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"Phytochemical Screening and Mineral Analysis of *Solanum anguivi* Lam. plant by FTIR, GC-HRMS and AAS, UV-VIS Spectroscopy Methods".

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Abstract

The *Solanum anguivi* Lam. plant provides both medicinal and nutritional benefits. The preliminary qualitative phytochemical examination reveals the existence of possible bioactive components such as phenol, alkaloids, cardiac glycosides, flavonoids, saponins, sterols, tannins, terpenoids, quinones, oxalate, and lipids. The **FTIR** analysis data indicated the presence of numerous functional groups, including alcohol, carboxylic acid, phenols, alkenes, lipids, triglycerides, nitro, aromatics, alkyl halides, alkyne, and glycogen. **GC-HRMS** analysis of fruits reveals the presence of medicinally important bioactive compounds such as trans-β-Ocimene, Piperidine-2,5-dione, p-Cymene, 3-p-Menthen-7-al, γ-Elemene, α-Cubebene, Caryophyllene, α-Guaiene, Humulene, Ginsenol, α-Muurolene, Santolina triene, aR-Turmerone, Turmeronol A, Piperidine. The AAS and UV-VIS spectrophotometer findings showed that fruits, leaves, and stems contained varied levels of nutritionally important minerals like Na, K, Mg, P, Ca, Cu, Zn, Fe, Mn, and S etc.

Several analytical approaches demonstrated that the *Solanum anguivi* Lam. plant contains a high concentration of medicinally and nutritionally important compounds

Introduction

Solanum anguivi Lam. is a medicinally beneficial plant. It is found in Maharashtra's Western Ghats (Singh *et al*. 2001; Bhagat *et al*. 2016). It belonged to the Solanaceae family. Local tribal cultures consume the fruits of these plants. These plants provide a variety of medicinal advantages, including lowering acidity, relieving toothaches, and giving additional nutrition for nursing mothers (Kumbhojkar *et al*., 1999). In Ayurveda, Bruhati is identified as the root of *Solanum anguivi* Lam, which was used to manufacture Dashmula (Dalvi and Patil, 2016). It possesses antibacterial, antidiabetic, anti-cancer, antioxidant, allergy, and wound-healing properties (Ojo and

Adanlawo, 2024). This plant contains medicinally important metabolites such phenols, alkaloids, flavonoids, cardiac glycosides, tannins, saponin, terpenoids, quinone, and vitamin C. Because of their anti-pathogenic effects, these bioactive compounds have been found to boost plant immunity. The plant's nutritional value was estimated using minerals such as Na, K, Ca, Mg, P, Zn, Cu, Fe, and Mn.

This study's phytochemical examination focused on the fruits, leaves, and stem extract. Bioactive compounds were examined qualitatively and quantitatively using a number of methods, including Soxhlet Extraction, FTIR, AAS, and UV-VIS spectrophotometers

Materials & Method

Plant Material Collection & Identification:

The fresh plant material was collected in a zippered plastic bag near Lohgad Fort, which is located in Maval Tehsil of Pune District. An herbarium of gathered plant samples was created for identification reasons. Plant material was identified and certified by the Botanical Survey of India, Pune Regional Office, Pune)

Sample preparation

The fruits, leaves, and stem were washed with tap water. These fruits were smashed with a mortar pestle and dried in the shade; the stem was chopped into small pieces and dried; and the leaves were dried immediately. The dry material was grinded using a mixer grinder. The resulting fine powder was kept at room temperature in a small, closed plastic container for future tests.

Extraction

The produced fine powder was employed for soxhlet extraction with an n-hexane solvent (Tegegne *et al*., 2021). The n-hexane extract was employed immediately for qualitative analysis. The excess n-hexane was evaporated using a rotary evaporator; ultimately, a jelly-like material was deposited in the bottom of the flask, which carried out the **GC-HRMS** analysis and characterisation of bioactive chemicals.

Preliminary Phytochemical Analysis

The n-hexane plant extract was employed for preliminary phytochemical analysis. **Table No.1** in the qualitative analysis provides the preliminary phytochemical tests and associated observations.

FTIR Analysis:

The concentrated n-hexane extracts (fruits, leaves, and stem) were utilized for FTIR analysis. The Bruker FTIR instrument was employed, which has a resolution of -4

cm1 and an optical bench detector. The FTIR wavelength range was 500-4000 cm-1, and Platinum ATR was employed. The resulting FTIR graphical data (Wavelength cm-1 versus Transmittance), i.e. obtained peak values, were interpreted according to the Pavia et al., (2013) approach (Mane & Khaire, 2021, Ralte *et al*., 2022, Abdul Roman *et al*., 2015).

GC-HRMS Analysis of n-Hexane Fruits Extract

The GC-HRMS analysis of n-hexane extract (fruits, leaf, stem, and root) was performed at IIT Bambay's Sophisticated Analytical Instrument Facility in Pawai, Mumbai. Thermo Scientific's orbitrap exploris instrument was utilized for the GC-HRMS study. The ionization mode EI consists of both positive and negative ion chemical ionization. A triplus RSH sampler was utilized. The Orbitrap mass analyzer has a mass range of 30–3000 m/z and a mass resolution of 60,000 at 200 m/z. The analysis was performed on a TG-5SIL MS column (30m, I.D-0.25mm, 0.25 um film). The running time was 68.00 minutes, the temperature range was 50°C to 300°C, the front inlet rate was 1ml/min, the scan range was 40-600 m/z, and the ion source temperature was 280°C (Abd El-Ghffar *et al*., 2017).

Plant Minerals analysis

Atomic Absorbance spectroscopy:

The plant mineral composition was determined by atomic absorbance spectroscopy (Paul *et al*., 2014). Chemito AA 201 atomic absorbance spectroscopy was utilized in the study. In the radiation source, a hollow cathode lamp was employed. This hollow cathode lamp was constructed using metals of interest (Fe, Cu, Mn, Zn, K, Ca, Mg, Na) with precise wavelengths (248.30 nm for Fe, 324 nm for Cu, 279.5 nm for Mn, 213.90 nm for Zn, 766.5 nm for K, 422.67 nm for Ca, 285.2 nm for Mg, and 589.6 nm for Na). (Mahood *et al*., 2021)

UV- Vis Single Beam Spectrophotometer

The Phosphorus was measured using a Chemito UV-2010 single beam spectrophotometer. The spectrophotometer's wavelength was set to 882 nm, and three standards were utilized for analysis. First, three standards were exposed for absorbance at 882 nm wavelength, then plant ethanolic samples (fruits, leaves, stem) were treated to the same wavelength (Mahood *et al*., 2021).

Result &Discussion:

Table: 1. The preliminary phytochemical analysis of n- hexane extract of different plant part is listed in below table:

Sr. No.	Tests of Extraction	Observation	Result		
			Fruit	Leaves	Stem
1	Test for alkaloids (Wagner's reagent) (Jha *et al.,*2016).	Reddish brown colouration was formed	Absent	Present	Present
3.	Test for cardiac glycosides (Keller Kelliani's test) (Ajayi *et al.,* 2011).	Brown ring at interphase was formed	Absent	Absent	Absent
4.	Test for flavonoids (Alkaline reagent test) (Kumar *et al.,* 2019).	The intense yellow colouration	Absent	Present	Present
5.	Test for phenols (Ferric chloride test) (Sabale *et al.,* 2017).	Green colour was formed	Present	Present	Present
6.	Test for saponin (Foam test) (Auwal *et al.,* 2014).	Persistent foam was formed	Present	Absent	Present
7.	Test for sterols (Salkowaski Test) (Jha *et al.,* 2016)	Reddish brown colouration at interphase was formed	Present	Absent	Present
8.	Test for tannins (Ferric Chloride test) (Das *et al.,* 2017).	Greenish colouration was formed	Absent	Present	Absent
9.	Test for terpenoids (Salkowaski Test) (Das *et al.,* 2017).	Reddish brown colouration at interphase was formed	Present	Absent	Present
10.	Test for quinone (Sulphuric acid test) (Maheshwaran *et al.,* 2024).	Yellow precipitate was formed	Absent	Present	Present
11.	Test for oxalate (Kgosana, 2019).	Greenish black colouration was formed	Present	Present	Present
12.	Test for lipids (Precipitate test) (Shrivastva *et al.,* 2024)	Red precipitate was formed	Present	Present	Present

Table: 2. Qualitative Phytochemical Screening result of *Solanum anguivi* Lam.

Sr. No.	Test	Fruit	Leaf	Stem
1.	Alkaloid	-	+	+
3.	Cardiac Glycoside	-	-	-
4.	Flavonoid	-	+	+
5.	Phenol	+	+	+
6.	Saponin	+	-	+
7.	Steroid	+	-	+
8.	Tannin	-	+	-
9.	Terpenoid	+	-	+
10.	Quinone	-	+	+
11.	Oxalate	+	+	+
12.	Lipids	+	+	+
(+Ve)- Present and (-Ve) – Absent				

FTIR analysis of n-hexane extract of *Solanum anguivi* Lam.

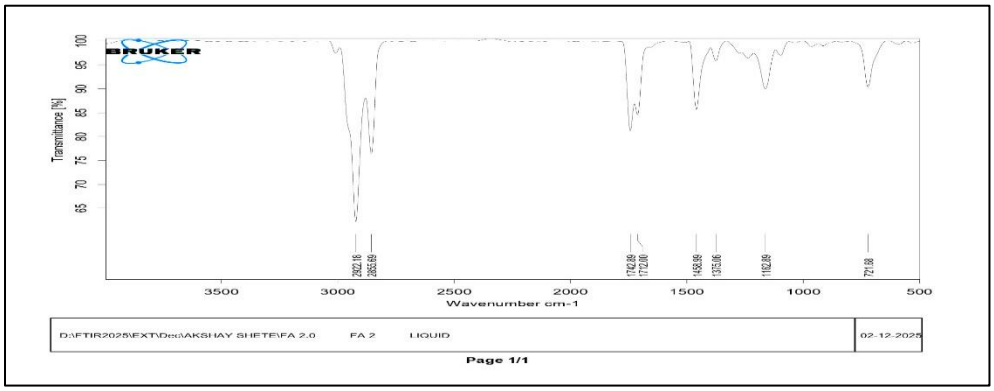

Figure .1. Graph of FTIR peak values of *Solanum anguivi* Lam. n-hexane fruits extract (Maval location)

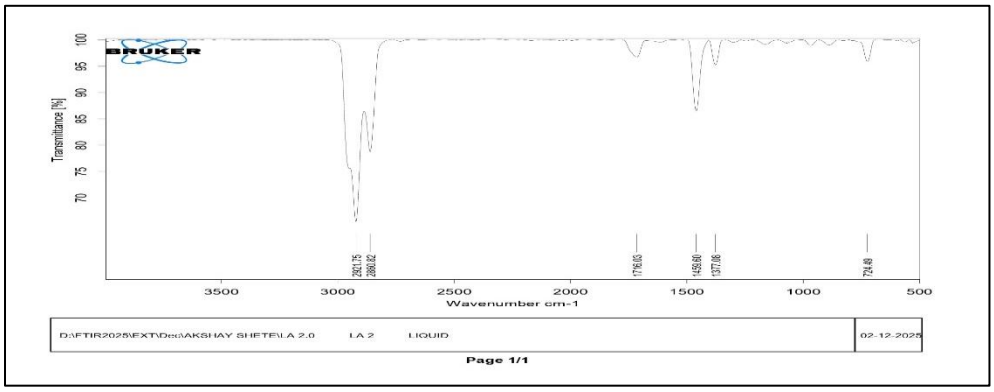

Figure .2. Graph of FTIR peak values of *Solanum anguivi* Lam. n-hexane leaves extract (Maval location)

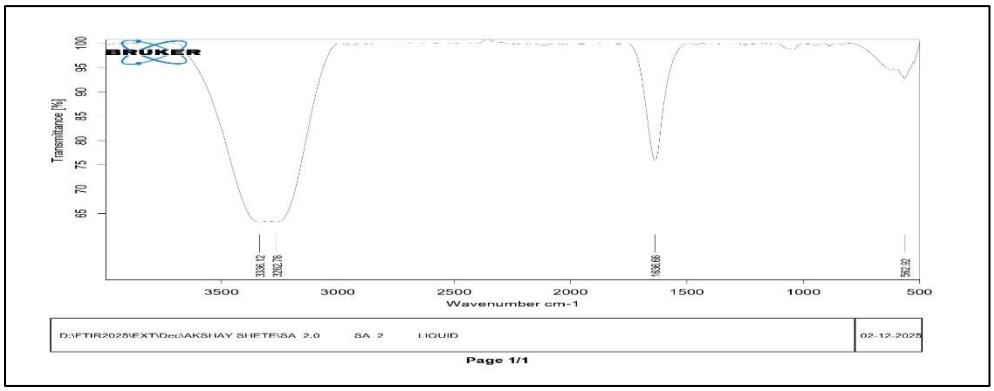

Figure .3. Graph of FTIR peak values of *Solanum anguivi* Lam. n-hexane stem extract (Maval location)

Table.3. Evaluation of FT-IR spectra of n-Hexane extract of *Solanum anguivi* Lam.

GC-HRMS Analysis of Fruits n-Hexane Extract

Frequency range (cm^{-1})	Plant Part			Functional group
	Fruit	Leaf	Stem	
3870-3550				O-H stretch alcohol
3500-3200			3336.13 3262.78	O-H stretch vibration presence of alcohols, phenols
3300-2850	2922.18 2855.69	2921.75 2860.82		O-H stretch vibration, carboxylic acids
2500-2300				C-H stretch vibration, alkenes
2260-2100				C=C stretch vibration, alkynes
1990-1739	1742.89	1716.03		Ester C=O stretch, lipids, triglycerides
1700-1600			1636.66	C=C stretch vibration, alkenes
1550-1475				N-O asymmetric stretch, nitro compounds
1470-1400		1459.60		C-C stretch vibration, aromatics
1400-1320	1375.06	1377.08		N-O stretch vibration, nitro compound
1300-1290				C-O stretch vibration, alcohols, carboxylic acids, esters, ethers
1275-1150	1162.89			C-H wag stretch vibration, alkyl halides
1020-1000				C-N stretch vibration, aliphatic amines
990-800				N-H wag stretch vibration, primary and secondary amines
790-690	721.68	724.49		C(triple bond) C-HC-H bend stretch vibration, alkynes
680-510			562.92	C-Br stretch vibration, alkyl halide, glycogen
490-400				Halogen compound

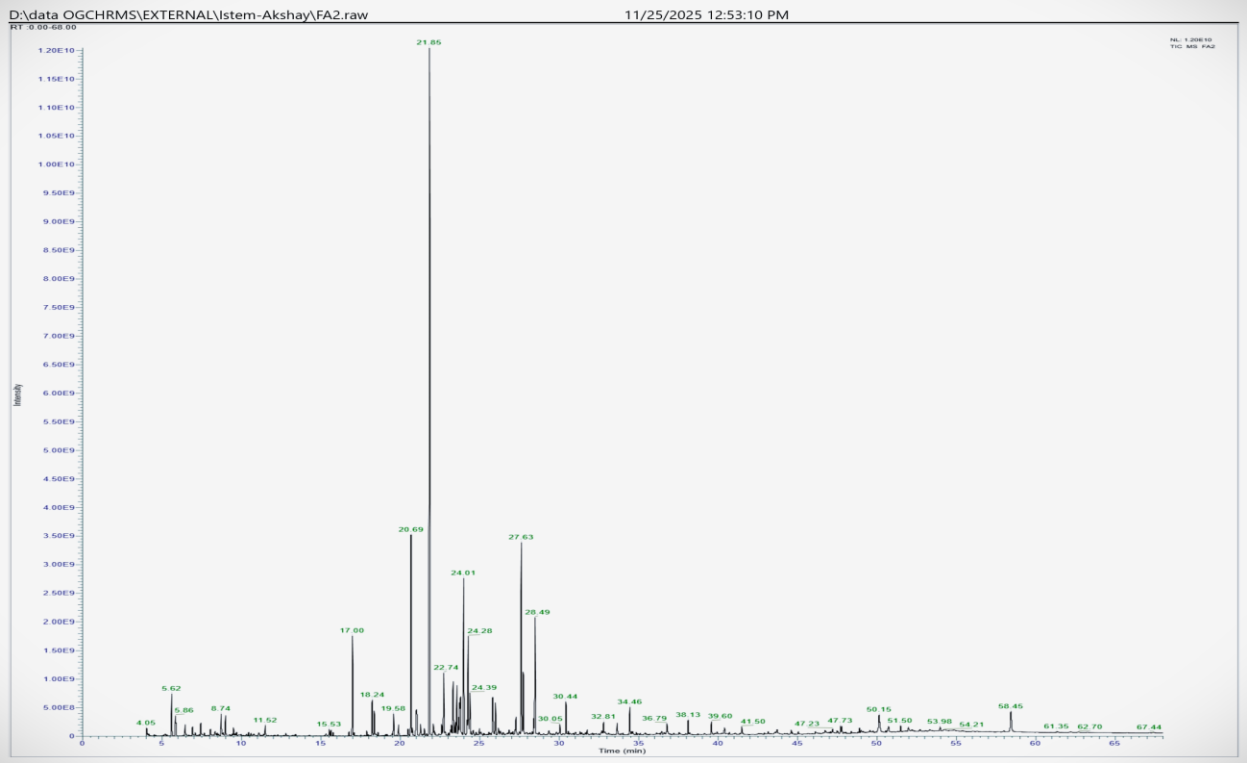

Fig.4. Chromatogram of GCMS analysis of fruits n- hexane extract of *Solanum anguivi* Lam

Table.4. Identified phytochemical constituent of n-hexane fruits extract of *Solanum anguivi* Lam. by GC-HRMS.

Name of compound	m/z	RT	Area	Height	Formula
trans-β-Ocimene	91.05	7.67	17916739	7541395	C10H16
3-Carene	91.05	8.87	18861018	7930570	C10H16
o-Cymene	119.09	11.5	13021504	5193002	C10H14
3-Carene	91.05	11.5	85181351	33596004	C10H16
Piperidine-2,5-dione	113.05	12.5	2334046	765768	C5H7NO2
p-Cymene	119.09	13.3	12845831	5169052	C10H14
3-p-Menthen-7-al	79.05	15.7	30679890	12256140	C10H16O
γ-Elemene	121.10	19.6	158661554	64000335	C15H24
α-Cubebene	105.07	19.9	90626533	36787745	C15H24
Hexadecane	57.07	20.3	4894401	1924946	C16H34
Caryophyllene	91.05	21.9	3775921651	1294682449	C15H24
α-Guaiene	105.07	22.2	14405543	5951504	C15H24
n-Decane	57.07	22.5	6198935	2123686	C10H22
Humulene	93.07	22.7	415762058	159710669	C15H24
Ginsenol	207.17	23.7	3796575	1419870	C15H26O
α-Muurolene	105.07	23.8	288844291	104213286	C15H24
Santolina triene	93.07	23.9	6389157	2501969	C10H16

trans-Calamenene	159.12	24.4	114673770	43459726	C15H22
Hexadecane	57.07	25.3	7231175	2949261	C16H34
Germacrene D	105.07	26.3	11776128	4344600	C15H24
aR-Turmerone	119.09	27.6	1379229938	531365890	C15H20O
Turmeronol A	83.05	34.5	51168282	19176117	C15H20O2
Piperidine, 1-acetyl-	127.10	38.2	4121812	1410949	C7H13NO
Glycidyl palmitate	55.05	39.8	6063212	969175	C19H36O3
Piperidine, 1-acetyl-	127.10	41.7	2270732	719309	C7H13NO
1-(Piperidin-1-yl)hexadecan-1-one	127.10	45	5804963	1602409	C21H41NO
Squalene	81.07	47.7	45463139	16628802	C30H50
Piperine	115.05	49	22663348	7002896	C17H19NO3
Stigmasta-3,5-diene	147.12	51.4	1203284	364532	C29H48
dl-α-Tocopherol	165.09	51.9	1740955	381025	C29H50O2
γ-Sitosterol	145.10	54.2	4639777	586307	C29H50O

Table.5: Observation table of AAS and UV-VIS Spectrophotometer analysis.

Sr. No.	Parameter	Unit	Fruits	Leaves	Stem
1	Sodium (Na)	ppm	438.5	417.6	537.5
2	Calcium(Ca)	%	0.03	0.11	0.11
3	Magnesium(Mg)	%	0.09	0.20	0.086
4	Phosphorus (P)	%	0.27	0.20	0.068
5	Potassium (K)	%	1.92	1.58	0.61
6	Copper(Cu)	ppm	12.2	13.7	13.7
7	Zinc(Zn)	ppm	106.5	82.3	70.8
8	Iron (Fe)	%	0.036	0.18	0.075
9	Manganese(Mn)	ppm	77.8	74.5	124.0
10	Sulphur (S)	ppm	40.2	45.3	156.3

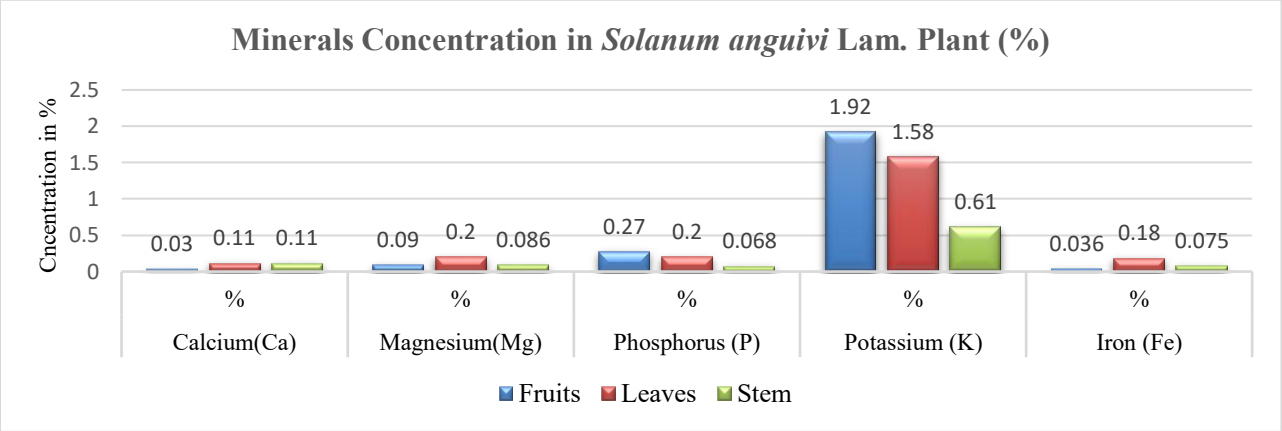

Fig.5. Graph of Comparative chart of Minerals concentration (%) in fruits, leaves and stem of *Solanum anguivi* Lam.

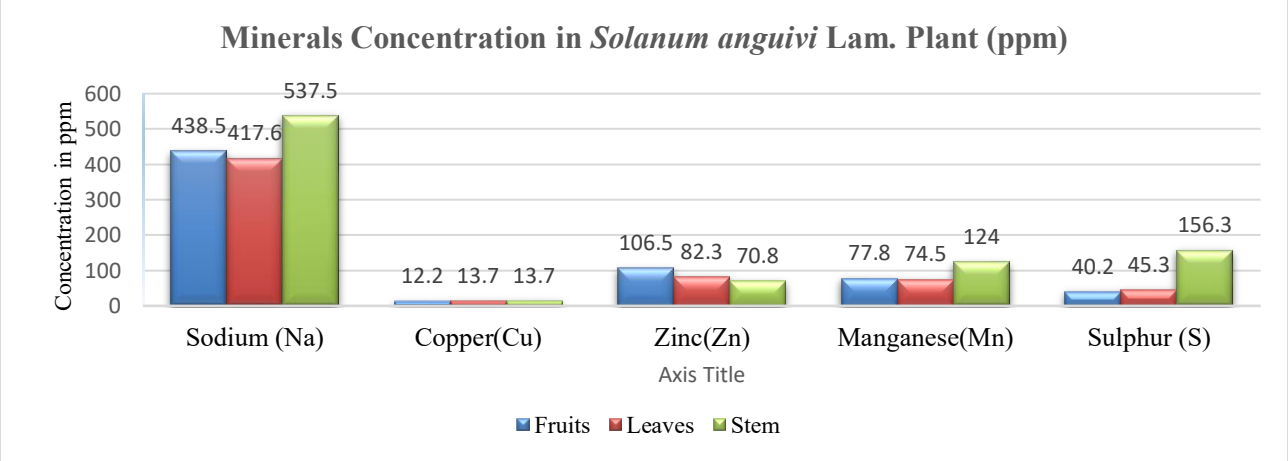

Fig.6. Graph of Minerals concentration (ppm) in fruits, leaves and stem of *Solanum anguivi* Lam.

The early phytochemical examination of *Solanum anguivi* plant n-hexane extract revealed the presence of phenols, saponins, steroids, terpenoids, oxalate, and lipid components. Alkaloids, cardiac glycosides, flavonoids, tannins, and quinones were all lacking. The leaf extract's preliminary phytochemical study indicated the presence of alkaloids, flavonoids, phenols, tannis, quinones, oxalates, and lipids, while cardiac glycosides, steroids, saponins, and terpenoids were lacking. The stem extract included alkaloids, flavonoids, phenols, saponins, steroids, terpenoids, quinones, oxalates, and lipids, but no cardiac glycosides or tannins were detected. **Table 2** summarizes all of the preliminary phytochemical analysis results. Previous researchers Oyeyemi *et al*. (2015) found same results in fruits from the same plant. Kartika *et al*. (2017) conducted phytochemical analyses on *Solanum anguivi* Lam. The same results were obtained in

fruits' methanolic extracts. Mehaboob *et al*. (2019) discovered the same result in fruit extracts while doing phytochemical research.

The FTIR examination of fruit, leaf, and stem extracts reveals the presence of carboxylic acids, triglycerides, nitro, alkyl halide, and alkyne function groups. Only aromatic functions have been described in leaves. The stem FTIR analysis results include alcohols, phenols, alkenes, and glycogen function groups. The findings of the analysis were summarized in **Table 3** and Figures 1-3. Dalvi and Patil (2016) FTIR observed a similar conclusion in their work using fruit mathnolic extract. Garnepudi *et al*. (2023) found the same functional groups in a leaf methanolic extract of Solanum nigrum. Chinenyenwa *et al*., (2024) FTIR study of *Solanum aethiopicum* revealed the same functional groups in methanol solvent.

The GC-HRMS analysis of fruits n-hexane extract result shows the presence of various bioactive compounds such as trans-β-Ocimene, Piperidine-2,5-dione, p-Cymene, 3-p-Menthen-7-al, γ-Elemene, α-Cubebene, Caryophyllene, α-Guaiene, Humulene, Ginsenol, α-Muurolene, Santolina triene, aR-Turmerone, Turmeronol A, Piperidine, 1-acetyl-, Glycidyl palmitate, Piperidine, Squalene, Piperine, Stigmasta-3,5-diene, dl-α-Tocopherol and γ-Sitosterol. Figure 4 and **Table 5** summarize the data from the GC-HRMS investigation. Previous researchers, Hongal et al., (2024), used GCMS to analyze *Solanum salviifolium* (L.f) and found same chemicals in an ethanolic extract of the *Solanum nigrum* plant. Rautela *et al*. (2025) and Khan *et al*. (2016) found comparable results in ethanolic and methanolic extracts of Solanum nigrum fruits. Steroidal chemicals were identified in the GCMS analysis of a methanolic extract of *Solanum nigrum* fruits.

The AAS, UV-VIS spectrophotometer analysis results shows the variable amount of Na, Ca, Mg, P, K, Cu, Zn, Fe, Mn and S in different plant parts. The fruits sample contain nutritionally important minerals like Na (438.5 ppm), Ca (0.03%), Mg (0.09%), P (0.27%), K (1.92%), Cu (12.3 ppm), Zn (106.5 ppm), Fe (0.036%), Mn (77.8 ppm) and S (40.2 ppm). The leaves samples contain Na (417.6 ppm), Ca (0.11%), Mg (0.20%), P (0.20%), K (1.58%), Cu (13.7 ppm), Zn (82.3ppm), Fe (0.18%), Mn (74.5 ppm) and S (45.3 ppm). The stem contains Na (537.5 ppm), Ca (0.11%), Mg (0.086%), P (0.068%), K (0.61%), Cu (13.7ppm), Zn (70.8 ppm), Fe (0.075%), Mn (124.0 ppm) and So_4 (156.3 ppm). The minerals analysis obtained results were

summarised in Table **No.5.** and graph of comparative chart figure no.5 and 6. Oyeyemi *et al.,* (2015) carried out minerals analysis of same plants fruit and analysis observed the same minerals in by using same analysis methodology. Karthika *et al.,* (2017) reported that fruits of this plant was rich source of minerals. Aghrahar-Murugkar and Subbulakshmi (2005) observed similarly, fruits of *Solanum indicum* was rich in phosphorous and magnesium like *Solanum anguivi* Lam. fruits.

Conclusion

Solanum anguivi Lam's fruit, leaves, and stem were identified using phytochemical research. The plant contains several types of medicinally significant bioactive chemicals. The minerals examination revealed that the plant's various portions were rich in mineral content, proving that this plant was nutritionally essential.

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