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PHYTOCHEMICAL INVESTIGATIONS OF *SOLANUM VIRGINIANUM* L. IN THREE DIFFERENT GEOGRAPHICAL REGIONS

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Abstract:

Solanum virginianum L., commonly known as Indian nightshade or golden-berried nightshade, is a mystical member of the Solanaceae family with a rich history in traditional healing practices, particularly in Ayurveda. This study explores the medicinal potential of this enigmatic plant, encompassing various aspects of pharmacognosy, chemistry, pharmacology, and clinical applications. The research involves the collection of plant material from different regions and the extraction of bioactive compounds using various solvents. Phytochemical screening reveals the presence of alkaloids, glycosides, carbohydrates, proteins, phenols, flavonoids, and terpenoids in the plant extracts. Scanning electron microscopy (SEM) analysis uncovers the mineral content, including calcium, potassium, sodium, phosphorus, and copper, in *Solanum virginianum* leaves, providing insights into their nutritional value. Fourier transform-infrared spectroscopy (FT-IR) spectroscopic analysis identifies functional groups in the plant extracts, such as alcohols, amines, carboxylic acids, and more. The study sheds light on the diverse chemical composition and potential therapeutic properties of *Solanum virginianum*, with variations based on the extraction location and solvent. This research contributes to our understanding of the plant's medicinal significance and its potential applications in modern medicine.

1. Introduction

Solanum virginianum L., an enigmatic member of the Solanaceae family, known by the mystical monikers of Indian nightshade and golden-berried nightshade (1), is an ancient, revered figure in the botanical saga. Ayurveda, a timeless Indian healing tradition practised over millennia, serves as the epicentre of a grand exploration into the therapeutic potential of medicinal plants. This journey encompasses the vast landscapes of pharmacognosy, chemistry, pharmacology, and the art of clinical healing. The bedrock of this endeavour remains deeply rooted in nature's offerings, where the bountiful resources of plants, animals, and minerals have always been our allies in the quest for healing. Guided by the diligent hands of scientists, this journey has paved the path to the esteemed fortress of modern medicine, or allopathy, without forsaking its ancestral wisdom(2).Within this realm of herbal enchantment, plant-based remedies have flourished, casting their nurturing aura over a diverse array of health concerns, including those that affect the mind (3*). Solanum virginianum*, a botanical enigma, conceals within its leaves a treasury of healing components: glycosides, anthraquinones, flavonoids, sterols, saponins, and alkaloids, each a potent ingredient in its own right (4). This mystical plant plays a multifaceted role, acting as a vigilant antibacterial guardian, a valiant warrior against cancer, a soothing remedy for fever, an ally in alleviating inflammation, a guardian against allergies, a protector of fertility, a regulator of blood sugar, a staunch defender against free radicals, and a troubadour against histamine-related woes (5). The journey of exploration we embark upon in this quest delves deep into the essence of *Solanum virginianum's* leaves,

unraveling their secrets through the lenses of SEM and FTIR studies, spanning three different domains of this magnificent natural tapestry.

2. Materials and Methods

2.1 Collection of Plant material: The plant material(Leaves and fruits) were collected from Annamalai Nagar, Chidambaram and Kodaikanal. the collected plant material was taxonomically identified. The derived plant material was washed three times with tap water and then with distilled water. For two to three weeks the plant parts are dried in the shade.

2.2 Extract preparation: Shade-dried leaves are ground into a coarse powder (100g), which is then exposed to hot continuous extraction with ethanol, methanol, ethyl acetate, and petroleum ether using a soxhlet apparatus(in accordance with the solvent's boiling point).

2.3 Phytochemical screening

1.Test for alkaloids

Mayer's Test: To two ml of extract two ml of mayer's reagent was added(1.36 g mercuric chloride and 5.0 g of Potassium iodide in 100 ml). Formation of dull white or cream-coloured precipitate denotes the presence of alkaloids (6).

2. Test for glycosides

Lieberman's test: To two ml of extract, 2ml chloroform and 2 ml acetic acid was added. If the solution turns violet or blue green colour indicates the presence of glycosides.

Test for carbohydrates

Molisch's test: To two ml of extract was treated with a few drops of molisch's reagent(α-naphthol, 20% in ethyl alcohol). Then about one ml of concentrated sulphuric acid was added belatestedly along the sides of the tube. Formation of violet colour indicates the presence of carbohydrates.

Test for proteins and free amino acids: To two ml of extract was treated with 1 ml of Ninhydrin solution. The mixture was boiled on a water bath for 3-5 minutes. Appearance of blue to purple colour shows the presence of amino acids.

Test for Phenolic compounds and tannins

Ferric chloride test: To two ml extract, two ml of 5% ferric chloride (Prepared in ethanol) solution was added. Blue or dark green colour appeared indicates the presence of phenolic compounds and tannins.

Test for flavonoids

Sodium hydroxide test: To two ml of extract a few drops of 20% NaOH were added yellow colour will appear in the solution then a few drops of 70%HCI was added till yellow colour disappears' shows the presence of flavonoids.

Test for terpenoid

Salkowski test: Two ml of extract was mixed with 2 ml of chloroform and concentrated sulphuric acid was added carefully along the sides of tube to form a layer. A reddish brown colouration of the interface was formed to indicate positive results for the presence of terpenoids

2.4 SEM analysis ;

the mineral element constituents (calcium, potassium, sodium, phosphorus, copper) in *solanum virginianum* leave were analyzed separately using scanning electron microscope centralised instrumentation and service laboratory, Annamalai university.

2.5 Fourier transform –infrared spectroscopy (FT-IR) spectroscopic analysis

FT-IR analysis of ethanol leaf extracts of *Solanum virginianum* were carried out to identity the functional groups .about 1.0 mg of crude extracts of selected species were separately made into thin discs with 10-100 mg of potassium bromide using a mouid and pressed under anhydrous conditions .the pellets were measured in an automatic recording IR spectrophotometer (agilent resolutions pro, carry 630 FTIR agilent technologies, India)in the range of 800 to 3800 cm

The percentage of transmission was recorded against the wave number .the peak values of FT-IR were recorded and the functional groups were predicted (Mistry, 2009)

Results and discussion

The Phytochemical screening of *S. virginianum* showed the presence of various phytochemical constituents (Table No. 1 and 2). The major phytochemical constituent flavonoid is present in all leaf extracts of these three regions. Followed by alkaloids are present in all extracts of kodaikanal region. Glycosides, Phenols and terpenoids are present in almost all three regions of leaf extracts. Carbohydrates is strongly present in leaf extracts of kodaikanal region. Certainly, here's a simplified interpretation of the results. Alkaloids are found in the fruit extracts when using methanol and ethanol in Kodaikanal, Coimbatore, and Annamalai Nagar. Glycosides are present in various extracts, primarily in Coimbatore and Annamalai Nagar. Carbohydrates are detected in the methanol and ethanol extracts of all locations, as well as in the ethyl acetate extract from Coimbatore. Proteins are found in the ethanol extract from Kodaikanal and the petroleum ether extract from Coimbatore .Phenols are present in the methanol and ethanol extracts from Kodaikanal and Coimbatore. Flavonoids are generally found in most extracts, except for Annamalai Nagar's petroleum ether extract Terpenoids are detected in various extracts from Kodaikanal, Coimbatore, and Annamalai Nagar. These results provide insights into the types of chemical compounds present in the *Solanum virginianum* fruit, and their presence varies depending on the location and the type of solvent used for extraction.

SEM spectral analysis

Sem analysis of *Solanum virginianum* leaf sample the study further revealed that it is a good source of mineral content such as Calcium (Ca) - 1.17 mg/100g: There's a little bit of calcium in the leaves. Calcium is important for plants and for building strong bones in animals.. Potassium (K or Na) - 0.19 mg/100g: There's not much potassium in the leaves. Plants need it for growth. Sodium (Na) - 0.10 mg/100g: There's only a tiny amount of sodium in the leaves. It's necessary for plants and animals but not in large quantities. Phosphorus (P) - 0.39 mg/100g: There's a bit more phosphorus in the leaves. It helps with plant growth. Copper (Cu) - 1.02 mg/100g: There's a relatively higher amount of copper in the leaves. It's essential for various plant processes. These results help us understand the nutritional value of the leaves for both plants and animals, including humans, and can also indicate the overall health of the plant. Sem analysis result shown in Table no. 3

FT-IR spectral analysis

FT-IR analysis of ethanol leaf extracts of *Solanum virginianum* were carried out to identity the functional group according their wave number, molecular motion, functional group and absorption intensity presented in table 4. The FT-IR analysis of leaf extract showed some functional group such as 3744.099, 3280.041, 2919.967, 2853.210, 2319.617, 2222.233, 2106.613, 1910.100, 1618.176, 1542.556, 1375.860, 1316.283, 1244.935, 1019.878, 878.554, 814.266, and 774.980, the FT-IR spectrum of *Solanum virginianum* L. is shown in (figure 2).The leaves of *Solanum virginianum* contain various chemical groups ;Alcohol ,Aliphatic primary amine ,Alkene, Alkane, Carboxylic acid Nitrile, Carbodiimide, Aromatic ester, Amine. These groups are identified based on the specific wavenumbers where they absorb infrared light. The absorption intensities tell us how much of each group is present, with "strong" indicating a higher concentration and "medium" indicating a moderate concentration. In summary, this table provides information about the different chemical components present in the *Solanum virginianum* leaves and their relative concentrations.

S. No	Name of the Phytochemical tests	Kodaikanal				Coimbatore				Annamalai Nagar			
		M	E	E A	P	M	E	E A	P	M	E	E A	P
1.	Alkaloids	+	++	+	+	_	+	+	_	+	+	_	_
2.	Glycosides	_	+	_	+	+	+	_	+	_	+	+	+
3.	Carbohydrates	++	++	+	++	_	_	_	_	_	+	_	_
4.	Protein	_	_	+	+	_	+	+	+	_	_	_	_
5.	Phenol	++	+	+	+	_	+	+	_	+	+	_	−
6.	Flavonoid	++	+	++	++	+	+	+	+	+	+	+	+
7.	Terpenoid	+	+	+	++	+	+	_	+	+	_	+	+

Table.1 A preliminary phytochemical analysis in ethanolic extract of *Solanum virginianum*
M = methanol, E=ethanol, EA= ethyl acetate, P = petroleum ether

Table 2 A preliminary phytochemical analysis in ethanol extract of solanum virginianum fruit

S. No	Name of the Phytochemical tests	Kodaikanal				Coimbatore				Annamalai Nagar			
		M	E	EA	P	M	E	EA	P	M	E	EA	P
1.	Alkaloids	+	+	+	−	−	+	+	−	+	+	−	−
2.	Glycosides	−	+	−	+	+	+	−	+	−	+	+	+

3.	Carbohydrates	+	+	+	+	–	–	–	–	+	+	–	–
4.	Protein	–	–	+	–	–	+	+	+	–	–	–	–
5.	Phenol	+	+	+	+	–	+	–	–	+	+	–	–
6.	Flavonoid	+	+	+	+	+	+	+	+	–	+	+	–
7.	Terpenoid	+	+	–	+	+	+	–	+	+	–	+	+

M = methanol, E=ethanol, EA= ethyl acetate, P = petroleum ether

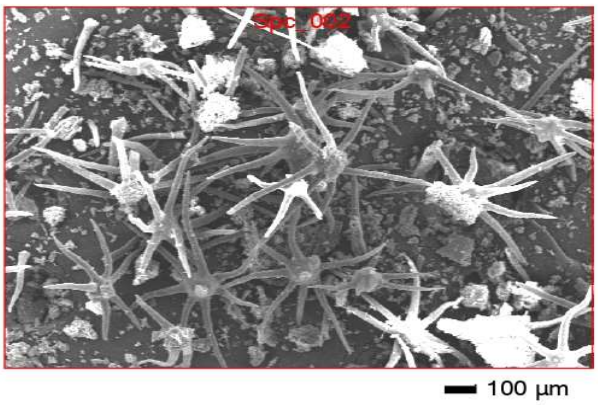
Table3 Element composition of *Solanum virginianum* L. leaf

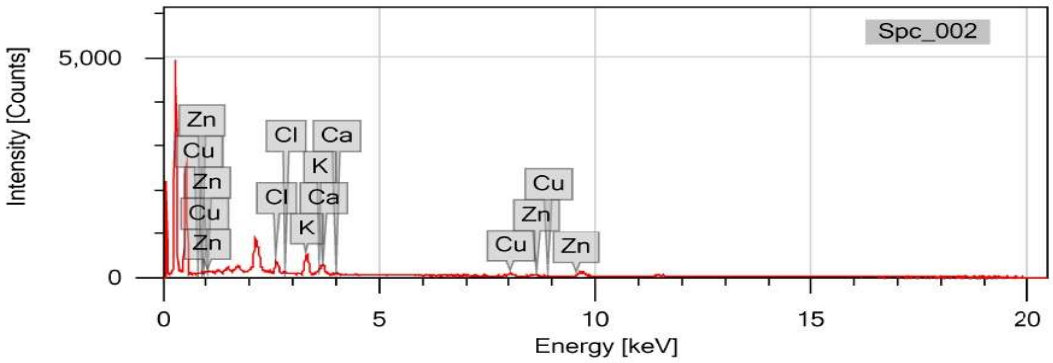
Mineral element	**Composition (mg/100g) of leaves**
Calcium, ca	**1.17**
Potassium, na	**0.19**
Sodium, na	**0.10**
Phosphorus,p	**0.39**
Copper (cu)	**1.02**

Table 4: FT-IR absorption and functional group of leaf of *Solanum virginianum*

S.No	**Wave number**	**Molecular motion**	**Functional group**	**Absorption intensity**
1	3744.099	O-H stretching	Alcohol	Medium sharp
2	3280.041	N-H stretching	Aliphatic primary amine	Medium
3	2919.967	C-H stretching	Alkene	Medium
4	2853.210	C-H stretching	Alkane	Medium
5	2319.617	O-H stretching	Carboxylic acid	Strong broad
6	2222.233	C=N stretching	Nitrile	Weak
7	2106.613	N=C=N stretching	carbodimide	Strong
8	1910.100	C=C=C stretching	Alkene	Medium
9	1618.176	C=C stretching	Alkene	Medium
10	1542.556	C=C stretching	Cyclic alkene	Medium
11	1375.860	C-H bending	Alkane	Medium
12	1316.283	O-H bending	Alcohol	Medium
13	1244.935	C-O stretching	Aromatic ester	Strong
14	1019.878	C-N stretching	Amine	Medium

15	878.554	C=C bending	Alkene	Strong
16	814.266	C-H bending	1,3-disubstituted	Strong
17	774.980	C-H bending	1,4-disubstituted	Strong





Element	Line	Mass%	Atom%
Cl	K	15.62±0.43	19.25±0.53
K	K	34.05±0.71	38.06±0.79
Ca	K	20.63±0.66	22.49±0.71
Cu	K	18.26±0.99	12.56±0.68
Zn	K	11.45±0.98	7.65±0.66
Total		100.00	100.00
Spc_002			Fitting ratio 0.9319

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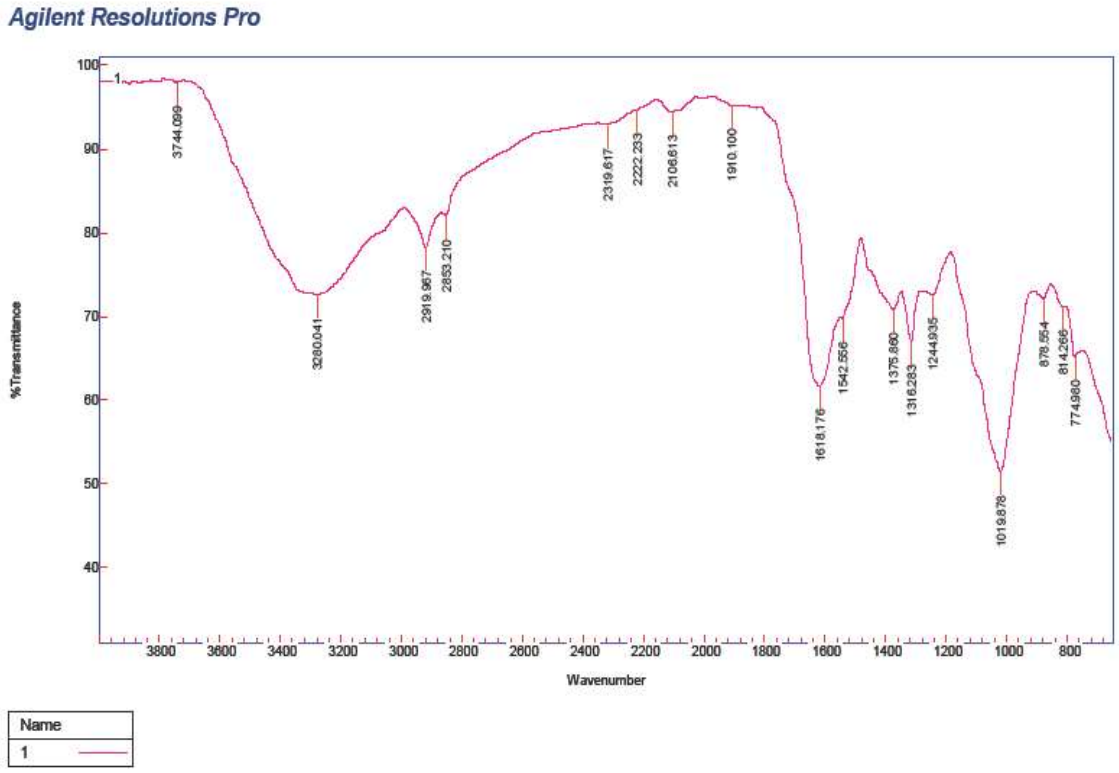

Conclusion

This comprehensive analysis of *Solanum virginianum* leaves sheds light on their diverse chemical composition and potential therapeutic applications. It serves as a valuable foundation for further research into the plant's medicinal and nutritional properties.

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