

A REVIEW ON SECONDARY METABOLITES FROM ABIES WEBBIANA OF ANTI-DIABETIC ACTIVITY

Nasiruddin Ahmed Farooqui, Km. Banti*, Praveen Kumar, Mohammad Mujahid and Shamim Ahmad

Translam Institute of Pharmaceutical Education and Research, P.O. Rajpura, Mawana Rd, Meerut, Uttar Pradesh 250001.



*Corresponding Author: Km. Banti

Translam Institute of Pharmaceutical Education and Research, P.O. Rajpura, Mawana Rd, Meerut, Uttar Pradesh 250001.

Email ID: honeysharma00214@gmail.com

Article Received on 22/05/2024

Article Revised on 12/06/2024

Article Accepted on 02/07/2024

ABSTRACT

Abies webbiana, is an evergreen perennial tree, commonly known as Himalayan silver fir, found in the Himalayan range and other regions of South Asia. This article explores its botanical characteristics, chemical composition, and pharmacological properties. With a rich history of traditional medicinal use, *Abies webbiana* has garnered scientific interest due to its diverse phytochemical profile, including essential oils, flavonoids, and various terpenoids. Pharmacological investigations have revealed its potential therapeutic applications, including antimicrobial, anti-arthritic, neurological, anti-platelet, sedative, anti-tussive, anti-pyretic, anti-cancer, bronchodilator, and antioxidant activities. Studies highlight its efficacy in inhibiting bacterial growth, reducing arthritic symptoms, modulating neurological functions, preventing platelet aggregation, inducing sedation, relieving cough, reducing fever, inhibiting cancer cell proliferation, relaxing bronchial contractions, and scavenging free radicals. These findings underscore the pharmacological significance of *Abies webbiana* and its potential for the development of novel therapeutic agents.

KEYWORDS: Bacterial growth, *Abies Webbiana*, bronchodilator, etc.

INTRODUCTION

Nature has been a source of therapeutic agents throughout human history, traditional systems of medicine such as *Ayurveda*, which is based on natural products has been used by people of Indian subcontinent for the treatment of various types of ailments.^[1] Nature has not only been limited to traditional knowledge but has also provided numerous pharmacological agents that are used or have to potential to be developed to treatment of diseases such as cancer, microbial infections,^[2] diabetes,^[3] Parkinson,^[4] hyperlipidemia^[5] and several other diseases. Nature has provided innumerable amount of pharmacologically active agents that have the potential to be developed into drugs and several of which are already being used for various applications in pharmaceutical industry, namely, cannabidiol, galanthamine, dronabinol, colchicine, capsaicin, arglabin^[6] and cucurbitacins.^[7]

Since the scientific exploration of plants as a source of drugs began, plants have emerged as viable source of pharmaceutically active compounds. Plants such as *Taxus braviifolia*, produces taxol, an alkaloid widely used as anticancer agent,^[8] *Artemisia annua*, produced artemisinin, which became a significant treatment for malaria,^[9] another such example is *Curcuma longa*,

known for its marker compound curcumin which is reported to possess various biological effects.^[10]

Abies webbiana (Family: *Pinaceae*) alternatively known as *Abies spectabilis* is perennial evergreen plant. It is widely distributed in the elevated portions of the temperate and sub-alpine regions of the Himalayan range, with a maximum height of 60 meters.^[11] Its habitat stretches from northern state of Kashmir to northern eastern state of Assam in India. It is also found, mainly at elevations between 2500 and 4000 meters, in Bhutan, the Karakoram Range, Tibet (China), Nepal, and Afghanistan (Hindu Kush range). These regions are distinguished by high relative humidity, significant precipitation, and thick fog. This plant is also known for treating various conditions ranging from respiratory disorders, vascular conditions, digestive issues, and cold.^[12] In traditional and vernacular languages, it is known by many names; Hindi: *Talish patra*, Sanskrit: *Patradhyam*, Bengali: *Talish pala*, English: Himalayan silver fir, Assam: *Talish*, Marathi: *Laghu taleespatra*, Gujarati: *Talish patra*, Tamil: *Talispatra*.^[11]

Taxonomy

Abies webbiana has been used for numerous applications by humans and has been around for millions of years. Botanists have classified it as a member of

Pinaceae family of *pinopsida* class. Table 1: Depicts a detailed taxonomy of the plant.^[13]

Table 1: Taxonomy of *abies webbiana*.

Kingdom	<i>Plantae</i>
Sub-kingdom	<i>Viridiplantae</i>
Infra-kingdom	<i>Streptophyta</i>
Super division	<i>Embryophyte</i>
Division	<i>Tracheophyte</i>
Sub division	<i>Spermatophytina</i>
Class	<i>Pinopsida</i>
Sub class	<i>Pinidae</i>
Order	<i>Pinales</i>
Family	<i>Pinaceae</i>
Genus	<i>Abies</i>
Species	<i>Webbiana</i> .

Morphology

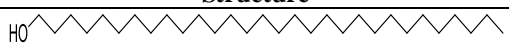
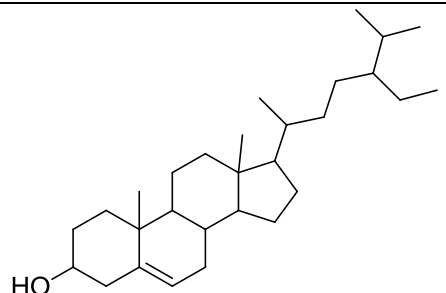
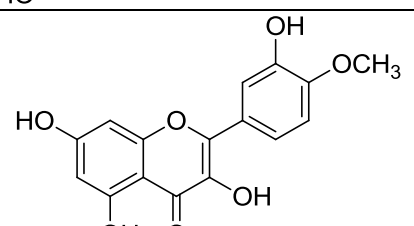
Abies webbiana is an evergreen tree that can reach a maximum reported tallness of approximately 60 meters. Its leaves are long, flattened, brittle and stiff, they are arranged in a spiral pattern and can 1.3 to 2.5 cm long, 2mm broad and cone shaped, midrib is channeled un the upper side while raised on the lower portion. Upper surface of the leaves is dark green to brown whereas lower part is silvery white in colour. Its odour is aromatic, taste is astringent and slightly pungent. The upper epidermis is single layered, followed by the sclerenchymatous hypodermis; the lower epidermis is also single layered; there are sunken stomata on the lower surface; the spongy parenchyma is 4-6 layered; the vascular bundle is single; there are two secretory cavities on either type of vascular bundle. These observations were made under a microscope.^[11,14,15]

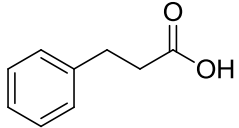
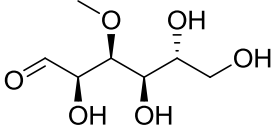
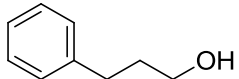
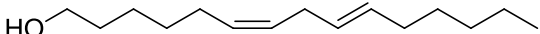
Chemical constituents

Abies webbiana has a rich diversity of phytochemicals present in it, these phytochemicals have been reported to have various pharmacological activities.

A. webbiana is reported to have essential oil concentrated in its leaves.^[16] A bioflavonoid called Abiesin is isolated from the leaves of the plant.^[17] Selin-11-en-4 β -ol, α -bisabolol, β -pinene, camphene, limonene, bornyl acetate, camphene, α -pinene, β -phellandrene, α -pinene, bornyl acetate, and β -pinene are detected in the leaves.^[16,17] Toluene, Santene, Tricyclene, α -Thujene, Camphene, Thuja-2,4(10)-diene, Sabinene, 3,7,7-Trimethyl-1,3,5-cycloheptatriene, Myrcene, α -Terpinene, p-Cymene, Limonene, Linalool, Perillene, and other chemical components have also been reported. Nezuol, Zonarene, γ -Elemene, δ -Selinene, and β -Selinene.^[18] Apart from these phytoconstituents there are few more which are depicted in the table2.

Table 2: List of chemical constituents present in various parts of *A. webbiana*.

Name	Structure	Reference
<i>n</i> -triacontanol		[19]
β -Sitosterol		[19]
3,5,7-trihydroxy-2-(3-hydroxy-4-methoxyphenyl)-4H-chromen-4-one		[20]

Benzenepropanoic acid		[21]
3-O-Methyl-d-glucose		[21]
3-phenyl-1-propanol		[21]
(Z) 6, (Z) 9-Pentadecadien-1-ol		[21]

Pharmacological activities

Abies Webbiana has been used for various therapeutic purposes in the Indian subcontinent and other parts of South Asia. The pharmacological properties of *Abies*

webbiana are well documented in traditional literature as well as modern literature. Its potential pharmaceutical applications range from antimicrobial, anti-cancer, anti-arthritic and many more.

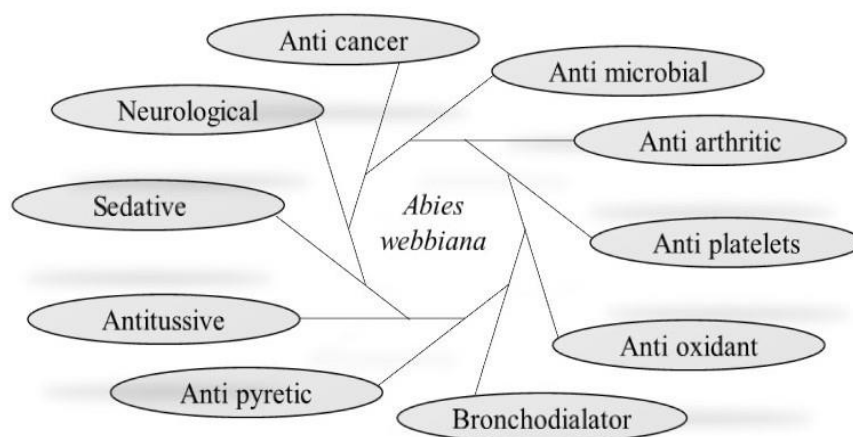


Figure 1: Pharmacological actions exhibited by *Abies webbiana*.

Antimicrobial activity

Antimicrobial activity of *Abies webbiana* has been explored extensively and has produced significantly positive results, indicating that *A. webbiana* could be explored more and potentially be developed into an effective antimicrobial agent.

In a comprehensive exploration, the antibacterial properties of an ethanolic extract mouthwash derived out of *Abies webbiana* were meticulously evaluated by Timothy et al. The study utilized amoxicillin as the standard reference antibiotic to benchmark the effectiveness of the *Abies webbiana* extract. The findings revealed that the ethanolic extract demonstrated a potent antibacterial effect against *Staphylococcus aureus*. However, the extract exhibited relatively weaker antimicrobial activity against other tested microorganisms, specifically *Enterococcus faecalis*, *Streptococcus mutans*, and *Candida albicans*. Notably, the response of *Candida albicans* to both the ethanolic extract and the amoxicillin was negligible, indicating

minimal susceptibility. In contrast, the susceptibility of *Streptococcus mutans* to the ethanolic extract was comparable to that observed at higher concentrations of the standard antibiotic, amoxicillin. These results suggest that while the *Abies webbiana* extract shows promising antibacterial properties, particularly against *S. aureus*, its efficacy varies significantly across different microbial species, underscoring the necessity for further research to optimize its antimicrobial potential.^[22] In another detailed study conducted by Vishnoi et al., the extract obtained methanolic fraction of the powder of dried-up leaves extract of *Abies webbiana* was investigated for its activity against microbes. This study assessed the extract's efficacy against a variety of Gram +ve and Gram -ve bacterial strains. The Gram +ve strains that the extract was tested against were *Staphylococcus aureus*, *Micrococcus luteus*, and *Staphylococcus epidermidis*. The Gram -ve strains tested were *Escherichia coli*, *Salmonella typhi*, *Vibrio cholerae*, and *Shigella dysenteriae*. The results demonstrated that the methanolic extract exhibited potent antimicrobial activity

across these bacterial strains, with effectiveness varying according to the concentration of the extract. The study used a standard drug as a benchmark for comparison, and the findings indicated that the *Abies webbiana* methanolic extract could potentially serve as an effective antimicrobial agent. This highlights the extract's broad-spectrum antibacterial capabilities, warranting further investigation into its therapeutic applications and the specific mechanisms underlying its antimicrobial activity.^[23] In an evaluation conducted by Sowmiya and Prakash, the antibacterial properties of silver nanoparticles synthesized from *Abies webbiana* were examined. The study focused on the efficacy of these nanoparticles against three bacterial strains: *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa*. The results demonstrated significant antibacterial activity of the silver nanoparticles against all three bacterial species. This finding suggests that *Abies webbiana*-derived silver nanoparticles possess potent antibacterial properties, making them a promising candidate for the development of new antimicrobial agents. Further research into the mechanisms of action and potential clinical applications of these nanoparticles could provide valuable insights into their role in combating bacterial infections.^[24]

Anti-arthritic activity

Anti-arthritic activity of *A. webbiana* is evident by the study performed by Prajapati & Gajera, in which they explored extract obtained from methanolic fraction of dried leaf powder of *A. webbiana* in Freund's adjuvant-induced arthritis in experimental rats. Test group treated with *A. webbiana* leaves methanolic extract exhibited dose dependent anti-arthritic effect when compared with negative control group and decent effect against standard group (Methotrexate). The test revealed that *A. webbiana* leaf extract reduced paw volume of the experimental animal alongside with increasing RBC count, Hb levels and normalized WBC and platelets counts and reduced ESR and CRP levels as well by the end of the study.^[25]

Neurological activity

Abies webbiana extract evaluated for its neurological activity by Prakash et.al., revealed that the plants possess anti-anxiety, anti-depressant, anti-convulsant as well as anti-stress properties. The finding indicates that the plant has immense potential to be used as a neurological agent.^[26]

Anti-platelets activity

Yasin et al. evaluated the anti-platelet activity of *Abies webbiana* by examining the effects of its leaf extract on platelet aggregation. In their study, they used a model of human platelets induced by epinephrine and compared the results with ADP as the standard. The findings revealed that the *Abies webbiana* leaf extract effectively inhibited platelet aggregation. Furthermore, the extract demonstrated a significant thrombolytic effect when compared to ADP, indicating its potential to prevent blood clot formation. These results suggest that *Abies*

webbiana leaf extract may possess substantial anti-platelet and thrombolytic properties, making it a promising candidate for further research in the prevention and treatment of thrombotic disorders. The study highlights the extract's potential role in modulating platelet activity and reducing the risk of thrombosis, which could have significant implications for cardiovascular health. Further investigations are warranted to explore the underlying mechanisms and to assess the clinical applicability of *Abies webbiana* extract in therapeutic settings.^[27]

Sedative activity

The sedative effect of *A. webbiana* was uncovered when *A. webbiana* methanol extract (100–200 mg/kg) was assessed by Nayak et al. in experimental animals, pre-administration of methanol extract of leaves of *A. webbiana* to the experimental mice, prior to pentobarbitone sodium and diazepam significantly increased the sedative effect of the drugs and increased the duration of sedation, suggesting a synergistic sedative interaction.^[28]

Anti-tussive activity

The impact of *A. webbiana* Lindl's methanol extract examined, employed mice with induced cough caused by sulfur dioxide gas was assessed. When taken orally, it demonstrated a dose-dependent pattern of considerable antitussive efficacy in comparison to the control. The extract's antitussive properties were contrasted with those of codeine phosphate, a standard antitussive drug. When compared to the control group, the *A. webbiana* leaf extract (400 and 600 mg/kg) demonstrated the greatest suppression of cough frequency by 71.69% and 78.67%, respectively, and had an effect similar to that of codeine phosphate.^[29]

Anti-pyretic activity

Rats with normal body temperature and yeast-induced pyrexia were used to test the activity against pyrexia ability of methanolic extract of *Abies spectabilis* (MEAS) leaves. At intraperitoneal (i.p.) dosages of 200 and 400 mg/kg body weight, MEAS demonstrated considerable action. The extract significantly lowered body temperature for up to three hours when given at a dose of 200 mg/kg body weight. The 400 mg/kg body weight dose significantly lowered body temperature for up to six hours following treatment. MEAS demonstrated dose-dependent decrease of the body temperature up to 4 hours at both dosages in the model of yeast-induced rise of body temperature. The outcomes were similar to those of the common antipyretic drug paracetamol.^[30]

Anti-cancer

Ghosh et al. conducted an investigation into the anticancer efficacy of *Abies webbiana* dry leaf powder in a murine model. Mice were injected with Ehrlich Ascites Carcinoma (EAC) cells and subsequently treated with a suspension of the dry leaf powder. The suspension was prepared by mixing the powder with a phosphate buffer

solution, resulting in a 2 ml formulation that was administered intraperitoneally. After a period of nine days, the mice that received the *Abies webbiana* suspension exhibited significantly lower EAC cell counts compared to the control group. These findings indicate that *Abies webbiana* dry leaf powder may possess anticancer properties, as evidenced by its ability to reduce the proliferation of EAC cells *in vivo*. This study underscores the potential of *Abies webbiana* as a candidate for further research in cancer treatment and warrants additional investigations to elucidate its mechanisms of action and therapeutic efficacy.^[31] The anticancer potential of gold nanoparticles (AuNPs) synthesized using an extract from the *Abies webbiana* plant was investigated by Wu *et al.* The synthesis utilized plant extracts to produce AuNPs, which were further examined for their cytotoxic effects on T24 cell lines using the MTT assay. The results showed dose-dependent cytotoxicity in the range of 1 to 25 µg/ml concentration after a 24-hour exposure period. The study further explored the mechanisms underlying this cytotoxicity by examining apoptosis markers. Techniques such as TUNEL staining and DAPI staining were employed to confirm the induction of apoptosis. Additionally, molecular analyses revealed the overexpression of pro-apoptotic markers including caspase 3, Bax, and Beclin-1, alongside the downregulation of anti-apoptotic markers Bcl-2 and Bid. These findings strongly suggest that the gold nanoparticles induced apoptosis in T24 cells. This research highlights the significant potential of gold nanoparticles synthesized from *Abies webbiana* extracts as a promising treatment option for cancer. The observed dose-dependent cytotoxicity and the triggering of apoptosis pathways underscore the therapeutic viability of these AuNPs, warranting further investigation into their clinical applications and underlying molecular mechanisms.^[32] Phan *et al.* conducted an evaluation of the ethanolic extract derived from the stem of *Abies spectabilis*, focusing on its cytotoxic effects on human pancreatic cancer cells. Their study revealed that the extract exhibited high cytotoxicity, particularly under conditions of nutrient scarcity. Further mechanistic investigations indicated that the extract functions as an inhibitor of the Akt/mTOR/autophagy signaling pathway, which is crucial for the survival and proliferation of cancer cells. The inhibition of this pathway suggests that the *Abies spectabilis* stem extract disrupts critical survival mechanisms within the cancer cells, thereby enhancing its cytotoxic effects. This discovery underscores the potential therapeutic value of the extract in targeting pancreatic cancer, especially in environments where nutrient availability is limited. The findings from this study suggest that the ethanolic extract of *Abies spectabilis* stem could be a promising candidate for the development of new anticancer therapies, particularly for treating pancreatic cancer. Further research into its specific molecular interactions and potential clinical applications is warranted to fully realize its therapeutic potential.^[33]

Bronchodilator activity

A study by Yasin *et al.* found that *A. webbiana* leaves produced relaxation against contractions caused by potassium ions and carbachol in isolated rabbit tracheal samples. These results were comparable to those shown with the common medication verapamil. This suggests a possible bronchodilatory effect that might be brought about by blocking calcium channels. It demonstrated its Ca²⁺ channel blocking (CCB), akin to verapamil. It produced contractions similar to those induced by verapamil at concentrations of 1 µM of carbachol and 80 mM of K⁺ in isolated rabbit tracheal preparations, indicating that the observed bronchodilatory effect could potentially be mediated via CCB activity.^[27]

Anti-oxidant activity

Using DPPH, BR, and TEAC tests, Dall'Acqua *et al.* explored the methanol fraction of the extract and discovered that it had a considerable total phenol content (IC₅₀ 4.13 µg/mL, 0.20 µg/mL eq. resorcinol, 4.22 mM eq. Trolox, and 3.9 µg/g eq. gallic Acid).^[34] The DPPH radical assay was used by Tote *et al.* to examine the hydroalcoholic extract and showed 76.33% inhibition at 100 µg/ml, compared to 81.53% for ascorbic acid, with IC₅₀ values of 38 µg/ml and 21.50 µg/ml, respectively. Additionally, the extract demonstrated a strong lowering power by changing Fe⁺³ to Fe⁺². When compared to gallic acid, the total polyphenolic concentration was significant (p<0.05) at 23.37 mg/g. Using IC₅₀ values of 49 µg/ml and 111 µg/ml, respectively, it demonstrated inhibition of nitric oxide (NO) and hydrogen peroxide (H₂O₂) radicals in comparison to curcumin (IC₅₀ = 41 µg/ml) and α-tocopherol (IC₅₀ = 63 µg/ml) standards. These observations demonstrate the hydro-alcoholic extract of *Abies spectabilis*'s notable concentration-dependent antioxidant activity.^[35]

CONCLUSION

The review underscores the profound significance of *Abies webbiana*, an evergreen plant indigenous to the Indian subcontinent, known for its extensive array of medicinal properties. Its chemical makeup is notably diverse, harboring a plethora of bioactive compounds and phytochemicals, which have been the subject of extensive research. Through scientific inquiry, its therapeutic potential has been elucidated, showcasing promising attributes such as anti-cancer, antitussive, neurological modulation, sedative, antimicrobial, antiarthritic, and antioxidant properties, among others. While strides have been made towards harnessing its medicinal benefits, more work needs to be done to develop it into a viable pharmaceutical product. Further investigation is imperative to fully unlock its therapeutic repertoire and develop efficacious pharmaceutical products. Continued research endeavors are warranted to comprehensively understand and exploit the therapeutic potential of *Abies webbiana*, paving the way for novel medicinal interventions and contributing to the advancement of healthcare practices.

REFERENCES

- Mukherjee, P.K., et al., *Development of Ayurveda-tradition to trend*. Journal of ethnopharmacology, 2017; 197: 10-24.
- Cragg, G.M. and D.J. Newman, *Nature: a vital source of leads for anticancer drug development*. Phytochemistry reviews, 2009; 8: 313-331.
- Sivakumar, G., et al., *Plant-based corosolic acid: Future anti-diabetic drug?* Biotechnology Journal: Healthcare Nutrition Technology, 2009; 4(12): 1704-1711.
- Ríos, J.-L., et al., *Medicinal plants and natural products as potential sources for antiparkinson drugs*. Planta Medica, 2016; 82(11/12): 942-951.
- Gong, X., et al., *Effects of phytochemicals from plant-based functional foods on hyperlipidemia and their underpinning mechanisms*. Trends in Food Science & Technology, 2020; 103: 304-320.
- Atanasov, A.G., et al., *Discovery and resupply of pharmacologically active plant-derived natural products: A review*. Biotechnology advances, 2015; 33(8): 1582-1614.
- Sharma, R., et al., *Synthetic Modifications of Therapeutically Relevant Pre-assembled Cucurbitacins: Synthetic Strategies and Structure-Activity Relationships*. Journal of Molecular Structure, 2024; 138321.
- Wani, M.C., et al., *Plant antitumor agents. VI. Isolation and structure of taxol, a novel antileukemic and antitumor agent from Taxus brevifolia*. Journal of the American Chemical Society, 1971; 93(9): 2325-2327.
- Brown, G.D., *The biosynthesis of artemisinin (Qinghaosu) and the phytochemistry of Artemisia annua L.(Qinghao)*. Molecules, 2010; 15(11): 7603-7698.
- Kocaadam, B. and N. Şanlıer, *Curcumin, an active component of turmeric (Curcuma longa), and its effects on health*. Critical reviews in food science and nutrition, 2017; 57(13): 2889-2895.
- Yadav, D.K. and A.K. Ghosh, *A review of pharmacognostical, phytochemical and pharmacological effect of Abeis webbiana Lindl. leaves*. World J Pharm Res, 2015; 4: 736-740.
- Yeşilada, E., et al., *Traditional medicine in Turkey. V. Folk medicine in the inner Taurus Mountains*. Journal of ethnopharmacology, 1995; 46(3): 133-152.
- chauhan, M. *Talisa Patra (abies webbiana)*, 2019 [2024; 23/4/2024]; Available from: <https://www.planetayurveda.com/library/talisa-patra-abies-webbiana/>.
- Kirtikar, K. and B. Basu, *Indian medicinal plants edition*. M/S Bishen Singh Pal Singh, Delhi, 1975; 2: 1465-1472.
- Gupta, A., *Anonymous: Quality Standards of Indian Medicinal Plants*. NewDelhi, 2003; 1: 212-218.
- Agarwal, S., R. Thappa, and T. Srivastava, *Some industrially important aromatic plants of Sikkim*. Indian Perfumer, 1987; 31(2): 113-115.
- Chatterjee, A., et al., *Abiesin, a biflavonoid of Abies webbiana*. Phytochemistry, 1984; 23(3): 704-705.
- Satyral, P. and W.N. Setzer, *Chemical composition and enantiomeric distribution of monoterpenoids of the essential oil of Abies spectabilis from Nepal*. American Journal of Essential Oils and Natural Products, 2017; 5(1): 22-26.
- Arora, P., S. Ansari, and A. Ahmad, *A Mini Review on Abies Webbiana Lindl.: A Medicinally Important Plant of India*.
- Yadav, D.K., et al., *Isolation of flavonoid from Abies webbiana leaves and its activity*. Pharmacognosy Journal, 2016; 8(4).
- Rajalakshmi, P., et al., *Pharmacognostic evaluation of Abies webbiana leaf: a Siddha herbal ingredient*. Asian J Pharm Clin Res, 2016; 9(4): 213-9.
- Timothy, C.N., et al., *Abies webbiana ethanolic extract based mouthwash and its antimicrobial and cytotoxic effect*. Journal of Pharmaceutical Research International, 2021; 33(62): 371-385.
- Vishnoi, S.P., et al., *Antibacterial activity of Abies webbiana*. Fitoterapia, 2007; 78(2): 153-155.
- Sowmiya, K. and J.T.J. Prakash, *Green-synthesis of silver nanoparticles using Abies webbiana LEAVES and evaluation of its antibacterial activity*. Journal of Pharmacognosy and Phytochemistry, 2018; 7(5): 2033-2036.
- Prajapati, P. and V. Gajera, *Anti-arthritic Effect of Methanol Extract of Leaves of Abies Webbiana Lindl. in Complete Freund's Adjuvant-induced Arthritis in Albino Rats*. International Journal of Health Sciences, 2022; (I): 7400-7417.
- Parkash, O., D. Kumar, and S. Kumar, *Screening of methanol extract and ethyl acetate fraction of Abies webbiana Lindl. for neuropharmacological activities*. Indian Journal of Pharmaceutical Sciences, 2015; 77(5): 536.
- Yasin, M., et al., *Pharmacological studies on the antispasmodic, bronchodilator and anti-platelet activities of Abies webbiana*. Phytotherapy Research, 2014; 28(8): 1182-1187.
- Nayak, S.S., et al., *Synergistic effect of methanol extract of Abies webbiana leaves on sleeping time induced by standard sedatives in mice and anti-inflammatory activity of extracts in rats*. Journal of ethnopharmacology, 2004; 93(2-3): 397-402.
- Nayak, S.S., et al., *Antitussive activity of Abies webbiana Lindl. leaf extract against sulphur dioxide-induced cough reflex in mice*. Phytother Res, 2003; 17(8): 930-2.
- Visnoi, S.P., et al., *Evaluation of the antipyretic potential of methanol extract of the leaves of Abies spectabilis (D. Don) Spach*, 2007.
- Ghosh, A., K. Srikanth, and T.J. Tarun Jha, *Inhibitory effect of Abies webbiana on tumour cells in mice*, 2001.
- Wu, T., et al., *Synthesis and characterization of gold nanoparticles from Abies spectabilis extract and its anticancer activity on bladder cancer T24 cells*.

- Artificial cells, nanomedicine, and biotechnology, 2019; 47(1): 512-523.
33. Phan, N.D., et al., *Abietane diterpenes from Abies spectabilis and their anti-pancreatic cancer activity against the MIA PaCa-2 cell line*. Bioorganic & Medicinal Chemistry Letters, 2022; 66: 128723.
 34. Dall'Acqua, S., et al., *Phytochemical and antioxidant-related investigations on bark of Abies spectabilis (D. don) spach. from Nepal*. Molecules, 2012; 17(2): 1686-1697.
 35. Tote, S., V. Kadam, and R. Ghosh, *In vitro antioxidant activity of Abies spectabilis D. Don*. Pharmacol Ther, 2009; 2: 170-85.