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Antimicrobial activity of Lichens and their role in environmental monitoring

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ABSTRACT

Lichens are association of specific fungi and algae or cyanobacteria which are morphologically so intimately integrated that a third kind of organism, resembling neither of its components is formed. This review paper assesses the significance of lichens in maintaining ecosystem services and the use of lichen substances in medicines.

Lichens are suitable biomonitors due to their sensitivity to air pollution, their growth and distribution is influenced by a wide variety of primary (sulphur dioxide, nitrogen dioxide, fluoride) and secondary pollutants (peroxyacetyl nitrates, tropospheric ozone and sulphuric acid and nitric acid in acid rains).

The secondary metabolites of the lichen are active substances exhibiting activity against pathogenic microorganisms. Thus, lichens extracts can be used as natural antimicrobial agents for possible formulation of new drug to fight against pathogens.

Keywords: lichen; antimicrobial; antioxidant; bioindicators; biomonitoring

1.INTRODUCTION

Lichens are mutualistic association of a fungus (mycobiont) and a photosynthetic organism, either a green alga or cyanobacteria species (photobiont). This group comprises of a wide variety of growth forms like crustose, foliose and fruticose (Swinscow and Krog 1988). Lichen is a cosmopolitan taxon found in a wide variety of habitats throughout the world from tundras to temperate and tropical regions but its occurrence and distribution is restricted by its dependence upon the substrate and the habitat preference. Lichens are extremely diverse (Galloway, 1992; Hawksworth, 2001), and provide many services to the terrestrial ecosystem (Knops *et al*., 1991, 1996; Arseneault *et al*., 1997). They generally grow on rocks and non-fertile ground, as well as on other plants (epiphytes) (Fabin *et al*., 2005). Besides, having a functionally important role in ecosystems, lichen provide products that are used as food, fodder, dyes, perfumes (Kirmizigul *et al*., 2003) and also for curing many diseases like stomach disorder, diabetes, whooping cough, pulmonary tuberculosis, cancer and skin diseases (Vartia, 1973; Rankovic *et al*. 2011)

Lichens as indicators of air pollution

Various chemical contaminants are released into the environment as a result of deliberate or indeliberate human activities which can cause damage to property or any living organism. In general a wide variety of methods are available for estimation of such pollutants, one such approach is the use of organisms to indicate the availability of pollutants in an area over time. The utilization of living organisms for identification and qualitative determination of pollutants in the environment is called biological monitoring (Tonneijk and Posthumus, 1987; Conti and Cecchetti, 2001). These bioindicators are sensitive to specific pollutants and some are known to accumulate these chemical compounds in their tissues. Lichens are sensitive to air pollution due to the impact of pollutants on their primary metabolic functions (Brodo *et al.*, 2001; Wakefield and Bhattacharjee, 2011). Thus, they are known as the best bioindicator organisms of air pollution, due to susceptibility of species to pollutants, especially sulphur dioxide (Saxena *et al*. 2007), and also as biomonitors for trace element and heavy metal as they accumulate and deposit lead, zinc, sulfur, nitrogen, and radionuclides in their tissues (Nash, 1996 ; Garty, 2001). The lichens lack root system therefore they do not have access to soil nutrients, thus, depend on the deposition and absorption of water and nutrients from atmosphere. Hence, their tissues indicate the atmospheric sources of nutrients and contaminants (Hutchinson *et al*. 1996).

Lichens are sensitive and therefore susceptible to natural and anthropogenic disturbances as this group provide an early warning system to control detrimental effects of air pollutants. Of the many sources of air pollution, the most significant are burning of fossil fuels in industries and automobiles, which leads to production of sulfur (SO_x) and nitrogen oxides (NO_x), volatile organic compounds(VOC), and carbon dioxide (CO_2), which in turn contribute to acid rains, phototchemical smog and global warming (Duffus and Worth, 2006). As a result of degradation of air quality, the most sensitive lichen species may become locally extinct in urban areas or near industrial facilities, while a few, pollution tolerant species will survive and some may even flourish in sites with poor air quality (Riddell *et al.*, 2008). Lichens can be monitored in almost any season with relatively easy in-field identification that usually does not call for removing large samples from the field and carrying out elaborate laboratory analyses (Wakefield and Bhattacharjee, 2011).

Antimicrobial and antioxidant properties of lichens

Continuous and uncontrolled use of synthetic drugs may cause persistent lethal health effects, it is widely known that their long-term use often cause numerous side effects and sometimes the pathogens develop resistance against the drug (Karaman *et al*. 2003) also it has been reported that residues of these drugs can accumulate in food and also pose threat to environment (Waller, 2006). These disadvantages of synthetic drugs initiated emphasis to find new preparations which are of natural origin to control and prevent various diseases. Unlike synthetic drugs, bioactive natural products obtained from various natural sources have been found to have beneficial effects on the organism, without causing undesired effects. The usage of lichens in the medicines has been confirmed by numerous researches that establish presence of various biologically active substances in their structure (Chauhan and Abraham, 2013). For example, *Lobaria pulmonaria* and *Parmelia sulcata* have been used in the treatment of pulmonary and cranial diseases, respectively. Similarly, *Xanthoria parietina* is used to cure jaundice and *Letharia vulpina* in stomach diseases (Huneck, 1999; Kirmizigul *et al*., 2003; Malhotra *et al*., 2008). Innumerable primary and secondary metabolites with identified chemical structures are currently derived from lichens (Karagoz et al., 2010; Molnar and Farkas, 2010).

Generally, metabolites from lichens can be divided into two groups: primary metabolites and secondary metabolites. Primary metabolites include proteins, lipids, carbohydrates and other organic compounds are utilised by in lichen's in their metabolism and structure and secondary metabolites also known as lichens substances, are complex molecules that comprises of depsides, depsidones, dibenzofurans, xanthones and terpene derivatives. They are produced by the fungus or the alga part of Lichens, while others are exclusively produced by synergistic action of both partners in lichens. Secondary metabolites are usually insoluble in water and can be extracted into organic solvents like methanol and ethanol, their amount ranges from 0.1 to 10% of the dry weight of thallus and sometimes reaches 30% (Galun, 1988; Muggia *et al*., 2009). They can be used for their antiviral, antibacterial, antifungal, antiprotozoal, antiherbivore, antmutagenic, antioxidant, antitumor, antipyretic, anti-inflammatory activities (Huneck, 1999; Kosanic and Rankovic, 2011).

In fact the work of Nayaka *et al*. (2010), listed 137 species of lichens that are being used in antimicrobial, anticancer, antioxidant and anti-inflammatory activities. Yilmaz *et al*. (2003) investigated the antimicrobial activity of the chloroform, diethyl ether, acetone, petroleum ether, and ethanol extracts of the lichen *Cladonia foliacea* and its acidic constituents against bacteria and fungi. It was reported that the extracts and pure compounds alone were active against bacteria and the yeasts, Similarly, Odabasoglu *et al*. (2004) worked on the methanol extracts of two lichen species, *L. pulmonaria* and *U. longissima* for antioxidant activity by measuring the total phenolic contents. However, it exhibited a potent antioxidant activity and also showed a strong correlation between the reducing power and the total phenolic contents of the extracts. The extracts obtained from the lichen species also showed antimicrobial activity against some test microorganisms including bacteria and fungi. Kosanic and Rankovic (2010) analysed the antimicrobial potential of some extracts from some lichen species (*Lecanora atra, L. muralis, Parmelia saxatilis, P. sulcata* and *Parmeliopsis ambigua*) and showed that the aqueous extracts of these species didn't show any antimicrobial activity on any of the test microorganisms, whereas the acetone and methanol extracts of these species exhibited some activity with the test organisms.

II CONCLUSION

Lichens are composed of two different species consisting of a fungus and algae, living together in an obligate mutualistic relationship. The algae are either green algae or bluegreen algae/cyanobacteria they produce carbohydrates through photosynthesis which serve as food for the fungus, while the fungus physically protects the algae and provides it with water. Lichens inhabit a wide range of climatic conditions from the polar regions to the tropics. These groups of organisms are indispensible for terrestrial ecosystems due to the extensive variety of functional and biological roles in environment. They are important agents of biomonitoring indicating the ambient air quality of a particular location. The secondary metabolites from it can be used for treating an assortment of diseases ranging from stomach disorder to cancer, due to the antimicrobial properties of the lichen extracts and substances.

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