An Investigation into the Endophytic Medicinal and Biological Properties of *Solidago sempervirens*

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Abstract

The study of medicinal plants is a rapidly growing area of research. Historically, medicinal plants have been used in traditional medicine from which many modern medicines are inspired. Plant essential oils are promising natural products as they exhibit biological, medicinal, and nutritional properties. Endophytes are microbes that are found in plants and have symbiotic relationships with the plants they reside in. Endophytes are relatively less-studied microorganisms that present various benefits due to their bioactive metabolites.[1] The purpose of this research is to grow and isolate endophytes from a local plant and analyze the medicinal properties of this plant based on the compounds found in it.

Introduction

Solidago sempervirens, also known as seaside goldenrod, is a member of the Asteraceae family and is native to North America and parts of the Caribbean. Goldenrods have been used in traditional medicines to treat chronic nephritis, cystitis, rheumatism, and inflammation. They have also shown antioxidant, antibacterial, anti-cough, analgesic, antispasmodic, sedative, cardioprotective, antitumor, antifungal, and antihypertensive properties.[2] Goldenrod is most notable for treating urinary tract conditions and anti-inflammatory agents.[3] Extracts from goldenrod plants have shown antibacterial activity against both Gram-positive and Gram-negative bacteria. It has also been found that goldenrod extracts can have an antidepressant effect, as it shows effective action against neuroinflammation and antioxidant activity on the central nervous system.[4]

Experimental Procedure

Sample Collection, Preparation, and Plating

Seaside goldenrod was collected at Pickman Park in Salem, MA. This sample included a stem, leaves, and flowers. A portion of each part of the plant (stem, leaf, and flower) was obtained, washed, and sterilized. Each sterilized plant part was grown on a potato dextrose agar (PDA) plate.

Isolation and Extraction of Endophytes

The plates showing endophytic growth were re-plated onto new PDA plates. The pure endophytes from the leaf and flower were extracted from the plates and transferred to vials containing potato dextrose broth to grow further. Each broth sample was purified through extraction with ethyl acetate, isolating the endophyte metabolites.

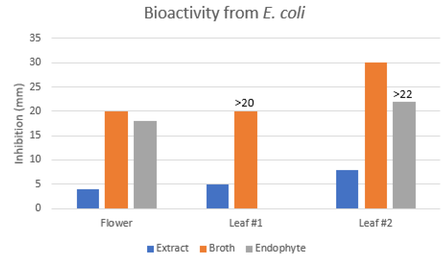
Bioactivity Test

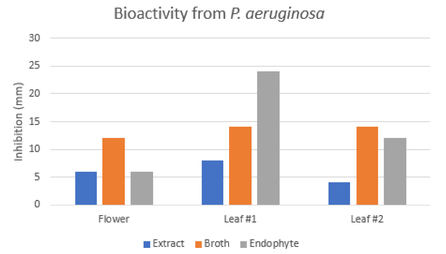
The bioactivity of all samples was tested against *E. coli*, *P. aeruginosa*, *S. aureus*, and *V. parahaemolyticus* by transferring the samples on PDA plates containing each bacteria. At 48 hours of incubation, bioactivity was determined for each sample by measuring inhibition zones.

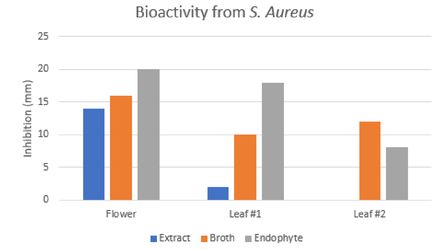
Identification of Endophytic Metabolites

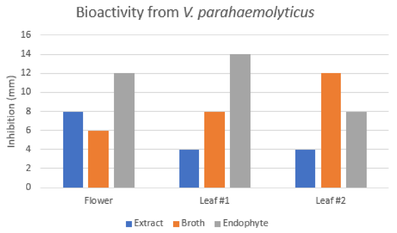
To identify bioactive metabolites produced by the endophytes, Liquid Chromatography Mass Spectrometry (LC-MS) was used. Compounds found in the LC-MS were analyzed for their medicinal properties.

Results from Bioactivity Test









Results from LC-MS Analysis

Table 1: Compound data found from LC-MS regarding allergy and pain relief

Sample(s)	Common Name	Uses	Structure
1. White fuzz leaf #2	Levomenthol	Used as a local anesthetic(loss of sensation) and analgesic (pain relief)	
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Desloratadine	Provides symptomatic relief of allergic symptoms (second generation antihistamine)	
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Anileridine	Useful for relief of moderate to severe pain; mild antihistamine, spasmolytic and antitussive effects	

Table 2: Compound data found from LC-MS regarding psychological health

Sample(s)	Common Name	Uses	Structure
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	(Z) Fluvoxamine	Used in antidepressant and antianxiety drugs; selective serotonin reuptake inhibitor (SSRI); used primarily for OCD	
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Barbital	Induces drowsiness or sleep; reduces psychological excitement or anxiety	
1. Black fuzz flower 2. White fuzz leaf #1	5-MeO-DiPT	Used recreationally as a psychedelic or hallucinogen	
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Imipramine	Used for the treatment of major depression, dysthymia, bipolar depression, attention-deficit disorders, agoraphobia, and panic disorders	
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Lisuride	Has a role as an antiparkinson drug, a serotonergic agonist, a dopamine agonist and an antispasmodic agent	

Table 3: Compound data found from LC-MS regarding reproductive and pediatric health

Sample(s)	Common Name	Uses	Structure
1. White fuzz leaf #1	Diethylstilbestrol	A chemical, nonsteroidal form of estrogen; induces chemical castration; treats menopausal and postmenopausal disorders	
1. White fuzz leaf #2	Norethindrone	Inhibits ovulation and changes normal cycle of cervical mucus and endometrium	
1. Black fuzz flower 2. White fuzz leaf #1	Taurine	Prevents nitrogen or weight loss in pediatric patients	

Table 4: Compound data found from LC-MS regarding bacterial control

Sample(s)	Common Name	Uses	Structure
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Neomethymycin	Antibiotic biosynthesized by *Strep. venezuelae*; Activity against *Bacillus subtilis* (gram +)	
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Troleandomycin	Used to treat bacterial infection; binds to bacterial ribosome to prevent protein synthesis (gram + and -)	
1. Black fuzz flower	Ethionamide	A second-line drug in the treatment of tuberculosis (gram +)	
1. Black fuzz flower 2. White fuzz leaf #1	Capreomycin IB	Used to kill a wide variety of bacteria; most commonly treats tuberculosis (gram +)	
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Maraviroc	Active agent against HIV and AIDS; inhibits HIV-1 entry via CCR5 coreceptor interaction	

Table 5: Compound data found from LC-MS regarding cardiac health

Sample(s)	Common Name	Uses	Structure
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Timolol	Used in management of glaucoma, hypertension, angina pectoris and myocardial infarction, and for the prevention of migraine	
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Aprinidine	Used to treat arrhythmias as a cardiac depressant	
1. White fuzz leaf #2	Dipyridamole	Inhibits platelet aggregation (vasodilator) to decrease thromboembolic complications and stroke	
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Dicumarol	Used as an anticoagulant; role as a vitamin K antagonist (reduces action of vitamin K, which reduces blood clotting)	
1. Black fuzz flower 2. White fuzz leaf #1	2,3-Dimercaptosuccinic acid	Counteracts the effects of poison; chelating agent (reacts with metal ions to form stable compound)	

Table 5: Compound data found from LC-MS regarding cancers and other illnesses

Sample(s)	Common Name	Uses	Structure
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Altretamine	A second therapy for advanced ovarian cancer (breakage of DNA strand to prevent cancer cells from multiplying)	
1. Black fuzz flower 2. White fuzz leaf #2	O-Phosphoethanolamine	Linked to Alzheimer's and cancer (breast, pancreatic)[5]	
1. Black fuzz flower 2. White fuzz leaf #1 3. White fuzz leaf #2	Imiquimod	Used to treat genital warts, superficial basal cell carcinoma (anti-tumor), and actinic keratosis	
1. Black fuzz flower	Calcium acetate	Used to treat hyperphosphatemia in patients with kidney disease	
1. Black fuzz flower 2. White fuzz leaf #2	Pralidoxime	Controls overdosage by anticholinesterase drugs used for myasthenia gravis	
1. Black fuzz flower 2. White fuzz leaf #2	2,3-dihydroxybenzoate	Used to treat heatstroke; Iron chelating agent; thermoregulation[6]	

All structures were obtained from http://www.chemspider.com/
All common names and uses were obtained from https://pubchem.ncbi.nlm.nih.gov/

Discussion and Conclusion

Goldenrod plants have shown antioxidant, antibacterial, anti-cough, analgesic, antispasmodic, sedative, cardioprotective, antitumor, antihypertensive, and antidepressant properties. All these properties correspond to compounds found in the LC-MS analysis. Table 1 includes compounds related to relief of pain, sedation, antihistamine, antispasmodic, and anti-cough abilities. Table 2 includes those related to psychological health, such as antidepressant behavior. Table 3 includes compounds related to reproductive health, which is an aspect of medicine not previously linked to goldenrod. Table 4 includes compounds with antibacterial effects. Compounds were found that kill both Gram-positive and Gram-negative bacteria. As seen in the bioactivity results, the goldenrod samples showed inhibition against all bacteria tested (both Gram-positive and Gram-negative). Table 5 includes compounds that are involved in cardiac health, such as antihypertensives. Table 6 includes compounds involved in the treatment of cancer and other illnesses. Additionally, several compounds found are anti-inflammatory, which is a quality found in goldenrod as a traditional medicine. The endophytes extracted from the goldenrod plant contain compounds that could be useful in future medicines. Future research should be conducted to investigate the possible use of goldenrod endophytes in cancer treatments. This would allow for more natural, less harmful treatments that would greatly benefit patients. Another new avenue of research would be to investigate the role that goldenrod endophytes could play in natural birth control methods.

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