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CHEMICAL COMPOSITION AND BIOTECHNOLOGICAL POTENTIAL OF LICHENS FROM DESERT AND COASTAL OASES IN CHILE

Javiera Lagos[1,*], Mario Simirgiotis[1], Alfredo Torres-Benitez[2]

[1] Institute of Pharmacy, Faculty of Sciences, Austral University of Chile, Valdivia, Chile

[2] Chemistry and Pharmacy Program, Faculty of Sciences, San Sebastián University, Valdivia, Chile. *javiera.lagos01@alumnos.uach.cl

INTRODUCTION

Chile is characterized for being a country with multiple climatic conditions and climates that can be identified in its territory. The multiple natural resources present in these landscapes make Chile a country of high relevance in biotechnological knowledge, with extensive opportunities for the study of the molecular composition and secondary metabolites of multiple species.

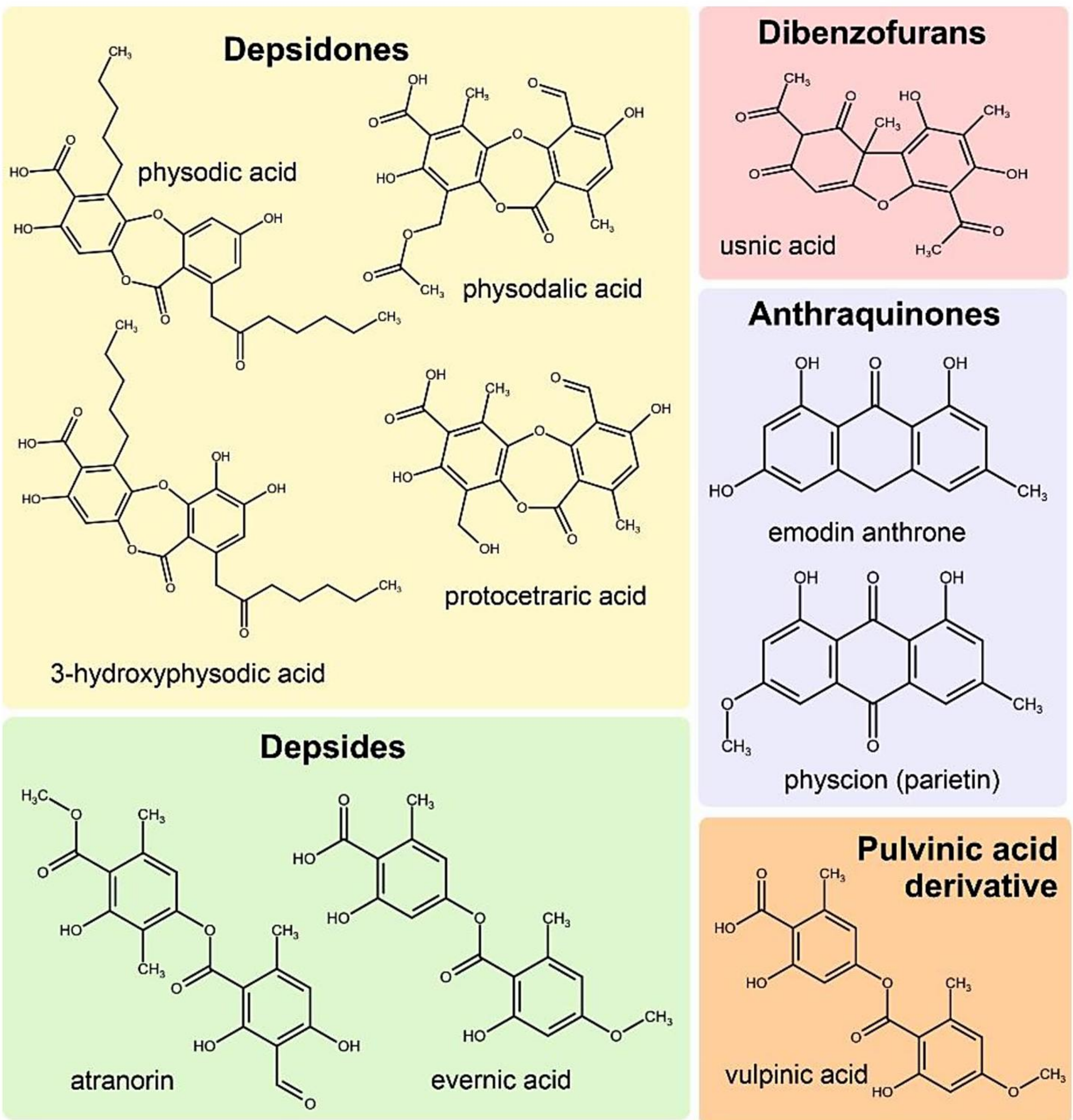

Figure 1: Five types of lichen compounds found in lichens[3].

The study of lichen biota in desert areas such as the Atacama Desert and the coastal fog oases has been a scarce topic[1], even though a long list of bioactive molecules has already been documented in these kinds of organisms[2,3]. For that reason, we don't have information regarding the composition of desert lichens and most of the conclusion regarding their potential as sources of biologically active compounds is made under generalization based on the available research done on different lichen species that share the same genus or family with desert species found in the Atacama Desert and related ecosystems.

Until a complete and specific research can be proposed for these species, it can be a useful approach to describe the presence of possible metabolites and the potential biological action that have been studied around them.

FAMILY	NUMBER OF SPECIES	EXAMPLES	SECONDARY METABOLITES OF PHARMACEUTICAL INTEREST [3,4,5,6,7,8,9,10,11]
Roccellaceae	24	*Roccellina cerebriformis, Opegrapha atacamensis*	Lecanoric acid*, lepraric acid*, roccellic acid*.
Caliciaceae	9	*Amandinea efflorescens, Buellia jorgensis*	Pulvinic acid*, usnic acid*
Physciaceae	8	*Heterodermia galactophylla, Physcia adscendens*	Atranorin*, lecanoric acid*, obtusic acid*.
Teloschistaceae	7	*Caloplaca rubina, Follmannia orthoclada*	Undetermined
Arthoniaceae	6	*Arthonia atacamensis, Arthothelium halophilum*	Undetermined
Ramalinaceae	6	*Niebla ceruchis, Ramalina peruviana*	Tumidulin*, usnic acid*, ramalin*, sekikaic acid*, norstictic acid*.
Chrysothricaceae	4	*Chrysothrix granulosa, Byssocaulon cf. niveum*	Undetermined
Graphidaceae	4	*Diorygma hololeucum, Redonographa chilensis*	Undetermined
Acarosporaceae	2	*Acarospora rouxii, Myriospora smaragdula*	Rhizocarpic acid*.
Candelariaceae	2	*Candelariella terrigena, Placomaronea kaernefeltii*	Pulvinic acid*
Rhizocarpaceae	2	*Rhizocarpon simillimum, Rhizocarpon superficiale*	Psoromic acid*
Arthopyreniaceae	1	*Arthopyrenia planorbis*	Undetermined
Megasporaceae	1	*Aspicilia aff. phaea*	Undetermined
Aspidotheliaceae	1	*Aspidopyrenis cf. insignis*	Undetermined
Porinaceae	1	*Porina cf. chilena*	Undetermined
Lecanoraceae	1	*Lecanora coquimbensis*	Atranorin*, usnic acid*.
Parmeliaceae	1	*Usnea rubicunda*	Usnic acid*, physodic acid*, protolichesterinic acid, diffractaic acid*, salazinic acid*, vulpinic acid*
Incertae sedis	1	*Roccellinastrum spongoideum*	Undetermined

Table 1: Lichen population in Alto Patache's coastal fog oases in the Atacama Desert and their secondary metabolites (*potential secondary metabolite, found in other species of the same genus/family).

We propose a literature review that ties the more representative lichen families of the Atacama Desert with the bioactive potential that has been associated with them, with the purpose to have a general idea of what lies in this specific population of Chilean biota.

METHOD

The literary review was conducted on multiple databases such as ***PubMed, Scielo and ScienceDirect*** and ***high-impact scientific publishers***. As part of the inclusion criteria, we considered the families with the highest number of species found in the Atacama Desert (Roccellaceae, Caliciaceae, Physciaceae, Teloschistaceae, Arthoniaceae and Ramalinaceae). We also considered some of the bioactive molecules and lichen species/families described in literature[2].

RESULTS & DISCUSSION

The most known lichen-derived secondary metabolites are ***atranorin, fumarprotocetraric acid, gyrophoric acid, salazinic acid, and usnic acid***[12]. These compounds have been characterized as ***antibacterial, anti-inflammatory and cytotoxic***.

Considering these qualities, we can associate certain bioactive potential to the most abundant families present in the Atacama Desert:

FAMILY	SECONDARY METABOLITES	ACTIVITY REPORTED
Caliciaceae	Pulvinic acid, Usnic acid	**TUMIDULIN** ❑ Significant antitumor activity on colorectal cancer stem cells at 5 µg/mL[13].
Physciaceae	Atranorin, Lecanoric acid, Obtusic acid	**USNIC ACID** ❑ Superoxide anion scavenging activity of ~60% (compared to 74% for ascorbic acid)[14]. ❑ Potent activity against Gram-positive pathogens. MIC values of 4−16 µg/mL against clinically relevant Gram-positive cocci and bacilli[15]. ❑ Cytotoxic effect over colon cancer (IC50 ~10 µg/mL, 72 h, no enantiospecificity), (+) enantiomer more effective against prostate cancer cells, notorious effect over breast câncer cells (IC50 15.8 and 20.2 µg/mL for (+)- and (−)-usnic acid, 72 h)[16].
Ramalinaceae	Tumidulin, Usnic acid, Ramalin	**ATRANORIN** ❑ Superoxide anion scavenging activity of ~60% (compared to 74% for ascorbic acid)[14]. **RAMALIN** ❑ DPPH IC50 = 3.14 µM. Ramalin derivatives maintain a DPPH IC50 = 12–14 µM and become more stable[17]. ❑ Ramalin derivative showed most effective BACE-1 inhibitory activity, with an IC50 value lower than that of the positive control[17]. ❑ Ramalin derivative exhibited the most significant inhibitory activity with an inhibition level of ~40% for p-tau.

Lichen species present in the Atacama Desert that belong to the Caliciaceae, Physciaceae and Ramalinaceae posses these phytochemicals protect against radiation, desiccation and consumption by herbivores, being excellent candidates for the generation of pharmaceuticals, cosmetics and natural antioxidants.

Nonetheless, it's required to identify the exact composition of these species, so there's certainty of the amounts present in reality.

CONCLUSIONS

Chilean desert lichens have shown to have the potential to be more important than the scientific community has given it credit for, not only as an ecosystem, but as a source of important molecules that can help create new and innovative products.

Considering this, the conservation of lichen biodiversity in desert areas can be proposed as a strategy in biotechnological innovation and in the research of extreme environments.

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