THE THERAPEUTIC POTENTIAL OF LICHENS IN INDIA: A REVIEW

[1*]Preeti Handa Kakkar, [2]Chandrika Bhatt, [3]Rupinder Kaur, [4]Prerana Badoni, [5*]Kanchan Chatterjee , [6]Dhyal Singh, [7]Shruti Saxena, and [8]Shefalee Singh

[1] School of Agriculture , Dev Bhoomi Uttrakhand University, Dehradun -248001,(UK),India, Email: Preetisep3@gmail.com

[2&4]Dept of Microbiology, Combined (PG) Institute of Medical Sciences & Research, Kuanwala, Dehradun. Email: chandrikabhatt333@gmail.com, Email: prerana.badoni@gmail.com

[3]Department of Agriculture,Tula's institute, Dehradun (UK)- 24800, India, Email: roopnarang@gmail.com

[5]Assistant professor, SoAS, Department of Zoology, Devbhoomi Uttarakhand University, Email: kanchanchatterjee608@gmail.com

[6]Department of Zoology, School of Life and Applied Sciences, Maya Devi University, Dehradun-248011, Uttarakhand., Email: dhyalsingh85@gmail.com

[7]School of Basic and Applied Sciences, Shri Guru Ram Rai University Dehradun, Email: shrutigwl@gmail.com

[8]School of Applied and Life Sciences, Uttaranchal University, Dehradun, Uttarakhand-248007. Email: shefalee.singh@gmail.com

Corresponding Author's email- kanchanchatterjee608@gmail.com

ABSTRACT

Since ancient times, Lichens have been used as a great source for flavouring, dyeing, smoking tobacco, cigars, spices, scenting soaps, and cosmetics and manufacture of Dhoop and Hawan Samagri. Lichens in the field of medication for different disease and disorders are being used from centuries. Traditional knowledge is an important source for the development of new drugs. It has been observed that, strong metabolites from mycobiont culture of lichens and their extracts can be used in various ways to treat many human diseases. Keeping above point in view, an attempt has been made to review the therapeutic potential of lichens in India.

Key Words: Lichens, medicines, therapy, symbiotic.

INTRODUCTION

In nature, number of organisms play specific ecological role in their specialized functional niches and lichens are the excellent example of such associations with remarkable alliance between algal and fungal partners. These are those lichenized fungi that form symbiotic association with a photosynthetic alga or cyanobacteria through the process of lichenization. Therefore, fungal association within the lichen thallus is called Lichenized fungus. Theophrastus (370−285), the Father of Botany is credited to introduce the term lichen from the

Greek origin 'Leikhén'. Tournfort in 1700 (A.D.) proposed lichen as one of the plant genera. Scholar of Linnaeus, Erik Acharius is known as Father of Lichenology, and described many genera of lichens.

Fungal partner in lichens is known as Mycobiont and Photosynthetic partner as Photobiont where main thallus body formed by mycobiota (about 95%) whereas photobiont contributes only 5% of the total thallus. In the thallus body fungal partner provides moisture, protection and shelter to the algal partner while algal partner provides carbon food through photosynthesis. The photobiont may be one or more green algal species, one or more cyanobacterial species or the combination of both. Within a thallus, the mycobiont's hyphae exudes chemicals which increases (Grover and Seshadri, 1959) the permeability of the photobiont cell wall or cell membrane and allow increased transference of organic carbon from the photobiont to the mycobiont. Sometimes, the relation is called controlled or balanced parasitism because the fungus does not kill the alga but at the same time it does not allow alga to flourish.

DISTRIBUTION OF LICHENS

Lichens are widely distributed throughout the world, and occur almost in all climatic conditions where even little favorable conditions are available. They are found in most extreme environments, from the Arctic to Antarctic, deserts to tropics, littoral zones to mountain peaks, etc. Some live on desert floors or near hot springs where temperatures can soar to 148°C. Lichens are one of the first colonizers or pioneers and colonize almost any substrate such as rocks, soils, man-made surfaces (Metal, polythene, rubber, glass, bricks, etc.) and bark and leaves of a variety of plants. Lichens may absorb certain mineral nutrients from any of these substrates on which it grows, but is generally self-reliant in feeding itself through photosynthesis in the algal cells. Lichens growing on rocks, though, may release chemicals which speed the degradation of the rock resulting in weathering process, and thus promote production of new soil. About 85% of lichen−forming fungi associate with green algae. About 10% with cyanobacteria (Ahmadjian, 1993) and about 4% with both green and blue green algae. The most common lichen photobiont belongs to green algae *Trebouxia*, *Trentepohlia* and the cyanobacterium *Nostoc*. The bulk of the ground tissue of lichen is made up of the mycobiont. When moisture is completely absent, lichen tissues may undergo desiccation and this is not a simple dehydration as it occurs in other plants but the lichen thallus becomes quite brittle when the body water is completely lost (Tuovinen, 2017). Even the lichen can quickly absorb the water when the moisture is once again available and become soft and fleshy. Not only lichens can undergo this drying, but while they are dry and brittle, pieces may flake off and later grow into new lichens. The Indian region with a total of 3029 million hectare is considered to be one of the 12 centres of origin and diversity of several plant species in the world. In terms of plant diversity India ranks 10th in the world and 4th in the Asia (Nayaka *et al.,* 2010).

Lichens can be classified mainly into five growth forms: *viz.,* 1. Crustose, 2. Foliose, 3. Fruticose 4. Squamulose and 5. Leprose 6. Placodioid. Crustose lichens are those that closely attached to the substratum like trees, side walls or soils and they cannot be removed without damaging the substrate *viz., Xanthoria*. Loose, powdery lichen crusts without a layered structure called Leprose lichens *viz., Chrysothrix*. Foliose lichens are leaf-like structures, composed of lobes and can be detached to their substrates very easily *viz., Lobaria*. Fruticose lichens are usually round in cross section and most are branched. They can like little shrubs growing upward, or they can hang down in long strands viz. *Usnea longissima*. In Squamulose Lichen the thallus is in the form of minute lobes, having dorsiventral differentiation like some species of *Cladonia.* In case of Placodioid Lichens the thallus is closely attached to the substratum at centre and lobate or free at the margin, but lacking rhizinae.

Based on their habitat lichens can be categorized into six types *viz.,* Lignicolous (on woods), Corticolous (on bark), Saxicolous (on rock), Marine (sores of sea), Freshwater (on siliceous rock), Terricolous (on Soil). Based on their Internal Structure: 1. Heteromerous lichens (Photobiont cell filaments are stratified in a layer) 2. Homoiomerous lichens (when two symbionts are uniformly distributed). Based on their fungal partner: Zahlbruckner (1907, 1926) divided the lichens into following 3 sub-classes on the basis of their fungal partner: 1. 1. Ascolichens (Fungus belongs to Ascomycetes), Basidiolichens (Fungus belongs to Basidiomycetes), and Hymenolichens (Fungus belongs to Deuteromycetes) where algal partner belongs to members of Chlorophyceae, Cynophyceae and rarely to Xanthophyceae and Phaeophyceae (Awasthi, 2000).

LICHENS HAVE VAST HISTORY IN MEDICINES

In India, lichens mainly used in Medicine, flavouring, dyeing, smoking tobacco, cigars, spices, scenting soaps, and cosmetics and manufacture of Dhoop and Hawan Samagri (Singh and Sinha,1997). Written in the 15th century, the Doctrine of Signatures stated that a plant could be used to treat diseases that were most likely caused by nature. This led to the development of Phyto-therapeutics that are used in traditional medicines (TIM) or Ayurveda. Records of Medicinal plants in India also shows the word ‘Shipal’ (algae) in Rigveda, in which a medicine named "Oushadhi" had been described (Nayaka *et al.,* 2010). Subsequently a number of Sanskrit synonyms of lichens, for example, 'Shailaya' and 'Shilapushp' have been described in Sushruta Samhita (1000 BC), Charaka Samhita (300-200 BC) and several Nighantu (1100-1800 AD). Chharila is widely known Ayurvedic medicine used in ancient system of Indian medicine, for different human disorders, e.g., headache, skin disorder, diarrhoea, leprosy and urinary trouble etc (Nayaka *et al.,* 2010).

Evernia furfuracea lichen has been found in an Egyptian vase since 18th Dynasty (1700-1600 BC) it was used in the form of medicine (Llano, 1948). The word lichen is derived from Greek word 'Leprous' and refers to lichens in treating skin diseases as they also has their peeling-skin appearance. Lichen like *Lobaria pulmonaria* (L.) Hoffm. and *Parmelia sulcata* Taylor (Parmeliaceae) have been used in the treatment of pulmonary and cranial diseases, respectively since the ages (Rizzini, 1952).

The source of Lichen chemical are basically their Metabolites produced by mycobiont by three pathways *viz.,* Shikimic Acid Pathway, Mevalonic Acid Pathway and Acetyl-Polymalonyl Pathway (Susana *et al.,* 2005). In this study Susana and co-workers have also provided the metabolites with their respective pathways. About 800 metabolites are produced by lichens and many are still unidentified to the mankind (Huneck and Yoshimura, 1996). On other hand Bousite and Grube have also published a paper on diversity of lichen metabolite, their pattern of evolution and genes involved in the production of metabolites.

LICHENS USED AS MEDICINES IN INDIA:

India represents 2450 lichen species (Singh and Sinha, 2010; Nayaka and Upreti, 2013) which, accounts 14% of the world lichen population. Out of this total number, 137 lichens have medicinal values. Most of all the lichen species (57) have antioxidant property, while a large number (55) has antibacterial capacity and some (37) has properties to treat cancer and cytotoxicity (Table 1).

Table 1. Important Lichen species used in different Human Aliments

Lichen Species	Metabolites/ Extract	Disease Name (Effective against)	References
Acarosporaceae			
Acarospora gobiensis H. Magn.	Acarogobien A, B	*Bacillus subtilis, Staphylococcus aureus*	Řezanka and Guschina 1999
Caliciaceae			

Acroscyphus sphaerophoroides Lév.	Methanol Extract	Bacteria- *Bacillus cereus, B. subtilis, Enterobacter aerogens, Escherichia coli, Klebsiella pneumoniae, Micrococcus luteus, Proteus mirabilis, Pseudomonas aeruginosa, Salmonella typhimurium, Staphylococcus aureus, Streptococcus pneumoniae* Fungi- *Aspergillus flavus, A. nidulans, A. niger, A. sulphuricus, A. terreus, Candida albicans, Cryptococcus albidus, Trichophyton rubrum.*	Singh *et al.*, unpublished data
Alectoriaceae			
Alectoria ochroleuca (Hoffm.) Massal.	Methanol Extract	Cancer chemopreventive and cytotoxic activity	Ingólfsdóttir *et al*., 2000.
Arthoraphidaceae			
Arthoraphis alpina (Schaer.) R. Sant. in D. Hawksw., P. James and Coppins	Alcohol Extract	Cytotoxicity against slow growing BS-C-1 cells	Perry *et al.*, 1999
Arthoniaceae			
Arthothelium awasthii Patw. and Kulk.	Methanol Extract and Barbatic acid	Anti-oxidant activity includes lipid peroxidation and tyrosinase enzyme activity	Verma *et al.*, 2008a, 2008b
Parmeliaceae			
Bulbothrix setschwanensis (Zahlbr.) Hale	Acetone and Methanol Extract	Inhibition of tyrosinase and xanthine oxidase activity	Behera and Makhija 2002
Cetraria aculeata (Schreb.) Fr.	The acetone Extract and Protolichesterinic acid	*Escherichia coli, Staphylococcus aureus, Aeromonas hydrophila, Proteus vulgaris, Streptococcus faecalis, Bacillus cereus, Bacillus subtilis, Pseudomonas aeruginosa*, and *Listeria monocytogenes, Salmonella typhimurium.*	Zeytinoglu *et al*., 2008
Cetraria islandica (L.) Ach.	Aqueous Extract, Methanol Extract, Protolichesterinic acid	Cancer chemopreventive and cytotoxic activity, antibacterial activity against *M. aurum*	Bachereau and Asta 1997
Cetrelia braunsiana (Muell. Arg.) W. Culb. and C. Culb.	Methanol Extract	*Bacillus cereus, B. subtilis, Enterobacter aerogens, Escherichia coli, Klebsiella pneumoniae, Micrococcus luteus, Proteus mirabilis, Pseudomonas aeruginosa,*	Singh *et al.*

		Staphylococcus aureus, Streptococcus pneumoniae *Aspergillus flavus, A. nidulans, A. niger, A. sulphuricus, A. terrcues, Candida albicans, Cryptococcus albidus, Trichophyton rubrum*	
Cladoniaceae			
Cladia aggregata (Swaerz.) Nyl.	Alcohol Extract, Methanol Extract	*Bacillus subtilis, Trichophyton mentagrophytes,* cytotoxicity against murine leukemia cells and slow growing BS-C-1 cells, *Bacillus subtilis, Propionibacterium acnes* and *Staphylococcus aureus*	Turner *et al.,* 1980
Cladonia chlorophaea (Flörke in Sommerf.) Spreng.	Boiled thallus	Used to wash sores, and immunity booster	Turner *et al.,* 1980
Cladonia coccifera (L.) Willd.	Boiled thallus	Immunity Booster	Vartia 1973
Cladonia crispata (Ach.) Flotow	Water-soluble polysaccharides	Antitumor activity	Nishikawa *et al.,* 1974
Cladonia deformis (L.) Hoffm.	Boiled Thallus Extract	Pulmonary tuberculosis and cough	Vartia 1973
Cladonia fimbriata (L.) Fr.	Alcohol Extract	Antimicrobial activity against *Bacillus subtilis, Candida albicans, Trichophyton mentagrophytes* and cytotoxicity against murine leukemia cells and slow growing BS-C-1 cells	Perry *et al.,* 1999
Cladonia furcata (Huds.) Schrad.	Methanol Extract	Exhibited cancer chemopreventive, cytotoxic activity	Ranković *et al.,* 2007
Cladonia humilis (With.) J. Laundon	Methanol Extract	Exhibited superoxide dismutase like activity	Yamamoto *et al.,* 1998
Cladonia pyxidata (L.) Hoffm.	Crushed Lichen	Symptoms that include hurried feeling, but less anxious and nervous; bloated abdomen, disorientation, uncertainty, dryness of tongue, lips, throat, skin and rectum; tired and yet sleeplessness, desire for open air; difficulty in breathing in hot room	Rogers, internet
Cladonia rangiferina (L.) Webber ex Wigg.	Dried thalli powder	Newborn baby bather, removing kidney stones	Vogel 1970

Coccocarpiaceae			
Everniastrum cirrhatum (Fr.) Hale	Alcohol Extract	Against murine leukemia cells and slow growing BS-C-1 cells	Perry *et al.,* 1999
Collemataceae			
Collema flaccidum (Ach.) Ach.	Bianthraquinone glycosides, Colleflaccinosides	Antitumor activity	Řezanka and Dembitsky 2006
Verrucariaceae			
Dermatocarpon miniatum (L.) Mann	Methanol Extract	Antimicrobial activity	Aslan *et al.,* 2006
Thelotremataceae			
Diploschistes scruposus (Schreber) Norman	Acetone Extract	*Bacillus cereus, B. megaterium, Staphylococcus aureus* and *Klebsiella pneumoniae*	Saenz *et al.,* 2006
Parmeliaceae			
Evernia divaricatica (L.) Ach.	Methanol Extract	Antimicrobial activity, immunity Booster	Aslan *et al.,* 2006
Evernia prunastri (L.) Ach.	Methanol Extract, Methanol Extract	Antibacterial (*Staphylococcus aureus, Bacillus mycoides, B. licheniformis, Mycobacterium phlei*) and antifungal (*Actinomyces sulfuroides, Tricophyton farineculatum, T. interdigitalis, Epidermophyton inguinale*	Bustinza 1952, Aslan *et al.,* 2006
Everniastrum cirrhatum (Fr.) Hale	Chharila, Aqueous Extract, Ethanol Extract	Useful in dyspepsia, spermatorrhoea, amenorrhoea, calculi, diseases of blood and heart, stomach disorders, enlarged spleen, bronchitis, bleeding piles, scabies, leprosy, excessive salivation, soreness of throat, tooth-ache and general pain	Chandra and Singh 1971, Gupta *et al.,* 2007
Everniastrum nepalense (Taylor) Hale	Antiproliferative agents	against human keratinocyte line HaCaT and also inhibited the leukotriene B4 biosynthesis	Kumar and Muller 1999a, b
Flavoparmelia caperata (L.) Hale	Usnic acid	Antibacterial activity	Gupta *et al.,* 2007
Graphidaceae			

Graphina acharii (Fée) Müll. Arg., *G. adscribens* (Nyl.) Müll. Arg., *G. glaucorufa* (Vainio) Zahlbr., *G. glaucorufa* (Vainio) Zahlbr., *G. multistriata* Müll. Arg., *G. norlabiata* Patw. and Kulk., *G. adscribens* (Nyl.) Müll. Arg., *G. glaucorufa* (Vainio) Zahlbr. , *G. multistriata* Müll. Arg., *Graphina norlabiata* Patw. and Kulk., *Graphina nylanderi* Patw. and Kulk., *Graphina perstriatula* (Nyl.) Zahlbr., *Graphina salacinilabiata* Patw. and Kulk., *Graphina simulans* (Leighton) Müll. Arg.,	Methanol Extracts	Inhibitory properties of tyrosinase and xanthine oxidase	Behera *et al.,* 2003, 2004, 2006
Graphis assamensis Nagar. and Patw ,	Similar to *Graphina acharii*	Inhibitory properties of tyrosinase and xanthine oxidase	Behera *et al.,* 2003, 2004, 2006

G. exalbata Nyl., *G. garoana* Nagar. and Patw., *G. glauconigra* Vainio, *G. guimarana* Vainio, *G. hossei* Vainio, *G. inamoena* Zahlbr., *G. inquinata* (Knight and Miller) J.D. Hooker, *G. nakanishiana* Patw. and Kulk. , *G. patwardhanii* Kulk. , *G. persicina* Mey and Flotow, *G. persulcata* Stirton, *G. pyrrhocheiloides* Zahlbr.,			
Graphis scripta (L.) Ach.	Methanol Extract	Inhibition of tyrosine activity, Epstein-Barr virus activation induced teleocidin B-4	Yamamoto *et al.,* 1998
Graphis sikkimensis Nagar. and Patw., *G. sorediosa* Nagar. and Patw.	Similar to *Graphina acharii*	Similar to *G. acharii*	Behera *et al.,* 2003, 2004
Physciaceae			
Heterodermia diademata (Taylor) D.D. Awasthi	Paste	On cuts and wound as plaster, Immunity Booster	Saklani and Upreti 1992
Heterodermia microphylla (Kurok.) Skorepa	Seconadry Metabolites	Antimicrobial activity	Santos *et al.,* 2004

Heterodermia podocarpa (Bél.) D.D. Awasthi	Methanol Extract	Exhibited anti-oxidant activity, Immunity booster	Verma *et al.,* 2008a, b
Heterodermia leucomelos (L.) Poelt	Ethanol Extract	Antibacterial activity against *Mycobacterium tuberculosis*	Gupta *et al.,* 2007
Parmeliaceae			
Hypogymnia enteromorpha (Ach.) Nyl.	Methanol Extract	Inhibition of tyrosine and superoxide	Yamamoto *et al.,* 1998
Hypogymnia physodes (L.) Nyl.	Methanol Extract	*Bacillus mycoides, B. subtilis, Staphylococcus aureus, S. albus*, *Sarcina lutea, Propionibacterium acnes, Enterobacter cloacae, Escherichia coli, Klebsiella pneumoniae* and fungi *Aspergillus flavus, A. fumigatus, Botrytis cinerea, Candida albicans, Fusarium oxysporum, Mucor mucedo, Paecilomyces variotii, Penicillium purpurescens, P. verrucosum, Trichoderma harzianum*	Yamamoto *et al.,* 1998, Ranković *et al.,* 2007, 2008
Hypogymnia tubulosa (Schaer.) Havaas	3-hydroxyphysodic acid	Antimicrobial activity against *Aeromonas hydrophila, Bacillus cereus, B. subtilis, Escherichia coli, Klebsiella pneumoniae*	Yilam *et al.,* 2005
Umbilicariaceae			
Lasallia pustulata (L.) Mérat	The acetone and methanol Extracts	*Aspergillus flavus, A. fumigatus, Botrytis cinerea, Candida albicans, Fusarium oxysporum, Mucor mucedo, Paecilomyces variotii, Penicillium purpurescens, P. verrucosum, Saccharomyces cerevisiae, Trichoderma harzianum*	Ranković *et al.,* 2007
Lecanoraceae			
Lecanora muralis (Schreb.) Rabenh. *em* Poelt	Usnic acid and Acetone Extract	Antibacterial activity against *Bacillus cereus, B. megaterium, Staphylococcus aureus*	Saenz *et al.,* 2006
Collemataceae			
Leptogium cyanescens (Rabenh.) Koerb.	Alcohol Extract	Cytotoxicity against murine leukemia cells	Perry *et al.,* 1999
Parmeliaceae			
Lethariella cashmeriana Krog	Sub-ingredient of	Antimicrobial activity	Wang *et al.,* 2001

	some treatments		
Lobaria discolor (Bory in Del.) Hue	Methanol Extract	Antibacterial and antifungal activity	Singh *et al.,* unpublished data
Lobaria isidiosa (Mull. Arg.) Vainio, *Lobaria japonica* (Zahlbr.) Asahina, *Lobaria pseudopulmonaria* Gyeln.	Polysaccharides	Antitumor agent	Takahashi 1974
Lobaria quercizans Michaux, *Lobaria retigera* (Bory) Trevisan	Stored after drying	Tonic effect on the body systems, Inc. Immunity	Smith 1923, Hu *et al.,* 1980
Mykoblastaceae			
Mykoblastus sanguinarius (L.) Norman	Methanol Extract	Exhibited superoxide dismutase like activity	Yamamoto *et al.,* 1998
Parmeliaceae			
Myelochroa entotheiochroa (Hue) Elix and Hale, *Myelochroa irrugans* (Nyl.) Elix and Hale	Methanol Extract	Inhibition of Tyrosin activity	Yamamoto *et al.,* 1998
Nephromataceae			
Nephroma expallidum (Nyl.) Nyl.	Methanol Extract	Exhibited cancer chemopreventive and cytotoxic activity	Ingólfsdóttir *et al*., 2000).
Parmeliaceae			
Parmelaria thomsonii (Stirton) D.D. Awasthi	Smoke of the lichen	To relive eye pain	Sinha and Singh 2005
Parmelia saxatilis (L.) Ach.	Organic Extract	Exhibited antibacterial against *Pseudomonas aeruginosa*	Ingólfsdóttir *et al.,* 1998
Parmelia squarrosa Hale	Methanol Extract	Antibacterial and antifungal activity	Singh *et al.,* unpublished data

Parmelia sulcata Taylor	Acetone, chloroform, diethyl ether, methanol and petroleum ether Extracts	*Aeromonas hydrophila, Bacillus cereus, B. mycoides B. subtilis, Enterobacter cloacae, Klebsiella pneumoniae, Listeria monocytogenes, Proteus vulgaris*	Candan *et al*., 2007, Ranković *et al.,* 2007
Parmotrema abessinicum (Krempelh.) Hale	Indigenous medicine	Rathipuvvu	Watt and Breyer-Brandwijk 1962, Llano 1951
Parmotrema austrosinense (Zahlbr.) Hale	Alcohol Extract	Showed beta-glucosidase inhibitor activity	Lee and Kim 2000
Parmotrema chinense (Osbeck) Hale and Ahti	Water tonic	Used in diarrhoea, dyspepsia, spermatorrhoea, amenorrhoea, dysentery and headache	Nadkarni 1976, Abdulla *et al.,* 2007).
Parmotrema dilatatum (Vain.) Hale	Metabolites isolated	Antimicrobial activity	Santos *et al.,* 2004
Parmotrema praesorediosum (Nyl.) Hale	Hexane, dichloromethane, ethyl acetate, acetone and methanol Extracts	Beta-glucosidase inhibitor activity, *Bacillus cereus, Corynebacterium diptheriae, Shigella flexnerii, Staphylococcus aureus, Vibrio cholerae* and *Candida albicans.*	Balaji and Hariharan 2007).
Parmotrema reticulata (Taylor) M. Choisy	Ethanol Extract	Antibacterial activity against, *Mycobacterium tuberculosis*	Gupta *et al.,* 2007
Parmotrema saccatilobum (Taylor) Hale	Methanol Extract	Inhibition of Epstein-Barr virus activation induced teleocidin B-4 and superoxide dismutase like activity	Yamamoto *et al.,* 1998
Parmotrema sancti-angelii (Lynge) Hale	Mixing the ash with mustard or linseed oil	To treat ring-worm	Brij Lal and Upreti 1995
Parmotrema stuppeum (Taylor) Hale	Methyl orsenillate, orsenillic acid, atranorin and lecanoric acid	Antioxidant activity and Immunity booster	Jayapraksha and Rao 2000
Parmotrema tinctorum (Nyl.) Hale	Methanol Extract, lecanoric acid	Exhibited lipid peroxidation and tyrosinase enzyme activity, anti-oxidant activity	Verma *et al.,* 2008a, b

Peltigeraceae			
Peltigera canina (L.) Willd.	Polysacchari des	Influence cells of the immune system	Omarsdottir *et al.,* 2005
Peltigera dolichorhiza (Nyl.) Nyl.	Alcohol Extract	Cytotoxicity against murine leukemia cells	Perry *et al.,* 1999
Peltigera horizontalis (Huds.) Raumg.	Water Extract	Antimicrobial activity and Immunity booster	Vartia 1973
Peltigera leucophlebia (Nyl.) Gyelin.	Tenuiorin and Methyl orsellinate	Inhibitory activity against 15-lipoxygenase from soybeans, 5-lipoxygenase from porcine leucocytes and proliferation of cultured human breast, pancreatic and colon cancer cell lines	Ingólfsdóttir *et al.,* 2002).
Peltigera membranacea (Ach.) Nyl. emend. Thomson	Alcohol Extract	Antimicrobial against *Bacillus subtilis, Trichophyton mentagrophytes,* cytotoxicity against murine leukemia cells and slow growing BS-C-1 cells	Perry *et al.,* 1999
Peltigera polydactylon (Neck.) Hoffm.	Crushed thallus	Cuts to stop bleeding and as an antiseptic,	Saklani and Upreti 1992
Peltigera praetextata (Flörke ex Sommerf.) Zopf	Acetone Extract	*Epidermatophyton floccosum, Microsporum audounii, M. canis, M. nanum, M. gypseum, Trichophyton mentagrophytes, T. rubrum, T. tonsurance, T. violaceum*	Shahi *et al.,* 2003
Peltigera rufescens (Weiss.) Humb., *Peltigera venosa* (L.) Hoffm.	Methanol Extract	Highest antioxidant activity	Odabasoglu *et al*., 2005
Pertusariacea e			
Pertusaria amara (Ach.) Nyl.	Methanol Extract	Intermittent fever	Smith 1921
Graphidaceae			
Phaeographin a caesiopruinosa (Fée) Müll. Arg., *P. noralboradian*	Similar to *Graphina acharii*	Similar to *Graphina acharii*	Behera *et al.,* 2003, 2004

s Patw. and Kulk., *P. indica* (Patw. and Nag.) Sipman and Aptroot, *P. angulosa* Muell. Arg. *P. submaculata* Zahlbr., *P. subritigrina* (Vainio) Zahlbr.			
Physciaceae			
Physcia aipolia (Ehrh. ex Humb.) Fürnr.	Atranorin	*Bacillus mycoides, B. subtilis, Staphylococcus aureus, Enterobacter cloacae, Escherichia coli, Klebsiella pneumoniae* and fungi *Aspergillus flavus, A. fumigatus, Botrytis cinerea, Candida albicans, Fusarium oxysporum*	Ranković *et al.,* 2008
Lobariaceae			
Pseudocyphellaria aurata (Ach.) Vainio	Water Extract	Antimicrobial activity	Sharnoff, internet
Parmeliaceae			
Punctelia rudecta (Ach.) Krog.	Extract	Exhibited antibacterial activity	Bustinza 1952
Ramalinaceae			
Ramalina celastri (Sprengel) Krog and Swinsc.	α-D-glucan polysaccharide	Activity against Sarcoma-180 tumor cells	Fazio *et al.,* 2007
Ramalina conduplicans Vainio	Methanol Extract	*Bacillus cereus, B. subtilis, Enterobacter aerogens, Escherichia coli, Klebsiella pneumoniae, Micrococcus luteus*	Singh *et al.,* unpublished data
Ramalina farinacea (L.) Ach.	Methanol and water Extract	Reduce HIV-I vector	Esimone *et al.,* 2005
Ramalina pacifica Asahina	Methanol Extract	Exhibited inhibition of tyrosine activity	Yamamoto *et al.,* 1998
Ramalina pollinaria (Westr.) Ach.	Methanol Extract	*Escherichia coli*, *Enterococcus faecalis*, *Proteus mirabilis*, *Staphylococcus aureus*, *Bacillus subtilis* and *B. megaterium*	Cansaran *et al.,* 2007
Ramalina sinensis Jatta	Methanol Extract	High antibacterial and antifungal activity	Singh *et al.,* unpublished data

Ramalina subfarinacea (Nyl.) Nyl.	Usnic acid and Acetone Extract	*Bacillus cereus, B. megaterium, Staphylococcus aureus* and *Klebsiella pneumoniae*	Saenz *et al.,* 2006
Rocellaceae			
Roccella montagnei Bel. em. D.D. Awasthi	Ethyl acetate, acetone, and methanol Extracts	*Staphylococcus aureus, Salmonella typhi, S. para typhi-B, Proteus vulgaris, Klebsiella pneumoniae, Candida albicans*	Balaji *et al.,* 2006
Peltigeraceae			
Solorina crocea (L.) Ach.	Methanol Extract	Exhibited cancer chemopreventive and cytotoxic activity	Ingólfsdóttir *et al*. 2000
Stereocaulaceae			
Stereocaulon alpinum Laurer	Lobaric acids and atranorin	*Mycobacterium aurum*, a nonpathogenic organism with sensitivity similar to the *Tuberculinum bacterium*	Ingólfsdóttir *et al*. 1998).
Stereocaulon foliolosum var. foliolosum Nyl.	Ethanol Extract	Antibacterial activity against virulent strain of *Mycobacterium tuberculosis* H37Rv	Gupta *et al.,* 2007
Stereocaulon foliolosum var. *strictum* (C. Bab.) Lamb.	Chew the raw thalli	Cure kidney stones	Sinha and Singh 2005).
Stereocaulon himalayense D.D. Awasthi *et* Lamb.	Water Extract	For urinary, trouble and blisters of tongue.	Saklani and Upreti 1992
Lobariaceae			
Sticta nylanderiana Zahlbr**.**	Crushed thalli	Excessive cough	Sinha and Singh 2005
Alectoriaceae			
Sulcaria sulcata (Lev.) Bystrek ex Brodo and D. Hawks.	Methanol Extract	Inhibition of Epstein-Barr virus activation induced teleocidin B-4 and superoxide dismutase like activity	Yamamoto *et al.,* 1998).
Imperfect lichen			
Thamnolia vermicularis var. *subuliformis* (Ehrh.) W. Culb.	Heteroglycans and a beta-glucan	immunomodulating activity	Omarsdottir *et al.,* 2007
Thamnolia vermicularis	Methanol Extract	Teleocidin B-4 and superoxide dismutase like activity	Bustinza (1952)

var. *vermicularis* (Swartz) Schaer			
Umbillicariaceae			
Umbilicaria cylindrica (L.) Delise ex Duby	Alcohol Extract	Cytotoxicity against slow growing BS-C-1 cells	Perry *et al.,* 1999
Parmeliaceae			
Usnea bismolliuscula Zahlbr.	Methanol Extract	*Bacillus subtilis, Propionibacterium acnes* and *Staphylococcus aureus*	Yamamoto *et al.,* 1998
Usnea ghattensis G. Awasthi	Methanol Extract	activity against *Bacillus licheniformis, B. megaterium, B. subtilis, Staphylococcus aureus*	Behera *et al.,* 2005a. 2005b, 2006, 2009; Verma *et al.,* 2008
Usnea longissima Ach.	Diffractaic acid and usnic acid	showed antioxidant activity	Bayir *et al.,* 2006, Odabasoglu *et al.,* 2004, 2006
Usnea montifuji Mot.	Methanol Extract	*Bacillus subtilis, Propionibacterium acnes* and *Staphylococcus aureus*	Yamamoto *et al.,* 1998
Usnea sikkimensis Biswas	Methanol Extract	remedy for lung troubles, haemorrhage and asthma, while powdered lichen used to strengthen hair	Biswas 1956
Usnea subflorida (Zahlbr.) Mot.	Usnic acid Extracted with acetone	*Escherichia coli*, *Enterococcus faecalis*, *Proteus mirabilis*, *Staphylococcus aureus*, *Bacillus subtilis* and *B. megaterium*	Cansaran *et al.,* 2006
Xanthoparmelia conspersa (Ach.) Hale	Water Extract	Exhibited antibacterial activity against *A. faecalis*	Bustinza 1952).
Xanthoparmelia coreana (Gyeln.) Kurok.	Methanol Extract	*Bacillus subtilis, Propionibacterium acnes* and *Staphylococcus aureus*	Yamamoto *et al.,* 1998
Xanthoparmelia pulla (Ach.) O. Blanco, A. Crespo, Elix & D. Hawksw.	Methanol Extract	Against colloidal bismuth subcitrate genotoxicity	Geyikoglu *et al.,* 2007
Teloschistaceae			
Xanthoria elegans (Links) Th. Fr.	Methanol Extract	Exhibited cancer chemopreventive and cytotoxic activity	Ingólfsdóttir *et al.*, 2000

Xanthoria fallax (Hepp) Arnold	Methanol Extract	Epstein-Barr virus activation induced teleocidin B-4 and superoxide dismutase like activity	Yamamoto *et al.,* 1998
Xanthoria parietina (L.) Th. Fr.	Methanol Extract	Exhibited cancer chemo-preventive and cytotoxic activity	Ingólfsdóttir *et al*., 2000

CONCLUSION AND FUTURE PERSPECTIVES

It is evident from the study that lichens offer a great source of remedies that can cure almost all the ailments of mankind. In spite of the variety of problems and challenges encountered in the drug discovery from various lichens, these lichens still play a significant role in isolation and prospects of finding new compounds from their culture extracts in the new era of medicines.

Further, researchers, government and communities all need to be aware of and care about the conservation and development activities of the lichens for future references.

REFERENCES

- Abdulla, S.T., Hamid, H., Ali, M., Ansari, S.H. and Alam, M.S. 2007. Two new terpenes from the lichen Parmelia perlata. *Indian Journal of Chemistry, Section B, Organic and Medicinal Chemistry.* **46**(1): 173-176.
- Ahmadjian, V. 1993. *The Lichen Symbiosis.* John Wiley and Sons: New York, NY. 250 pp.
- Aslan, A., Güllüce, M., Sökmen, M., Adıgüzel, A., Sahin, F. and Özkan, H. 2006. Antioxidant And antimicrobial properties of the lichens Cladonia foliacea, Dermatocarpon miniatum, Everinia divaricata, Evernia prunastri, and Neofuscella pulla. *Pharmaceutical Biology.* **44**(4): 247 – 252.
- Awasthi, D. D. 2000. *Lichenology in Indian subcontinent: A supplement to A hand book of lichens*. Bishen Singh Mahendra Pal Sin.
- Bachereau, F., and Asta, J. 1997. Effects of solar ultraviolet radiation at high altitude on thephysiology and biochemistry of a terricolous lichen (Cetraria islandica (L.) Ach. *Symbiosis.* **23**: 197-217

- Balaji, P., Bharath, P., Satyan, R.S. and Hariharan, G.N. 2006. In vitro antimicrobial activity of Roccella montagnei thallus Extracts. *Journal of Tropical Medicinal Plants.* **7**(2): 1531-1539.
- Balaji, P. and Hariharan, G.N. 2007. In vitro antimicrobial Activity of Parmotrema Praesoredioswn thallus Extracts. *Research Journal of Botany.* **2**(1): 54-59.
- Bayir, Y., Odabasoglu, F., Cakir, A., Aslan, A., Suleyman, H., Halici, M. and Kazaz, C. 2006. the inhibition of gastric mucosal lesion, oxidative stress and neutrophil-infiltration in rats by the lichen constituent diffractaic acid. *Phytomedicine*. **13**(8): 584-590.
- Behera, B.C. and Makhija, U. 2002. Inhibition of tyrosinase and xanthine oxidase by lichen Species Bulbothrix setschwanensis. *Current Science.* **82**(1): 61-66.
- Behera, B.C., Adawadkar, B. and Makhija, U. 2003. Inhibitory activity of xanthine oxidase and Superoxidase-scavenging activity in some taxa of the lichen family Graphidaceae. *Phytomedicine.* **10**: 536-543.
- Behera, B.C., Adawadkar, B. and Makhija, U. 2004. Capacity of some Graphidaceous lichens to Scavenge superoxide and inhibtion of tyrosinase and xanthine oxidase activities. *Current Science.* **87**(1): 83-87.
- Behera, B.C., Verma, N., Sonone, A. and Makhija, U. 2005a. Antioxidant and antimicrobial activities of lichen Usnea ghattensis in vitro. *Biotechnology Letters.* **27**: 991-995.
- Behera, B.C., Verma, N., Sonone, A. and Makhija, U. 2005b. Evaluation of antioxidant potential of the cultured mycobiont of a lichen Usnea ghattensis. *Phytotherapy Research* **19***:58*-64.
- Behera, B.C., Verma, N., Sonone, A. and Makhija, U. 2009. Optimization of culture conditions for lichen Usnea ghattensis G. Awasthi to Increase biomass and antioxidant metabolite production. Food Technol. *Biotechnol.* **47**(1): 7–12.
- Behera, B.C., Adawadkar, B. and Makhija, U. 2006. Tyrosinase-inhibitory activity in some
- species of the lichen family Graphidaceae. *Journal of Herbal Pharmacotherapy* **6**(1): 55-69.
- Biswas, K. 1956. Common medicinal plants of Darjeeling and the Sikkim Himalayas. Calcutta Bustinza, F. 1952. Antibacterial substances from lichens. *Economic Botany* **64**(4): 402-406.

- Bondarenko, V., Kelley, L., & Argyle, D. (2022). Fraction-ated Lichen Parmelia vagansExtract Exhibits Two distinct Antiproliferative Activities Against Human Cancer Cells.The FASEB Journal, 36.
- Candan, M., Yılmaz, M., Tay, T., Erdem, M. and Türk, A.Ö, 2007. Antimicrobial activity of
- extracts of the lichen Parmelia sulcata and its salazinic acid constituent. *Zeitschrift für Naturforschung* **62**(7-8): 619-21.
- Chandra, S. and Singh, A. 1971. A lichen crude drug (Chharila) from India. *Jour. Rese. Ind. Med.* **6**(4): 209-215.
- Cansaran, D., Kahya, D., Yurdakulol, E. and Atakol, A. 2006. Identification and quantification of usnic acid from the lichen Usnea species of Anatolia and antimicrobial activity. *Zeitschrift für Naturforschung* **61C**(11-12): 773-776.
- Cansaran, D., Atakol, O., Halici, M.G. and Aksoy, A. 2007. HPLC analysis of usnic acid in some *Ramalina* species from Anatolia and investigation of their antimicrobial activities. *Pharmaceutical Biology* **45**(1): 77-81.
- Esimone, C.O., Grunwald, T., Wildner, O., Nchinda, G., Tippler, B., Proksch, P. and Überla, K. 2005. In vitro pharmacodynamic evaluation of antiviral medicinal plants using a vector-based Assay technique. *Journal of Applied Microbiology.* **99**(6): 1346-1355.
- Fazio, A.T, Adler, M.T., Bertoni, M.D., Sepúlveda, C.S., Damonte, E.B. and Maier, M.S. 2007. Lichen secondary metabolites from the cultured lichen mycobionts of Teloschistes Chrysophthalmus and Ramalina celastri and their antiviral activities. *Zeitschrift für Naturforschung*. **62**(7-8): 543-9.
- Gaikwad, S. B., Mapari, S. V., Sutar, R. R., Syed, M., Khare, R., & Behera, B. C. (2023). In vitro and in silico studies of lichen compounds atranorin and salazinic acid as potential antioxidant, antibacterial and anticancer agents. Chemistry & Biodiversity, 20(12), e202301229. https://doi.org/10.1002/cbdv.202301229
- Geyikoglu, F., Turkez, H. and Aslan, A. 2007. The protective roles of some lichen species on colloidal bismuth subcitrate genotoxicity. *Toxicology and Industrial Health* 23(8): 487-492.
- Grover, P. K., and Seshadri, T. R. 1959. Chemical investigation of Indian lichens: Part XXIII–Imperfect lichens. *J. scient. ind. Res*, 238-240.

- Gupta, V.K., Darokar, M.P., Saikia, D., Pal, A., Fatima, A. and Khanuja, S.P.S. 2007. Antimycobacterial activity of lichens. *Pharmaceutical Biology* 45(3): 200–204.
- Hu, S.Y., Kong, Y, C. and But, P.P.H. 1980. *An enumeration of the Chinee materia medica*. The Chinese University Press. Hong Kong.
- Huneck, S. and Yoshimura, Y. 1996. *Identification of lichen substances.* Springer, Berlin, Heidelberg, New York.
- Ingólfsdóttir, K., Chung, G.A.C., Skúlason, V.G., Gissurarson, S.R. and Vilhelmsdóttir, M. 1998. Antimycobacterial activity of lichen metabolites in vitro. *European J. Pharmaceutical Sciences* **6**: 141-144.
- Ingólfsdóttir, K., Lee, S.K., Bhat, K.P.L., Lee, K., Chai, H., Kristinsson, H., Song, L.Y., Gills, J., Gudmundsdóttir, J.Th., Mata-Greenwood, E., Jang, M. and Pezzuto, J.M. 2000. Evaluation of Selected lichens from Iceland for cancer chemopreventive and cytotoxic activity. *Pharmaceutical Biology*. **38**(4): 313-317.
- Ingólfsdóttir, K., Gudmundsdóttir, G.F., Ögmundsdóttir, H.M., Paulus, K., Haraldsdóttir, S., Kristinsson, H. and Bauer, R. 2002. Effects of tenuiorin and methyl orsellinate from the Lichen Peltigera leucophlebia on 5-/15-lipoxygensases and proliferation of malignant cell Lines in vitro. *Phytomedicine***.** **9**: 654-658.
- Jayapraksha, G.K. and Rao, L.J. 2000. Phenolic constituents from the lichen Parmotrema Stuppeum (Nyl.) Hale and their antioxidant activity. *Zeitschrift für Naturforschung* **55**(11-12): 1018-22.
- Kumar, K.C. and Mueller, K. 1999b. Lichen metabolites 2: Antiproliferative and cytotoxic Acitivity of Gyrophoric, usnic and diffractaic acid on human keratinocyte growth. *J. Nat. Prod.* **62**(6): 821-823.
- Llano, G.A. 1948. Economic uses of lichen. *Economic Botany* **2:** 26.
- Llano, G.A. 1951. *Economic uses of lichen*. Ann. Rep. Smithis. Insti. Volume 385-422.
- Lee, K.A. and Kim, M.S. 2000. Glucosidase inhibitor from Umbelicaria esculenta. *Can. J. Microbiol.* **46**(11): 1077-81.
- Nadkarni, K.M. 1976. Indian materia medica. South Asia Books, India. Nishikawa, Y., Ohki, K., Takahashi, G., Fukuoka, F. and Emori, M. 1974. Studies on the watersoluble constituents of lichens. II. Antitumor polysaccharides of Lasallia, Usnea and Cladonia species. *Chem. Pharm. Bull*. **22**: 2692-2702.
- Nayaka S., Upreti D. K. and Khare R. 2010. Medicinal Lichens of India. In *Drugs from plants* (Ed. P.C. Trivedi). Avishkar Publishers, Distributors, Jaipur, India.

- Omarsdottir, S., Freysdottir, J., Barsett, H., Smestad, B. and Olafsdottir, E.S. 2005. Effects of lichen heteroglycans on proliferation and IL-10 secretion by rat spleen cells and IL-10 and TNF-Î± secretion by rat peritoneal macrophages in vitro. *Phytomedicine* **12**(6-7): 461-467.
- Odabasoglu, F., Aslan, A., Cakier, A., Suleyman, H., Karagoz, Y., Bayir, Y. and Halici, M. 2005. Antioxidant activity, reducing power and total phenolic content of some lichen species. *Fitoterapia* **76**: 216-219.
- Perry, N.B., Benn, M.H., Brennana, N.J., Burgess, E.J., Ellis, G., Galloway, D.J., Lorimer, S.D. and Tangney, D.J. 1999. Antimicrobial, antiviral and cytotoxic activity of New Zealand Lichens. *Lichenologist.* **31**(6): 627-636.
- Ranković, B., Mišić, M. and Sukdolak, S. 2007. Evaluation of antimicrobial activity of the Lichens Lasallia pustulata, Parmelia sulcata, Umbilicaria crustulosa and Umbilicaria Cylindrica. *Mikrobiologya.* **76**(6): 817-821.
- Ranković, B., Mišić, S. and Sukdolak, S. 2007. Antimicrobial activity of Extracts of the lichens Cladonia furcata, Parmelia caperata, Parmelia pertusa, Hypogymnia physodes and Umbilicaria polyphylla. *British Journal of Biomedical Science*. **64**(4): 143-148.
- Ranković, B., Mišić, M. and Sukdolak, S. 2008. The antimicrobial activity of substances derived from the lichens Physcia aipolia, Umbilicaria polyphylla, Parmelia caperata and Hypogymnia physodes. *World J. Microbiol. Biotechnol.***24**: 1239–1242
- Řezanka, T. and Guschina, I.A. 1999. Brominated depsidones from Acarospora gobiensis, a lichen of Central Asia. *J. Nat. Prod.* **62**: 1675-1677.
- Rezanka, T., Dembitsky, V.M. 2006. The colleflaccinosides, two chiral bianthraquinone Glycosides with antitumor activity from the lichen Collema flaccidum collected in Israel and Russia. *Natural Product Research.* **20**(10): 969-80.
- Rizzini, CT. 1952. The uses of lichens in medicine. *Bras Med*. **66**(38-39): 589-96.
- Rogers, R. Medicinal Lichens http://www.wildmushrooms.ws/c/document_library/get_file?- Uuid=3e2830ba-bc55-4385-869e-f5278c33a7d3&groupId=10128.
- Saklani, A. and Upreti, D.K. 1992. Folk use of lichens in Sikkim. *J. Ethnopharmacology* **37**:229-233.
- Santos, L.C., Honda, N.K., Carlos, I.Z. and Vilegas, W. 2004. Intermediate reactive oxygen and Nitrogen from macrophages induced by Brazilian lichens. *Fitoterapia* **75**: 473-479.

- Saenz, M.T., Garcia, M.D. and Rowe, J. G. 2006. Antimicrobial activity and phytochemical studies of some lichens from south of Spain. *Fitoterapia*. **77**(3): 156-159.
- Shahi, S.K., Patra, M., Dikshit, A. and Upreti, D.K. 2003. *Botanical antifungal drug fight fungal Infection*. Proc. Firtst National Interactive Meet on Medicinal and Aromatic Plants. (Eds. Mathur, A.K., Dwivedi, S., Patra, D.D., Bagchi, G.D., Sangwan, N.S., Sharma, A. and Khanuja, S.P.S.). CIMAP, Lucknow. Pp. 302-307.
- Sharnoff, S.D. www.lichen.com/usetaxon.html
- Singh, K.P. and Sinha, G.P. 1997. In Lichens. *Floristic diversity and conservation strategies in India.* Vol. I. Ed V. Mudgal and P.K. Hajra. Botanical Survey of India, Kolkata. 195−234 pp
- Sinha, G.P. and Singh. K.P. 2005. Macrolichens of Sikkim. Botanical Survey of India. Ministry of Environment and Forests, New Delhi, India.
- Smith, A.L. 1921. *Lichens. Chapter X. Economic and technical*. Cambridge Univ. Press. Smith, H.H. 1923. Ethnobotany of the Menomini Indians. Bull. of the Public Museum of City of Milwauke **4**(1): 60.
- Susana V., Edward H. and Nauk S. 2005. Raman Spectroscopy of hot deser, high altitude epiphytic lichens. *The Analyst.* **130** (5): 1−9.
- Takahashi, K., Takeda, T., Shibita, S., Inomata, M. and Fukroka, F. 1974. Polysaccharides of lichens and fungi VI. Antitumor active plysaccharides of lichens of Stictaceae. *Chem. Pharm. Bull.* **22**(2): 404-408
- Tuovinen, V. 2017. *Hidden Complexity of lichen symbiosis*. Swedish University of Agricultural sciences Uppsala. Pp. 7−40.
- Turner, N.J., Bouchard, R., Kennedy, D.I.D. 1980. *Ethnobotany of the Okanagan-Colville Indians of British Columbia and Washington*. Occasional papers of the British Provincial Museum. No. 21, Province of British Columbia.
- Vartia, K.O. 1973. *Antibiotics in lichens*. In The Lichens (Eds. Ahmadjian, V. and Hale, M.E.). Academic Press. New York and London. Pp 547-561.
- Verma, N., Behera, B.C., Sonone, A. and Makhija, U. 2008a. Lipid peroxidation and tyrosinase inhibition by lichen symbionts grown in vitro. *African Journal of Biochemistry Research* **2**(12): 225-231.

- Verma, N., Behera, B.C., Sonone, A. and Makhija, U. 2008b. Cell aggregates derived from Natural lichen thallus fragments: Antioxidant activities of lichen metabolites developed in Vitro. *Natural Product Communications* **3** (11): 1911-1918.
- Watt, J.M. and Breyer-Brandwijk, M.R. 1962. *The medicinal and poisonous plants of Southeastern and Eastern Africa.* E and S. Livingstone Ltd. Edinburgh and London.
- Wang. Li-S, Narui, T., Harada, H., Culberson, C.F. and Culberson, W.L. 2001. Ethnic Uses oflichens in Yunnan, China. *Lichenologist.* **104**(3): 345-349.
- Yamamoto, Y., Kinoshita, Y., Matsubara, H., Kinoshita, K., Koyama, K., Takahashi, K., Kurokawa, T. and Yoshimura, I. 1998. Screening of biological activities and isolation of Biological-active compounds from lichens. *Recent Res. Devl. In Phytochem.* **2**: 23-33.
- Yilam, M., Tay, T., Kivanc, M., Turk, H. and Türk, A.Ö. 2005. The antimicrobial activity of Extracts of the lichen Hypogymnia tubulosa and its 3-hydroxyphysodic acid constituent. *Zeitschrift für Naturforschung*. **60**(1-2): 35-8.
- Vogel, V.J. 1970. *American Indian medicine*. U. of Oklahoma Press. Norman.
- Watt, J.M. and Breyer-Brandwijk, M.R. 1962. The medicinal and poisonous plants of Southeastern and Eastern Africa. E and S. Livingstone Ltd. Edinburgh and London.
- Zahlbruckner A. 1907. *Lichenes (Flechten)*. B. Spezieller Teil. In: Engler A, Prantl K. Die natu¨rlichen Pflanzenfamilien. 1. Teil pp 49–249. Leipzig: W. Engelmann.
- Zahlbruckner, A. 1926. Lichenes. *Engler & Prantl, Die Naturlichen Pflanzenfamilien 2 Aufl*, **8:** 61-270.
- Zeytinoglu, H., Incesu, Z., Tuylu, B.A., Türk, A.O., Barutca, B. 2008. Determination of Genotoxic, antigenotoxic and cytotoxic potential of the Extract from lichen Cetraria aculeata (Schreb.) Fr. In vitro. *Phytotherapy Research*. **22**(1): 118 – 123.