Cedrus deodara (Roxb.) Loud.: A Review on its Ethnobotany, Phytochemical and Pharmacological Profile

Amrendra Kumar Chaudhary*[1,2], Shamim Ahmad[3], Avijit Mazumder[4]

[1]Uttarakhand Technical University, Dehradun, Uttarakhand-248007, India. [2]School of Pharmaceutical Sciences, Shobhit University, Meerut, UP-250110, India. [3]Translam Institute of Pharmaceutical Education and Research, Meerut-250001, India. [4]Noida Institute of Engineering & Technology, Greater Noida-201306, India

ABSTRACT

Cedrus deodara (Roxb.) Loud. commonly called as deodar, is a species of cedar native to the Western Himalayas in Eastern Afghanistan, Northern Pakistan, North-Central India, South Western Tibet and Western Nepal. The chemical constituents obtained from different parts of plant include wikstromal, matairesinol, dibenzylbutyrolactol, berating, isopimpillin, lignans 1, 4 diaryl butane, benzofuranoid neo lingam, isohemacholone, sesquiterpenes LIII: deodarone, atlantone, deodarin, deodardione, limonenecarboxylic acid, α-himacholone, β-himacholone, α-pinene, β-pinene, myrcene, cedrin (6-methyldihydromyricetin), taxifolin, cedeodarin (6-methyltaxifolin), dihydromyricetin and cedrinoside. Various parts of this plant are used in traditional system of medicine for the treatment of different ailments such as fever, inflammation, pain, ulcer, apoptosis, spasmodic, hyperglycemia, infections, insomnia, disorder of mind, disease of skin and blood. Recent *in-vivo* and *in-vitro* studies have indicated its anti-inflammatory, analgesic, anti-hyperglycemia, anti-spasmodic, insecticidal, anti-apoptotic, anti-cancer, immmunomodulatory, molluscidal, anxiolytic and anticonvulsant properties. Exhaustive literature survey reveals that there are some activities which are still not validated scientifically. The current review compiles and presents an up-to-date comprehensive review of the traditional and folklore medicinal uses, phytochemistry and biological activities of *Cedrus deodara* plant.

Keywords: *Cedrus deodara*, Ethnomedicinal, Phytochemical, Traditional uses.

INTRODUCTION

Various drugs have entered into the international market through exploration of ethnopharmacology and traditional medicine. Although scientific studies are carried out on a large number of plants but smaller numbers of phytochemical entities have entered the evidence-based therapeutics. Efforts are therefore needed to establish and validate evidence regarding practice of Ayurvedic medicines. *Cedrus deodara* (Roxb.) Loud. commonly called as deodar, is a species of cedar native to the Western Himalayas in Eastern Afghanistan, Northern Pakistan, North-Central India, South Western Tibet and Western Nepal. It is a majestic and handsome tree, growing to a great height and wide girth and living to a great age. It is a pyramidal shape tree having soft grayish-green (or blue) needles and drooping branches, growing rapidly to 40-50 feet tall and 20-30 feet wide. It is an oldest tree of 745 years with 900 rings as described by Bhattacharyya *et al* in 1988.[1,2]

***Address for correspondence:**
Mobile: 91-9450883086, Fax: 91-121-2575724
E-mail: amrendrapharma@gmail.com

DOI: 10.5530/pj.2011.23.2

Classification

Kingdom – Plantae, Subkingdom – Trachibionta, Division – Conoferophyta, Class – Dinopsida, Order – Pinales, Family – Pinaceae, Genus – Cedrus, Species – Deodara.[3]

Morphological characteristics

Cedrus deodara is a large evergreen tree often reaching 60 meter in height (Figure 1A). Branches and branchlets are horizontal, tips slender and nodding. The leaves are 2.5 to 5 cm. long, acicular glaucous green, mostly in dense fasciles with few solitary scattered between fassicles, leaf is niddle like as shown in Figure 1B.[3] Bark is grayish or radish brown with vertical and diagonal fissures. It is monocious plant, although male and female cones appear

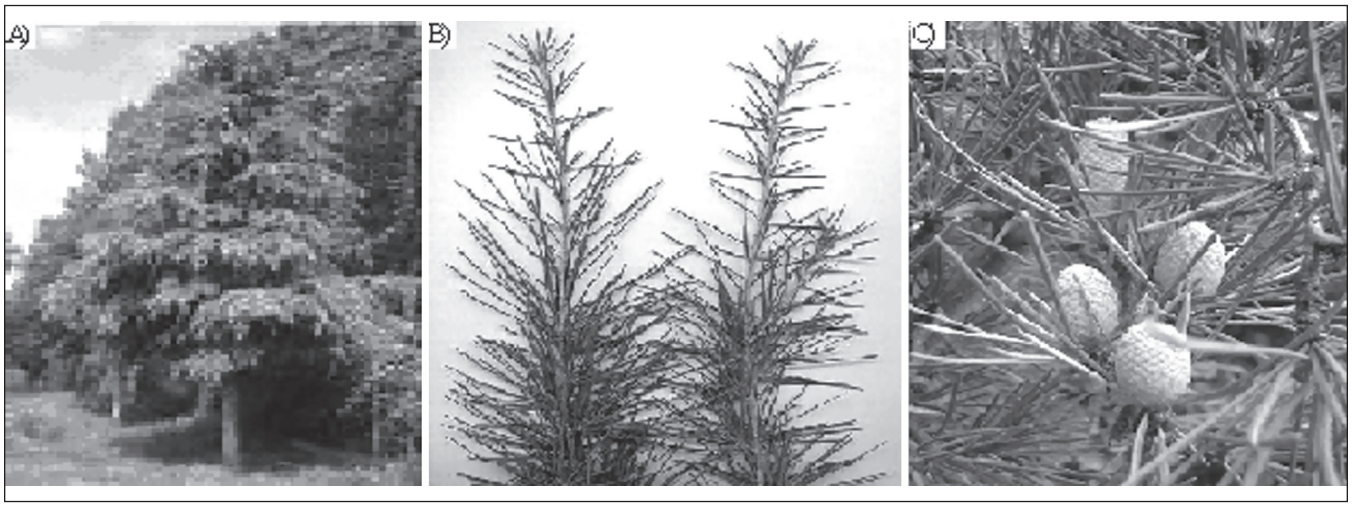

Figure 1: *Cedrus deodara*: (A) Tree (B) Needles (C) Cone

on separate branches. Female cones are barrel-shaped and borne singly at the tip of the dwarf shoots (Figure 1C). They are cylindrical and 2.5 to 4.5 cm. in length. Fruit shape is oval, 3 to 6 inches in length, brown in color and covering is dry or hard. Flowers are bisexual and appear in the month of the autumn.[4]

PHYTOCHEMICAL CONSTITUENTS

Cedrus deodara has been explored phytochemically by various researchers and found to possess number of chemical constituents of wide range of structures as illustrated in figure 2. The main chemicals in wood of *Cedrus deodara* include: wikstromal, matairesinol, dibenzylbutyrolactol,[5,6] 1, 4 diaryl butane, benzofuranoid neo lingam,[7] cedrin (6-methyldihydromyricetin), taxifolin, cedeodarin (6-methyltaxifolin), dihydromyricetin, cedrinoside,[8] deodardione, diosphenol, limonenecarboxylic acid,[9] (–)-matairesinol, (–)-nortrachelogenin, and a dibenzylbutyrolactollignan (4, 4', 9-trihydroxy-3, 3'-dimethoxy-9, 9'-epoxylignan).[10] A new dihydroflavonol named deodarin (3, 4, 5, 6-tetrahydroxy-8-methyl dihydroflavonol) has been isolated from the stem bark.[11] The ethanolic extract of pine needles of *Cedrus deodara* showed presence of many compounds viz. 10-nonacosanol, dibutyl phthalate, protocatechuic acid, phthalic acid bis-(2-ethylhexyl) ester, (E)-1-O-p-coumaroyl-beta-D-glucopyranoside and 5-p-trans-coumaroylguinic acid, 9-hydroxy-dodecanoic acid, ethyl laurate, ethyl stearate, 3-beta-hydroxy-oleanolic acid methyl ester, beta-sitosterol, shikimic acid, methylconiferin and ferulic acid beta-glucoside.[12,13] The essential oil from wood was reported to contain a sesquiterpenes-L II: isohemacholone and sesquiterpenes L III: deodarone, atlantone,[14] α-himacholone, β-himacholone,[15,16] ά-pinene, β-pinene, myrcene,[17] himachalene, cis-atlantone, ά-atlantone.[18]

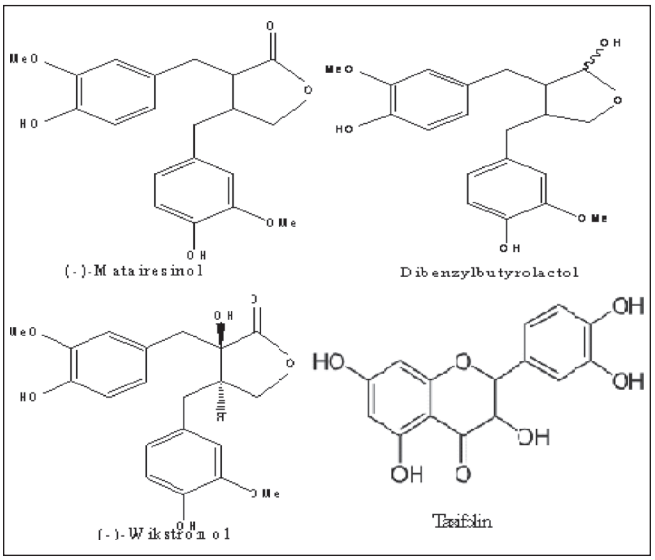

Figure 2: Chemical structure of some phytoconstituents isolated from *Cedrus deodara*

ETHNOPHARMACOLOGICAL USES

Cedrus deodara oil and gum have medicinal value and are used in treatment of inflammations, dyspepsia, insomnia, hiccough, fever, urinary discharge, ozoena, bronchitis, itching, elephantitiasis, tuberculous glands, leucoderma, ophthalmia, piles, disorder of mind, disease of skin and blood. Leaves are used in treatment of inflammation and applied to tuberculous glands. Wood is bitter and is used as diuretic, diaphoretic, carminative. It finds wild application in treatment of fever, rheumstism, piles, palsy, epilepsy, prolapsus recti, skin disease, pulmonary and urinary disorder. All parts of *Cedrus deodara* are useful in Ayurveda system of medicine for the treatment of insomnia, disorder of

mind, disease of skin and blood.[19] Oil is used as analgesic, alexipharmic, diaphoretic and is used in treatment of bruises, injuries to joint, boils, tuberculous glands, skin diseases and for ulcers. Bark is astringent and is useful for fever, diarrhea and dysentery. Turpentine oil is used for treatment of ulcer, skin diseases and leprosy.[4] *Cedrus deodara* used in preparation of V-gel, which is commonly used as antiseptic.[20]

PHARMACOLOGICAL ACTIVITY

Several workers have reported various biochemical activities of *Cedrus deodara* in various *in-vivo* and *in-vitro* test models. Different parts of this plant have been found to exhibit anti-inflammatory, analgesic, immunomodulatory, anti-spasmodic, anti-hyperglycemic, anti-cancer, molluscidal, insecticidal, anti-apoptotic, anti-bacterial, antisarcoptic, anxiolytic and anticonvulsant activities.

Anti-inflammatory activity

The volatile oil extract (50 and 100 mg/kg body weight) of wood of *Cedrus deodara* was evaluated for its oral anti-inflammatory activity by carragenan induced rat paw edema method. Diclofenac sodium (10 mg/kg) served as reference control for the study. The extract showed significant inhibition of carrageenan induced rat paw edema.[21] In another study, volatile oil extract (50 and 100 mg/kg body weight) was examined for its anti-inflammatory activity by adjuvant induced arthritis method. The extract showed significant inhibition of both exudative-proliferative and chronic phase of inflammation.[22]

Analgesic activity

The wood oil (50 and 100 mg/kg body weight) of *Cedrus deodara* was evaluated for its analgesic potentiality by acetic acid induced writhing response and hot plate reaction time model in mice. Aspirin (25 mg/kg p.o.) and morphine (1 mg/kg, s.c.) served as reference control for the study, respectively. *Cedrus deodara* wood oil showed significant analgesic activity at both the dose levels, relative to the control group in both the pain models.[23]

Immunomodulatory activity

Immunomodulatory potential of volatile oil of wood of *Cedrus deodara* was evaluated by using several pharmacological models like neutrophill adhesion test in rats,[24] Athrus reaction in mice,[25] SRBC- induced delay type hypersentivity (DTH) and hemagglutination antibody titer in mice[26,27] and oxazolone-induced contact hypersensitivity in mice.[28] *Cedrus deodara* wood oil at doses of 50 and 100 mg/kg significantly inhibited the adhesion of neutrophils to nylon fibers which simulate the process of margination of cells in blood vessels. This indicates that the *Cedrus deodara* wood oil reduces the number of neutrophils, thus decreasing their phagocytosis action and the release of various enzymes and mediators that make inflammation worse.[27] At the same doses, *Cedrus deodara* wood oil significantly inhibited the Arthrus rection due to its inhibitory effects on any of the following steps which characterize the following reaction: formation of antibodies against antigenic MBSA, formation and precipitation of an immune complex at the site of injection, activation of complement system, neutrophil aggregation, and release of lysosomal enzymes.[29] Mast cell degranulation has been reported to be an early event in contact hypersensitivity reaction to oxazolone.[30] Inhibition of edema due to oxazolone-induced contact hypersensitivity might also be due to mast cell stabilization. These result shows that *Cedrus deodara* wood oil produces an inhibitory effect on humoral and cell-mediated immune response in experimental animals justified its therapeutic usefulness in inflammatory disorder.

Anti-spasmodic activity

The wood of *Cedrus deodara* has himachalol identified as the major antispasmodic constituent. The pharmacological studies of himachalol on various isolated smooth muscles (guinea pig ileum, rabbit jejunam, rat uterus and guinea pig seminal vesicles) and against different agonist (acetyl choline, histamine, serotonin, nicotine and barium chloride) indicated spasmolytic activity similar to that of papavarine. In the conscious immobilize cat, iritragastric administration of himachalol or papavarine (100 mg/kg) produced equal inhibition of carbachol and induced spasm of intestine, lasting about 2 h, but himachalol had a faster on set of action. Himachalol devoid of spasmolytic on the bronchial musculature of guinea pig but was 3.3 times more potent than papaverine in antagonizing epinephrine-induced contraction of the guinea pig seminal vesicles. Intravenous injection of himachalol (3-10 mg/kg) in the cat produced dose dependent fall in blood pressure and an increased femoral blood flow.[16]

Anti-hyperglycemic activity

The ethanolic extract of wood of *Cedrus deodara* exhibited antihyperglycemic activity on streptozotocin-induced diabetic rats from 1 to 7 h. The maximum lowering in blood pressure was found to be at 7 h. post treatment.[31] *Cedrus deodara* shows 6% significant fall in blood glucose profile in a single dose experiment on streptozotocin-induced diabetic rats.[32,33,34] Shivanand *et al* in 2009 formulated and evaluated an antihyperglycemic preparation obtained from the ethanolic extract of *Cedrus deodara*.[35]

Anti-cancer activity

"CD lignan mixture" viz. (–)-wikstromal (75-79%), (–)-matairesinol (9-13%) and benzy1butyrolactol (7-11%) isolated from stem wood of *Cedrus deodara* were evaluated for their in-vitro cytotoxcity against human cancer cell lines

and *in-vivo* anti-cancer activity using Ehrlich ascites carcinoma and colon carcinoma (CA-51) models in mice. *In-vitro* studies showed significant dose dependent effects against several cancer cell lines from different tissues such as breast, cervix, neuroblastoma, colon, liver and prostrate at 10, 30 and 100 μg/ml. The results obtained also revealed IC_{50} values ranging from 16.4 ng/ml to 116.0 μg/ml depending on the cell lines. Comparative data of IC_{50} values of CD lignan mixture showed a synergistic effect in comparison to the individual molecules, i.e., (–)-matairesinol, (–)-wikstromol present in CD lignan mixture. The tumor regression observed with Ehrlich ascites carcinoma and CA-51 was 53% and similar to 54%, respectively, when CD lignan mixture was given at 300 mg/kg, i.p. for nine days in the Ehrlich ascites carcinoma model and 400 mg/kg, i.p. for the same period in the CA-51 model. It was comparable with 5-fluorouracil at 22 mg/kg and 20 mg/kg, respectively. CD lignan mixture at 10, 30 and 100 pg/mL increased the percentage of annexin V positive HL-60 cell is to 1.9 17.18% as compared to control (1.04%). In K562 cells CD lignan mixture at 10, 30 or 100 pg/ml and staurosporine (1 μM) showed 9.13%, 11.38%, 17.22% and 28.07% intracellular caspases activation, respectively. It indicates that CD lignan mixture has cytotoxic potential against human cancer cell lines. It has the ability to induce tumor regression *in-vivo*.[36]

Molluscidal activity

Cedrus deodara wood essential oil was tested for its ovicidal and molluscicidal activities against *L. a. rufescens*. In the laboratory, the 8% suspension of wood oil showed 100% ovicidal and molluscicidal at 15 and 20 ppm, respectively, at 24 h exposure time. In field trials, the solution sprayed to a final concentration of 30 ppm in small pools of water with naturally occurring fauna and flora and large numbers of *L. a. rufescens* and other species of aquatic snails (*Indoplanorbis exustus, Gyraulus convexiusculus* and *Vivipara* sp.) showed 100% mortality of snails and their eggs within 24 h whereas freshwater fishes (*Channa* sp. and *Heteropneustes* sp.), dipterous naiads, leeches and some microfauna was found to be insignificant.[37] In a further study the mixture of cedar and neem oils was most toxic to *Lymnaea acuminata* of the combinations tested.[38,39] It was also observed that *L. inermis* seed powder in combination with *Cedrus deodara* oil and *Azadirachta indica* oil was more toxic than their individual components and other combinations.[40]

Insecticidal activity

Chromatographic fractions of Himalayan cedar wood oil were bioassayed against the pulse beetle (*Callosobruchus analis* F.) and the housefly (*Musca domestica* L.). Almost all fractions showed insecticidal activity against both test species. Fractions I and V led to the highest mortality and also produced a quick knockdown effect. Fractions I and V, after rechromatography and purification, yielded himachalol (3%) and β-himachalene (31%), based on essential oil weight, respectively. Further evaluation of these two naturally occurring sesquiterpenes indicated 97.5% mortality at 0.56 μ mol/insect against the pulse beetle. These biologically active natural products of plant origin may serve as suitable prototypes for development of commercial insecticides.[41]

Anti-apoptotic activity

AP9-CD, a standardized lignan composition from consisting of (–)-wikstromal (75-79%), (–)-matairesinol (9-13%) and dibenzylbutyrolactol (7-11%) was obtained from wood powder of *Cedrus deodara*. The individual constituents isolated from chloroform extract showed lesser cytotoxicity than AP9-CD when tested against many cancer cell lines.[5,6] Wikstromal is the major ingredient that occurs both in (–) and (+) forms; the (−) form is active against leukemia and HIV while the (+) form is biologically inactive.[42] The AP9-CD has been reported to be cytotoxic to numerous human cancer cell lines at concentration between 10 to 30 μg/ml *in-vitro*.[43] The apoptotic assays using light electron microscopy revealed that this agent induced Molt-4 cell process at varied concentration. The morphological change of intracellular organelles in Molt-4 cell treated with 30 μg/ml of AP9- CD revealed the disruption of mitochondrial cristae. Incubation of Molt-4 cells with different concentration of AP9-CD for 6-24 h resulted in time and dose-dependent toxicity. After 6, 12, and 24 h incubation, the cell viability at concentrations of 10, 30 and 50 μg/ml was reported to be 93.78, 84.36, 76.93, 87.50, 79.86, 68.95 and 73.59, 53.16, 35.93 respectively. The decrease in cell viability was significant at all the concentrations from 6-24 h.[44]

Antibacterial activity

The antibacterial activity of the alcoholic and aqueous extracts of the roots, stems and leaves of *Cedrus deodara* was evaluated against *E. coli* only. The aqueous extract of the leaf was observed to be a better inhibitory agent as compared to the stem and root as revealed by larger zone of inhibition. However the alcoholic extract of leaf showed much stronger inhibitory potentiality as compared to the stem extract. It may be noted that the alcoholic extract of root was devoid of any action against *E. coli*. However one needs to study against other microorganisms before claming it to be an anti-bacterial agent.[45]

Antisarcoptic mange activity

Two commonly used acaricidal drugs in India containing oil *Cedrus deoduru* (OCD) and benzyl benzoate (BB), respectively, were used in 24 lambs (3-6 months) naturally infected with Sarcoptes mites. Drugs were applied locally on affected parts on alternate days and recovery changes in skin lesions were observed regularly at the time of application. Blood samples from each group were

collected and analyzed for total erythrocytes, leukocytes, and haemoglobin concentration every 10 day of Post treatment (PI). The two treated groups responded to the treatment but recovery in the *Cedrus deodara* group (CDG) was faster and lesions were free from mites after 5 applications (tenth day) as compared to the seventh application (fourteenth day) in the benzyl benzoate group (BBG). Erythrocyte and leukocyte counts were significantly different in treated groups as compared to control. Animals treated with OCD had significantly more erythrocyte and leukocyte counts compared to control; however, haemoglobin did not show significant difference. Oil of *Cedrus deodara* was found more efficacious in controlling sarcoptic mange in sheep.[46]

Anxiolytic activity

The alcoholic extract of heart wood (50, 100 and 200 mg/kg body weight) of *Cedrus deodara* was evaluated for its anxiolytic activity by elevated plus maze model, light-dark model and actophotometer. The results suggested that alcoholic extract reduced the aversion fear and produced anxiolytic activity in a dose dependent manner. Estimation of GABA in rat brain after administration of extract showed significant modulation of GABA levels. These findings suggested that the alcoholic extract of heartwood of *Cedrus deodara* possess significant anxiolytic through modulation of GABA levels in brain.[47,48]

Anticonvulsant activity

The alcoholic extract of heart wood (50, 100 and 200 mg/kg body weight) of *Cedrus deodara* was evaluated for its anticonvulsant activity by Pentylenetetrazole (PTZ) induced convulsions and maximal electro shock (MES) induced convulsions models in mice. The results showed that 100 and 200 mg/kg of alcoholic extract increased the onset of clonus and tonic seizures in PTZ induced convulsions model and decreased the duration of tonic extensor phase in MES induced convulsions model and also increased the percentage protection in PTZ and MES induced convulsions. Estimation of GABA in rat brain after administration of extract showed significant modulation of GABA levels. These findings suggest that the alcoholic extract of heartwood of *Cedrus deodara* possess significant anticonvulsant activity through modulation of GABA levels in brain.[47,48]

TOXICOLOGICAL STUDIES

In many study, safety profile of *Cedrus deodara* showed non-toxic, non- irritant to the skin of rabbit and sheep and did not alter blood urea nitrogen and blood glucose levels.[49,50] Perveen *et al*., in 2008 reported the mammalian toxicity of *Cedrus deodara* root oil against Albino rats. They reported 34.4 gm/kg as LD50, which was quite safe as compared to neem oil LD50, 5 gm/kg.[51]

CONCLUSION

Cedrus deodara (Roxb.) Loud. is a well known plant used in the Indian system of medicine, besides which folklore medicine also claims its use in cancer, fever, inflammation, pain, ulcer, apoptosis, spasmodic, hyperglycemia and neurological disorder. It is used in the manufacture of various Ayurvedic preparations for a wide range of ailments. Research carried out using different *in-vivo* and *in-vitro* techniques of biological evaluation support most of these claims. Recent study have focused mainly on its anti-inflammatory, analgesic, immunomodulatory, anti-spasmodic, anti-hyperglycemic, anti-cancer, molluscidal, insecticidal, anti-apoptotic, antisarcoptic, anxiolytic and anticonvulsant activities. Some of the compound present in *C. deodara* (himachalol, wikstromal, matairesinol, dibenzylbutyrolactol) are pharmacologically well known and provide additional supporting evidence for possible mechanism of action. This study is an attempt to compile an up-to-date and comprehensive review of *Cedrus deodara* that covers its distribution, description, traditional and folk medicinal uses, phytochemistry and pharmacology.

ACKNOWLEDGEMENTS

Authors would like to thanks Prof. (Dr.) Ranjit Singh, Director, School of Pharmaceutical Sciences, Shobhit University for his technical assistance.

REFERENCES

1. Bhattacharyya A, La Marche VC, Telewski FW. Dendrochronological reconnaissance of the conifers of Northwest India. Tree-Ring Bulletin 1988; 48:21-30.
2. Yadav RR, Bhattacharyya A. A 745-year chronology of *Cedrus deodara* from Western Himalaya, India. Dendrochronologia 1992; 10:53-61.
3. Farjon A. Drawings and descriptions of the Genera. Koeltz Scientific Books. 1990.
4. Shah R. Nature's Medicinal plant of Uttaranchal. Nainital: Gyanodaya Prakhasan; 2006. 1:15-16.
5. Rao JM, Srinivas PV, Yadav JS, Raghavan KV, Saxena AK, Shanmugavel M, Kampasi H, Qazi GN. Herbal chemical composition for the treatment of cancer. US Patent 2003; 6:649-650.
6. Singh SK, Shanmugavel M, Kampasi H, Singh R, Mondhe DM, Rao JM, Adwankar MK, Saxena AK, Qazi GN. Chemically standardized isolates from *Cedrus deodara* stem wood having anticancer activity. Planta Med 2007; 73:519-526.
7. Agrawal PK, Rastogi RP. Two lignans from *Cedrus deodara*. Phytochemistry 1982; 21:149-146.
8. Agrawal PK, Agarwal SK, Rasgi RP. Dihydroflavonoids from *Cedrus deodara*. Phytochemistry 1980; 19:893-896.
9. Krishnappa S, Dev S. Studies in sesquiterpenes LVIII: Deodardione, a sesquiterpene diosphenol and, limonenecarboxylic acid, a possible norsesquiterpene compounds from the wood of *Cedrus deodara* Loud. Tetrahedron 1978; 34:599-602.
10. Tiwari AK, Srinivas PV, Kumar SP, Rao JM. Free Radical Scavenging Active Components from *Cedrus deodara*. Journal of Agricultural and Food Chemistry 2001; 49(10):4642-4645.

11. Adinarayana D, Seshadri TR. Chemical investigation of the stem-bark of *Cedrus deodara*: Isolation of a new dihydroflavonol, deodarin. Tetrahedron 2001; 21:3727-30.
12. Zhang JM, Shi XF, Ma QH, He FJ, Wang DD, Liu DY, Fan B. Studies on the chemical constituents from pine needles of *Cedrus deodara* (II). Zhong Yao Cai 2010; 33(7):1084-6.
13. Zhang JM, Shi XF, Li C, Fan B, Wang DD, Liu DY. Study on the chemical constituents from pine needles of *Cedrus deodara*. Zhong Yao Cai 2010; 33(2):215-8.
14. Shankaranarayan R, Krishnappa S, Bisarya SC, Dev S. Studies in sesquiterpenes-LIII: Deodarone and atlantolone, new sesquiterpenoids from the wood of *Cedrus deodara* Loud. Tetrahedron 1977; 33:1201-1205.
15. Gulati BC. Oil of *Cedrus deodara*, cultivation and utilization of aromatic plants. Regional Research Laboratory, Jammu-Tawi, India; 1977. pp. 640.
16. Kar K, Puri VN, Patnaik GK, Rabindra N, Sur Dhawan BN, Kulshrestha DK, Rastogi RP. Spasmolytic constituents of Cedrus deodara (Roxb.) Loud: Pharmacological evaluation of himachalol. Journal of Pharmaceutical Sciences 1975; 64: 258-262.
17. Yan-qiu C, Xin-hong C, Yi Z, Qun Z, Peng N. Chemical Composition and Antimicrobial Activity of Volatile Oil of Six Gymnosperm Species Leaves from Shanghai. Bioinformatics and Biomedical Engineering 2008:4573-4577.
18. Makhaik M, Naik SN, Tewary DK. Evaluation of anti-mosquito properties of essential oils. Journal of Scientific and Industrial Research 2005; 64:129-133.
19. Kirtikar KR and Basu BD. Indian Medicinal Plants. Volume III. International Book Distributors, Dehradun; 2006.
20. Pandey S. Efficacy of V-gel in vaginitis and cervicitis. The Antiseptic 2000; 5(97):155.
21. Winter CA, Risley EA, Nuss GW. Carrageenan-induced edemas in hind paw of the rat as an assay for anti-inflammatory drugs. Proceedings for the Society Experimental Biology and Medicine 1962; 11:544-547.
22. Newbould BB. Chemotherapy of arthritis induced in rats by mycobacterial adjuvants. British Journal of Pharmacology and Chemotherapy 1963; 21:127-136.
23. Shinde UA, Phadke AS, Nair AM, Mungantiwar AA, Dikshit VJ, Saraf MN. Studies on the anti-inflammatory and analgesic activity of *Cedrus deodara* (Roxb.) Loud. Wood oil. Journal of Ethnopharmacology 1991; 65:21-27.
24. Wilkonson PC, Vane JK, Ferreria SH. Handbook of experimental pharmacology. Berlin: Springer-Verlag. 1962; 109.
25. Goldlust MB, Harrity TW, Palmer I, Numonde DC, Jasani MK. The recognition of anti-rheumatic drugs. Lancaster: MTP Press. 1978; 119.
26. Saraf MN, Ghooi RB, Patwardhan BK, Studies on the mechanism of action of *Semecarpus anacardium* in rheumatoid arthritis. J. Ethnopharmacol 1989; 25:159-164.
27. Ray A, Mediratta PK, Puri S, Sen P. Effect of stress on immune reponsiveness, gastric ulcerogenesis and plasma corticosterone in rats: modulation by diazepam and naltrexone. Indian Journal Experimental Biology 1991; 29:233.
28. West GB. Effects of levamisole and *D*-penicillamine on contact sensitivity to oxazolone in rats. Int Archs Aller Appl Immunol 1982; 67:184-186.
29. Rodnan GP, Schumacher HR. Role of immunologic mechanisms in the pathogenesis of rheumatic diseases. The Arthritis Foundation, Atlanta, GA. 1989:38.
30. Thomas WR, Vardinon N, Walkins MC, Ashershon GL. Antigen-specific mast cell degranulation in contact sensitivity to picryl chloride, An early event. Immunology 1980; 29:331.
31. Ahmad R, Srivastava PS, Maurya R, Rajendran SM, Aryan KR, Srivastava AK. Mild antihyperglycaemic activity in *Eclipta alba, Berberis aristata, Betula utilis, Cedrus deodara, Myristica fragrans* and *Terminalia chebulaIndian.* Journal of Science and Technology 2008; 5:1-6.
32. Gupta RK, Kesari AN, Murthy PS, Chandra R, Tandon V, Watal G. Hypoglycemic and hypoglycemic effect of ethanolic extract of leaves of *Annona squamosa* L. in experimental animals. J. Ethnopharmacol 2005; 99:75-81.
33. Rajasekaran S, Sivagnanam K, Ravi K, Subramanian S. Hypoglycemic effect of Aloe vera gel on streptozotocin-induced diabetes in experimental rats. Journal of Medicinal Food 2004; 7:61-66.
34. Upadhya S, Shanbhag KK, Suneetha G, Balachandra Naidu. A study of hypoglycemic and antioxidant activity of *Aegle marmelos* in alloxan induced diabetic rats. Indian J. Physiol. Pharmacol 2004; 48:476-480.
35. Shivanand, P, Viral D, Goyani M, Vaghani S, Jaganathan K. Formulation and evaluation of *Cedrus deodara* Loud. extract. International Journal of ChemTech Research 2009; 1(4):1145-1152.
36. Singh SK, Shanmugavel M, Kampasi H, Singh R, Mondhe DM, Rao JM, Adwankar MK, Saxena AK, Qazi GN. Chemically standardized isolates from *Cedrus deodara* stem wood having anticancer activity. Planta Med 2007; 73:519-2637.
37. Gupta SC, Yadav SC, Jawaharlal CR. Molluscicidal activity of *Cedrus deodara* (wood essential oil) against Lymnaea auricularia rufescens Grey: laboratory and field evaluations, India. Journal of Veterinary Parasitology 1988; 2:109-112.
38. Singh A, Singh DK. Effect of herbal molluscicides and their combinations on the reproduction of the *Snail lymnaea acuminata*. J. Archives of Environmental Contamination and Toxicology 2004; 6:470-477.
39. Singh K, Singh DK. Molluscicidal activity of plant derived molluscicides. Journal of Herbs, Spices & Medicinal Plants 1988; 5:67-72.
40. Singh A, Singh DK. Molluscicidal activity of *Lawsonia inermis* and its binary and tertiary combinations with other plant derived molluscicides. Indian Journal of Exp Biol 2001; 3:263-8.
41. Singh D, Agrawal SK. Himachalol and β-himachalene: Insecticidal principles of himalayan cedar wood oil. J Chem Ecology 1988; 14:1145-1151.
42. Khamlach MK, Brown R. D-E. Lignanes. 16. Premieres syntheses totales du (+)-Wikstromal, de la (−)-Trachelogenine de la (−) nortrachelogenine et des lignoides apparentes. Tetrahedron 1992; 48:10115-10126.
43. Monks A, Seudiero D, Skeham P, Shoemaker R, Paull K, Vistica D, Hose C, Langley J, Cronise P, Vaigro WA, Gray- Goodrich M, Campbell H, Mayo J, Boyd M. Feasibility of a high flux anticancer drug screen using a diverse panel of cultured human tumor cell lines. J Nat Can Inst 1991; 83:757-766.
44. Parduman R, Sharma M, Shanmugavel AK, Saxena G, Qazi N. Induction of apoptosis by a synergistic lignan composition from *Cedrus deodara* in human cancer cells. Phytother Research 2008; 22:1587-1594.
45. Chopra AK, Gupta V, Gupta KK, Prasad G. Antibacterial activity of root, stem and leaf extract of *Cedrus deodara* against *Escherichia coli in vitro*. Flora and Fauna 2006; 10(2):101-103.
46. Sharma DK, Saxena VK, Sanil NK, Singh N. Evaluation of oil of *Cedrus deodura* and benzyl benzoate insarcoptic mange in sheep. Small Ruminant Research 1997; 26:81-85.
47. Dhayabaran D, Jeyaseeli FE, Nanda K, Puratchikody A. Anxiolytic and anticonvulsant activity of alcoholic extract of heart wood of *Cedrus deodara* Roxb. in rodents. Journal of Medicinal Plants Research *2010;* 4(14):1374-1381.
48. Viswanatha GL, Kumar KN, Shylaja H, Ramesh C, Rajesh S, Srinath R. Anxiolytic and anticonvulsant activity of alcoholic extract of heart wood of *Cedrus deodara* Roxb. in rodents. Journal of Pharmaceutical Research and Health Care 2009; 1(2):217-239.
49. Tondon SK, Singh S, Gupta S, Chandra S, Jawahar L. Sub acute dermal toxicity study of *Cedrus deodara* wood essential oil. Indian Veterinary Journal 1989; 66(11):1088.
50. Mall HV, Asthana A, Dubey NK, Dixit SN. Toxicity of cedar wood oil against some dermatophytes. Indian Drugs 1985; 22(6):296.
51. Parveen R, Azmi MA, Tariq RM, Mahmood SM, Hijazi M, Mahmud S, Naqvi SNH. Determination of antifungal activity of *Cedrus deodara* root oil and its compounds against *Candida albicans* and *Aspergillus fumigatus.* Pakistan Journal of Botany 2010; 42(5):3645-3649.