Research Article

FTIR Spectroscopic Screening of Phytochemicals of Two Medicinally Important Species of Solanum Used in Preparation of Dashmula Formulation.

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ABSTRACT

In the present study an attempt has been made to establish the preliminary FTIR profile of *Solanum anguivi* Lam. and *Solanum virginianum* L. These two plants are used in preparation of Dashmula formulation as they have therapeutic potential. FTIR spectral data indicates specific fingerprint region for the different species. Methanolic extracts of root, stem, leaf and fruit samples (fresh and dry) of *Solanum anguivi* and *Solanum virginianum* were analysed. From present analyses, characteristic functional groups such as amines, amides, alkanes, carboxylic acids, esters, amino acids, acid unhydrides, nitro compounds, aromatic compounds, aliphatic amines, ketones, phenols, sulfoxides and halogens were detected in the methanolic extracts of different plant parts of both these plants. Through this preliminary FTIR spectral analyses, species specific information has been documented for both the species of *Solanum* under investigation.

Keywords: FTIR, dashmula, *Solanum anguivi*, *Solanum virginianum*.

INTRODUCTION

Fourier Transform Infrared Spectrophotometer (FTIR) can be employed to determine the functional groups in the structure of unknown composition and the intensity of the absorption spectra associated with molecular composition or content of the chemical group. It measures the vibrations of bonds within chemical functional groups and generates spectrum that can be regarded as a biochemical or metabolic "fingerprint" of the sample. By attaining IR spectra from plant samples, it might be possible to detect the minor changes of primary and secondary metabolites[1,2]. FTIR is the most powerful tool for the identification of the various types of chemical bonds (functional groups) present in compounds. The wavelength of light absorbed, is an attribute of the chemical bond as can be seen in the annotated spectrum. By interpreting the infrared absorption spectrum, the chemical bonds in a molecule can be determined[3].

Several years ago plants have been used in traditional medicine and comprise about 8000 species in India. The information of medicinal plants has been mounting up in the course of many centuries based on different medicinal systems such as Ayurveda, Unani and Siddha[4]. The World Health Organization (WHO) estimated that 80 % of the population of developing countries still relies on the traditional medicines[5]. Generally, all plant species are a rich source of secondary metabolites and are important source with a variety of structural arrangements and properties[6,7].

Plant natural product chemistry has played an active role in generating a significant number of candidate compounds in drug discovery programs[8]. The traditional medical sources indicate that out of 33 species of *Solanum*, two species are used in "Dashmula". In Ayurveda "Dashmula" means combination of roots of different ten plants together (*Aegle marmelos, Desmodium gangeticum, Gmelina arborea, Oroxylum indicum, Premna integrifolia, Solanum anguivi, Solanum virginianum, Stereospermum suaveolens, Tribulus terrestris, Uraria picta*). It comprises root of five trees (brihat panchmula) and root of five small herbs (laghu panchmula). *Solanum anguivi* Lam. (Bruhati) and *Solanum virginianum* L. (Kantkari) belonging to family Solanaceae, are used in preparation of dashmula[9].

Solanum virginianum L. (Kantkari) is a very prickly diffuse, bright green perennial herb, 2-3 m high; stems zigzag; prickles compressed, straight, yellow and shining; leaves ovate or elliptic, sinuate or sub pinnatified, hairy on both sides, petiole prickly. Flowers are small, in extra-axilliary few flowered cymes. Corolla is purple. Fruits are of 1.3 cm diameter berry, yellow or white with green veins, surrounded by enlarged calyx[10]. Native people of Cholistan desert use this plant in hepatobiliary disorders. In folk medicine, decoction of its root is used to treat phlegmatic cough while fever and decoction of its fruit is given in bronchial asthma. Whole plant decoction is very effective in skin diseases. Leaves juice with few seed of black pepper is a very useful remedy in joint pain. Whole plant decoction is given in case of jaundice[11]. In some places, whole plant and fruit are used for food purposes[12]. Solasodine is the principle alkaloid present in this plant along with that solasonine, solasodine, solamargine, solasocarpidine are also present[13,14].

Solanum anguivi Lam. (African eggplant) is a rare ethno-botanical plant found throughout non-arid part of Africa. *S. anguivi* is a shrub, up to 3 m tall with spreading branches, often prickly, bearing small, sessile stellate

hairs. Leaves are usually alternate, simple and sometimes opposite. The inflorescence is a raceme-like cyme, comprising about 5-15 flowers per inflorescence. The fruit is a subglobose berry 7-18 mm in diameter, smooth, green or white when young and red when ripe usually in clusters of up to 20 fruits. In Ghana they are used as an appetizer[15]. The roots are used as carminative and cough expectorant, nasal ulcers, asthma, difficult parturition, toothache, cardiac disorder, worm expeller, nervous disorder and fever. The leaves and fruits rubbed up with sugar are used as external application for itching[16]. Cholesterol lowering properties of saponin from *S. anguivi* has also been reported[17]. It has been reported that earlier, fruits and roots of this plant contains wax, fatty acids, alkaloid solanine and solanidine, disogenin, lanosterol, beta-sitosterol, solasornine, solamargine and solasidine[18-21].

FTIR provides biochemical profiles containing overlapping signals from a majority of the compounds that are present when whole cells are surely analyzed[22]. In the present investigation extracts of root, stem, leaf and fruit samples (fresh and dry) of *Solanum virginianum* and *Solanum anguivi* were analyzed. With this background the present study was aimed to report the main functional components present in leaves, root, stem and fruit of both these plants using FTIR spectrophotometer.

MATERIALS AND METHODS

Collection and processing of plant material

Plant material of *Solanum anguivi* was collected from Panhala, Dist: Kolhapur, Maharashtra, India (GPS- N 16^0 48.884' E 074^0 06.729') and *Solanum virginianum* was collected from Haripur, Dist: Sangli, Maharashtra, India (GPS- N 16^0 49.994' E 074^0 32.820'). The plants were identified at the Department of Botany, Shivaji University Kolhapur. Voucher specimens were prepared and deposited in the Herbarium of the Department of Botany, Shivaji University, Kolhapur. The collected samples were dried and were cut into small pieces and then ground into fine powder with a grinder. The powdered samples were bagged in black plastic bags and stored in an air tight container for further examination.

Preparation of extract

The fresh plant parts were directly ground and used for further analyses while the dried plant parts were powdered in mechanical grinder. 25g of each plant part (root, stem, leaves and fruits) was weighed; 100ml of methanol was added in each sample and continuous shaking was done for 12 hours on mechanical shaker. The extracts were filtered through Whatman No. 1 filter paper and stored in air tight glass vials in refrigerator. The stored extract was used for further analysis.

FTIR Spectroscopic analysis

All spectra were obtained with the aid of an OMNI-sampler attenuated total reflectance (ATR) accessory on a JASCO FTIR spectrophotometer (FTIR-4600) followed by previous methods with some modifications[22]. Small amount of each sample extract was respectively placed directly on the germanium piece of the infrared spectrometer with constant pressure applied. Data of infrared absorbance was collected over the wave number ranged from 4000 cm^{-1} to 650 cm^{-1}. The reference spectra were acquired from the cleaned blank crystal prior to the presentation of each sample replicate. All spectra were collected with a resolution of 4.0 - 1.0 cm and to improve the signal-to-noise ratio. Samples were run in triplicates. The FTIR spectrum of all samples was analyzed on the basis of peak values in the region of infrared radiation[24].

RESULTS AND DISCUSSION

The FTIR spectrum was used to identify the functional groups of the active components in plant samples based on the peak value in the region of infrared radiation[22]. The methanolic plant extracts were passed one after the other into the FTIR and the functional groups of the components were separated based on its peak ratio. The results of FTIR peak values and functional groups are represented in Figs.1-4 and Tables 1-8. The presences of various functional groups of different compounds were investigated. FTIR spectroscopy is proved to be a reliable and sensitive method for detection of biomolecular composition.

The absorption spectra of *S. anguivi* fresh and dry root sample extracts are shown in Fig.1 and Table 1 & 2. The band in fresh root extract was observed at 3618.77 cm^{-1} which represented occurrence of alcohols and phenol compounds. The band at 3333.36 cm^{-1} represented amine and amide compounds. The peak around 2940.91 and 2832.92 cm^{-1} denoted alkanes. Peak at 1634.38 cm^{-1} indicated amino acids. Remaining peaks observed at 1509.99, 1445.39, 1380.78, 1273.75, 1103.08, 1017.27, and 924.7 cm^{-1} indicated nitro compounds, aromatics, alcohols, carboxylic acids, esters, ethers, alkyl halides, ketone, aliphatic amines and ethers collectively. In case of dry root extract, the peak observed at 3322.75 cm^{-1} showed amines and amides. The band at 2924.52, 2852.2 and 1717.3 cm^{-1} indicated alkanes, Carboxylic acid and esters. Peak at 1633.41 cm^{-1} signified amino acids and remaining peaks observed at 1514.81, 1414.53, 1259.29, 1038.48, 917.95 and 816.706 cm^{-1} represented the nitro compounds, aromatics, alcohols, carboxylic acids, esters, ethers, alkyl halides, ketone and aliphatic amines.

The absorption spectra of *S. anguivi* fresh and dry stem sample extract are elucidated in Fig.2 and Table 1 & 2. The band in fresh stem extract was observed at 3284.18 cm^{-1} which represented hydroxy compounds. The peaks at 2933.2 and 2192.67 cm^{-1} represented alkanes and alkynes respectively while that at 1717.3 cm^{-1} point out the presence of carboxylic acid and esters. The remaining peaks observed at 1605.45, 1509.99, 1391.39, 1238.39 and 1051.01 cm^{-1} indicated nitro compounds, alcohols, carboxylic acids, esters, ethers, alkyl halides and aliphatic amines together. In case of dry stem extract, the peak observed at 3357.46 cm^{-1} showed amines and amides.

The band at 2925.48, and 1632.45 cm^{-1} indicated alkanes. Peaks at 1632.45 and 1453.1cm^{-1} showed the presence of amino acids and aromatics respectively. Remaining peaks observed at 1328.71, 1259.29, 1163.83, 1018.23 and 917.95cm^{-1} represented the alcohols, carboxylic acids, esters, ethers, alkyl halides, ketone, aliphatic amines and alkyl halides.

The absorption spectra of *S. anguivi* fresh and dry leaf sample extract are shown in Fig.3 and Table 1 & 2. The band in fresh leaf extract was observed at 3284.18 cm^{-1} represented hydroxy compound and band at 2929.34 cm^{-1} represented alkanes. The peak at 1597.73cm^{-1} represented aldehyde. Peak at 1513.85 cm^{-1} indicated nitro compounds and remaining peaks observed at 1445.39, 1389.46, 1283.39, and 1044.26 cm^{-1} indicated aromatics, alcohols, carboxylic acids, esters, ethers, alkyl halides and aliphatic amines. In case of dry leaf extract, the peak observed at 3336.25 cm^{-1} showed amines and amides. The band at 2925.48 and 2852.2 cm^{-1} indicated alkanes, the peak at 1703.8 designated carboxylic acid and esters. Peak at 1615.09 cm^{-1} showed amino acids and remaining peak observed at 1513.85, 1454.06, 1328.71, 1261.22 and 1049.09 cm^{-1} represented the nitro compounds, aromatics, alcohols, carboxylic acids, esters, ethers, alkyl halides and aliphatic amines.

The absorption spectra of *S. anguivi* fresh and dry fruit sample extract are revealed in Fig.4 and Table 1 & 2. The band in fresh fruit extract was observed at 3624 cm^{-1} represented alcohols and phenols and band at 3286.11cm^{-1} represented hydroxyl compounds. The peaks around 2936.09 and 2849.31 cm^{-1} depicted the presence of alkanes and carboxylic acid respectively. Peaks at 2185.92 and 1729.83cm^{-1} indicated alkynes and carboxylic acid, esters. Remaining peaks observed at 1603.52, 1516.74, 1402, 1280.5 and 1052.94 cm^{-1} indicated amino acids, nitro compounds, aromatics, alkyl halides and aliphatic amines respectively. In case of dry fruit extract, the peak observed at 3374.82cm^{-1} showed presence of amines and amides. The band at 2930.31 cm^{-1} indicated alkanes. Peak at 1723.09 cm^{-1} showed carboxylic acid and esters and remaining peaks observed at 1651.73, 1455.03, 1244.83 and 1045.23cm^{-1} represented the amino acids, aromatics, alkyl halides and aliphatic amines respectively. The observed peaks indicate that, the extract of root, stem, leaf and fruit (all fresh and dry) of *S. anguivi* contained an array of active constituents as linked secondary metabolites which actually excavate the medicinal properties bestowed to the specific plant species.

The absorption spectra of *S. virginianum* fresh and dry root sample extract are shown in Fig.5 and Table 3 & 4. The band in fresh root extract was observed at 3335.28cm^{-1} represented amines and amides while band at 2924.52 and 2853.17cm^{-1} represented alkanes. The peaks at 1795.4, 1747.19 and 1716.34 cm^{-1} were of acid unhydride, carboxylic acids and esters respectively. Peaks at 1670.05 and 1621.84 cm^{-1} specified the existence of amino acids. Peaks at 1541.81, 1508.06 and 1500.35 cm^{-1} indicated nitro compounds and peaks at 1460.81 and 1413.57 represented alkanes. The peak at 1362.46 cm^{-1} represents alcohols, carboxylic acids, esters, ethers. Alkyl halides are represented by 1269.9, 1241.93 and peak at 1212.04 cm^{-1} indicated the presence of nitro compounds. Remaining peaks observed at 1105.01, 1047.16, 993.16 and 925.664 cm^{-1} indicated aliphatic amines and aromatic compounds. In case of dry root extract, the peak observed at 3375.78 cm^{-1} showed amines and amides. The bands at 2924.52, 2259.2 and 1716.34 cm^{-1} indicated alkanes plus amino acids, carboxylic acids and esters respectively. Amino acids are represented by peaks at 1646.91, 1625.7 and 1613.16 cm^{-1} wavelengths. The peaks at 1582.31 and 1558.2 cm^{-1} indicated nitro compounds. Alkanes a rerepresented by the peaks present at 1495.53, 1455.03, 1411.64, 1368.25 and 1314.25 cm^{-1}. Remaining peaks observed at 1233.25, 1211.08, 1171.54, 1042.34, 983.518, 871.667, 762.709 and 669.178 cm^{-1} represented fluorides, aliphatic amines, aromatic compounds, halogen and aromatic compounds.

The absorption spectra of *S. virginianum* fresh and dry stem sample extract are described in Fig.6 and Table 3 & 4. The band in fresh stem extract was observed at 3310.21 cm^{-1} representing amines & amides and peaks at 2926.45 and 2849.31 cm^{-1} represented alkanes. The peak at 1795.4 cm^{-1} represented acid unhydrides and peaks at 1747.19 and 1715.37 cm^{-1} represented carboxylic acid and esters. Amino acids are represented by peak at 1670.05 and 1622.8 cm^{-1}. Peaks at 1541.81, 1508.06 and 1500.35 cm^{-1} indicated nitro compounds and remaining peaks observed at 1456.96, 1414.53, 1348.96, 1269.9 and 1013.41 cm^{-1} indicated alkanes, alcohols, carboxylic acids, esters, ethers and aliphatic amines. In case of dry stem extract, the peak observed at 3373.85 cm^{-1} showed amines and amides and that at 2939.95 cm^{-1} indicated alkanes. The band at 1716.34 cm^{-1} indicated Carboxylic acid and esters. Peaks at 1647.88, 1625.7 and 1613.16 cm^{-1} showed amino acids. Peak at 1582.31 and 1558.2 cm^{-1} showed nitro compounds. Alkanes are represented by the peaks at 1495.53, 1455.03, 1412.6 and 1367.28 cm^{-1}. The peaks at 1297.86, 1234.22 and 1211.08 cm^{-1} indicated fluorides. Remaining peak observed at 1170.58, 1021.12, 983.518, 764.637, 720.282 and 668.214 cm^{-1} represented aliphatic amines, aromatic compounds and halogen.

The absorption spectra of *S. virginianum* fresh and dry leaf sample extract are depicted in Fig.7 and Table 3 & 4. The band in fresh leaf extract was observed at 3375.78 cm^{-1} denoted amines and amides. The band at 2924.52cm^{-1} illustrated alkanes. The peak at 1716.34 cm^{-1} representing carboxylic acids and peaks at 1646.91, 1625.7and 1613.16 symbolized amino acid. Aldehydes and nitro compounds represented by peak at 1582.31and 1558.31 cm^{-1}. Alkenes denoted by 1455.53, 1455.03, 1411.64, 1314.25 cm^{-1} and peak at 1368.25 cm^{-1} indicated by alcohols, carboxylic acids, esters and ethers. Remaining peaks observed at 1233.25, 1211.08, 1171.54,

1042.34, 983.518, 871.667, 762.709 and 669.178 cm^{-1} indicated alkyl halides, aliphatic amines, aromatic compounds, halogen, and chloride. In case of dry leaf extract, the peak observed at 3375.78 cm^{-1} showed amines and amides; and at 2924.52 cm^{-1} indicated alkanes. The band at 1716.34 cm^{-1} signified the presence of Carboxylic acid and esters. Peaks at 1646.91, 1625.7 and 1613.16 cm^{-1} described that those were of amino acids. Peaks at 1582.31 and 1558.2 cm^{-1} showed nitro compounds. Alkanes are represented by the peaks present at 1495.53, 1455.03, 1411.64, 1368.25 and 1314.25 cm^{-1}. The peaks at 1233.25 and 1211.08 cm^{-1} demonstrated fluorides. Remaining peaks observed at 1171.54, 1042.34, 983.518, 871.667, 762.709 and 669.178 cm^{-1} represented aliphatic amines, aromatic compounds and halogen.

The absorption spectra of *S. virginianum* fresh and dry fruit sample extract are shown in Fig.8 and Table 3 & 4. The peak in fresh fruit extract observed at 3356.5 cm^{-1} represented amines and amides. The bands at 2927.41 and 2849.31cm^{-1} represented alkanes. The peaks at 1795.4 and 1716.34 cm^{-1} were of carboxylic acids and esters. Peak at 1671.02 represented amino acid. Aldehydes are represented by peak at 1592.91cm^{-1}. The peaks at 1541.81, 1508.06 and 1500.35 indicated nitro compounds and alkenes were represented by 1456.96 and 1414.53cm^{-1}. Peak at 1375 cm^{-1} indicated alcohols, carboxylic acids, esters and ethers. Remaining peaks observed at 1269.9, 1118.51, 1043.3, 989.304, 813.813 and 765.601 cm^{-1} indicated alkyl halides, ketone, aliphatic amines, aromatic compounds, halogen and chlorides. In case of dry fruit extract, the peak observed at 3376.75 cm^{-1} showed amines and amides while at 2940.91 and 2832.92 cm^{-1} indicated alkanes. The band at 1716.34 cm^{-1} indicated Carboxylic acid and esters. Peaks at 1648.84 and 1612.2 cm^{-1} showed amino acids. Peaks at 1582.31 and 1557.24 cm^{-1} showed nitro compounds. Alkanes were represented by the peaks present at 1494.56, 1455.03, 1411.64, 1368.25 and 1313.29 cm^{-1}. The peaks at 1233.25 and 1211.08 cm^{-1} indicated fluorides. Aliphatic amines, aromatic compounds and halogen were represented by the remaining peaks at 1170.58, 1019.19, 871.667, 781.029, 762.709, 721.247 and 669.178 cm^{-1}.

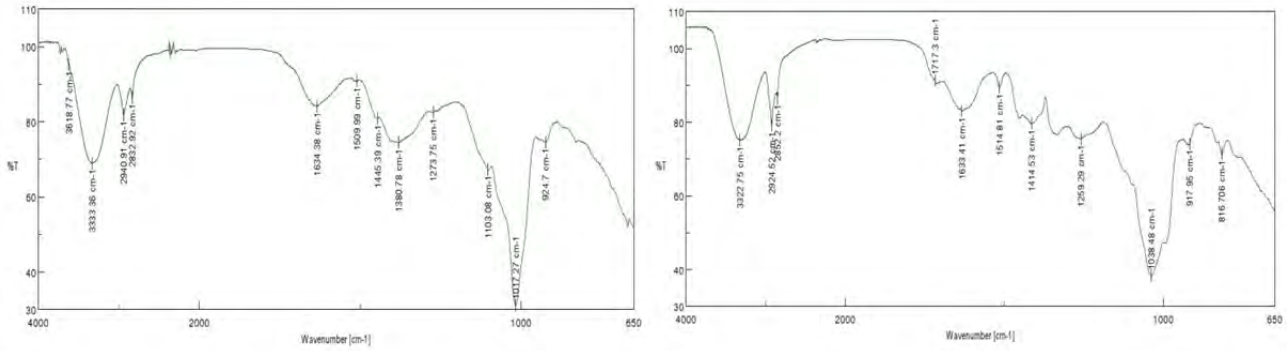

Figure 1: Infra red spectrum (FTIR) analysis of *S. anguivi* fresh and dry root extract

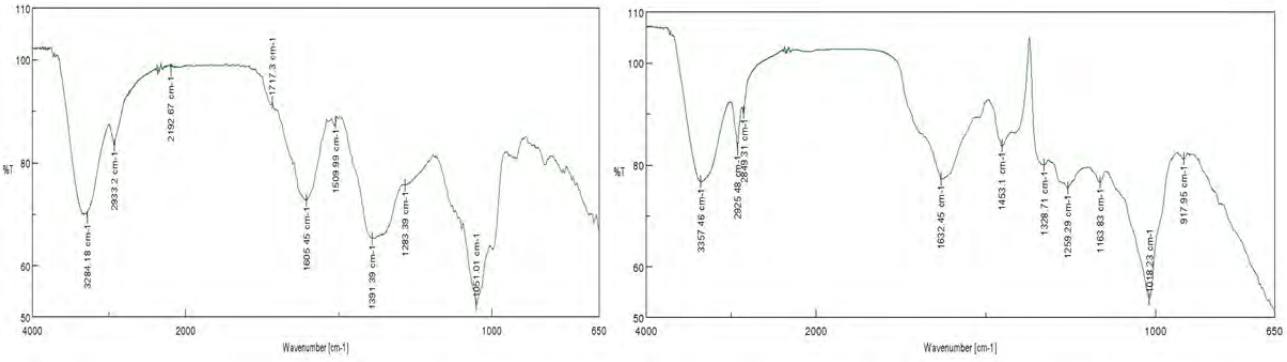

Figure 2: Infra red spectrum (FTIR) analyses of *S. anguivi* fresh and dry stem extract

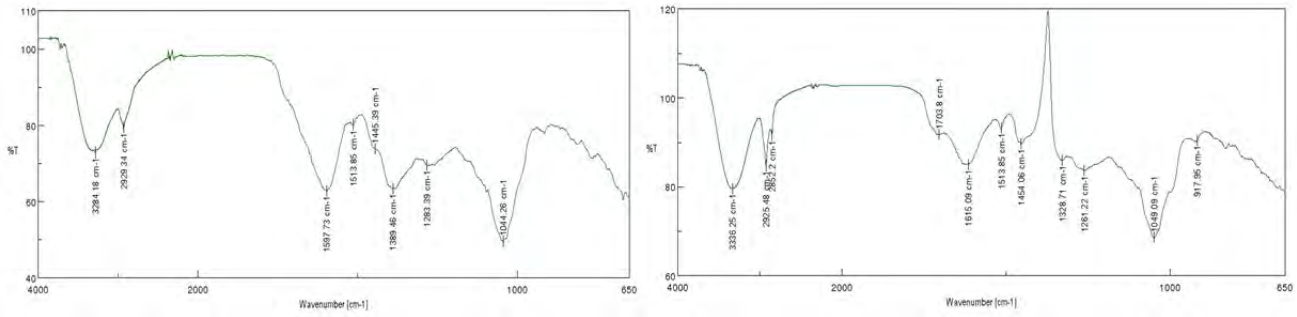

Figure 3: Infra red spectrum (FTIR) analyses of *S. anguivi* fresh and dry leaf extract

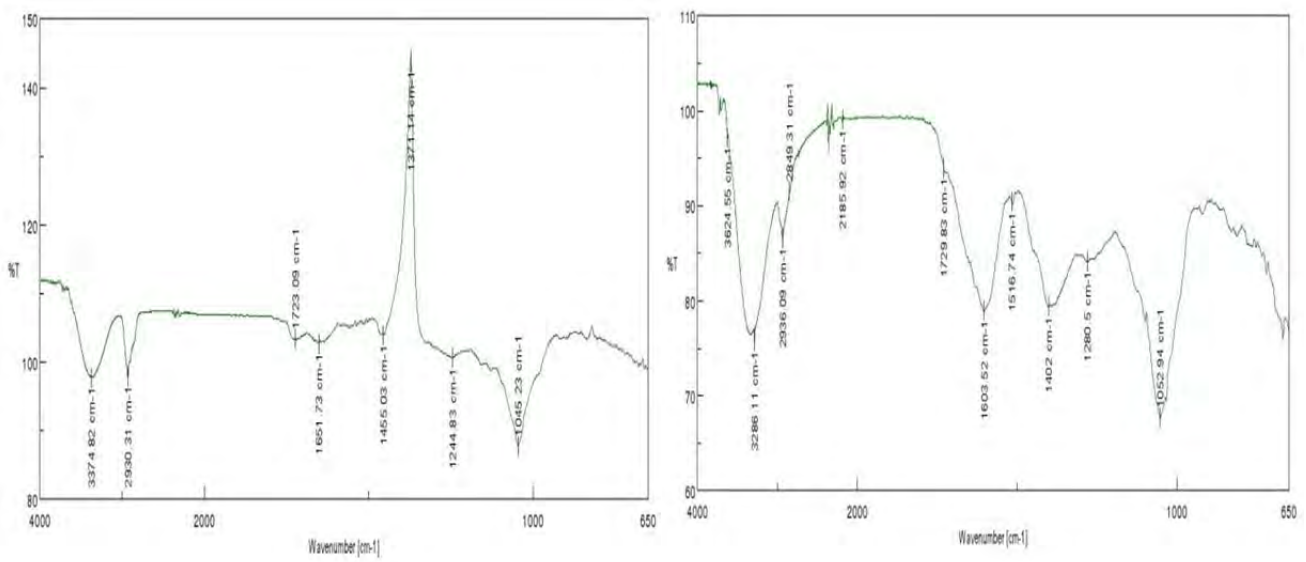

Figure 4: Infra red spectrum (FTIR) analyses of *S. anguivi* fresh and dry fruit extract

Table 1: FTIR peak values and functional groups in fresh parts of *S. anguivi*

Sr. No.	Functional groups of the active components in fresh parts of *S. anguivi*							
	Fresh Root	**Functional groups**	**Fresh Stem**	**Functional groups**	**Fresh Leaf**	**Functional groups**	**Fresh Fruit**	**Functional groups**
1	3618.77	Alcohols and phenols	3284.18	Hydroxy compounds	3284.18	Hydroxy compounds	3624.55	Alcohols and phenols
2	3333.36	Amines, Amides	2933.2	Alkanes	2929.34	Alkanes	3286.11	Hydroxy compounds
3	2940.91	Alkanes	2192.67	Alkynes	1597.73	Aldehyde	2936.09	Alkanes
4	2832.92	Alkanes	1717.3	Carboxylic acid,esters	1513.85	Nitro compounds	2849.31	Carboxylic acids, Esters
5	1634.38	Amino acids	1605.45	Amino acids	1445.39	Aromatics	2185.92	Alkynes
6	1509.99	Nitro compound	1509.99	Nitro compounds	1389.46	Alcohols, carboxylic acids, esters, ethers	1729.83	Carboxylic acid, esters
7	1445.39	Aromatics	1391.39	Alcohols, carboxylic acids, esters, ethers	1283.39	Alkyl halides	1603.52	Amino acids
8	1380.78	Alcohols, carboxylic acids, esters, ethers	1238.39	Alkyl halides	1044.26	Aliphatic amines	1516.74	Nitro compounds
9	1273.75	Alkyl halides	1051.01	Aliphatic amines			1402	Aromatics
10	1103.08	Ketone					1280.5	Alkyl halides
11	1017.27	Aliphatic amines					1052.94	Aliphatic amines
12	924.7	Ethers						

Table 2: FTIR peak values and functional groups in dry parts of *S. anguivi*

Sr.No	Functional groups of the active components in dry parts of *S. anguivi*							
	Dry Root	Functional groups	Dry Stem	Functional groups	Dry Leaf	Functional groups	Dry Fruit	Functional groups
1	3322.75	Amines, Amides	3357.46	Amines, Amides	3336.25	Amines, Amides	3374.82	Amines, Amides
2	2924.52	Alkanes	2925.48	Alkanes	2925.48	Alkanes	2930.31	Alkanes
3	2852.2	Alkanes	2849.31	Alkanes	2852.2	Alkanes	1723.09	Carboxylic acid,esters
4	1717.3	Carboxylic acid,esters	1632.45	Amino acids	1703.8	Carboxylic acid,esters	1651.73	Amino acids
5	1633.41	Amino acids	1453.1	Aromatics	1615.09	Amino acids	1455.03	Aromatics
6	1514.81	Nitro compound	1328.71	Alcohols, carboxylic acids, esters, ethers	1513.85	Nitro compounds	1244.83	Alkyl halides
7	1414.53	Aromatics	1259.29	Alkyl halides	1454.06	Aromatics	1045.23	Aliphatic amines
8	1259.29	Alkyl halides	1163.83	Ketone	1328.71	Alcohols, carboxylic acids, esters, ethers		
9	1038.48	Aliphatic amines	1018.23	Aliphatic amines	1261.22	Alkyl halides		
10	917.95	Alkyl halides	917.95	Alkyl halides	1049.09	Aliphatic amines		
11	816.706	Halogen						

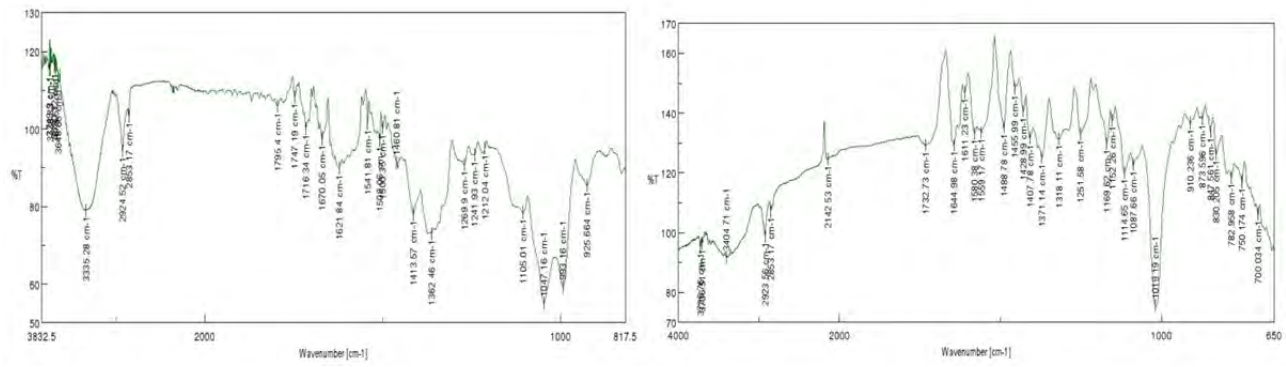

Figure 5: Infra red spectrum (FTIR) analyses of *S. virginianum* fresh and dry root extract

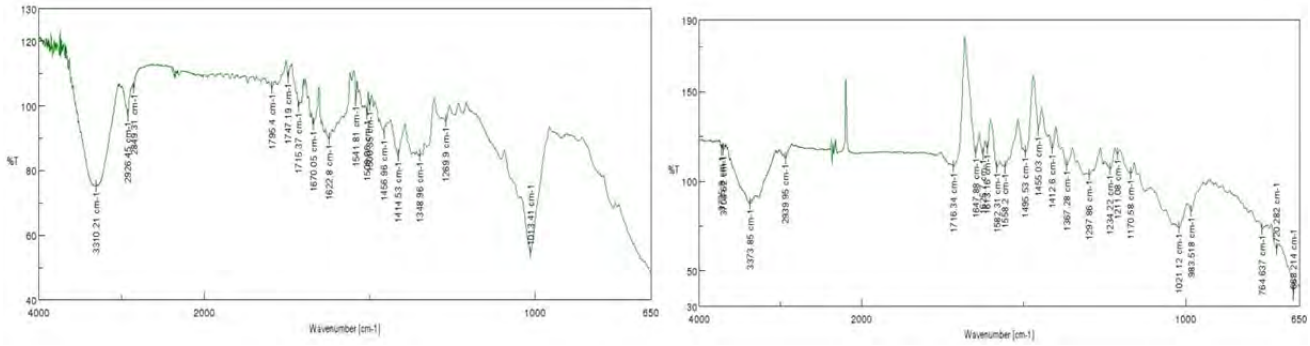

Figure 6: Infra red spectrum (FTIR) analyses of *S. virginianum* fresh and dry stem extract

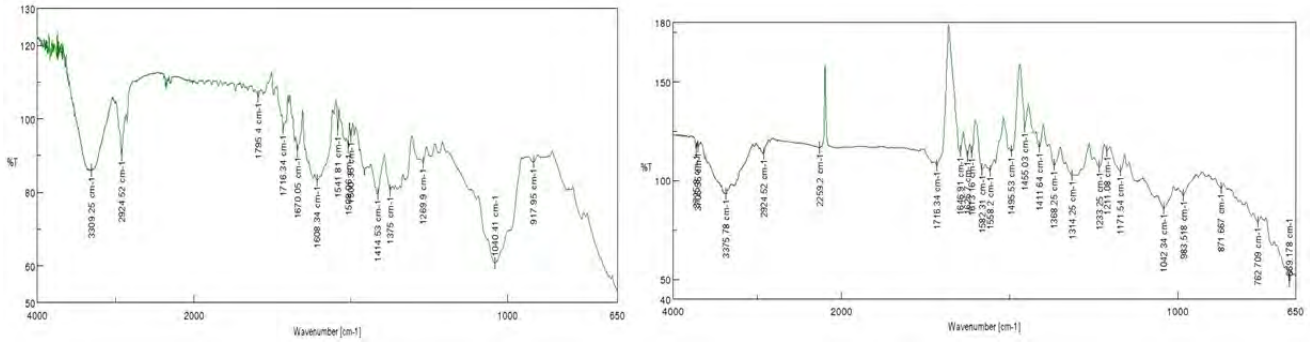

Figure 7: Infra red spectrum (FTIR) analyses of *S. virginianum* fresh and dry leaf extract

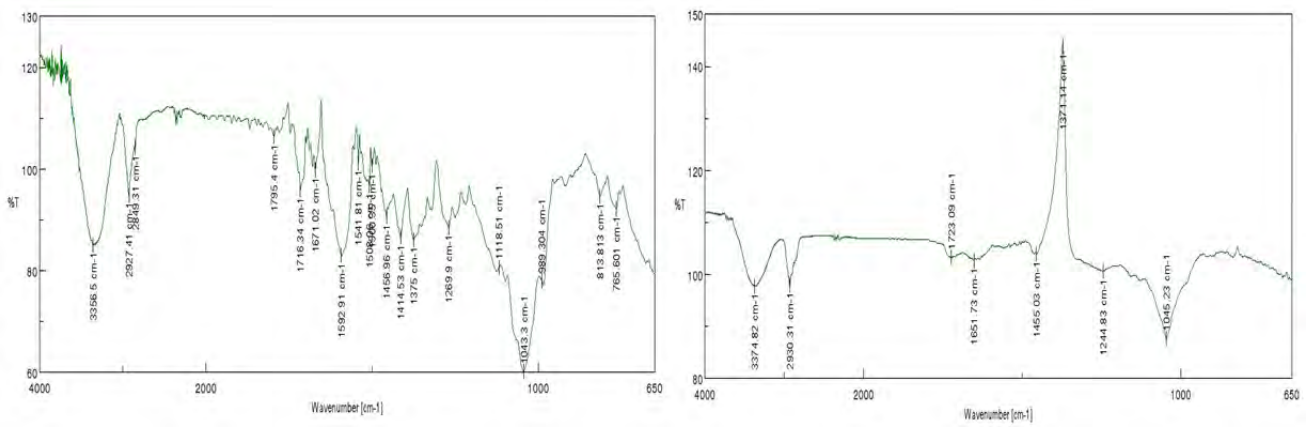

Figure 8: Infra red spectrum (FTIR) analyses of *S. virginianum* fresh and dry fruit extract

Table 3: FTIR peak values and functional groups in fresh parts of *S. virginianum*

Sr.No	Functional groups of the active components in fresh parts of *S. virginianum*							
	Fresh Root	Functional groups	Fresh Stem	Functional groups	Fresh Leaf	Functional groups	Fresh Fruit	Functional groups
1	3335.28	Amines, Amides	3310.21	Amines, Amides	3375.78	Amines, Amides	3356.5	Amines, Amides
2	2924.52	Alkanes	2926.45	Alkanes	2924.52	Alkanes	2927.41	Alkanes
3	2853.17	Alkanes	2849.31	Alkanes	1716.34	Carboxylic acid, esters	2849.31	Alkanes
4	1795.4	Acid anhydrides	1795.4	Acid anhydrides			1795.4	Acid anhydrides
5	1747.19	Carboxylic acid, Esters	1747.19	Carboxylic acid, esters	1646.91	Amino acids	1716.34	Carboxylic acid, esters
6	1716.34	Carboxylic acid, Esters	1715.37	Carboxylic acid, esters	1625.7	Amino acids	1671.02	Amino acids
7	1670.05	Amino acids	1670.05	Amino acids	1613.16	Amino acids	1592.91	Aldehydes
8	1621.84	Amino acids	1622.8	Amino acids	1582.31	Aldehydes	1541.81	Nitro compound
9	1541.81	Nitro compound	1541.81	Nitro compound	1558.31	Nitro compounds	1508.06	Nitro compound
10	1508.06	Nitro compound	1500.06	Nitro compound	1495.53	Alkanes	1500.35	Nitro compound
11	1500.35	Nitro compound	1500.35	Nitro compound	1455.03	Alkanes	1456.96	Alkanes
12	1460.81	Alkanes	1456.96	Alkanes	1411.64	Alkanes	1414.53	Alkanes
13	1413.57	Alkanes	1414.53	Alkanes	1368.25	Alcohols, carboxylic acids, esters, ethers	1375	Alcohols, carboxylic acids, esters, ethers
14	1362.46	Alcohols, carboxylic acids, esters, ethers	1348.96	Alcohols, carboxylic acids, esters, ethers	1314.25	Alkanes	1269.9	Alkyl halides
15	1269.9	Alkyl halides	1269.9	Alkyl halides	1233.25	Alkyl halides	1118.51	Ketone
16	1241.93	Alkyl halides	1013.41	Aliphatic amines	1211.08	Nitro compounds	1043.3	Aliphatic amines
17	1212.04	Nitro compound			1171.54	Aliphatic amines	989.304	Aromatic compound
18	1105.01	Aliphatic amines			1042.34	Aliphatic amines	813.813	Halogen
19	1047.16	Aliphatic amines			983.518	Aromatic compounds	765.601	Chloride
20	993.16	Aromatic compound			871.667	Halogen		
21	993.16	Aromatic compound			762.709	Chloride		
22	925.664	Aromatic compound			669.178	Chloride		

Table 4: FTIR peak values and functional groups in dry parts of *S. virginianum*

Sr.No	Functional groups of the active components in dry parts of *S. virginianum*							
	Dry root	Functional groups	Dry Stem	Functional groups	Dry Leaf	Functional groups	Dry Fruit	Functional groups
1	3375.78	Amines, Amides	3373.85	Amines, Amides	3375.78	Amines, Amides	3376.75	Amines, Amides
2	2924.52	Alkanes	2939.95	Alkanes	2924.52	Alkanes	2940.91	Alkanes
3	2259.2	Amino Acids	1716.34	Carboxylic acid, esters	1716.34	Carboxylic acid, esters	2832.92	Alkanes
4	1716.34	Carboxylic acid, esters	1647.88	Amino acids	1646.91	Amino acids	1716.34	Carboxylic acid, esters
5	1646.91	Amino acids	1625.7	Amino acids	1625.7	Amino acids	1648.84	Amino acids
6	1625.7	Amino acids	1613.16	Amino acids	1613.16	Amino acids	1612.2	Amino acids
7	1613.16	Amino acids	1582.31	Nitro compounds	1582.31	Nitro compound	1582.31	Nitro compound
8	1582.31	Nitro compounds						
9	1558.2	Nitro compounds	1558.2	Nitro compounds	1558.2	Nitro compound	1557.24	Nitro compound
10	1495.53	Alkanes	1495.53	Alkanes	1495.53	Alkanes	1494.56	Alkanes
11	1455.03	Alkanes	1455.03	Alkanes	1455.03	Alkanes	1455.03	Alkanes
12	1411.64	Alkanes	1412.6	Alkanes	1411.64	Alkanes	1411.64	Alkanes
13	1368.25	Alkanes	1367.28	Alkanes	1368.25	Alkanes	1368.25	Alkanes
14	1314.25	Alkanes	1297.86	Fluoride	1314.25	Alkanes	1313.29	Alkanes
15	1233.25	Fluoride	1234.22	Fluoride	1233.25	Fluoride	1233.25	Fluoride
16	1211.08	Fluoride	1211.08	Fluoride	1211.08	Fluoride	1211.08	Fluoride
17	1171.54	Aliphatic amines	1170.58	Aliphatic amines	1171.54	Aliphatic amines	1170.58	Aliphatic amines
18	1042.34	Aliphatic amines	1021.12	Aliphatic amines	1042.34	Aliphatic amines	1019.19	Aliphatic amines
19	983.518	Aromatic compounds	983.518	Aromatic compounds	983.518	Aromatic compound	871.667	Halogen
20	871.667	Halogen	764.637	Aromatic compounds	871.667	Halogen	781.667	Aromatic compound
21	762.709	Aromatic compounds	720.282	Aromatic compounds	762.709	Aromatic compound	781.029	Aromatic compound
22	669.178	Halogen	668.214	Halogen	669.178	Halogen	762.709	Aromatic compound
23							721.147	Aromatic compound
24							669.178	Halogen

The extracts of fresh and dry material subjected to FTIR analysis is used for the identification of functional constituents present in *S. anguivi* and *S. virginianum*. The FTIR analysis revealed the similarity and variation between the various parts of *S. anguivi* and *S. virginianum* based on the functional group presence and absorption spectrum. From the spectra we can see clearly that although they show substantial overlap of each absorption spectrum of various components, each band represents an overall overlap of some characteristic absorption peaks of functional groups in the samples. Screening of functional groups of carboxylic acids, sulphur derivatives, amides, organic hydrocarbons and halogens in *Aerva lantana* has previously been reported[4]. Similar type of analysis has been documented in *Ichnocarpus frutescens*[25], where FTIR has been used to analyse the functional group components of amino acids, amides, amines, carboxylic acids etc. FTIR spectral analysis of

plant parts like leaf, root and stem of two species of *Elicpta*; *E.alba and E. prostrate* showed the presence of characteristic functional groups of carboxylic acids, amines, amides, sulphur derivatives which were responsible for medicinal properties of both these species[26].

CONCLUSION

The presence of characteristic functional groups Carboxylic acids, amines, aromatic compounds, amides, alkanes, esters, ethers, amino acids, organic hydrocarbons, halogens are responsible for various medicinal properties of *S anguivi* and *S virginianum*. Furthermore, the study also depicted that due to the presence of characteristic functional groups, both these species may act as sustainable source of antibiotics as well as it justifies the use of various plant parts for different ailments by traditional and ayurvedic practitioners. This study may fruitfully help in the identification of individual phytochemicals having different biological activities and both the species may prove to be phytopharmaceutically significant.

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