



## AN APPRAISAL ON PHARMACOGNOSY, PHYTOCHEMISTRY AND BIOACTIVITY OF *THUJA OCCIDENTALIS* LINN. (CUPRESSACEAE)

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### ABSTRACT

*Thuja occidentalis* Linn. (Cupressaceae) has been widely used for many ailments in the traditional system like hepatoprotection, anti-oxidant, anti-diabetic, anti-arthritis, anti-microbial, anti-cancer etc. because of its medicinal properties. In the nineteenth century, *Thuja* was commonly used as an externally applied tincture or ointment for the treatment of warts, ringworm and thrush, and a local injection of the tincture was used for treating venereal warts. The present paper summarizes a concise detail about pharmacognostic, phytochemistry and bioactivities of *T. occidentalis* Linn.

**Keywords:** Ailments, bioactivity, pharmacognostic, phytochemistry, *Thuja occidentalis*.

### INTRODUCTION

*Thuja occidentalis* is an evergreen, monoecious conifer american tree about 15-38 m in height, grows on rocky banks of rivers and in low swamps, from Pennsylvania northward.<sup>1</sup>

*Thuja* is the greek name for Juniper, which means common evergreen shrub or tree, *occidentalis* translates as "western", referring to it being native to the western hemisphere.<sup>2</sup>

#### Synonyms

Arborvitae, eastern arborvitae, northern white-cedar, swamp-cedar, white-cedar, cedre blanc, thuier cedre, thuya du Canada, lebensbaum.<sup>1</sup>

#### Other names

Hindi- morpankhi, Sanskrit- kshirakakoli, Bengali- bilatijhau, French- Thuya d'occident, Italian- Thuia, Russian- Tuja, Swedish- Livstrad, Czech- Zerav zapadni.<sup>3</sup>

#### Taxonomic classification<sup>1</sup>

Kingdom : Plantae  
Division : Pinophyta  
Class : Pinopsida  
Order : Pinales  
Family : Cupressaceae  
Subfamily : Cupressoideae  
Genus : *Thuja*  
Species : *Thuja occidentalis*

#### Various species of *Thuja*<sup>2</sup>

*T. koraiensis* - Korean Thuja  
*T. occidentalis* - Eastern Arborvitae, Northern Whitecedar  
*T. plicata* - Western Redcedar  
*T. standishii* - Japanese Thuja  
*T. sutchuenensis* - Sichuan Thuja

#### Macroscopic studies of *T. occidentalis*

Twigs of *T. occidentalis* L. are fan-shaped, flattened dark-green on top and significantly lighter in colour on the under sides bearing paired, decussate scaly leaves. Leaves are closely imbricate, ovate, acute, 2-4 mm long, glandular, bearing gland on back, bright green above and yellowish green beneath. Color of *T. occidentalis* changes in winter usually to dull brownish green. Leaves have aromatic odour with camphoraceous, turpentine & bitter taste.

#### Microscopic studies of *T. occidentalis*

**Leaf:** Leaves are isobilateral, single layered epidermis; stomata anomocytic, broadly elliptical, large & sunken. Mesophyll cells are thin walled, parenchymatous containing one resin duct on both sides of the stele; small, circular stele surrounded by single layer of endodermis; pericycle indistinct; xylem surrounded by phloem, centre parts of the stele is very small & parenchymatous.

**Young Twig:** Young twig transection shows angiospermic leaf like structure, having two lateral lamina like projections; epidermis single layered with thin cuticle and anomocytic stomata; a discontinuous layer of sclerenchymatous hypodermis in the centre part only, ground tissue consists of parenchymatous cells, stele small containing single layer of endodermis; pericycle indistinct, xylem surrounded by phloem with scanty parenchymatous pith. Two lateral lamina like projections containing parenchyma & vascular strands are present at the place constrictions.

**Stem:** Stem transection shows 6-8 layers of cork cells with brown contents; hypodermis two layered & sclerenchymatous; cortex thinwalled parenchymatous containing resin ducts and isolated scattered fibres; phloem consists of alternate layers of phloem fibres & phloem parenchyma.<sup>4</sup>

#### Habitat:

*T. occidentalis* grows naturally in wet forests, being particularly abundant in coniferous swamps where other larger and faster-growing trees cannot compete successfully. It also occurs on other sites with reduced tree competition such as cliffs. Although not currently listed as endangered, wild *T. occidentalis* populations are threatened in many areas by high deer numbers; deer find the soft evergreen foliage a very attractive winter food, and strip it rapidly. The largest known specimen is 34 m tall and 175 cm diameter, in South Manitou Island within Leelanau County, Michigan.

*T. occidentalis* is a very long-lived tree in certain conditions, with notably old specimen growing on cliffs where they are inaccessible to deer and wildfire; the oldest known living specimen is just over 1,100 years old, but a dead specimen

with over 1,650 growth rings has also been found. These very old trees are, despite their age, small and stunted due to the difficult growing conditions.<sup>2</sup>

#### Geographical distribution:

Canada: Manitoba, Ontario, Québec; Prince Edward Island, New Brunswick, Nova Scotia; USA: Minnesota, Michigan, Wisconsin, Illinois, Indiana, Ohio, Kentucky, Tennessee, North Carolina, Virginia, West Virginia, Maryland, Pennsylvania, New York, Connecticut, Massachusetts, Vermont, New Hampshire, Maine; at 0-900 m elevation on mostly calcareous substrates, neutral to basic swamps, shores of lakes and rivers, uplands, cliffs, and talus. Isolated stands occur north and east of its general range in Canada (to 51° 31' N latitude in Ontario, 50° N in Quebec). In United States, south of the Great Lakes and in southern New England, it occurs locally in scattered stands and is rare or extirpated at numerous former sites. In some areas, heavy winter browsing by deer greatly reduces reproductive success through elimination of seedlings.<sup>2</sup>

#### Plant description

*Thuja occidentalis* height is 20 to 50 feet and spread in 10 to 12 feet. Its crown uniformity is symmetrical canopy with a regular (or smooth) outline, forms pyramidal crown shape with denser crown density. Its growth rate is slow with fine texture.

#### Foliage

*T. occidentalis* leaf arrangement is alternate with simple leaf type and entire leaf margin. Its leaf shape is scale-like with no leaf venation. Its leaf blade length is less than 2 inches. Its leaf color is green and when fall, no color change occur and fragrance persists.

#### Flower

*T. occidentalis* flower colour is yellow and flowering takes place in spring season.

#### Fruit

*T. occidentalis* fruit colour is brown and shape is oval with < .5 inch fruit length and covering is dry or hard. It show no significant litter problem and persist on the tree.

#### Trunk and Branches

Trunk/ bark/ branches grows mostly upright and not droop, no thorns are present. It needs little pruning to develop a strong structure and has resistant breakage. Its twig color is green, brown and thickness is thin. Its wood specific gravity is 0.31. Its culture light requirement is part shade/part sun or tree grows in full sun and its soil tolerances are clay, loam, sand, slightly alkaline and acidic.

#### Pests

Arborvitae leaf miner eats out the leaf tips, causing them to turn brown. Translucent areas are seen where the miner has been active. Scales of several types infest the stems and foliage. Sprays of horticultural oil control overwintering stages. Mites cause yellowing and speckling of the foliage. The mites are seldom noticed because they are so small. Bagworms can devour large quantities of foliage very quickly.

Leaf blight causes brown spots on the leaves in late spring. The affected foliage appears scorched, then drops.<sup>1,5</sup>

#### Cultures

##### *In vitro* propagation of *T. occidentalis* through apical shoot culture

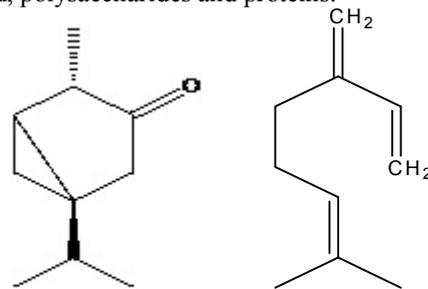
In *in vitro* apical shoot cultures *T. occidentalis* regenerates in hormone free MS medium. No morphological variants are observed.<sup>6</sup>

#### Mono- and diterpenes from cell cultures of *T. occidentalis*

Cell cultures of *T. occidentalis* biosynthesize various mono- and diterpenes when grown on B5-medium. The identification of the constituents may be achieved mainly by capillary GLC-MS using fused silica columns and electronic ionization mass spectrometry. Monoterpenes of the menthane type are only isolated from the culture medium whereas diterpenes are found in the cell extracts. Thujaplicin derivatives, monoterpenes of an irregular type, may be detected in the medium as well as in the cells. Major differences are found between the terpene composition of the cell culture extracts and those from *Thuja* leaves. The cell cultures accumulated some compounds which are presently unknown as constituents of *Thuja* plants. On the other hand, the cultures are evidently unable to synthesize the thujone type of monoterpenes.<sup>7</sup>

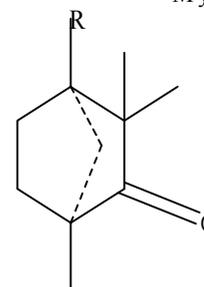
#### Chemical constituents

The fresh plant (related to the dry substance) contains 0.6% essential oil, 2.07% reducing sugar, 4.9% water-soluble polysaccharides, 2.11% water-soluble minerals, 1.67% free acid and 1.31% tannic agents. The essential oil of the fresh leaves (related to the monoterpene fraction) contains 65% thujone, 8% isothujone, 8% fenchone, 5% sabinens and 2%  $\alpha$ -pinene as the main monoterpenes. Other monoterpenes, namely carvotanacetone, origanol, origanones, myrcene and camphene, have also been identified. Recently, further bioactive constituents have been found. High molecular weight glycoproteins/polysaccharides are found to be highly relevant for the activity of the plant. Although some minor differences exist in the actual ingredients of several varieties of *T.*, generally the major components are found in extracts of all varieties of *T. occidentalis* comprised of essential oil (1.4–4%) as the principle constituent. Other constituents include coumarins (*p*-coumaric acid, umbelliferone) flavonoids (catechine, galocatechine, etc.), tannic acid, polysaccharides and proteins.<sup>8</sup>

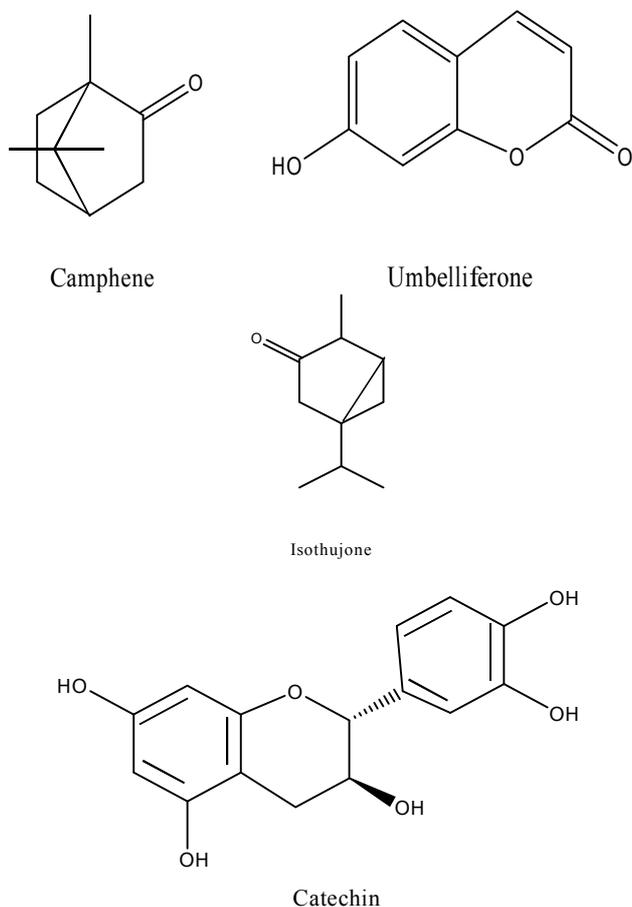


Beta-thujone

Myrcene



Fenchone



## BIOACTIVITIES OF *T. OCCIDENTALIS* L.

### Hepatoprotective activity

*T. occidentalis* ethanolic fraction produced hepatoprotective potential effect against carbon tetrachloride induced liver damage in rats. A dose of 400 mg/kg p.o. exhibited significant protection from liver damage in acute and chronic CCl<sub>4</sub> induced liver damage model. The ethanolic fraction was found to possess good hepatoprotective potential.<sup>9</sup>

### Antioxidant activity

*T. occidentalis* ethanolic fraction of aerial parts has been evaluated for anti-oxidant activity in various systems like 1, 1-diphenyl-2-picryl-hydrazyl (DPPH) radical, superoxide anion radical, hydroxyl radical scavenging and lipid peroxidation. The antioxidant activity of ethanolic extract was found to be increased in a concentration dependent manner. About 100, 150, 200, 250 & 300 µg of ethanolic fraction of *T. occidentalis* inhibited the ferrous sulphate (FeSO<sub>4</sub>) induced lipid peroxidation in a dose dependent manner.<sup>10</sup>

### Antibacterial activity

Methanolic extract of *T. occidentalis* exhibit potent antibacterial activity at dose level of less than 1 mg against both gram negative and gram positive organisms i.e., *Pseudomonas aeruginosa*, *Yersinia aldovae*, *Shigella flexneri*, *Escherichia coli*, *Staphylococcus aureus* and at dose level less than 5mg, against *Citrobacter*.<sup>11</sup>

### Antifungal activity

Methanolic extract of *T. occidentalis* exhibit potent antifungal activity against *Saccharomyces cerevisiae* at dose level of less than 75 mg, less than 25 mg for *Candida albicans* & *Aspergillus parasiticus* and less than 1 mg for *Trichophyton rubrum*.<sup>11</sup>

### Antipsychotic activity

*T. occidentalis* had been considered as antipsychotic homeopathic drug used mainly for wart like excrescences upon mucous & cutaneous surface, vegetative condylomata and spongy tumours.<sup>12</sup>

### Anti-arthritic activity

*T. occidentalis*, in small doses had been used against arthritis and gout.

*T. occidentalis* tea would help to alleviate cold and headache and in syrups to alleviate coughs. *T. occidentalis* essential oil has been widely used in steam bath.<sup>13</sup>

### Anticancer activity

*T. occidentalis* ethanolic extract is used as homeopathic mother tincture to treat various ailments, particularly moles and tumors, and also used in various other systems of traditional medicine. Anti-proliferative and apoptosis-inducing properties of *Thuja* with the thujone-rich fraction (TRF) separated from it have been evaluated for its possible anti-cancer potential in the malignant melanoma cell line A375. On initial trial by S-diphenyltetrazolium bromide assay, it showed maximum cytotoxic effect on A375 cell line while the other three principal fractions separated by chromatography had negligible or no such effect, because of which TRF was further characterized and subjected to certain other assays for determining its precise anti-proliferative and apoptotic potentials. TRF caused a significant decrease in cell viability, induced inter-nucleosomal deoxy-ribose nucleic acid fragmentation, mitochondrial transmembrane potential collapse, increase in reactive oxygen species generation, and release of cytochrome c and caspase-3 activation, all of which are closely related to the induction of apoptosis in A375 cells.<sup>14</sup> *T. occidentalis* also confirmed the activity against breast cancer cell lines by inducing apoptosis (programmed cell death).<sup>15</sup>

### Expectorant property

*T. occidentalis* exhibits expectorant property which expels phlegm and catarrh deposited in the respiratory tract and lungs. It gives clear chest, helps breathe easily, clears congestion and gives relief from cough.<sup>16</sup>

### Insect repellent property

*T. occidentalis* has insect repellent property also. The toxicity of oil kill insects and keeps them away from households. This is as true for parasitic insects like mosquitoes, lice, ticks, fleas, bed bugs etc. as it is for other insects found in households like cockroaches, ants, white ants, moths etc. This oil replace the costly synthetic chemicals in the mosquito and cockroach repellent sprays, fumigants, vapourizers etc.<sup>16</sup>

### Rubefacient activity

*T. occidentalis* has rubefacient activity. This is another outcome of the irritant property of the oil which again comes from its stimulating properties. It produces very mild irritation on the skin and stimulates circulation of blood below the skin, which makes the skin red. Since it is more visible on the face, called rubefacient activity, meaning "Red Face", property. This, besides making look vibrant, helps in the regeneration and rejuvenation of the skin due to increased circulation.<sup>16</sup>

### Insecticidal activity

*T. occidentalis* essential oil is also used for insect fumigation, which is analysed by gas phase chromatography and revealed the presence of 22 compounds including  $\alpha$ -thujone (49.64%), fenchone (14.06%), and  $\beta$ -thujone (8.98%). Fumigation of

adult bruchids with the oil alone resulted in lethal doses (LD<sub>50</sub>) of 1.1, 0.7, 0.5 and 0.2 ml/ insect after 3, 6, 9 and 12 hours respectively.<sup>17</sup>

#### Diuretic property

*T. occidentalis* increases frequency and quantity of urination. This helps in keeping the body healthy and free of diseases as it removes unwanted water, salts and toxins like uric acid, fats, pollutants and even microbes from the body. It cures diseases like rheumatism, arthritis, boils, moles, acne etc. which are caused by accumulation of these toxins. It helps to reduce weight by removing water and fat and to get rid of problems of swelling, edema etc. Further, calcium and other deposits in kidney and urinary bladder are washed away with urine. This prevents formation of stones and renal calculi.<sup>18</sup>

#### Emenagogue property

*T. occidentalis* has emenagogue property which is very helpful for women. It gives them relief from obstructed menses as well as from the abdominal pain, cramps, nausea, fatigue etc. associated with the periods. It also makes periods regular and keeps the female reproductive organs in good health by promoting secretion of certain hormones like estrogen and progesterone.<sup>18</sup>

#### Anti-ulcer activity

*T. occidentalis* ethanolic fraction possess significant anti-ulcer activity against the gastric lesions induced by different experimental models like aspirin, stress, alcohol and hydrochloric acid. It also produced significant protection and showed increase in blood glutathione level due to the presence of rich amount of phenolic compounds.<sup>19</sup>

#### Anti-diabetic activity

*T. occidentalis* ethanolic fraction has anti-diabetic activity also. It produces a significant protection at dose level of 200mg/kg body weight. Further analysis of fasting blood glucose, blood glutathione level and serum biochemical analysis in alloxan-induced diabetes showed that this plant was able to induce a significant increase in blood glutathione level due to the presence of rich amount of phenolics.<sup>20</sup>

#### Stimulant activity

*T. occidentalis* possess stimulant activity too. Besides stimulating blood circulation, it stimulates secretion of hormones, enzymes, gastric juices, acids and bile etc. as well as stimulates peristaltic motion, nerves, heart and the brain. Further, it stimulates regeneration of growth cells, erythrocytes, leucocytes and platelets.<sup>18</sup>

#### Immunopharmacological activity

The immunopharmacological potential of *Thuja* has been investigated in various *in vitro* and *in vivo* test models.<sup>8</sup>

*T. occidentalis* essential oil tones and fortifies as a skin tonic. It tones up all the functions in the body like metabolic functions such as anabolism and catabolism and tones up the liver, stomach and intestines, thus helping in growth. It also tones up the excretory, endocrinal and nervous systems operating in the body and ensures proper excretion, promotes the endocrinal secretions of hormones and enzymes. Basically, it tones up the immune system and therefore prevent infections.<sup>18</sup>

#### Vermifuge activity

*T. occidentalis* has vermifuge activity. The toxicity of its essential oil, due to the presence of thujone, kills the worms in the body. It eliminates worms like round worms, tape worms and hook worms residing in the body.<sup>18</sup>

#### Neuropharmacological activity

*T. occidentalis* aqueous extract is used as a memory enhancer on rats in scopolamine induced amnesia model. The neuropharmacological effects suggested that the aqueous extract has a significant CNS depressant, anticonvulsant and muscle relaxant activity.<sup>21</sup>

#### Toxicity studies of *T. occidentalis*

In cases of overdose and abuse, oral intake of *T. occidentalis* extracts induced severe metabolic disturbances. Intoxication was accompanied by an irritant effect on the gastrointestinal tract, uterus, liver and kidney. Infants who ingested leaves and twigs of fresh plant showed mild gastrointestinal disorders and vomiting. It may also be abortifacient, so it cannot be used during pregnancy.<sup>16,22</sup>

#### CONCLUSION:

*T. occidentalis* Linn. (Cupressaceae) has been widely used for many ailments in the traditional system like hepatoprotection, anti-oxidant, anti-diabetic, anti-arthritic, anti-microbial, anti-cancer etc. because of its medicinal properties. The plant may also be further explored for its great variety of chemical constituents and wide range of bioactivities. As *T. occidentalis* is an endangered species it must be carefully used to study its biological performance and efforts must be made to make its potent drug formulations for group exploit.

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