IJBPAS, August, 2023, 12(8): 3523-3537

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

PHYTOCHEMICALS SCREENING AND COMPOUNDS IDENTIFICATION IN *THESPESIA POPULNEA* LEAF AND FRUIT EXTRACT THROUGH GC-MS & ACTIVITY VALIDATION AT INTERNATIONAL COMPOUND DATABASES

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Received 12th Sept. 2022; Revised 18th Oct. 2022; Accepted 7th Nov. 2022; Available online 1st Aug. 2023

https://doi.org/10.31032/IJBPAS/2023/12.8.7326

ABSTRACT

Thespesia populnea, commonly known as Paras Peepal is a large tree belongs to the family Malvaceae. It is found in tropical and coastal regions of India. The various parts of the tree are traditionally used for anti-inflammatory, hepatoprotective, anti-psoriasis, anti-diabetic, wound healing properties. The present study was done to identify the phytocompounds in methanolic extract of *Thespesia populnea* leaf (METPL) &and fruits (METPF) through Thin Layer Chromtography (TLC) & Gas Chromatography – Mass Spectrometry (GC-MS) techniques. The preliminary phytochemical screening showed the presence of various phytochemicals like Glycosides, Phenol, Tannins, Flavonoids, Phytosterols, Saponins, Steroid, Phenols, and Quininesetc. In a GC-MS examination of the said extracts, over200 compounds were attributed through Mass spectra matching with the National Institute Standard and Technology (NIST) database (ver. 2011). Out of them, 23 compounds like3-Eicosyne, 9-Octadecen-1-ol, (Z)-, n-Hexadecanoic acid, Octadecanoic acid, Octadecanoic acid 2-(2-hydroxyethoxy)ethyl ester,Dodecanoic acid, Heptadecane, 2,6,10,15-tetramethyl-, 2-methyloctacosane,n-Hexadecanoic acid, Octadecanoic acid, Undecanoic acid, Palmitoleic acid, Oleic Acid, 6-

Octadecanoic acid etc. were identified in 39.83% peakarea of the chromatogram. Further, on cross matching of the identified compounds at international compounds databases like PUBCHEM, the tree is found having compounds relating to antimicrobial, anti-inflammatory, antioxidant, anti-tumor, anti-inflammatory, antibacterial, antifungal, anti-viral medicinal properties. Therefore, *Thespesia populnea* can be a good source of pharmacological agents against infectious and life style disorders. Further studies may prove it a plant of great source of therapeutic agents.

Keywords: Paras peepal, *Thespesia populnea,* Indian Tulip, Thin Layer Chromatography, GC-MS analysis, PubChem, Phytochemical compound screening

1. INTRODUCTION

Thespesia populnea, commonly known as Paras Peepal or Indian Tulip, is a large tree that belongs to the Malvaceae family. It is mainly found in tropical and coastal forest areas of India. It grows in a wide soil pH range (6-7.5) to a height of 15m and bears heart-shaped leaves with a distinct tip. Fruits are brown in color with too many capsules. The tree provides valuable dark red wood and oil from its seeds. Almost every part of the tree above ground is traditionally known for several valuable medicinal values. Leaves are applied topically to swollen joints to reduce inflammation and joint pain. The decoction of the bark is commonly used for the treatment of cholesterol lowering, anti-cholinesterase, anti-inflammatory, and antioxidant activities **[1]**. A compound oil of the bark and capsules are useful in Gonorrhoea and Urethritis **[2]**. The bark, root, fruits are used in dysentery, cholera and haemorrhoids **[3]**. Fruit juices are used on rheumatism sprains, scabies, swellings, insect bites and warts **[4]**. Pulps of fresh fruits are applied for relief in migraine. Unripe fruit juice is used to cure piles **[5]**. Moreover, people use it against the Diabetes, Asthma, cough, psoriasis, wound and Urinary tract infections **[6]**. Chiefly, *Thespesia* plant is known among the local people for its healing effects against the cutaneous infections and liver diseases. Therefore, considering the popularity of the plant for above medicinal values among local people, a chromatographic analysis of the fruit and leaf extract in methanol solvents was undertaken in the present study through Thin Layer Chromatography (TLC) and Gas Chromatography-Mass Spectrometry (GC-MS) at the Innovation Centre of Bundelkhand University Campus, Jhansi, UP, India. In GC-MS study, above 200 compounds were reported in 33 different peaks of the chromatogram through National Institute Standard and Technology (NIST) database. Further, the identified compounds were searched for their known therapeutic effects at international chemical compound

databases like Pubchem, Chembank, etc. As per the activities reported there in databases, the identified compounds in plant extract are found having anti-fungal, anti-inflammatory, anti-oxidant, anti-leishmanial and anti-tumour properties. Therefore, plant may be a great source of agents against Aging, Cancer, Leishmaniasis, Inflammatory diseases, fungal diseases etc.

2. MATERIALS & METHODS

2.1 Collection of the plant material

The leaves and fruit samples of *Thespesia populnea* were collected from Nandanpura, Badagaon, Narayan Bagh areas of the Jhansi, Uttar Pradesh, India in February 2020. The collected samples were got authenticated from Central Council for Research in Ayruvedic Science (CCRAS) - Regional Ayurveda Research Institute Gwalior Road, Jhansi Uttar Pradesh (Accession No. 28685).

2.2 Preparation of the plant extract

The collected plant materials were firstly double washed by tap water and distilled water respectively, then shade dried at room temperature for 2-4 weeks. After drying, the leaves and fruits were transformed into a fine powder by an electric mixer. A20 gm well grinded leaf powder in a ratio of 1:10 was placed in a Soxhlet apparatus for extraction in 200ml Methanol solvent (AR grade) for 16-18 hours at 64.6°C. *Thespesia* fruit extraction was also done in the same manner. Further, the collected pure extracts of leaves and fruits were filtered by Whatman filter paper No.41 (110mm) and cotton wool. After filtration, the extracts were concentrated by a Rotary Evaporator (EYELA N-12008, EYELA- UNI TRAP UT-1000) associated with water bath at 45-50°C for 2-3 Hrs. The resulted solutions were stored in a refrigerator at 4°C for further analysis.

2.3.1 Preparation of Mobile phase for TLC plate chamber

10 microliters of the extract was spotted onto the 10 x 10 cm TLC plate using and separated in the saturated development TLC chamber containing the mobile phase as; 1-butanol, glacial acetic acid, water (4:2:2) to solvent font at 90 mm, TLC plate removed from developing TLC chamber and air dried. The fingerprint was examined under white light, 254 and 366 nm luminescent, and then documentation. The spots are given as retention factor (Rf), determined by using the following formula **[8]**.

$$Rf = \frac{\text{Distance travelled by solvent}}{\text{Distance travelled by solute}}$$

2.3 PRELIMINARY PHYTOCHEMICAL SCREENING

The preliminary phytochemical screening of primary metabolites (carbohydrates, Starch, proteins, amino acid, oils and fat) and secondary metabolites (Anthraquinones, Quinines, Glycosides, cardiac glycosides, Phenol, Tannins, Flavonoids, Phytosterols, Saponins, and Steroids) was done by following standard protocols **[9], [10]** for the same.

I. Qualitative Analysis of Primary Metabolites

2.3.1 Test for Carbohydrates

Benedict's test: About 0.5 ml filtrate was added in 0.5 ml Benedict's reagent and heated for about 2 minutes in a boiling water bath then observed for the appearance of red precipitate **[11]**

Test for Starch

About 5 ml distilled water, 0.01gm Iodine and 0.075 gm Potassium Iodide were added to make a solution and then added 2-3 ml of the plant extract in it for the appearance of blue colour.

2.3.2 Test for proteins

2ml plant extract was mixed in 2ml water and then added in 0.5% conc. HNO_3. The solution was then observed for the appearance of yellow colour for the confirmation of the presence of proteins.

2.3.3 Test for Amino Acids

1ml extract was added in2-3 drops of Ninhydrin reagent (10mg Ninhydrin mixed in 200ml acetone) and then observed for the appearance of purple colour if amino acid is present.

2.3.4 Test of fixed Oils & Fats (saponification test)

Few drops of 0.5N alcoholic KOH and few drops of phenolphthalein were added in 1ml extract and heated for about 2 hours. The mixture was then observed for the formation of soap or partial neutralization of alkali for the confirmation of the presence of fixed oils or fats **[12]**.

II. Qualitative Analysis of Secondary Metabolites

2.3.5 Test for Anthraquinones

5ml plant extract and few ml of conc.$H_2SO_4$was added in 1 ml diluted ammonia and then observe for the appearance of rose pink color.

2.3.6 Test for Quinones

1ml plant extract was added in alcoholic KOH and then observed for the change of color of solution from Red to Blue.

2.3.7 Test for Glycosides

2ml plant extract was mixed in about 0.4 ml glacial acetic acid containing traces of ferric chloride and 0.5 ml of conc. H_2SO_4 then observed for the appearance of blue colour.

2.3.8 Test for Cardiac Glycosides(Killer-Killani test)

5ml plant extract was mixed in 2ml glacial acetic acid and a drop of ferric chloride, then 1ml conc. $H_2SO_4$was added into the mixture and observed for the appearance of a brown ring for the confirmation of the presence of deoxy sugars of cardenolides.

2.3.9 Test for Phenol

Lead acetate test: 5 ml plant extract was added in 3ml 10%lead acetate solution and mixed gently, then observed for the production of bulky white precipitate.

2.3.10 Test for Tannins

Few drops of neutral 5% ferric chloride solution were added in the 5ml plant extract then observed for the production of dark green colour.

2.3.11 Test for Flavonoids

The plant extract was treated with concentrated $H_2SO_4$and then observed for the formation of orange colour.

2.3.12 Test for Phytosterols

The extract was refluxed with alcoholic KOH and saponification takes place. The solution was diluted with ether and then layer was evaporated and residue was tested for presence of phytosterols. It was dissolved in diluted acetic acid and few drops of concentrated H_2SO_4were added, then observed for the presence of bluish green colour.

2.3.13 Test for Saponin

0.5 mg plant extract was vigorously shaken with few ml of distilled water then observed for the froth formation.

2.3.14 Test for steroids

2ml plant extract was added in 2ml chloroform and 2ml concentrated H_2SO_4then observed for the appearance of red colour and yellowish green fluorescence.

3. GC-MS Analysis:

GC-MS analysis was performed on a PerkinElmer Turbo mass spectrophotometer incorporating a PerkinElmer XLGC auto-sampler. The column used in the GC was PerkinElmer Elite - 5 capillary columns with a length of 30 m, 0.25 mm and a film thickness of 0.25 mm, consisting of 95% dimethylpolysiloxane. Helium (99.999%) with a flow rate of 0.5 ml/min was used as carrier gas. The sample injection volume used was 1 µL. The inlet temperature was maintained at 250°C. The oven temperature was programmed at 110 °C (2 min isothermal) with a ramp of 10°C/min to 200°C, then 5°C/min to 280 °C, ending with a 5 min isotherm at 280°C. The total running time was 30 min. The MS transfer line was maintained at a temperature of 200°C. The source temperature was

maintained at 180°C. The chromatogram was analysed using electron impact ionization at 70 eV and the data were evaluated using total ion count (TIC) to identify and quantify compounds. The spectra of the components were compared to the database of spectra of known components stored in the GC-MS library. The measurement of the peak areas and the data processing were performed with the software Turbo-Mass OCPTVS-Demo SPL.

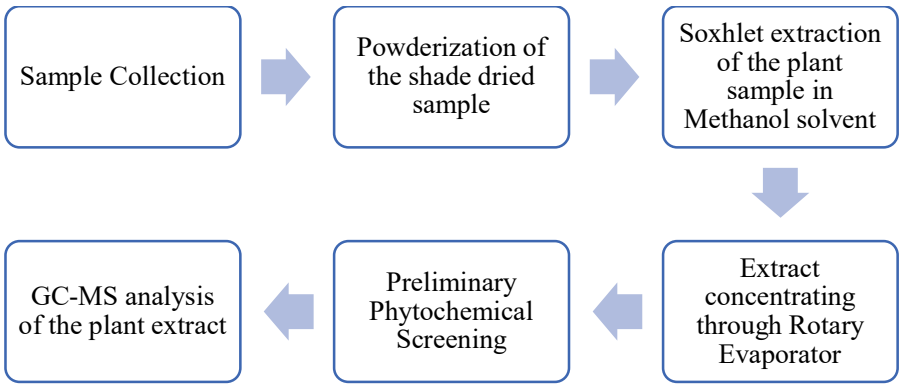

Figure 1: Showing steps of the work plan

3. RESULTS AND DISCUSSION

The phytochemical screening results have confirmed that the plant is rich in multiple phytochemicals such as Carbohydrates, Amino acids, Proteins, Oils and Fats, Anthraquinones, Quinines, Glycosides, Cardiac glycosides, Phenol, Tannins, Flavonoids, Phytosterols, Saponins, Steroids hence can be a good source of therapeutically and industrially useful agents as per the following details, given in **Table 1**.

TLC analysis reflected several distinct spots of varying intensity on the plate **(Figure: 2 & 3)**. While examining the plate under 254 and 365 nm wavelength bands, various colours including red, blue, light pink, sky blue, etc. were reflected. The results are summarized in **Table: 2 & 3**.

The Thin Layer Chromatography results of both leaf and fruit have shown that the plant is a good source of Carotene, Astaxanthin, and p-coumaric acid (p-CA) which is thought to prevent disease, mainly through their antioxidant and anti-microbial properties. Carotene which animals can't synthesize is known to exhibit many biological and pharmaceutical benefits like anti-cancers, anti-inflammatory and immunity booster **[13], [14]**. Some of the carotenoids are reported to be converted into vitamin A in the human body **[15]** thus

can be of great importance in treating vision problems. Astaxanthin is a potent anti-inflammatory and antioxidant agent as it reduces the release of ROS and inflammatory cytokines via the MAPK pathway **[16]**. Based on their anti-viral and anti-inflammatory properties they can be good candidates for treating emerging viral diseases including COVID-19 as reviewed by **[17]** also. p-CA has been reported as a hepatoprotective agent against the CCl_4 or common bile duct ligation (necrosis and cholestasis) induced liver damage and also exhibits amoebostatic activity against *Entamoeba histolytica* **[18]**, therefore, plant material can be a good source of developing therapeutic agents for liver diseases and Diarrhoea.

Acetophenone, another identified phytochemical in TLC analysis is known to be used as fragrance imparting agent in perfumes, soaps, detergents, and lotions **[19]**. It is generally recognized as safe, direct food additive being used as flavouring agent in various products like chewing gum and in some tobacco products **[19]**. In olden days, the acetophenone, due to its analgesic effects was used as an anesthetic agent in conjunction with chloroform. Also, it has been one of the most successful agents for treating insomnia **[19]**. Hence, *Thespesia* plant material (leaf & fruit) can be further explored for developing stress reducing agents and inducing sleep among the people suffering from sleep disorders and depression.

The Rosmarinic acid (RA) identified in Thespesia fruit through TLC analysis is a natural polyphenolic antioxidant which has displayed several significant bioactivities, including anti-inflammatory, anti-microbial, antidepressant, anti-cancer, and chemopreventive properties **[20]**.

Gas chromatography-mass spectrometer analysis of the METPL & METPF revealed 33 and 65 peaks, respectively **(shown in Figures 4 and 5)**. Examination of the significant peaks by MS examined about 250 phytochemical compounds (about 20 compounds/peak) in METPL and METPF. When screening the compounds by validating their biological activity in NCBI international compound databases such as PubChem, HMDB, Drug Bank Databases, mainly 23 compounds (11 in METPL & 12 in METPF) represented in 39.83% peak area of the chromatogram (26.87% at METPL and 12.96% at METPF) are the focus of this study. Details of all 23 main identified compounds are given in **Tables 4 and 5** with their name, RT value, peak area percentage, molecular formula, molecular weight and biological activities.

The biological activity search of 23 main identified compounds of METPL and METPF by GC-MS has revealed that the leaves and fruits of *Thespesia polpulnea*

have several important medicinal values. Compounds present in high concentration like 3-Eicosyne, 9-Octadecen-1-ol, (Z)-, Octadecanoic acid, Heptadecane, 2,6,10,15-tetramethyl-, 2-methyloctacosane, n-Hexadecanoic acid, Octadecanoic acid are known as a potential biomarker for the consumption of food, Viscosity controlling, used to make soaps, lubricating oils, waterproofing materials, food additives, Metabolite observed in cancer metabolism, a potential biomarker for the consumption of alcoholic beverages, cereals and cereal products, and citrus and used to make soaps, lubricating oils, waterproofing materials, food additives and to make other chemicals. The Undecanoic acid & à-Tocopheryl acetate are known to have anti-fungal and antioxidant properties respectively. The plant is identified as a good source of Vitamin E which is well known to be used as an antioxidant in vegetable oils, cosmetics and some antibacterial hand soaps. It prevents protein oxidation and inhibits lipid peroxidation, thereby maintaining cell membrane integrity and protecting the cell against damage. It inhibits the protein kinase C (PKC), platelet aggregation, and enhances vasodilation.

Table 1: Preliminary phytochemical evaluation of methanolic extracts of *Thespesia populnea leaves and fruits*(+) = Present; (-) =Absent

Phytochemical Compounds Name	Tests Name	*Thespesia populnea leaf*	*Thespesia populnea fruit*
Carbohydrates	Benedict's test	+	+
Starch	Iodine test	-	-
Proteins	Nitric acid test	+	+
Amino acids	Ninhydrin reagent test	+	+
Oils and Fats	Saponification test	-	+
Anthraquinones	H2SO4 test	-	+
Quinines	KOH test	-	+
Glycosides	Glacial acetic acid	-	+
Cardiac glycosides	Keller-Killani test	+	+
Phenol	Lead acetate test	+	+
Tannins	Ferric chloride test	+	+
Flavonoids	H2SO4 test	+	+
Phytosterols	KOH+ acetic acid+H2SO4	+	-
Saponins	Vigorously shaken of water test	+	+
Steroids	chloroform +H_2SO_4 test	-	-

Table 2: Retention factor values of *Thespesia populnea* leaf to identify plant pigments

Sr. No.	Spot Colour	Distance travelled by Solvent	Distance travelled by Solvent	Rf Values	Compounds Name
1	Blue	9 cm.	8.7 cm.	0.966	Carotene
2	Red	9 cm.	7.9 cm.	0.877	Echinenone
3	Light Pink	9 cm.	7.6 cm.	0.844	Acetophenone
4	Orange	9 cm.	6.8 cm.	0.755	Astaxanthin Di-esters
5	Light Red	9 cm.	6.3 cm.	0.700	Chlorophyll a
6	Light blue	9 cm.	5.4 cm.	0.600	Chlorophyll b
7	Light pink	9 cm.	5.1 cm.	0.566	Chlorophyll c
8	Sky blue	9 cm.	4.5 cm.	0.500	Astaxanthin Monoesters
9	Purple	9 cm.	3.0 cm.	0.333	Theronine
10	Pink	9 cm.	2.7 cm.	0.300	Astaxanthine free

Table 3: Retention factor values of *Thespesia populnea* fruit to identify plant pigments

Sr. No.	Spot Colour	Distance travelled by Solvent	Distance travelled by Solvent	Rf Values	Compounds Name
1	Pink	*9cm.*	8.7cm.	0.966	Carotene
2	Light Pink	*9cm.*	8.2cm.	0.916	Bi-phenyl
3	Light Sky	*9cm.*	7.8cm.	0.866	2-Methoxynaphalene
4	Radish Pink	*9cm.*	5.1cm.	0.566	p-Coumaric
5	Dark Sky	*9cm.*	4.8cm.	0.533	Rosmarinic acid
6	Sky	*9cm.*	3.6cm.	0.400	Glucose
7	Grey	*9cm.*	3.0cm.	0.333	Theronine
8	Light Grey	*9cm.*	2.1cm.	0.233	Arachidyle alcohol

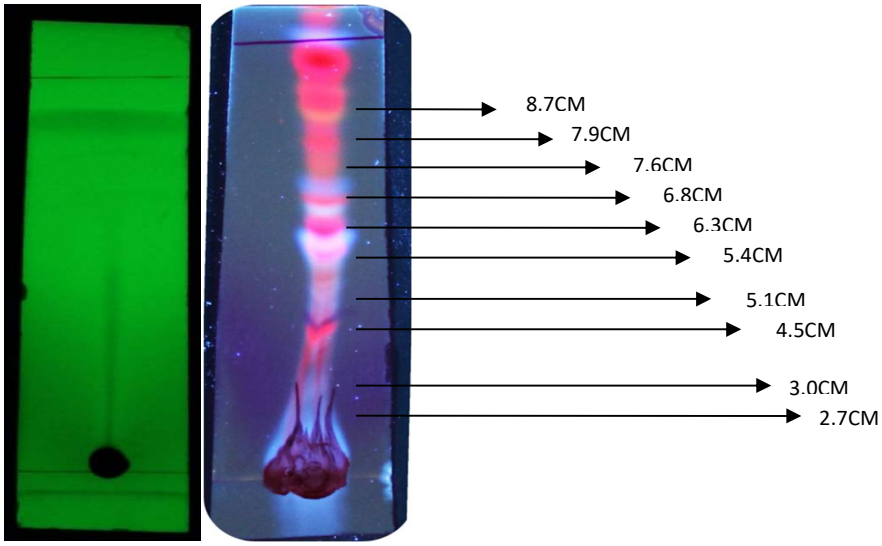

Figure 2: TLC plates of *TPL* visualize under 245& 365 nm wavelengths

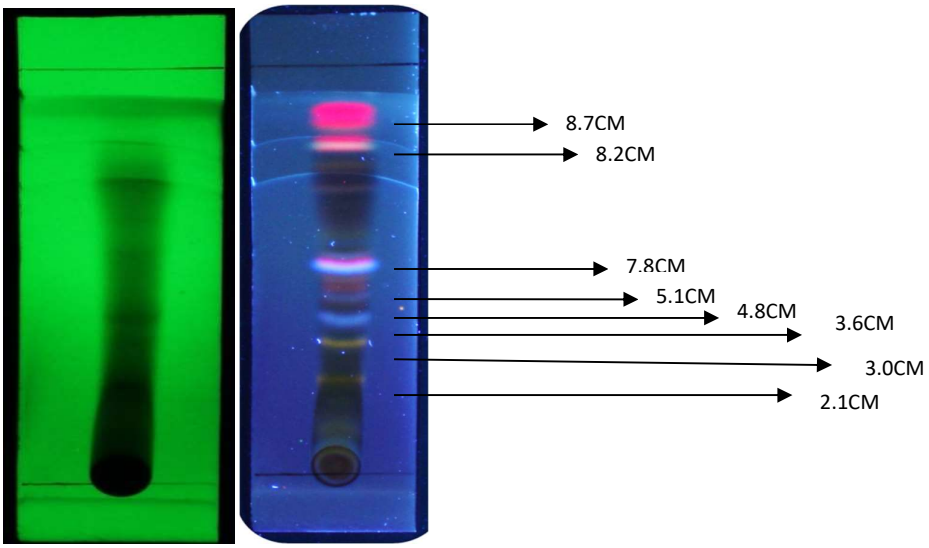

Figure 3: TLC plates of *TPF* visualized under 245& 365 nm wavelengths.

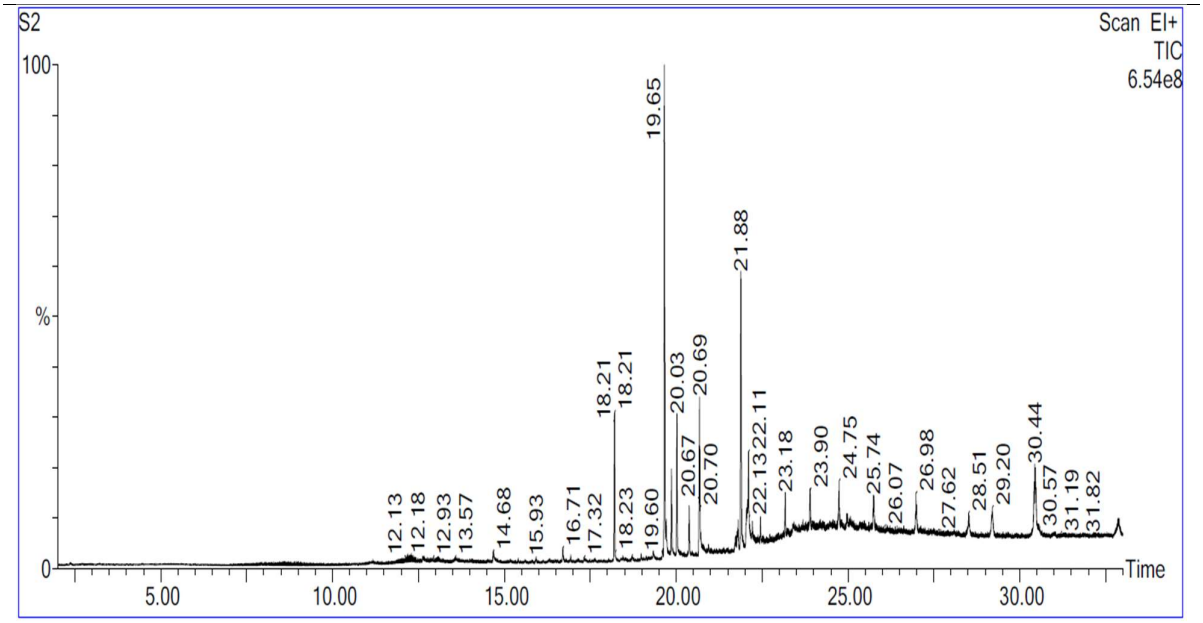

Figure 4: Chromatogram of Methanolic extract of *Thespesia populnea* leaf (METPL)

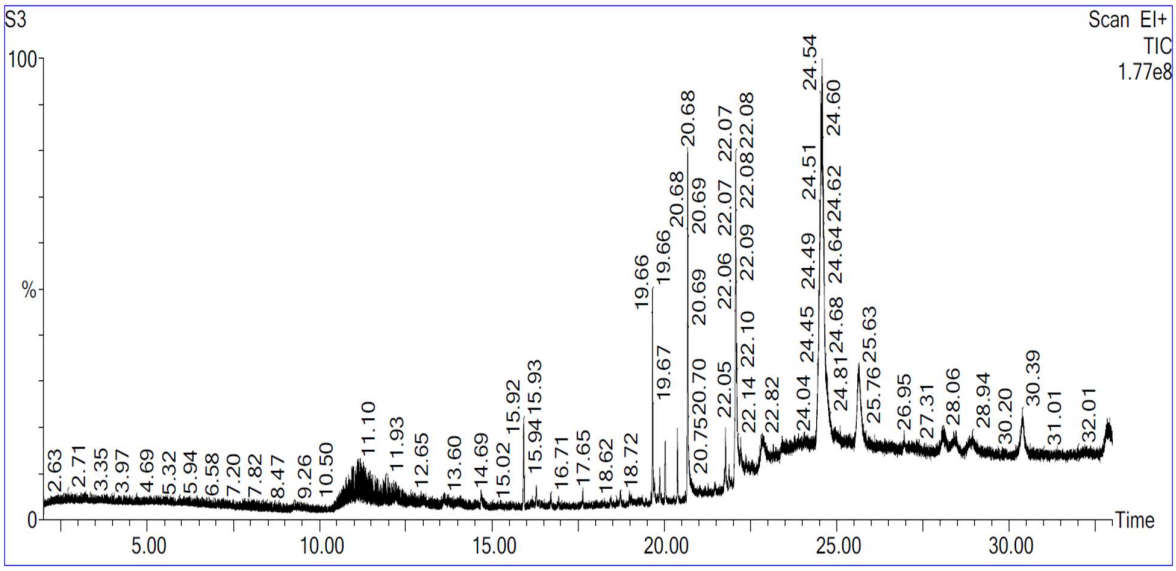

Figure 5: Chromatogram of *Thespesia populnea* fruits (TPF)

Table 4: Detail of compounds identified in methanolic extract of *Thespesia populnea* Leaf (TPL) through GC-MS analysis

Sr. No.	RT (in Minutes)	Compound Name	Peak area %	Mol. Formula	Mol. Wt.	Biological activities
1.	19.66	3-Eicosyne	8.82	$C_{20}H_{38}$	278	a potential biomarker for the consumption of foods [20]
2.	21.88	9-Octadecen-1-ol, (Z)-	5.89	$C_{18}H_{36}O$	268	role as a non-ionic surfactant and a metabolite,Cosmetics -> Emollient; Emulsifying; Opacifying; Viscosity controlling [20]
3.	20.68	n-Hexadecanoic acid	3.38	$C_{16}H_{32}O_2$	256	used to make soaps, lubricating oils, waterproofing materials, food additives [20]
4.		Octadecanoic acid	3.38	$C_{18}H_{36}O_2$	284	used in pharmaceuticals, cosmetics, soaps,

						phonograph records, insulators, candles, food packaging, modellingcompounds [20]
5.		Octadecanoic acid, 2-(2-hydroxyethoxy)ethyl ester	3.38	$C_{22}H_{44}O_4$	372	Cosmetics -> Emulsifying; Opacifying. [20]
6.		Dodecanoic acid	3.38	$C_{12}H_{24}O_2$	200	used in laboratory investigations of melting-point depression. [20]
7.	18.21	Butylated Hydroxytoluene	2.78	$C_{15}H_{24}O$	220	used in food, cosmetics and industrial fluids to prevent oxidation and free radical formation, role as an antioxidant and a food additive. [20]
8.	20.02	E-6-Octadecen-1-ol acetate	2.59	$C_{20}H_{38}O_2$	310	a potential biomarker for the consumption of burdocks and watermelons. [20]
9.	22.10	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	2.21	$C_{18}H_{30}O_2$	278	inhibit the synthesis of prostaglandin resulting in reduced inflammation and prevention of certain chronic diseases Cosmetics -> Antistatic; Cleansing; Emollient; Emulsifying; Hair conditioning; Skin conditioning; Surfactant. [20]
10.	29.20	Squalene	1.20	$C_{30}H_{50}$	410	used to make other chemicals such as drugs and rubber chemicals. It is used in cosmetics including sun screen lotions, lipstick foundations, nail products, hair conditioners and moisturizers. Squalene is used as a traditional medicine and dietary supplement.[20]
11.		trans-Geranylgeraniol	1.20	$C_{20}H_{34}O$	290	an antileishmanial agent. [20]

Table 5: Detail of compounds Identified from GC-MS analysis of a methanolic extract of *Thespesia populnea* fruit

Sr. No.	RT(in Minute)	Compound Name	%age Peak area	Mol. Formula	Mol .Wt.	Biological activities
1.	24.53	Heptadecane, 2,6,10,15-tetramethyl-	4.64	$C_{21}H_{44}$	296	Metabolite observed in cancer metabolism. [20]
2.	24.53	2-methyloctacosane	4.64	$C_{29}H_{60}$	408	a potential biomarker for the consumption of alcoholic beverages, cereals and cereal products, and citrus. [20]
3.	20.68	n-Hexadecanoic acid	3.029	$C_{16}H_{32}O_2$	256	used to make soaps, lubricating oils, waterproofing materials, food additives and to make other chemicals. [20]
4.	20.68	Octadecanoic acid	3.029	$C_{18}H_{36}O_2$	284	used in pharmaceuticals, cosmetics, soaps, phonograph records, insulators, candles, food packaging, modelling compounds. [20]
5.	20.68	Undecanoic acid	3.029	$C_{11}H_{22}O_2$	186	an antifungal agent. [20]
6.	22.07	Palmitoleic acid	3.025	$C_{16}H_{30}O_2$	254	a human blood serum metabolite.

						[20]
7.	22.07	Oleic Acid	3.025	$C_{18}H_{34}O_2$	282	used commercially in the preparation of oleates and lotions, and as a pharmaceutical solvent. [20]
8.	22.07	6-Octadecenoic acid	3.025	$C_{18}H_{34}O_2$	282	important oleochemical material for the food, cosmetics, chemistry and pharmaceutical. [20]
9.	25.63	dl-à-Tocopherol	2.27	$C_{29}H_{50}O_2$	430	used as an antioxidant in fats and oils and as a supplement in nutritional or fortified foods. [20]
10.	25.63	(+)-ç-Tocopherol, O-methyl	2.27	$C_{31}H_{52}O_3$	444	exhibits antioxidant activity by virtue of the phenolic hydrogen on the 2H-1-benzopyran-6-ol nucleus. [20]
11.	25.63	à-Tocopheryl acetate	2.27	$C_{31}H_{52}O_3$	472	Antioxidant. [20]
12.	25.63	Vitamin E	2.27	$C_{29}H_{50}O_2$	430	used as an antioxidant in vegetable oils and shortenings and cosmetics, used in some antibacterial hand soaps, prevents protein oxidation and inhibits lipid peroxidation, thereby maintaining cell membrane integrity and protecting the cell against damage. inhibits the activity of protein kinase C (PKC) and PKC-mediated pathways, inhibits platelet aggregation and enhances vasodilation. [20]

4. CONCLUSIONS

The present study on methanolic extraction of *Thespesia populnea* leaf and fruit has justified its use as antimicrobial, anti-inflammatory and anti-oxidant agent. Additionally, the plant materials are found rich in compounds of great pharmacological importance which can be used in developing therapeutic candidates for the treatment of vision problems, liver diseases, diarrhoea, stress, insomnia, depression, platelet aggregation, cancer, fungal infections, leishmaniasis, etc. through proper studies. Not only medicinal, the plant with its several identified compounds can be useful in making soap, lubricating oils, waterproofing materials, food additives, fragrance, oleates, lotions and other cosmetic products. Since it is rich in carotene and astaxanthin, the well-known anti-oxidant, anti-inflammatory and antiviral agents hence they can be explored for their effects on COVID-19 also.

Therefore, *Thespesia populnea* plant is a great source of several pharmacological and industrially important compounds which can be further explored for the development of therapeutic agents through systemic studies.

5. ACKNOWLEDGEMENTS

The present research work was carried out under the financial support of University Grants Commission under STRIDE component-I to Bundelkhand University Campus, Jhansi. We thankfully

acknowledge the support of the entire staff of Innovation Centre, Bundelkhand University Jhansi, laid during the experimental works on TLC, GC-MS, Rota-evaporator and other instruments of the Centre.

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