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ORIGINAL ARTICLE

Antibacterial Activity of Extracts of Pinus Wallachiana, Pinus Roxburgii and Cedrus Deodara Resins Against Some Common Pathogenic Bacteria

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ABSTRACTS

The current research was conducted in the department of chemistry at Microbiology lab, Govt Collage Madyan, District Swat Khyber Pakhtunkhwa, Pakistan. The aim of the current study was to determine the anti−bacterial activity of different resins extracts of Pinus roxburgii, wallachiana and Cedrus deodara against Salmonella typhi, Staphylococcus aureus, Pseudomonas aeruginosa and Escherichia coli by Disc diffusion method. The highest zone of inhibition was shown by methanolic extract of Cedrus deodara against S. aureus (19.6 mm) S. typhi (17 mm), E. coli (19.25 mm), and P. aeruginosa (15 mm) followed by ethanolic extract of the same plants against S. aureus (18.8 mm), S. typhi (19.33 mm), E. coli (18.1 mm), and P. aeruginosa (18.33 mm) followed by Acetone extracts of Cedrus deodara showed the maximum zone of inhibition against S. aureus (17 mm), E. coli (16.5 mm), S. typhi (16.33 mm), and P. aeruginosa (14.33 mm) followed by carbon tetrachloride extracts of Cedrus deodara against S. aureus (16.9 mm), S. typhi (16.5 mm), E. coli (12 mm), and P. aeruginosa (13.76 mm). The current study concluded that the methanolic extract of Cedrus deodara exhibit maximum anti-biogram against the test strains.

Keywords: Antibacterial Activity; Pinus wallachiana, Pinus roxburgii; Cedrus deodara; common pathogenic Bacteria

INTRODUCTION

Several compounds, both natural and man-made, exhibit antibacterial properties, such as the antibacterial properties of plant extracts. [1].

Resin is a sticky, solid or semisolid material generally a complicated mixture of organic compounds called Terpenes (secondary metabolites of plants) that is insoluble in polar solvent however soluble in non-polar solvent. They are excreted from the tree after the infection or damaging or for protection against fungal and bacterial infection [2-7]. It shows the anti-biogram against human pathogens and therefore used to cure human diseases [8-14]. The fundamental goal of human has to find out treatment for bacterial illness for this purpose they use various choices like allopathic, homoeopathic, and herbal medicines. Plant products such as fruits, seeds, flowers, bark, roots, and leaves have been found to contain a wide variety of bioactive chemicals such as glycosides, steroids, volatile oils, tannins, phenols, alkaloids, and flavonoids at high concentrations. [15].

Cedrus deodara, often known as the deodar cedar, is a species of cedar tree found in the Himalayan region. The tree produces a resin that has historically therapeutic uses in medicine. It resins shows the antiviral, anticancer, antibacterial, cytotoxic, antioxidant and antifungal effects [16-23]. Oleoresin are used for remedy of skin diseases and sore. It also showed therapeutic action against to spasm, cancer, pain and inflammation [28]. Cedrus deodara resin is used to treat skin disorders like eczema and psoriasis. [24]

Pinus roxburgii, resin has therapeutic uses in Ayurvedic medicine and anti-biogram both against Gram-positives and Gram-negative bacteria [25]. It is used as blood cleanser as well as for the remedy of snake bites, skin necrosis, scorpion sting, and for sore. [26].it is useful in the treatment of gonorrhea too [27]. P. roxburgii lotion are applied to the scar tissue for softness, recuring boils and fractures [28]

Pinus wallachiana, often known as the Himalayan blue pine, is a species of pine tree that may be found in the Himalayas. Resins of Pinus wallachiana is used for bruise [29] applied to treat boils and to prevent gastric problems [30, 31]. Mixture of resin and honey is used for bruise curing, sore, antiseptic, gonorrhea, burning sensation and abscess [32]. It is also used for treating chafing of heel [33], used with onion paste for curing bruise and cuts [34]. Its resins act as diuretic and to cure inflammation, scabies, piles, asthma, disease of spleen and liver and earache, chronic bronchitis, toothache, epilepsy and tuberculosis [35]. It is also applied to cure rheumatism and for remedy of syphilis and small pox [36].

In the current study resins of different plants were used to evaluate the anti-biogram of pathogenic bacteria against Salmonella typhi, Staphylococcus aureus, Pseudomonas aeruginosa and Escherichia coli.

MATERIAL AND METHODS

Laboratory work: The laboratory work was carried out in Microbiology and Chemistry research labs of Govt. Collage Madyan, District Swat Khyber Pakhtunkhwa (KPK), Pakistan.

Sample collection: For the anti-biogram study resins from the trunks of Pinus wallachiana and Cedrus deodara were collected from the forest of Village Gornai Tehsil Behrain Swat Khyber Pakhtunkhwa Pakistan. The altitude of forest was 2376m. The diameter of Pinus wallachiana trunk was 80.7 inches and that of Cedrus deodara was 87 inches. The resin of Pinus roxburgii were collected from the forest of Fatehpur Tehsil Khwaza khela Swat Khyber Pakhtunkhwa Pakistan. The altitude of forest was 1013m, the diameter of Pinus roxburgii trunk was 68 inches. The samples of resins were collected using knife and stored in sealed bottles.

Chemicals: Chemicals used in the current study are Methanol, Ethanol, Acetone, Carbon tetrachloride and phosphate buffer.

Apparatus: Apparatus used in the current research were Vernier caliper, Media shaker, pH meter, Drying Oven, Incubator and Autoclave.

Preparation of Methanolic, Ethanolic, Acetone and Carbon tetrachloride extracts of resins: The raw resins of Pinus wallachiana, Pinus roxburgii and Cedrus deodara were cleaned by removing surface impurities and were then extracted (10 g) separately with Methanol, Ethanol, Acetone and Carbon tetrachloride (50ml). The Methanolic, Ethanolic, Acetone and Carbon tetrachloride extracts were then filtered using Millipore filter paper and stored at 4 ^{0}C in sealed boxes. The stored samples were then used for their Antibiogram

Media preparation:

Nutrient Agar: Nutrient agar is a common growth media in microbiology for growing a variety of bacteria. It is a versatile medium that offers all the nutrients required to sustain the development of a variety of bacteria and fungi. Medium was prepared by suspending 20gram of powdered agar in 1 liter boiled distilled water in conical flask and shaking it thoroughly with the help of shaker to dissolve the nutrient agar completely. The pH of the media was adjusted at pH 7.4 using ph meter.

Media sterilization: Media sterilization was carried out in autoclave at 121°C for 15 minutes.
Media pouring: After the sterilization 25ml media was poured into previously sterilized petri dishes and allowed to solidify.
Microorganism culture; Tested microorganism samples both gram +ive and gram -ive were supplied by the clinical laboratory Saidu Teaching Hospital Saidu Sharif Swat. Gram +ive bacteria included S. aureus and Gram -ive bacteria included S. typhi, P. aeruginosa, and E. coli. Cultures of these bacteria were grown at 37 ^{0}C on nutrient agar in incubator.
Inoculation: From each bacterial culture bacteria were transferred on to the surface of nutrient agar plate with the help of wire loop.
Disc Diffusion method: The Kirby-Bauer method, sometimes referred to as the disc diffusion method, is a popular technique in microbiology for determining an antibiotic's susceptibility. Disk diffusion was employed to examine how well the resin extracts inhibits the development of bacteria [37]. From filter paper Discs of 5mm diameter were prepared with the help of punch machine. It was then kept in each extraction of plant resins and placed over the culture on nutrient media and incubated in incubator for 24 hours at 37 ^{0}C. The diameter of zone inhibition was then measured in millimeters using Vernier caliper.

RESULTS

In the present investigation, Methanolic, Ethanolic, Acetone and Carbon tetra chloride extracts of Pinus wallachiana, Pinus roxburgii and Cedrus deodara resins were tested for their anti-biogram against S. aureus (gram positive), P. aeruginosa, S. typhi and E. coli (gram negative). The zones of inhibition were measured against each bacterium.
Anti-biogram: The Methanolic, Ethanolic, Acetone and Carbon tetra chloride extracts of resins showed anti-biogram against the tested microorganism cultures.

Antibiogram activity of methanolic extracts is summarized in table 1. From the results obtained it is cleared that Cedrus deodara methanolic extract was more effective against S. aureus, P. aeruginosa and E. coli

The ethanolic extracts results are summarized in table 2. The highest zone of inhibition against each bacterium was shown by Cedrus deodara followed by Pinus roxburgii and Pinus wallachiana respectively.

Antibiogram activity of acetone extracts is summarized in table 3. It showed that the acetone extracts of Cedrus deodara resin showed highest zone of inhibition followed by, pinus roxburgii pinus wallachiana.

Antibiogram of carbon tetrachloride extracts are summarized in table 4. Carbon tetrachloride extraction of pinus wallachiana, pinus roxburgii and cedrus deodara plants resins.

Note: In all Figure s term A is used for extraction of pinus Roxburgii, B is used for pinus wallachiana, C is used for cedrus deodara and D is used for control group which was phosphate buffer of ph 7.

Table 1: anti-biogram of methanolic extracts against to gram +ive bacteria and gram -ive

Methanolic extracts	S. typhi	E. coli	P. aeruginosa	S. aureus
pinus roxburgii	14.7mm	17.5mm	11mm	18.2mm
pinus wallachiana	17.33mm	18.4mm	11.5mm	18.9mm
cedrus deodara	17mm	19.25mm	15mm	19.6mm
Control	0	0	0	0

Table 2: anti-biogram of Ethanolic extracts against to gram +ive and gram -ive bacteria

Ethanolic Extracts	S. typhi	E. coli	P. aeruginosa	S. aureus
pinus roxburgii	18.8mm	17.67mm	16mm	17.9mm
pinus wallachiana	18mm	17.3mm	14.3mm	17.4mm
cedrus deodara	19.3mm	18.1mm	18.3mm	18.8mm
control	0	0	0	0

Table 3: anti-biogram of Acetone extracts against to gram +ive and gram -ive bacteria

Extracts	S. typhi	E. coli	P. aeruginosa	S. aureus
pinus roxburgii	11.1mm	16mm	12.3mm	16.2mm
pinus wallachiana	13.7mm	12mm	11mm	14.3mm
cedrus deodara	16.2mm	16.5mm	14.4mm	17mm
Control	0	0	0	0

Table 4: anti-biogram of CCl4 extracts against to gram +ive and gram -ive bacteria

CCl4 Extracts	S. typhi	E. coli	P. aeruginosa	S. aureus
pinus roxburgii	15.7mm	13mm	13.3mm	15.9mm
pinus wallachiana	10.6mm	9mm	10.2mm	11.1mm
cedrus deodara	16.8mm	12mm	13.8mm	16.9mm
control	0	0	0	0

DISCUSSION

In the current study anti-biogram of different resin extracts were evaluated. The study showed that extracts from Cedrus deodara showed highest zone of Inhibition against all bacteria. For instance, study of (Chopra et al. 2004) examined the effectiveness of extracts from the cedrus deodara plant against several different bacterial cultures [38]. And they reported comparable results with our findings. Our results are also consistent with another study conducted by (Wu et al. 2016) who isolated terpenes from cedrus deodara which showed highest zone of inhibition against the pathogenic bacteria [39].

From our results it was demonstrated that Cedrus deodara methanolic extract was more effective against S. aureus (19.6mm), P. aeruginosa (15mm) and E. coli (19.25mm) . The same results were obtained by the study conducted by Singh, G., Kumar, P., & Joshi, S. C. (2012) on methanolic extracts of resin of Cedrus deodara. The results demonstrated significant antibacterial potential, inhibiting the growth of both Gram-positive and Gram-negative bacteria [40].

In our study the zone of inhibition of the ethanolic extracts results against S. aureus(18.8mm), P. aeruginosa (18.3mm), S. typhi (19.3mm) and E. coli (18.1mm). The highest zone of inhibition against each bacterium was shown by Cedrus deodara followed by Pinus roxburgii and Pinus wallachiana respectively.

Our results of ethanolic extract were accordance to the research conducted by Mohanty and, Sahoo G. in which they reported that Cedrus deodara Pinus roxburgii and Pinus wallachiana showed highest zone of inhibition against S. aureus, P. aeruginosa and E. coli [41].

Antibiogram of acetone extracts of our study results against S. aureus (17mm), P. aeruginosa (14.4mm), S. typhi (16.2mm) and E. coli (16.5mm). It showed that the acetone extracts of Cedrus deodara resin showed highest zone of inhibition followed by, pinus roxburgii and pinus wallachiana. Bhagat M, Arora VK, and Mishra A. (2010) study evaluated the anti-biogram of ethanolic and acetonic extracts of Cedrus deodara against various human pathogens, including Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, and Klebsiella pneumoniae. The results indicated significant anti-biogram of the acetonic extract against all tested strains[42].

Anti-biogram of carbon tetrachloride extracts of our study results against S. aureus (16.9mm), P. aeruginosa (13.8mm), and S. typhi (16.8mm). There is limited research specifically on carbon tetrachloride extracts of Cedrus deodara, Ghayur, M. N., Gilani, A. H., & Houghton, P. J. (2005) study has showed potential inhibitory activity against pathogenic bacteria such as Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa [43]. the most susceptible bacteria to cedrus deodara resins extracts was Staphylococcus aureus. The resin extracts used in our study showed highest zone of inhibition against Gram +ive bacteria in contrast to gram –ive bacteria. Panda SK, Padhi L, focuses on the anti-biogram of the methanol extract derived from the stem bark of Cedrus deodara. It evaluates the extract's efficacy against gram-

positive bacteria, including Staphylococcus aureus, and discusses the zone of inhibition observed [44] The outer membrane and cell wall of gram +ive bacteria are accountable for their greatest sensitivity to methanolic, Ethanolic, Acetone and Carbon tetra extracts of pinus wallachiana, pinus roxburgii and cedrus deodara resins. Staphylococcus aureus show maximum sensitivity to all extracts of resins than S. typhi, P. aeruginosa and E. coli.

This is due the fact that Gram -ive bacteria are distinct from Gram +ive bacteria due to the presence of peri-plasmic space and having outer membrane. Thus, it was evaluated that the anti-biogram of studied resin extracts was effective against gram +ive bacteria as compared to Gram –ive bacteria. The cell wall of gram-positive bacteria having thicker peptidoglycan layers are more susceptible to the bactericidal effect. The lipopolysaccharide-rich hydrophilic surface of the Gram -ive bacteria's outer membrane serves as a protective barrier to many antibiotics and is correlated with the peri-plasmic enzymes which can dissolve molecules brought in from the outside.

Gram +ive bacteria lack a cell wall outer membrane like that of gram –ive bacteria. Anti-microbiological agents break down the cytoplasmic membrane, allowing the cytoplasm to flow out and coagulate. For instance, one study examined the effectiveness of resin extracts from the Pistacia atlantica plant against to several different bacteria in light of the results, bacteria like Bacillus subtilis and S. aureus were more sensitivity to resin extracts than P. aeruginosa and E. coli [45].

In another investigation, gram -ive and gram +ive bacteria were put to the test for their anti-biogram of resin extracts from the Boswellia serrata tree. In the light of the results, gram +ive bacteria like Streptococcus pyogenes and S. aureus were more responsive to resin educes than gram -ive bacteria like Klebsiella pneumoniae and Escherichia coli [46] While not all resin extractions may exhibit this pattern of stronger activity against gram-positive bacteria, it is a widely reported observation in the literature and can be linked to the variations in gram -ive and gram +ive bacteria's cell wall structures.

CONCLUSIONS

The results of our study demonstrated that, the methanolic, Ethanolic, acetone and carbon tetra chloride extracts of cedrus deodara, pinus roxburgii and pinus wallachiana have good antibacterial activity against gram positive and gram negative bacteria.

REFERENCES

1. Burt, S. (2004). Essential oils: their antibacterial properties and potential applications in foods—a review. International journal of food microbiology, 94(3), 223-253
2. ANDERSON, D.M.W. (1991) recent changes in toxicological status of permitted food emulsifiers, stabilisers and thickeners. South African Journal of Food Science and Nutrition, 3(2), 25-28.
3. COPPEN, J.J.W. and HONE, G.A. (1995) Gum Naval Stores: Turpentine and Rosin from Pine Resin. Non-Wood Forest Products series. No. 2. 62 pp. Rome: Food and Agriculture Organization
4. GRAY, P.S. and PENNING, W. (1992) Present and future legislation of food hydrocolloids. pp 17-27. In Gums and Stabilisers for the Food Industry, Vol. 6. Proceedings of 6th International Conference, Wrexham, 1992. Oxford: IRL Press.
5. NAUDE, A. (1994) Food additives '94. Thickeners, the next generation. Chemical Marketing Reporter (27 June), pp SR16 and SR18.
6. ROBBINS, S.R.J. (1988) Gum arabic. pp 18-33. In A Review of Recent Trends in Selected Markets for Water-Soluble Gums. ODNRI Bulletin No. 2. 108 pp. London: Overseas Development Natural Resources Institute [now Natural Resources Institute, Chatham].
7. Trapp S, Croteau R. Defensive resin biosynthesis in conifers. Annu Rev Plant Physiol Plant Mol Biol 2001; 52:689–724.
8. Söderberg TA, Elmsros T, Gref R, Holm S, Hallmans G. Anti-biogram of rosin and resin acids in vitro. Scand J Plast Reconstr Hand Surg 1990;24:199–205
9. Söderberg TA. Effects of zinc oxide, rosin and resin acids and their combinations on bacterial growth and inflammatory cells. Scand J Plast Reconst Surg (Suppl) 1990;22:1–87
10. Mahady GB. Medical plants for the prevention and treatment of bacterial infections. Current Pharm Design 2005;11:2405–27
11. Martin K, Ernst E. Herbal medicines for treatment of bacterial infections: a review of controlled clinical trials. J Antimicrob Chemother 2003;51:241–6
12. Sharquie KE, al-Turfi IA, al-Salloum SM. The anti-biogram of tea in vitro and in vivo (in patients with impetigo contagiosa). J Dermatol 2000;27:706–10
13. Rabbani GH, Butler T, Knight J, Sanyal SC, Alam K. Randomized controlled trial of berberine sulphate therapy for diarrhea due to enterotoxigenic Escherichia coli and Vibrio cholerae. J Infect Dis 1987;155:979–84
14. Sipponen A, Lohi J. Resin-salve from Norway spruce – a ‘‘novel’’ method to treat chronic skin ulcers? J Wound Care. In press
15. Pathumthip, T., C. Supaporn, D.L. Peter and L. Walai. 2001. Supercritical CO2 extraction of nimbin from neem seeds? An experimental study. J. Food Eng., 47: 289-293
16. Oukhrib A, Zaki M, Benharref A. 2018. The chemistry of the himachalenes and atlantones from cedrus » édité par V. V. zhdankin. Arkivoc. 2018(1):134–178. doi:10. 24820/ark.5550190.p010.436
17. Shi X, Du R, Zhang J, Lei Y, Guo H. 2019. Evaluation of the anti-cancer potential of cedrus deodara total lignans by inducing apoptosis of A549 cells. BMC Complement Altern Med. 19(1):281. doi:10.1186/ s12906-019-2682-6
18. Huang X-F, Chang K-F, Lee S-C, Sheu G-T, Li C-Y, Weng J-C, Hsiao C-Y, Tsai N-M. 2020. Extract derived from Cedrus atlantica acts as an antitumor agent on hepatocellular carcinoma growth in vitro and in vivo. Molecules. 25(20):4608. doi:10.3390/molecules25204608
19. Alaydi H, Downey P, McKeon-Bennett M, Beletskaya T. 2021. Supercritical-CO 2 extraction, identi fication and quanti fication of polyprenol as a bioactive ingredient from Irish trees species. Sci Rep. 11(1):7461. doi:10. Table 11. 1038/s41598-021-86393-x
20. Alotaibi SS, Alshoaibi D, Alamari H, Albogami S, Khan E, Alshanbari A, Darwish H, Alshanqiti B, Alghamdi H, Almalki W. 2021. Potential significance of medicinal plants in forensic analysis: a review. Saudi J Biol Sci. doi:10.1016/j.sjbs.2021.03.071
21. Carneiro RCV, Ye L, Baek N, Gustavo H, Teixeira A, O’Keefe SF. 2021. Vine tea (Ampelopsis grossedentata): a review of chemical composition, functional properties, and potential food applications. J Funct Foods. 76:104317. doi:10.1016/j.jff.2020.104317
22. Kadam AA, Singh S, Gaikwad KK. 2021. Chitosan based antioxidant films incorporated with pine needles (Cedrus deodara) extract for active food packaging applications. Food Control. 124:107877. doi:10.1016/j. foodcont.2021.107877
23. Bai JR, Wu YP, Liu XY, Zhong K, Huang YN, Gao H. Anti-biogram of Shikimic Acid from Pine Needles of Cedrus deodara against Staphylococcus aureus through Damage to Cell Membrane. Int J Mol Sci. 2015;16(11):27145–55.
24. Gupta, V. K., Fatima, A., Faridi, U., Negi, A. S., & Shanker, K. (2010). Antibiogram potential of AgNPs synthesized using a medicinally important waste plant, Cedrus deodara. Journal of Analytical Science and Technology, 1(1), 1-7
25. Sipponen, A., & Laitinen, K. (2011). Antibiogram properties of natural coniferous rosin in the European Pharmacopoeia challenge test. APMIS, 119(10), 720-724.
26. Baquar, S.R. (1989). Medicinal and Poisonous plants of Pakistan. Printas Karachi, Pakistan. pp. 506.
27. Manandhar NP. Plants and people of Nepal. Timber Press Inc. Portland, Oregon, 2002
28. . Rajbhandari KR. Ethnobotany of Nepal. Ethnobotanical Society of Nepal, Kathmandu, 2001
29. Khan SW, Khatoon S. Ethnobotanical studies of useful trees and shrubs of Harmosh and Bugrote Valleys in Gilgit, Northern areas of Pakistan. Pak J Bot. 2007;39(3):699-710
30. KR Rajbhandari; Ethnobotany of Nepal. Ethnobotanical Society of Nepal, Kathmandu, 2001
31. NPManandhar; Plants and people of Nepal. Timber Press Inc. Portland, Oregon, 2002
32. Alamgeer, Sharif A, Asif H, Younis W, Riaz H, Bukhari IA, Assiri AM. Indegenous medicinal plants of Pakistan used to treat skin disease. Chin Med. 2018;13:52:1- 26.
33. Hassan A, Hassan S, Nasir MA. An ethnobotanical study of medicinal plants used by local people of Neel valley, Ramban, Jammu and Kashmir, India. SSRG International Journal of Agriculture & Environmental Science. 2018;5(3):17-20
34. Balodi KN, Purohit MV, Sridhar V, Arunachalam K. Ethno-medicinal uses of various plants species among the Jaad and Bhotiya community of Uttarakhand, Western Himalaya. Ethno Med. 2018;12(3):189-97

35. KR Kirtikar; BDBasu; Indian Medicinal Plants, 2nd Ed., International Book Distributors, Dehradun, 1999,2385- 88.
36. LHLangenheim; Plant resins: chemistry, evaluation, ecology and ethnobotany, Timber press, Auckland, New Zealand., 2003,(453-54)
37. Nostro, A., M. Germano, V. DÁngelo and M. Cannatelli, 2000. Extraction methods and bioautography for evaluation of medicinal plant Antibiogram activity. Lett. Appl. Microbiol., 30: 379-384.
38. Chopra A, Gupta V, Gupta KK, Prasad G. 2004. Anti-biogram of root, stem and leaf extract of Cedrus deodara against Escherichia coli in vitro. Flora and Fauna. 10:101–103.
39. Wu Y, Bai J, Zhong K, Huang Y, Qi H, Jiang Y, Gao H. 2016. Anti-biogram and membrane-disruptive mechanism of 3-p-trans-coumaroyl-2-hydroxyquinic acid, a novel phenolic compound from pine needles of Cedrus deodara, against Staphylococcus aureus. Molecules. 21 (8):1084. doi:10.3390/molecules21081084.
40. Singh, G., Kumar, P., & Joshi, S. C. (2012). In vitro evaluation of anti-biogram of root and heartwood extracts of Cedrus deodara. International Journal of Pharmaceutical Sciences and Research, 3(11), 4401-4406.
41. Basnet, B. B., & Kumar, R. (2014). Anti-biogram of methanolic extracts of some medicinal plants from Nepal. Journal of Applied Pharmaceutical Science, 4(5), 029-033
42. Anti-biogram of ethanolic and acetonic extracts of Cedrus deodara against selected human pathogens" by Bhagat M, Arora VK, and Mishra A. (2010)
43. Ghayur, M. N., Gilani, A. H., & Houghton, P. J. (2005). Pharmacological basis for the medicinal use of cedarwood oil (Cedrus deodara) in asthmatic conditions. Journal of Ethnopharmacology, 96(3), 235-241
44. Panda SK, Padhi L, Mohanty G, Sahoo G. Anti-biogram of methanol extract of the stem bark of Cedrus deodara (Roxb.) G. Don. Ancient Sci Life. 2011;30(4):114-117. doi:10.4103/0257-7941.103187
45. Bari, A., Hussain, F., Omer, M., & Shafi, M. (2014). Anti-biogram of Pistacia atlantica resin extracts against some human pathogenic bacteria. African Journal of Traditional, Complementary and Alternative Medicines, 11(1), 149-154
46. Al-Yasiry, A. R. M., & Kiczorowska, B. (2016). Frankincense--therapeutic properties. Postepy Higieny I Medycyny Doswiadczalnej, 70, 380-391