GC-MS Analysis of Phyto-components from the Leaves of Achyranthes aspera L. of Ranchi, Jharkhand used against Skin Diseases

Vikram Kumar Sharma[1] and Rashmi Mishra[2]
[1]*Research Scholar, Department of Botany, Dr. Shyama Prasad Mukherjee University, Ranchi, Jharkhand.*
[2]*Assistant Professor, Department of Botany, Dr. Shyama Prasad Mukherjee University, Ranchi, Jharkhand, India*

***Abstract*—The escalating rate of drug-resistant dermatological conditions demands the exploration of plant-derived alternatives. This study evaluates the lipophilic chemotype of Achyranthes aspera L. leaves from Ranchi, Jharkhand, validating its empirical use against skin diseases. Cold ethanolic maceration followed by Gas Chromatography-Mass Spectrometry (GC-MS) analysis revealed 17 distinct phyto-components over a 35-minute runtime. Hexadecanoic acid, methyl ester emerged as the predominant fraction (29.60), followed by methyl oleate (18.80), phytol (8.85), and methyl stearate (6.68). The presence of these fatty acid esters, along with bioactive tissue-repair agents like squalene (5.30) and lupeol (1.91), establishes a strong biochemical foundation for the plant's anti-inflammatory, antimicrobial, and barrier-recovery properties in ethno-dermatology.**

***Index Terms*—Achyranthes aspera L., GC-MS analysis, Phyto-components, Ranchi (Jharkhand), Skin diseases, Bioactive fatty acids.**

I. INTRODUCTION

The skin represents the body's largest organ system, serving as the primary barrier against environmental pathogens, UV radiation, and mechanical trauma. Globally, dermatological disorders ranging from bacterial infections like pyoderma and scabies to chronic inflammatory states such as eczema, psoriasis, and vitiligo pose a significant public health challenge [1]. The escalating problem of antimicrobial resistance among common skin pathogens, paired with the frequent adverse reactions associated with prolonged use of synthetic corticosteroids, has turned clinical attention toward natural alternatives [2]. Herbal medicine offers an expansive, molecularly diverse repository for structural leads capable of controlling tissue inflammation and accelerating epidermal tissue repair [3].

India's traditional healthcare systems, including Ayurveda and regional folk medicine, rely heavily on indigenous flora to treat deep-seated cutaneous anomalies [4]. Within this landscape, the state of Jharkhand, characterized by its dense forest reserves and deep-rooted tribal culture, serves as a crucial geographical center for ethnobotanical practices [5]. Traditional healers across Ranchi district actively exploit the local biodiversity, prescribing specific forest weeds to manage aggressive boils, chronic ulcers, and infectious skin eruptions [6].

Among the primary species valued by these local healers is Achyranthes aspera L. (Family: Amaranthaceae), widely known as the Prickly Chaff flower or 'Chirchiri' in regional dialects [7]. Achyranthes aspera is a stiff, erect perennial weed found extensively along roadsides and waste spaces across the Indian subcontinent [8]. In regional ethnomedicine, the leaves of this plant are heavily crushed into thick topical pastes or juiced to clear persistent skin eruptions, syphilitic sores, and insect bites [7,9]. Pharmacological validations have confirmed that raw leaf extracts display broad-spectrum antimicrobial, anti-inflammatory, and antioxidant properties, which directly support its wound-healing applications [10,11]. These therapeutic outcomes are driven by an underlying assembly of secondary metabolites, including saponins, alkaloids, flavonoids, and essential fatty acids [11].

To systematically transition this traditional knowledge into modern dermatological applications, a

comprehensive profiling of individual volatile bioactive compounds is required [12]. Gas Chromatography-Mass Spectrometry (GC-MS) represents the definitive analytical benchmark for resolving, screening, and structurally identifying complex matrices of lipophilic and volatile molecules in plant extracts [12,13]. However, a plant's exact secondary metabolic expression is not static; it is heavily modified by localized environmental factors such as soil chemistry, microclimatic stressors, altitude, and regional seasonal shifts [14]. Consequently, A. aspera specimens developing within the distinct ecological matrix of Ranchi, Jharkhand, are expected to present a unique chemotypic profile that directly influences their anti-dermatophytic and tissue-repair properties.

Despite its extensive local utilization, there is a distinct gap in literature regarding the exact volatile chemotype of A. aspera from this specific region, particularly regarding the identity of lipophilic components that readily penetrate the stratum corneum [6,15]. This research article evaluates the chemical profile of ethanolic leaf extracts of Ranchi-sourced A. aspera L. using GC-MS analysis. By identifying the specific phyto-components, this study aims to provide a rigorous molecular rationale for its empirical use against skin diseases, offering structural insights for the development of targeted, plant-derived topical therapeutics.

II. MATERIAL AND METHODS

A. Collection of Plant and Preparation of Extract

Fresh, disease-free leaves of Achyranthes aspera L. were collected from the localized geographical terrain of Ranchi, Jharkhand. The botanical identity of the specimen was authenticated using standard regional flora. The harvested leaf material was thoroughly washed under running tap water to eliminate surface dust and debris, rinsed with distilled water, and subsequently shade-dried at room temperature until a constant weight was achieved. The fully dried leaves were mechanically pulverized into a coarse powder using an electric blender.

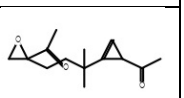
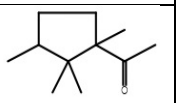
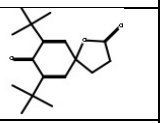
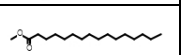
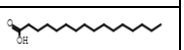
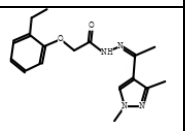
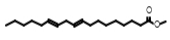
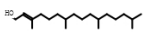
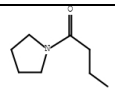
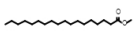
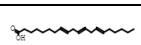
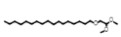
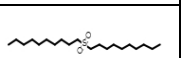
To prepare the crude phyto-extract, a fixed portion of the pulverized leaf powder was subjected to cold maceration using analytical-grade ethanol as the solvent phase. The mixture was kept in an airtight vessel and agitated periodically over a defined extraction window. Following maceration, the menstruum was double-filtered through Whatman No. 1 filter paper to separate the insoluble plant debris from the filtrate. The resulting liquid extract was concentrated under reduced pressure using a rotary evaporator at a controlled temperature to yield a thick, dark green semisolid residue. This ethanolic concentrate was stored in sterile, amber-colored glass vials at 4.00Cuntil further analytical screening.

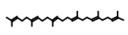
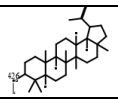
B. GC-MS Analysis and Identification of Components

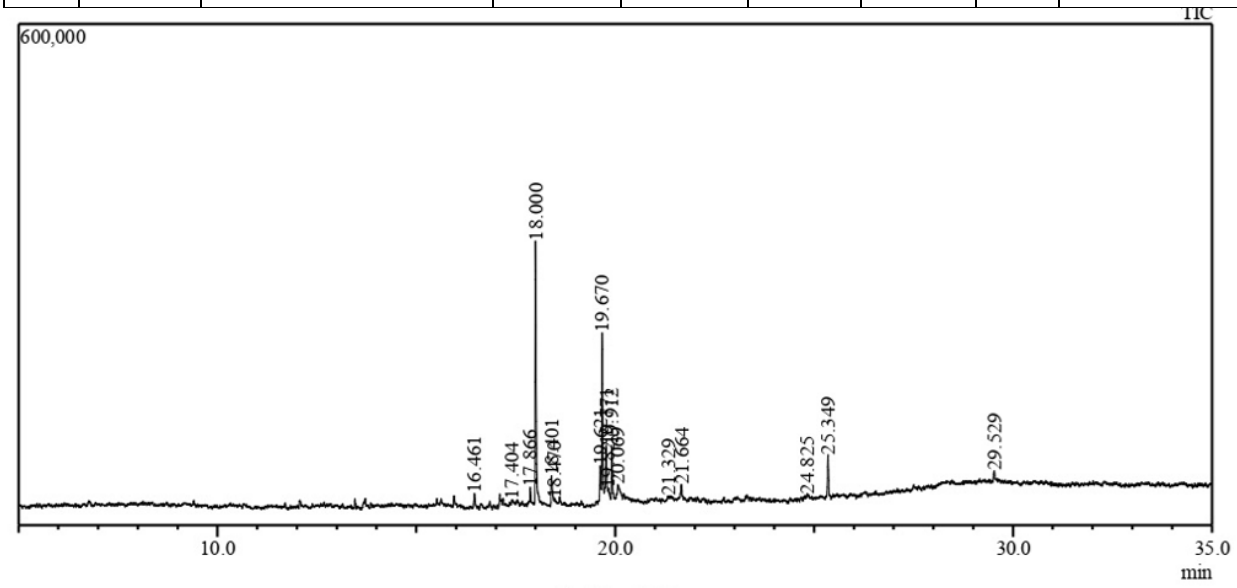
The chemical characterization of the volatile and lipophilic secondary metabolites present in the ethanolic leaf extract was executed using a Gas Chromatography-Mass Spectrometry (GC-MS) system handled via GCMS solution software. The analysis was conducted at the Central Laboratory of Patanjali Food and Herbal Park Pvt. Ltd., Haridwar, Uttarakhand. Chromatographic separation was achieved by injecting a 1.00 µL sample volume into the system configured under a validated scan method. Method Pathway: E:\Data Run 2025 JUNE 2025 12.06.2025\SCAN METHOD_17.04.2024-Copy.qgm Eluting chemical species were continuously monitored via a Total Ion Chromatogram (TIC) plot over a 35.0-minute total runtime. Mass spectrum generation utilized electronic impact ionization. Individual phyto-components resolved at distinct retention times (R.Time) were systematically identified by matching their experimental mass fragmentation spectrum fragments (m/z base peaks) against reference spectral profiles curated within the National Institute of Standards and Technology (NIST20M1, NIST20M2, and NIST20R) libraries. Quantitative calculation of individual components was expressed as an area percentage (%) relative to the total peak integration area.

III. RESULTS AND DISCUSSION

Table:1. Phytochemical Profile and Structural Skeletal Configurations of Achyranthes aspera

Peak	Retention Time (Rt, min)	Compound Name	Molecular Formula	Molecular Weight (g/mol)	Peak Area (Counts)	Area (%)	Base m/z	Molecular Structure Layout
1	16.461	1-(2-[3-(2-Acetyloxiran-2-yl)-1,1-dimethylpropyl] cycloprop-2-eny l) ethanone	C_{14} H_{20} O_3	236	34,195	1.78	43.1	
2	17.404	Ethanone, 1-(1,2,2,3-tetramethylcyclopentyl)-	C_{11} H_{20} O	168	34,743	1.81	43.1	
3	17.866	7,9-Di-tert-butyl-1-oxaspiro (4,5) deca-6,9-diene-2,8-dione	C_{17} H_{24} O_3	276	44,063	2.3	57.15	
4	18	Hexadecanoic acid, methyl ester (Methyl palmitate)	C_{17} H_{34} O_2	270	566,987	29.6	74.1	
5	18.401	n-Hexadecanoic acid (Palmitic acid)	C_{16} H_{32} O_2	256	86,589	4.52	41.1	
6	18.47	Acethydrazide, 2-(2-ethylphenoxy)-N2-[1-(1,3-dimethylpyrazol-4-yl) ethylidene]-	C_{17} H_{22} N_4 O_2	314	34,627	1.81	42.1	
7	19.621	9,12-Octadecadienoic acid, methyl ester (Methyl linoleate)	C_{19} H_{34} O_2	294	78,425	4.09	67.1	
8	19.67	9-Octadecenoic acid (Z)-, methyl ester (Methyl oleate)	C_{19} H_{36} O_2	296	360,087	18.8	55.1	
9	19.771	Phytol	C_{20} H_{40} O	296	169,569	8.85	71.1	
10	19.827	Pyrrolidine, 1-(1-oxobutyl)-	C_8 H_{15} NO	141	31,440	1.64	43.1	
11	19.912	Methyl stearate	C_{19} H_{38} O_2	298	128,052	6.68	74.1	
12	20.069	8,11,14-Eicosatrienoic acid, (Z, Z, Z)- (Dihomo-γ-linolenic acid)	C_{20} H_{34} O_2	306	95,076	4.96	79.05	
13	21.329	Chimilether	C_{21} H_{44} O_3	344	37,009	1.93	58.1	
14	21.664	Heptacosanoic acid, methyl ester	C_{28} H_{56} O_2	424	42,128	2.2	179	
15	24.825	Di-n-decylsulfone	C_{20} H_{42} O_2 S	346	34,654	1.81	44.1	

16	25.349	Supraene (Squalene)	$C_{30}H_{50}$	410	101,533	5.3	69.1	
17	29.529	Lupeol	$C_{30}H_{50}O$	426	36,560	1.91	93.15	
		Total Identified Percentage				100.00%		



Peak Report TIC

Peak#	R.Time	Area	Area%	Height	Height%	Name	Base m/z
1	16.461	34195	1.78	16589	1.79	1-(2-[3-(2-Acetyloxiran-2-yl)-1,1-dimethylpro	43.10
2	17.404	34743	1.81	7543	0.81	Ethanone, 1-(1,2,2,3-tetramethylcyclopentyl)-,	43.10
3	17.866	44063	2.30	22078	2.38	7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-dien	57.15
4	18.000	566987	29.60	316319	34.13	Hexadecanoic acid, methyl ester	74.10
5	18.401	86589	4.52	36629	3.95	n-Hexadecanoic acid	41.10
6	18.470	34627	1.81	8810	0.95	Acethydrazide, 2-(2-ethylphenoxy)-N2-[1-(1,3	42.10
7	19.621	78425	4.09	45683	4.93	9,12-Octadecadienoic acid, methyl ester	67.10
8	19.670	360087	18.80	204642	22.08	9-Octadecenoic acid (Z)-, methyl ester	55.10
9	19.771	169569	8.85	68758	7.42	Phytol	71.10
10	19.827	31440	1.64	16916	1.83	Pyrrolidine, 1-(1-oxobutyl)-	43.10
11	19.912	128052	6.68	67426	7.28	Methyl stearate	74.10
12	20.069	95076	4.96	18663	2.01	8,11,14-Eicosatrienoic acid, (Z,Z,Z)-	79.05
13	21.329	37009	1.93	5055	0.55	Chimilether	58.10
14	21.664	42128	2.20	16812	1.81	Heptacosanoic acid, methyl ester	179.00
15	24.825	34654	1.81	7369	0.80	Di-n-decylsulfone	44.10
16	25.349	101533	5.30	52942	5.71	Supraene	69.10
17	29.529	36560	1.91	14557	1.57	Lupeol	93.15
		1915737	100.00	926791	100.00		

The Gas Chromatography-Mass Spectrometry (GC-MS) analysis of the ethanolic leaf extract of Achyranthes aspera L. from Ranchi, Jharkhand, revealed a complex chemical profile consisting of 17 distinct phyto-components. The Total Ion Chromatogram (TIC) resolved these peaks over a 35-minute runtime, representing an array of fatty acid methyl esters, long-chain hydrocarbons, pentacyclic triterpenoids, and volatile organic fragments. These chemical constituents are known to play crucial, synergistic roles in mitigating dermatological pathologies through antimicrobial, anti-inflammatory, and tissue-regenerative mechanisms.

The predominant chemical fraction identified in the leaf extract was Hexadecenoic acid, methyl ester (also known as Methyl palmitate), which eluted at a retention time (R.Time) of 18.000 minutes and accounted for the highest peak area of 29.60. This was accompanied by its free fatty acid form, n-Hexadecenoic acid (Palmitic acid), at R. Time 18.401 minutes (4.52). Palmitic acid and its ester derivatives are widely recognized for their emollient properties, helping to restore the disrupted epidermal lipid barrier

characteristic of eczema and psoriasis [16]. Furthermore, literature confirms that hexadecenoic acid derivatives exhibit significant anti-inflammatory traits by inhibiting phospholipase A_2, thereby halting the arachidonic acid cascade responsible for cutaneous erythema and swelling [17].

Another highly significant therapeutic cluster observed in the chromatogram includes 9,12-Octadecadienoic acid, methyl ester (Methyl linoleate; R. Time 19.621; 4.09) and 9-Octadecenoic acid (Z)-, methyl ester (Methyl oleate; R. Time 19.670; 18.80). Linoleic and oleic acid derivatives are critical structural elements of the intercellular lipid lamellae of the skin. Topically applied linoleates have been proven to accelerate epidermal barrier repair, alleviate severe dry-skin conditions, and exert profound anti-dermatophytic activities against common superficial fungal pathogens like Trichophyton rubrum [18]. The presence of the diterpene alcohol Phytol (R.Time 19.771; 8.85) further enhances the clinical profile against skin diseases. Phytol acts as a potent antioxidant and a precursor to vitamins, demonstrating an ability to decrease tumor necrosis factor-alpha (TNF-alpha) and interleukin-6 (IL-6) expression, which are primary drivers of chronic skin inflammation [19].

At the later phase of the chromatographic run, squalene (identified here as its isomer, Supraene, at R. Time 25.349; 5.30) and the pentacyclic triterpenoid Lupeol (R. Time 29.529; 1.91) were successfully resolved. Squalene is a natural component of human sebum that acts as a superb singlet oxygen quencher, protecting epidermal cells from UV-induced oxidative damage and subsequent skin aging or carcinogenesis [20]. Concurrently, Lupeol is highly celebrated for its exceptional wound-healing potential. It accelerates the migration of keratinocytes and fibroblasts to wound margins, speeding up the remodeling phase of damaged cutaneous tissues [21].

Collectively, the GC-MS data validates that the Ranchi chemotype of Achyranthes aspera L. contains a unique, lipophilic molecular assembly. This structural cocktail easily permeates the stratum corneum, providing a solid scientific foundation for the plant's traditional use by local healers in Jharkhand to treat aggressive boils, chronic ulcers, and inflammatory skin conditions.

IV. CONCLUSION

This study successfully characterizes the lipophilic secondary metabolite profile of Achyranthes aspera L. leaves sourced from Ranchi, Jharkhand, using GC-MS analysis. The identification of 17 bioactive compounds, particularly the abundance of fatty acid methyl esters like methyl palmitate (29.60) and methyl oleate (18.80), alongside therapeutic markers such as phytol, squalene, and lupeol, provides a rigorous scientific validation for its traditional ethnobotanical application. These constituents possess demonstrated antimicrobial, anti-inflammatory, and skin-barrier restorative properties. Consequently, this phytochemical evidence supports the efficacy of A. aspera as a sustainable, plant-based candidate for developing topical formulations to treat dermatological disorders.

V. CONFLICTS OF INTEREST

There are no conflicts of interest.

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