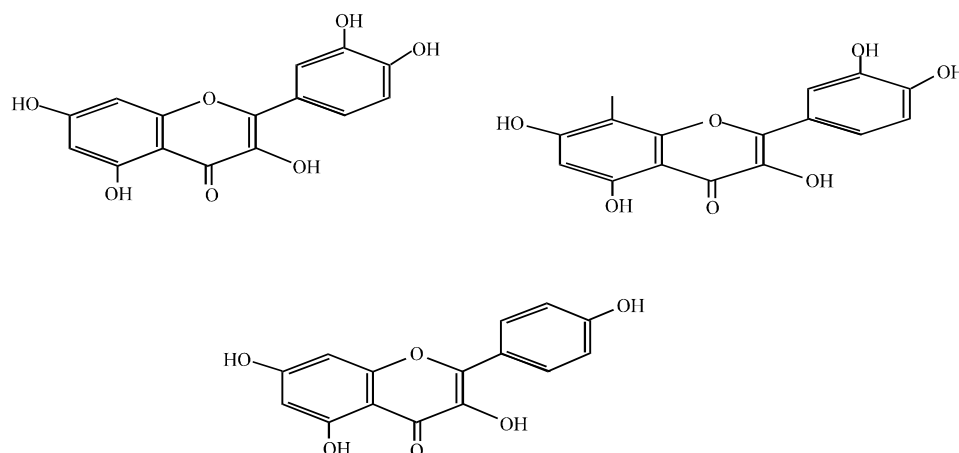


Fig. 9: Structures of phenolics from *Ailanthus excelsa*

potentates the cytotoxicity of DNA-damaging anticancer drugs, such as cis-platin. (Fig. 9) Ailantic acid: Bark contains wax like, reddish brown, water soluble bitter principle, known as ailantic acid. It is given as a tonic and alterative in dyspepsia and constipation.

Volatile constituents of *Ailanthus excelsa* Roxb: The volatile constituents from fresh aerial parts of *Ailanthus excelsa* were analysed by GC and GC-MS. Fatty acids and their esters represented the main fraction (40.9%) of the obtained oil, with 9, 12, 15-octadecatrienoic acid methyl ester (linolenic acid) being the main component (13.7%). The dominant component of the oil was phytol (26.7%)

A novel triterpenoid isolated from the root bark of *Ailanthus excelsa* Roxb (Fig. 10) (Tree of Heaven), AECHL-1 as a Potential Anti-Cancer Agent (Lavhale *et al.*, 2009).

Pharmacological properties

Antifertility activity: The alcoholic extract of the leaf and stem bark at a dose of 250 mg kg⁻¹ b.wt. exhibited a remarkable antimplantation and early abortifacient activity in female albino rats (Lavhale and Mishra, 2007).

Antifungal activity: Chloroform fraction of the ethanol extract of stem bark showed significant fungistatic and fungicidal activity against *Aspergillus fumigatus*, *Penicillium requeintence*, *Aspergillus niger*, *Penicillium notatum* and *Botrytis cinerea* (Lavhale and Mishra, 2007).

Antimalarial activity: It has been considered as a great discovery that several quassinoids possess potent antimalarial activity especially against the chloroquine-resistant *Plasmodium falciparum*. Excelsin was found to

inhibit the growth of malarial parasites even at a concentration of 0.2 RM. Glaucarubinone is much more potent than that of chloroquine and acts by inhibiting the protein synthesis in mammalian cells as well as in malaria parasites. It has been suggested that this effect also accounts for their amoebicidal activity. However, their antimalarial action is different from that of cytotoxicity, as some quassinoids have shown greater selectivity against *P. falciparum* than against KB cells. The cytotoxicity of glaucarubinone against KB cells is 285 times of its activity against *P. falciparum*. All quassinoids inhibits protein synthesis more rapidly than nucleic acid synthesis in the *P. falciparum* infected human erythrocytes which is mainly due to its effects upon ribosome rather than upon nucleic acid metabolism. Inhibition of nucleic acid synthesis was observed following the failure of protein synthesis. As chloroquine does not affect protein synthesis so the chance of cross-resistance of malaria between quassinoids and chloroquine is less (Lavhale and Mishra, 2007).

Anti-amoebic activity: *In vitro* anti-amoebic activity of stem bark of *Ailanthus excelsa*, roxb (simaroubaceae). The aqueous, petroleum ether and defatted ethanolic extracts (Quassinoid fraction) of stem bark of *Ailanthus excelsa* was tested against the laboratory cultured *Entamoeba histolytica* for its anti-amoebic action using metronidazole as standard drug. The EC₅₀ value for aqueous, petroleum ether and defatted ethanolic extracts (Quassinoid fraction) were 195, 185 and 150 µg mL⁻¹ against *E. histolytica* respectively (Yoganandam *et al.*, 2009a).

Antibacterial activity: Ethyl acetate fraction of dried stem bark inhibited the growth of *Staphylococcus aureus*,

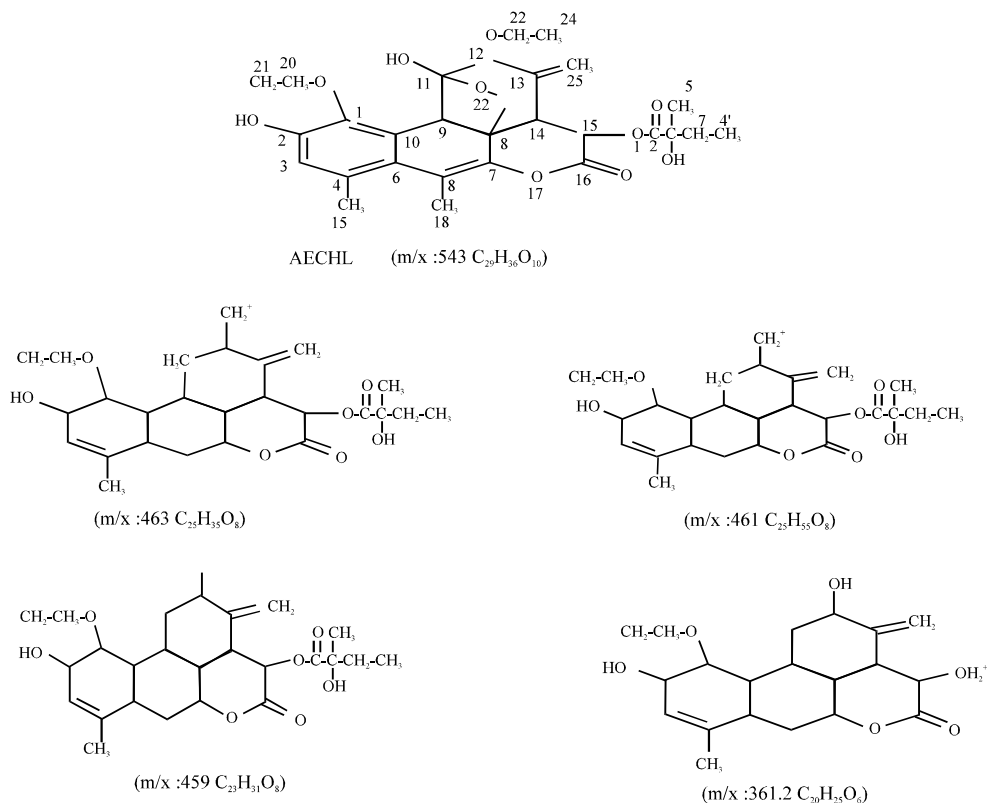


Fig. 10: Structures of a novel triterpenoid isolated from the root *Ailanthus excelsa* Roxb.

Escherichia coli and *Bacillus subtilis* (MIC: 6 mg disc⁻¹). Three active principles, excelsin, 13, 18-dihydroexcelsin and 1, 12- deoxy-13-formylailanthinol, isolated from bark are said to be responsible for this activity. The antibacterial activity of all three compounds was more pronounced than the antifungal potency (Lavhale and Mishra, 2007).

Hypoglycemic activity: A single administration of leaves or stem bark extracts of *A. excelsa* lowered the blood glucose of normal rats in a glucose tolerance test. Administration of each extract for 60 days produced a significant hypoglycemic effect on STZ-induced diabetic rats, with improved renal parameters which suggest of its potential use in the treatment of diabetes (Lavhale and Mishra, 2007).

Insect feedent-deterrent: Bioassay directed fraction of the methanol extract of the stem bark led to the isolation and identification of antifeedent constituent excelsin. A leaf disc method of bioassay showed the potency of excelsin to prevent feeding was 75.94% at a concentration of 1000 ppm against *Spilosoma oblique*. This insect is a destructive lepidopterous pest in the Northern parts of

India, attacking a wide range of crops. The ED₅₀ of excelsin was found to be 0.563% (Tripathi and Jain, 1993). Structure activity correlation indicates that cytotoxicity might be involved in the mode of action of these compounds. Ailanthone acts as a feeding deterrent to herbivores because of its extremely bitter taste (Lavhale and Mishra, 2007).

Antipyretic activity: Ethanol extract of *A. excelsa*, showed moderate to significant degree of antipyretic activity against yeast suspension induced hyperthermia in an experimental rat model (Lavhale and Mishra, 2007).

Leishmanicidal: A genus of parasitic flagellate protozoans causes leishmania. In man it invades the cells of the lymphatic system, spleen and bone (kala-azar). Canthin-6- one alkaloid from *Ailanthus* was found to be active against these protozoans (Lavhale and Mishra, 2007).

Antitumor and cytotoxicity: Aqueous extracts of roots when screened by the brine shrimp lethality assay it showed significant toxicity to the brine shrimp (<60 Rg mL⁻¹). The quassinoids like Ailanthone,

glaucarubinone and a mixture of glaucarubol 15-isovalerate have shown substantial antitumor and cytotoxic activities against the P 388 lymphocytic leukemia and KB test system respectively. The observed antitumor activity is by inhibiting the protein synthesis of ribosomal peptidyl transferase leading to the termination of chain elongation (Lavhale and Mishra, 2007).

Hepatoprotective activity:

Leaves: Leaves ethanol extract of leaves showed protective effects against CCL₄ induced liver injury as evidenced by a significant reduction in the CCL₄ induced elevated enzyme levels of serum glutamate oxaloacetate transaminase, serum glutamate pyruvate transaminase and serum alkaline phosphatase. The presence of phenolics might be the responsible factor for the above activity (Lavhale and Mishra, 2007).

Stem bark: Ethanol extract of stem bark of *Ailanthus excelsa* Roxb showed protective effects against CCL₄ induced hepatotoxicity in rats (Yoganandam *et al.*, 2009b).

Comparative study of leaves and bark of *Ailanthus excelsa* Roxb. for hepatoprotective activity: The ethanolic extracts of the bark and leaves of *Ailanthus excelsa* Roxb. (Simaroubaceae) were investigated for hepatoprotective activity on experimentally induced liver injury with CCL₄. Both the extracts caused significant reduction of the elevated enzyme levels of serum glutamate oxaloacetate transaminase, serum glutamate pyruvate transaminase and serum alkaline phosphatase. These findings are suggestive of a significant hepatoprotective activity of the extracts (Hukkeri *et al.*, 2002).

Toxicity: Large dosage of drug are said to lead queasiness, dizziness, headache, tingling in limbs and diarrhea, myocarditis associated with fever, chills, epigastric pain, substernal chest pressure and shortness of breath which may likely due to exposure to quassinoids present in tree sap (Bisognano *et al.*, 2005).

Antiasthmatic activity: Methanolic extract of stem barks of *Ailanthus excelsa* Roxb. showed antiasthmatic activity in animal models (Kumar *et al.*, 2010a,b).

Bronchodilatory activity: Aqueous extract of stem bark of *Ailanthus excelsa* Roxb. was evaluated for its bronchodilatory activity in milk induced leucocytosis and eosinophilia, Clonidine induced mast cell degranulation, BALF and lung histopathology models. Aqueous extract

of stem bark of *Ailanthus excelsa* Roxb. in doses of 100, 200, 400 mg kg⁻¹ showed significant activity (Kumar *et al.*, 2010c).

Gastroprotective and antisecretory effects: *Ailanthus excelsa* Roxb. Showed the Gastroprotective and antisecretory effects (Melanchauski *et al.*, 2010).

Functional properties of protein concentrate from *Ailanthus excelsa* Roxb. seed: The protein content, solubility and functional properties of a total protein concentrate prepared from the seeds of *Ailanthus excelsa* Roxb. were determined. The effects of pH and/or NaCl concentration on some of these functional properties were also investigated. The protein content of the seed protein concentrate was found to be 65.88%. The minimal protein solubility was observed at pH- 4 and the maximum was at pH- 12. Water- and oil-holding capacities of the seed protein concentrate were 2.77 g g⁻¹ and 5.79 g g⁻¹, respectively. The emulsifying activity and emulsion stability, as well as foaming capacity and foam stability, were greatly affected by pH levels and salt concentrations. Lower values were observed at slightly acidic pH (pH-4.0) and high salt concentration. Total protein concentrate was highly viscous which depends on concentration and pH levels. The lowest gelation concentration of seed protein concentrate was found to be 14 and 8% when the proteins were dissolved in distilled water and 0.5 M or 1 M NaCl solution, respectively (Kundu and Laskar, 2009).

Miscellaneous data: Evaluation of electroelution and immunodiffusion as methods for purification and identification of the allergenic proteins of *Ailanthus excelsa* Roxb. pollen (Mondal *et al.*, 2007): The pollen of *A. excelsa* is a highly potential allergen with almost all the protein fractions except AE3 (85.3 kDa) to be capable of inducing reactivity in sensitive patients. These areas, particularly during their peak flowering period between the months of January to April (Mondal and Mandal, 1997).

CONCLUSIONS

In the present review we have made an attempt to explore and provide the maximum information of botanical, pharmacognostical with history and cultivation, ethnopharmacological, ethno formulation and preparations, phytochemical, nutritional, pharmacological and toxicological information on *Ailanthus excelsa*, a medicinal herb used in the Indian system of medicine. Survey of literature revealed the vascular occlusions and

gum-resin cavities in the Stem of *Ailanthus excelsa* Roxb. The presence of quassinoids, alkaloids, proteins, triterpenoids, flavonoids and steroids in different parts of this plant were found. Research on quassinoids has gained a special attention in recent times as several of them have shown promising activities like antitumor, antiviral, antimalarial, antileukemic, antifeedent, hepatoprotective, antiasthmatic etc. The antitumor activity of quassinoids is definite, but most of the compounds are too toxic to be clinically used. Investigating the new sources of natural products to isolate more potent and less toxic quassinoids and structurally modifying the known compounds to retain activity and lower toxicity are still the best possible ways to develop safe and effective anticancer drugs of this class. A Novel Triterpenoid Isolated from the Root Bark of *Ailanthus excelsa* Roxb. (Tree of Heaven), AECHL-1 as a Potential Anti-Cancer Agent (Lavhale *et al.*, 2009). Malaria claims several million deaths every year on a global basis which is mainly due to increased resistance to chloroquine and quinine. In spite of the fact that two of the clinically used antimalarial, quinine and artemisinin, were originally derived from plants, further search for isolation and identification of new antimalarial lead structures from natural sources are extremely limited. The ethnopharmacological approach used in the search for new antimalarial compounds from such plants appears to be helpful compared to the random screening approach. However, a promising approach is needed to use these agents as templates for designing new derivatives with improved properties. Quassinoids have demonstrated a potent antimalarial activity against the chloroquine-resistant *P. falciparum* and the chances of cross-resistance of malaria between quassinoids and chloroquine is less, as quassinoids inhibits bacterial protein synthesis while chloroquine does not affect protein synthesis. Therefore, these triterpenoids offer a promising source for the development of new antimalarial agents. Few drugs of plant origin have been screened for antifertility but with only limited efficacy, where as *Ailanthus excelsa* would be worthwhile in serving as a tool, in birth control. Due to controversy in ayurvedic literature between *Ailanthus excelsa* and *Oroxylum indicum* for the common name, today also few practitioners are using *A. excelsa* roots in Dasmularista under the name Shyonak, but as these roots are reported to contain canthin group of alkaloids and the bitter quassinoids, one must keep in mind the toxicity of these compounds while using them in such a rejuvenating preparation. This review will definitely help for the researchers as well as practitioners, dealing with this plant, to know its nature proper usage. *A. excelsa* be

treated as highly palatable and nutritious fodder for sheep and goats, where the cytoplasmic protein fraction can be used for human consumption; and the other two fractions could be utilized as a nutritious feed for ruminants and nonruminants. The extract and purified fractions of *A. excelsa* were strong plant growth inhibitors, therefore could be considered as potent, effective and environmentally safe agricultural pesticides (Lavhale and Mishra, 2007). The *Ailanthus excelsa* Roxb. Pollen also contains allergenic proteins which causes for various respiratory diseases. So, the collection of plant material in specific time is necessary for the maximum rational use and utilization of plant. At last it is not wrong to say that this plant is really a plant of heaven which is due to wide scope in the treatment of serious and chronic diseases.

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