Original Article

Bioactivities of Isolated Phytochemicals and Extracts of *Abies spectabilis* (D.Don) Mirb.

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Abstract

Objectives: *Abies spectabilis* (D.Don) Mirb. belongs to the *Pinaceae* family. A. *spectabilis* is used for construction, fragrance, fuel, and medicine. In traditional medicine, this plant is used to cure several disorders such as asthma, cold, cough, tumor, vomiting. This work projects to explore the potential medicinal uses and phytochemical constituents of A. *spectabilis*. **Materials and Methods:** The compounds such as abiesin, betuloside, limonene, α-pinene, abiesadine, and myricetin have been discovered from different parts of this plant. The major electronic databases (Web of Science, PubMed, ScienceDirect, and Scopus) were applied to recognize the appropriate published studies from 1900 to June 2021. **Results:** Up to now, except for clinical studies, *in vitro* and *in vitro* scientific evidence are available for different extracts. **Conclusion:** The investigations were undertaken exhibit the potential use of this plant for various pharmacological purposes such as antianxiety, antidepressant, anti-inflammatory, antipyretic, antifungal, antiplatelet, antispasmodic. This work will support different researchers on pharmacological and phytochemical aspects in the future.

Keywords: *Abies spectabilis,* antibacterial, bioactivity, *Pinaceae*, siddha medicine

Introduction

Abies spectabilis (D.Don) Mirb. (synonyms: *Abies brevifolia* [A.Henry] Dallim.; *Pinus tinctoria* Wall. ex D.Don; *Abies chilrowensis* Parl.; *Pinus striata* Buch.-Ham. ex Gordon and Glend.; *A. spectabilis* subsp. *langtangensis* [Silba] Silba; *Pinus spectabilis* D. Don; *A. spectabilis* var. *langtangensis* Silba; *Picea webbiana* [Wall. ex D.Don] Loudon; *Abies webbiana* [Wall. ex D.Don] Lindl.; and *Picea naphta* Knight) is a tree that belongs to the *Pinaceae* family. It grows up to 30 m tall in forests situated at an elevation from 2450 to 4000 m. Moreover, *A. spectabilis* is called தாளிசபத்திரி (Thaalisapaththiri) in Tamil/Siddha Medicine; Dhaatriparni, Dhaatripatra, Patraadhya, Taalisa, Taalisapatra, and Taalisha in Ayurveda; Taalisapattar in Unani; and Himalayan fir and Webb fir in English. This plant species is native to Asia (India, Afghanistan, Pakistan, and Nepal).[1,2] This plant species has been categorized as near threatened by the International Union for Conservation of Nature and Natural Resources red list of threatened species.[3]

A. spectabilis is used for construction, medicine, fragrance, and fuel. It is utilized to treat such as asthma, bronchitis, colds, rheumatism, neuralgic pains, cough, tumors, hypochlorhydria, amoebiasis, hiccups, vomiting, helminthiasis, fever, diabetes, conception, dysphonia, bone fractures, and mouth and respiratory tract disorders Figure 1.[4-21]

Phytochemical constituents such as p-hydroxybenzoic acid; abiesin; methyl betuloside; betuloside; methyl betuloside acetate; betuloside acetate; 4'-methoxy quercetin; 1-(4'-methoxyphenyl)-aziridine; pindrolactone; limonene; α-pinene; bornyl acetate; β-phellandrene; camphene; β-pinene; α-pinene; bornyl acetate; selin-11-en-4 β-ol; α-bisabolol; abieta-7,13-diene-12α-methoxy-18-oic acid; 7α-methoxy-dehydroabietic acid; 5-hydroxy-6-methyl-7,4'-dimethoxyflavone-8-O-β-D-glucopyranoside; abiesadine R; 18-norabieta-8,11,13-trien-4-ol; 2-hydroxynaringenin; 9, 15-hydroxydehydroabietic acid; abiesadine I; abiesadine R;

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abiesadine X; abiesadine Y; apigenin; b-D-glucopyranosyl benzoate; benzoic acid; caffeic acid; cedrusin; daphneligin; dehydroabietic acid; D-glucopyranoside; ferulic acid; frambinone; icariside E; isopimaric acid; isorhamnetin-3-b-D-(6-O-acetyl) glucoside; manool; myricetin; nonadecadienoic acid; pallasiin; p-coumaric acid; phytol; abiesanordine F; schizandriside; serratenedione; torreferol; and tsugafolin have been isolated from *A. spectabilis*.[23-28]

This systematic review objects to scrutinize, synopsize, and archive the published papers connected to the reported biological activities of *A. spectabilis*. This systematic review will be valuable for future phytochemicals and biological activities of *A. spectabilis*.

Materials and Methods

Major electronic records (Scopus, Science Direct, Web of Science, Semantic Scholar, and PubMed) were utilized to detect the appropriate published papers from 1900 to June 2021. "*A. spectabilis,*" "*Pinus tinctoria,*" "*Pinus striata,*" "*Pinus spectabilis,*" "*Picea webbiana.*" "*Picea naphta,*" "*Abies webbiana,*" "*A. spectabilis* var. *langtangensis,*" *A. spectabilis* subsp. *langtangensis, Abies chilrowensis*, and "*Abies brevifolia*" were utilized as exploration terms. Only papers containing the reported biological activity of A. *spectabilis* were taken into account in this survey.

Reported biological activities of *Abies spectabilis*

Table 1 presents the details (level of scientific evidence, bioactivity, part used, extract/fraction/compound, assay/model, dose/concentration, and reference) of reported biological activities of *A. spectabilis*. To date, *in vivo* and *in vitro* scientific evidence is existing for several biological activities. The identified *in vivo* studies are analgesic, antianxiety, anticonvulsant, antidepressant, antihepatotoxic, anti-inflammatory, antinephrotoxic, antipyretic, antistress, antitussive, and sedative.[28-31] Similarly, antibacterial, antifungal, antioxidant, antiplatelet, antispasmodic, bronchodilatory studies were known under *in vitro* scientific evidence.[32-34] However, researches associated with the antibacterial property were found in a higher number of studies. Three different parts (aerial, bark, and leaf) of *A. spectabilis* were employed from different studies. However, the leaf was led in position. From different studies, dichloromethane:methanol (1:1), ethanol, and methanol were utilized to prepare extracts. Although, in many studies, methanol has been exploited. So far, from *A. spectabilis,* aziridine and abiesin are the bioactive compounds that have been isolated.[35] The scientific evidence is available only for neuralgic pains, fever, and cough. Furthermore, asthma, bronchitis, colds, rheumatism, tumors, hypochlorhydria, amoebiasis, hiccups, vomiting, helminthiasis, diabetes, conception, dysphonia, bone fractures, and mouth and respiratory tract disorders have identified with no scientific evidence. Only noteworthy researches which entail the highest level of scientific evidence available, the lowest concentration/dose employed, and active chemicals identified are discussed in detail underneath.

Reported *in vivo* studies

Analgesic activity

Dried aerial parts of *A. spectabilis* were extracted by methanol and ethyl acetate fraction which was separated from extract to study the analgesic effect. The extract at the dose of 200 mg/kg was orally administered using the tail immersion test. A standard drug, morphine sulfate, was exerted at the dose of 5 mg/kg. After the administration, the response of tail withdrawal from the heat was used as the indication to measure the time. The results showed that the extract exerted has shown a significant analgesic activity during 3 h period but it was not equivalent to the standard drug administered.[29]

Antianxiety activity

The orally administered methanol extract and ethyl acetate fraction of aerial parts were exposed to study the antianxiety activity of *A. spectabilis* using the plus-maze model. The number of entries and average time spent on the open arm by animals were recorded for 5 min and compared with standard drug (diazepam) at 2 mg/kg. From this study, it was evidenced that methanol extract showed more time spent in open arms associated with the potent antianxiety activity.[29]

Anticonvulsant activity

The maximal electroshock test model was utilized to study the anticonvulsant activity, and the stimulus used was 50 mA for 0.2 s. The 200 mg/kg orally administered methanol extract and ethyl acetate fraction of aerial part of *A. spectabilis* were prepared and used. After the treatment, the maximal electroshock-induced tonic extensor phase and protection of animals percentage-wise were observed. The significant effect was compared with phenytoin sodium (20 mg/kg) injection. Although the extract and fraction produced significant anticonvulsant activity, it was not equivalent to standard drug tested.[29]

Antidepressant activity

The total duration of immobility was recorded to study the antidepressant activity of methanol extract and ethyl acetate fraction of aerial parts of *A. spectabilis* at 200 mg/kg dose. After the 1 h oral administration of the test drug, the effect was compared with standard drug (imipramine) at the dose of 15 mg/kg using despair swim test. From this study, it was revealed that the extract exhibited the potential and equivalent activity with the standard drug used.[29]

Antihepatotoxic activity

An extract was prepared to study the hepatotoxic effect of 4-methoxyquercetin from the leaf sample of *A. spectabilis.* The carbon tetrachloride-induced hepatotoxic model was employed to see the effect at 50 mg/kg body weight. In this study, the serum biochemical parameters such as serum glutamate pyruvate transaminase, serum glutamate oxaloacetate transaminase, serum alkaline phosphates, and serum total bilirubin and serum direct bilirubin were evaluated for the blood samples. The effect was compared with the standard drug of CCl_4 at 0.1 mg/kg up to 5 days.[28]

Table 1: Reported bioactivities of *Abies spectabilis*

Level of scientific evidence	Bioactivity	Part used	Extract/fraction/compound	Assay/model	Dose/ concentration	Reference
In vivo	Analgesic	Aerial	Methanol, ethyl acetate fraction (methanol extract)	Tail immersion test	200 mg/kg	[29]
In vivo	Antianxiety	Aerial	Methanol, ethyl acetate fraction (methanol extract)	Plus maze	200 mg/kg	[29]
In vivo	Anticonvulsant	Aerial	Methanol, ethyl acetate fraction (methanol extract)	Maximal electroshock test	200 mg/kg	[29]
In vivo	Antidepressant	Aerial	Methanol, ethyl acetate fraction (methanol extract)	Despair swim test	200 mg/kg	[29]
In vivo	Antihepatotoxic	Leaf	4'-methoxy quercetin	Carbon tetrachloride-induced hepatotoxic	50 mg/kg	[28]
In vivo	Anti-inflammatory	Leaf	Methanol	Carrageenan-induced paw edema	400 mg/kg	[30]
In vivo	Antinephrotoxic	Leaf	4'-methoxy quercetin	Rat	50 mg/kg	[28]
In vivo	Antipyretic	Leaf	Methanol	Yeast-induced pyrexia	400 mg/kg	[31]
In vivo	Antistress	Aerial	Methanol, ethyl acetate fraction (methanol extract)	Cold swimming test	200 mg/kg	[29]
In vivo	Antitussive	Leaf	Methanol	Sulfur dioxide gas-induced cough	400 mg/kg	[36]
In vivo	Sedative	Aerial	Methanol, ethyl acetate fraction (methanol extract)	Thiopentone sodium-induced sleeping	200 mg/kg	[29]
In vitro	Antibacterial	Leaf	Dichloromethane: methanol (1:1)	*Bacillus cereus* var *mycoides, B. pumilus, B. subtilis, B. bronchiseptica, S. aureus, S. epidermidis, E. coli, K. pneumonia, P. aeruginosa*	500 µg/ml	[32]
In vitro	Antibacterial	Leaf	Methanol	*E. coli, M. luteus,* Salmonella typhi, *S. dysenteriae, S. aureus, S. epidermidis, V. cholera*	625 µg/ml	[37]
In vitro	Antibacterial	NS	Essential oil	*E. coli, K. pneumonia, S. aureus*	NS	[38]
In vitro	Antibacterial	NS	Methanol	*Enterobacter*	25 mg/ml	[39]
In vitro	Antifungal	Leaf	Dichloromethane: methanol (1:1)	*C. albicans, A. niger, S. cerevisiae*	500 µg/ml	[32]
In vitro	Antifungal	Leaf	Methanol	*A. niger, C. albicans*	2.5 mg/ml	[37]
In vitro	Anti-inflammatory	Leaf	Ethanol	Red blood cell membrane stabilization	NS	[35]
In vitro	Antioxidant	Bark	Methanol	Briggs-Rauscher oscillating reaction	0.20 µg/ml	[33]
In vitro	Antioxidant	Bark	Methanol	DPPH radical scavenging	4.13 µg/ml (IC_{50})	[33]
In vitro	Antioxidant	Bark	Methanol	Ferrous iron chelating capacity	3.9 µg/g equivalent gallic acid	[33]
In vitro	Antioxidant	Bark	Methanol	TEAC	4.22 mM equivalent Trolox	[33]
In vitro	Antioxidant	Leaf	Ethanol	DPPH radical scavenging	NS	[35]
In vitro	Antioxidant	NS	Methanol	DPPH radical scavenging	10.10 µg/ml (IC_{50})	[39]
In vitro	Antiplatelet	Leaf	Ethanol (80%)	Human platelet	0.04 mg/ml (IC_{50})	[34]
In vitro	Antispasmodic	Leaf	Ethanol (80%)	Rabbit jejunum	1.16 mg/ml (EC_{50})	[34]
In vitro	Bronchodilatory	Leaf	Ethanol (80%)	Rabbit trachea	0.41 mg/ml (EC_{50})	[34]

NS: Not stated, EC_{50}: Half-maximal effective concentration, IC_{50}: The half-maximal inhibitory concentration, DPPH: 2,2-diphenyl-1-picrylhydrazyl, TEAC: Trolox equivalent antioxidant capacity, *B. pumilus: Bacillus pumilus, B. subtilis: Bacillus subtilis, B. bronchiseptica: Bordetella bronchiseptica, S. aureus: Staphylococcus aureus, S. epidermidis: Staphylococcus epidermidis, E. coli: Escherichia coli, K. pneumonia: Klebsiella pneumonia, P. aeruginosa: Pseudomonas aeruginosa, M. luteus: Micrococcus luteus, S. dysenteriae: Shigella dysenteriae, V. cholera: Vibrio cholera, C. albicans: Candida albicans, A. niger: Aspergillus niger, S. cerevisiae: Saccharomyces cerevisiae*

Anti-inflammatory activity

Nayak *et al*. studied the potential inflammatory activity of methanol leaf extract using the carrageenan-induced paw edema model. In this study, the test drug at the dose of 400 mg/kg was orally administered to see the effect. The percentage reduction in inflammation was recorded to see the effect and compared with the standard drug administered. After 30 min of administration, the results exhibited good anti-inflammatory activity and were compared with standard diclofenac sodium at the dose of 150 mg/kg.[30]

Antinephrotoxic activity

A dose-response experiment was conducted in rats to study the nephrotoxic effect of 4-methoxy quercetin leaf extract. The extract at the dose of 50 mg/kg was employed in this experiment. In this experiment, the level of biochemical parameters, percentage change in body weight, serum creatinine, serum protein, and serum blood urea nitrogen were used to study the effect of the extract. The significant effect was compared with cisplatin, a standard drug, at a 6 mg/kg dose for 7 days.[28]

Figure 1: *Abies spectabilis* plant (Source: The gymnosperm database, 2021)[22]

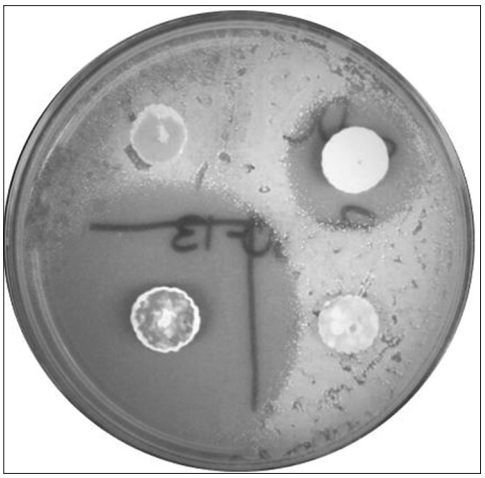

Figure 2: Antibacterial assay for *Escherichia coli*

Antipyretic activity

The methanol leaf extract at 400 mg/kg was practiced to study the antipyretic activity using yeast induced pyrexia model. The extract was intraperitoneally administered at the dose of 400 mg/kg. In this experiment, the standard antipyretic paracetamol was utilized as a standard drug at the dose of 150 mg/kg body weight. The results showed that after the administration, the extracts at the concentration of 200 mg/kg and 400 mg/kg were significantly lowered the body temperature up to 3 h and 6 h time duration correspondingly. At both doses, the extract lowered the body temperature up to 4 h period.[37]

Antistress activity

Parkash *et al*. investigated the antistress activity of orally administered methanol extract and ethyl acetate fraction of aerial parts of *A. spectabilis*. To study the effect, the average immobility time was recorded. In this experiment, a dose of 200 mg/kg of the extract was used in the cold swimming test. The extract exhibited the reduced mean immobility time in an immobile state. The results were compared with the standard drug, Diazepam, at 1 mg/kg dose after 1 h of administration of the test drug.[29]

Antitussive activity

A sulfur dioxide gas-induced cough model was utilized to see the antitussive effect of methanol leaf extract in mice. The extract (400 mg/kg) was orally administered for 1 min and exhibited a significant activity and compared with standard drug, codeine phosphate, at 10 mg/kg standard drug dose. The results exhibited prominent antitussive activity and the leaf extracts unveiled the maximum cough inhibition frequency. The results were comparable to the effect of codeine phosphate.[36]

Sedative activity

Thiopentone sodium-induced sleeping assay was used by Parkash *et al*. to study the sedative activity. The orally administered methanol extract and ethyl acetate fraction of aerial parts of *A. spectabilis* were used in this study. To see the significant effect, the extract and fraction were employed at the dose of 200 mg/kg. After the 30 min of administration of the extract, the average latency time and sleep duration were observed. In this experiment, thiopentone sodium (80 mg/kg), the standard drug, was used to compare the effect of test drugs.[29]

Reported *in vitro* studies

Antibacterial activity

Kumar *et al*. evaluated the antibacterial property of extract of *A. spectabilis* dried leaves sample extracted using dichloromethane:methanol (1:1). In this experiment, the activity was evaluated against selected bacterial strains including *Bacillus cereus* var *mycoides, Bacillus pumilus, Bacillus subtilis, Bordetella bronchiseptica, Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli, Klebsiella pneumoniae,* and *Pseudomonas aeruginosa* at 500 µg/ml concentration as shown in Figure 2. In this research work, the ciprofloxacin (3 µg/ml) was utilized as the positive control.[32]

Antifungal activity

The dichloromethane:methanol (1:1) crude extract was deployed at the concentration of 500 µg/ml to study the antifungal activity of the leaf sample. In this experiment, the fungal strains such as *Candida albicans, Aspergillus niger,* and *Saccharomyces cerevisiae* were exploited to see the significant activity of extract on agar dilution-streak method. In this experiment, amphotericin-B (3 µg/ml) was applied to compare the significant inhibition activity of the extract.[32]

Antioxidant activity

Antioxidant activity of methanol bark extract was investigated by Dall'Acqua *et al*., using DPPH free radical scavenging assay. In this investigation, a significant scavenging activity was observed at IC_{50} 4.13 µg/ml. The results were compared with standard positive controls, rutin, and ascorbic acid, at 4.8 µg/ml, and 3.5 µg/ml concentrations, respectively.[33]

Antiplatelet activity

The crude extract was tested to evaluate its antiplatelet aggregation activity against epinephrine-induced aggregation

assay. An ethanolic (80%) leaf extract was prepared to study such activity. The results disclosed that the concentration-dependent inhibition of platelet aggregation was induced at the concentration of 0.04 mg/ml (IC_{50}). The authors did not state the positive control utilized.[34]

Antispasmodic activity

Aqueous ethanol was exerted to prepare an extract from the leaf to study the antispasmodic activity using an isolated rabbit jejunum assay. The extract of 1.16 mg/ml (EC_{50}) showed the comparative inhibitory effect of crude extract of both spontaneous and K + induced contractions in isolated rabbit jejunum, and the effect was comparable with verapamil which inhibited both contractions completely.[34]

Bronchodilatory activity

Carbachol and K+ induced contractions were used to study the bronchodilatory activity of *A. spectabilis* using rabbit trachea assay. For this purpose, an ethanolic leaf extract was employed. The extract at the concentration of 0.41 mg/ml (EC_{50}) was applied to study the promising activity. The type of positive control exercised in this study was not mentioned.[34]

Toxicity studies

In this study, the animals were observed for their behavioral changes, neurological changes, and autonomic changes at the frequency of once in 30 min up to 14 days. The reported results exhibited that no lethality and toxic reactions were observed in mice for the orally administered methanol extract of aerial part at the dose of 2000 mg/kg during the 14-day interval.[29]

Conclusions

This systematic review may support this plant for being utilized in modern medicine for the treatment of various disorders. The numerous human ailments associated with have been cured through the application of various chemical compounds produced and derived from *A. spectabilis*. Thus, the active phytochemical compounds associated with curing various disorders should be explored more and their structures should also be elucidated. This work provides the foundation for future researches employing this plant species. This work analyzed, summarized, and documented the reported bioactivities using *A. spectabilis*.

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Conflicts of interest

There are no conflicts of interest.

References

1. Kew Science. Plants of the World Online, *Abies Spectabilis*; 2021. Available from: http://www.plantsoftheworldonline.org/taxon/urn: lsid: ipni.org: names: 60474520-2. [Last accessed on 2021 Jun 14].
2. *Abies spectabilis* (D. Don) Mirb. in GBIF Secretariat. GBIF Backbone Taxonomy; 2021. https://www.GBIF.org. [Last accessed on 2021 Jun 14].
3. Zhang D, Rushforth K, Katsuki T. *Abies spectabilis*. The IUCN Red List of Threatened Species; 2011. Available from: https://www.iucnredlist.org/species/42300/10686224. [Last accessed on 2021 Jul 12].
4. Vivekanandarajah S, Rajamanoharan PR, Heinrich M, Munday M. Preparations and plants used to treat diabetes in Sri Lankan Siddha Medicine. In: Presented at the 3rd International Conference on Ayurveda, Unani, Siddha and Traditional Medicine. Colombo: Institute of Indigenous Medicine, University of Colombo; 2015. p. 67.
5. Vivekanandarajah S, Rajamanoharan PR, Munday M, Heinrich M. Plants used to treat diabetes in Sri Lankan Siddha Medicine-an ethnopharmacological review of historical and modern sources. J Ethnopharmacol 2016;198:531-99.
6. Vivekanandarajah S, Rajamanoharan P, Munday M, Heinrich M. Plants currently used to treat diabetes in Sri Lankan Siddha Medicine-an ethnobotanical survey in the Eastern Province. In: Presented at the World Congress Integrative Medicine and Health 2017: Part Three. Berlin, Germany: Springer Nature; 2017. p. 333.
7. Vivekanandarajah S, Rajamanoharan PR, Heinrich M. Siddha medicine in Eastern Sri Lanka today-continuity and change in the treatment of diabetes. Front Pharmacol 2018;9:1022.
8. Nadkarni KM. Indian Materia Medica with Ayurvedic, Unani-Tibbi, Siddha Allopathic, Homeopathic, Naturopathic and Home Remedies. Bombay: Popular Prakashan; 1976.
9. Khare C. *Abies webbiana* Lindl. In: Khare C. editors. Indian Medicinal Plants. New York: Springer; 2007.
10. Kirtikar KR, Basu BD. Indian Medicinal Plants. 2nd ed., Vol. 1. Dehradun: Bishen Singh and Mahendra Pal Singh; 1975. p. 2392.
11. Ghosh AK, Srikanth K, Jha T. Inhibitory effects of *Abies webbiana* on tumor cells in mice. Indian J Nat Prod 2001;7:17-9.
12. Asolkar LV, Kakkar KK, Chakre OJ. Second Supplement to Glossary of Indian Medicinal Plants with Active Principles: Part-1 (A-K), (1965-1981). New-Dehli: Publications and information directorate, 1992.
13. Rajamanoharan P, Vivekanandarajah S. The role of honey in pediatric treatments in Sri Lankan Siddha Medicine. Uludag Bee J 2021;21:83-90.
14. Vivekanandarajah S. Antidiabetic plants used by Sri Lankan Tamils. Jaffna Sci Assoc Newsl 2021;28:3.
15. Vivekanandarajah S. Plants used by Sri Lankan Tamils to manage diabetes – Part: 1. India. Valampuri Newspaper. 2021.
16. Vivekanandarajah S. Plants used by Sri Lankan Tamils to manage diabetes – Part: 2. India. Valampuri Newspaper. 2021.
17. Vivekanandarajah S. Plants used by Sri Lankan Tamils to manage diabetes – Part: 3. India. Valampuri Newspaper. 2021.
18. Vivekanandarajah S. Plants historically used by Sri Lankan Tamils to treat diabetes. The International Dr. Safiye Ali Multidisciplinary Studies Congress in Health Sciences, Izmir, Turkey, 01.09.2021. 2021. Volume 3, Issue Supplement, 1 – 65.
19. Vivekanandarajah S. Plants Used to Treat Diabetes in Sri Lankan Siddha Medicine, Ph.D. Thesis. London, UK: University College London; 2018.
20. Vivekanandarajah S. Plants Historically Used to Treat Diabetes in Sri Lankan Siddha Medicine. Ooty, India: Presented at the International Seminar and Exhibition on Phytopharmaceuticals: Emerging Challenges and Opportunities; 2017.
21. Vivekanandarajah S. Plants with Anti-Diabetes Mellitus Properties. Vol. 191. Boca Raton, FL, USA: CRC Press, Taylor and Francis Group; 2016. p. 19-20.
22. The gymnosperm Database, *Abies spectabilis*; 2021. Available from: https://www.conifers.org/pi/Abies_spectabilis.php. [Last accessed on 2021 Jul 23].
23. Dall'Acqua S, Minesso P, Comai S, Shrestha BB, Gewali MB, Jha K, *et al*. Triterpene derivatives from *Abies spectabilis* leaves of Nepalese origin. Nat Prod Commun 2011;6:793-8.
24. Chatterjee A, Kotoky J, Das KK, Banerji J, Chakraborty T. Abiesin, a biflavonoid of *Abies webbiana*. Phytochemistry 1984;23:704-5.
25. Sarkar SK, Poddar G, Mahato SB. Glucosides from *Abies webbiana*. Planta Med 1987;53:219-20.
26. Satyal P, Setzer WN. Chemical composition and enantiomeric distribution of monoterpenoids of the essential oil of *Abies spectabilis* from Nepal. Am J Essential Oils Nat Prod 2017;5:22-6.
27. Tripathi M, Jain L, Pandey VB. Flavonoids of *Abies pindrow* leaves.

Fitoterapia 1996;67:477.
28. Yadav DK, Ali M, Ghosh AK, Kumar B. Isolation of flavonoid from *Abies webbiana* leaves and its activity. Pharmacogn J 2016;8:341-5.
29. Parkash O, Kumar D, Kumar S. Screening of methanol extract and ethyl acetate fraction of *Abies webbiana* Lindl. For neuropharmacological activities. Indian J Pharm Sci 2015;77:536-41.
30. Nayak SS, Ghosh AK, Debnath B, Vishnoi SP, Jha T. 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. J Ethnopharmacol 2004;93:397-402.
31. Visnoi SP, Basu A, Alam S, Samanta S, Jha T. Evaluation of the antipyretic potential of methanol extract of the leaves of *Abies spectabilis* (D. Don) Spach. Indian J Nat Prod Resour 2008;6:369-71.
32. Kumar VP, Chauhan NS, Padh H, Rajani M. Search for antibacterial and antifungal agents from selected Indian medicinal plants. J Ethnopharmacol 2006;107:182-8.
33. Dall'Acqua S, Minesso P, Shresta BB, Comai S, Jha PK, Gewali MB, *et al*. Phytochemical and antioxidant-related investigations on bark of *Abies spectabilis* (D. don) spach. from Nepal. Molecules 2012;17:1686-97.
34. Yasin M, Hussain Janbaz K, Imran I, Gilani AH, Bashir S. Pharmacological studies on the antispasmodic, bronchodilator and anti-platelet activities of *Abies webbiana*. Phytother Res 2014;28:1182-7.
35. Rajalakshmi P, Vadivel V, Abirami K, Brindha P. Evaluation of antioxidant and anti-inflammatory potentials of selected Siddha herbal drugs-an *in vitro* study. Int J Pharmacogn Phytochem Res 2016;8:519-23.
36. Nayak SS, Ghosh AK, Srikanth K, Debnath B, Jha T. Antitussive activity of *Abies webbiana* Lindl. leaf extract against sulphur dioxide-induced cough reflex in mice. Phytother Res 2003;17:930-2.
37. Vishnoi SP, Ghosh AK, Debnath B, Samanta S, Gayen S, Jha T. Antibacterial activity of *Abies webbiana*. Fitoterapia 2007;78:153-5.
38. Gyawali R, Bhandari J, Amatya S, Piya E, Pradhan UL, Paudyal R, *et al*. Antibacterial and cytotoxic activities of high-altitude essential oils from Nepalese Himalaya. J Med Plants Res 2013;7:738-43.
39. Shrestha T, Lamichhane J. Screening and Bioactivity Measurement of High-Altitude Medicinal Plants of Nepal. VEGETOS: An International Journal of Plant Research 2016;29:41.