Pharmacogn. Res., 2026; 18(4):1386-1394.
https://www.phcogres.com

Original Article

GC-MS Phytochemical Profiling of *Shatapaka Guduchi Taila* with Therapeutic Insights into *Vataraktam* (ED-8 Rheumatoid Arthritis)

Pradnya Prakash Hemke[1,#], Pankaj Sharma[2,#,*], Suhas Kumar Shetty[3], Arun Chougale[1], Sanyogeeta Ajay Dixit[2], Saurabh Singh Thakur[4], Vaibhav Shukla[5], Sonali Dayanand Konkeri[6]

[1]Department of Ayurveda Pharmacology, KAHER's Shri BMK Ayurveda Mahavidyalaya, Belagavi, Karnataka, INDIA.
[2]Department of Rejuvenative & Reproductive Medicine in Ayurveda, KAHER's Shri BMK Ayurveda Mahavidyalaya, Belagavi, Karnataka, INDIA.
[3]Department of Ayurveda Psychology and Psychiatry, KAHER's Shri BMK Ayurveda Mahavidyalaya, Belagavi, Karnataka, INDIA.
[4]Department of Ayurveda Surgery, Muniyal Institute of Ayurveda Medical Sciences, Manipal, Udupi, Karnataka, INDIA.
[5]Department of Undergraduate Studies, KAHER's Shri BMK Ayurveda Mahavidyalaya, Belagavi, Karnataka, INDIA.
[6]Department of Ayurveda Internal Medicine, KAHER's Shri BMK Ayurveda Mahavidyalaya, Belagavi, Karnataka, INDIA.
[#]Both Authors are First Authors.

ABSTRACT

Background: Rheumatoid Arthritis (RA), classified as *Vataraktam* in Ayurveda (WHO ITA-5.30/ NAMC ED-8), affects millions globally with chronic inflammation and joint damage. *Shatapaka Guduchi Taila* (SGT), a 100-cycle processed formulation of *Guduchi* (*Tinospora cordifolia* [Willd.] Miers), *Tila Taila* (*Sesamum indicum* L.) and *Goksheera* (cow milk), derived from classical Ayurveda texts *Chakradutta*, lacks systematic phytochemical documentation despite its proven role in *Vataraktam* management. **Aim and Objectives:** This study uses Gas Chromatography-Mass Spectrometry (GC-MS) analysis to examine the *Shatapaka Guduchi Taila*, intending to identify links between its medicinal properties and the biomolecules it comprises. **Materials and Methods:** SGT was prepared as per Ayurvedic Pharmacopoeia Standards at GMP-certified IMPCOPS Ltd., Chennai. GC-MS analysis used Shimadzu QP2020 (hexane extract, 1 µL injection, helium carrier 1.0 mL/min, oven: 70-280°C). The compounds were identified after comparing the spectral configurations obtained with those of the available mass spectral database via the NIST 2020 library (SI ≥90%). **Results:** Twelve compounds were detected, amongst which Cholesterol (49.06%, RT 34.292 min), 2,6-Bis(3,4-methylenedioxyphenyl)-3,7-dioxabicyclo (3.3.0) octane (32.69%), Beta-Sitosterol acetate (1.95%), Monolaurin (5.25%) dominated the chromatogram. The therapeutic profile showed antioxidant (6 compounds), anti-inflammatory (7), anti-cancer (4 compounds) and antimicrobial activities (4 compounds). **Conclusion:** *Shatapaka Guduchi Taila's* phytosterol-lipid synergy supports *Vataraktam* modulation via ROS scavenging, cytokine suppression, aligning Ayurvedic *sneha* principles with Rheumatoid Arthritis therapeutics, warranting clinical validation.

Keywords: GC-MS, Phytochemical profiling, Rheumatoid arthritis, *Shatapaka Guduchi Taila*, *Vataraktam*.

Correspondence:
Dr. Pankaj Sharma
Department of Rejuvenative and Reproductive Medicine in Ayurveda, KAHER's Shri BMK Ayurveda Mahavidyalaya, Belagavi, Karnataka, INDIA.
Email: ps214088@gmail.com
ORCID: 0009-0004-1223-4653

Received: 03-04-2026;
Revised: 19-05-2026;
Accepted: 14-07-2026

INTRODUCTION

Arthritic pain is currently one of the major burning issues in our society, with a total of 18 million people worldwide suffering from Rheumatoid Arthritis (RA) in 2019. This would translate into a total of almost seven million patients in India if projected to the entire population (Malaviya *et al*., 1993). The prevalence of RA in adults has been reported to vary from 0.5 to 3.8% in women and from 0.15 to 1.37% in men, with peak incidence in the fourth decade of life (Lawrence, 1977). It can affect any synovial joint in the body, most commonly starting in the small joints of the hands and feet, with the potential to impact every aspect of daily living. High levels of inflammation are associated with fatigue and impairment of participation in occupational, recreational, and societal roles (GBD 2021 Rheumatoid Arthritis Collaborators, 2023). The pathogenesis and clinical characteristics of RA do not match any specific Ayurvedic disease. However, *Vataraktam*, rheumatism due to *Vata* and *Rakta* (NAMC Code ED-8), covers various musculoskeletal and rheumatological disorders, along with conditions affecting the skin and vasculature. *Vataraktam* (polyarthritis caused by *Vata* and *Rakta*) is classified by the WHO Standard Terminologies (ITA-5.30) as a disorder that aligns with

DOI: 10.5530/pres.20260010

RA based on its symptoms. (Acharya, 2006) *Guduchi Taila* is one of the formulations mentioned in various Ayurveda texts, such as *Sushruta Samhita, Ashtanga Hridaya, Chakradutta* and *Vangasena* in the management of *Vataraktam* (Sharma *et al.*, 2025). This *Guduchi Taila* is processed for one hundred cycles through a process called *Aavartana*, to enhance its bioavailability, reduce the required dosage, and provide *Rasayana* (rejuvenative and therapeutic) effects, to finally get the formulation *Shatapaka Guduchi Taila* (100 Times Processed *Guduchi Taila*) (hereafter SGT).

Gas Chromatography-Mass Spectrometry (GC-MS) is a technique ideal for metabolomic profiling of vaporised single or a blend of various plant samples (Kanthal *et al.*, 2014). A wide range of phytochemical compounds can be sought with a single run of the sample based on its nature. The obtained metabolites are identified through mass spectrometry based on their mass-to-charge ratio (Venkataramanam *et al.*, 2023). Despite the prominent mention of *Shatapaka Guduchi Taila* across Ayurvedic classical treatises and its recognised therapeutic importance, a systematic GC–MS-based phytochemical profiling of the formulation has not yet been documented. This study aims to quantitatively analyse the phytochemical compounds present in SGT through the GC-MS analysis. Despite its traditional relevance in the management of *Vataraktam*, the broader therapeutic scope of SGT and its mechanism of action in classically enlisted disease have not been comprehensively investigated. The current study represents a preliminary attempt to expand this understanding.

MATERIALS AND METHODS

Study Conduction

The *Shatapaka Guduchi Taila* was prepared at The Indian Medical Practitioner's Co-operative Pharmacy Stores Ltd. (IMPCOPS) Chennai-41, a GMP-certified Ayurveda Pharmacy, as per Ayurveda Pharmacopeia standards. Table 1 shows the ingredients with proportions used for the preparation of SGT. The authentication of drugs and physicochemical analysis of SGT were done at IMPCOPS Ltd., Chennai. The prepared sample was analysed for organoleptic parameters, including colour, odour, taste, and consistency, as well as physico-chemical analysis detailed in Table 2. The GC-MS analysis was done at the Centre for Analytical Instrumentation-Kerala (CAI-K), Kerala Forest Research Institute (KFRI) at Peechi, Thrissur District, Kerala.

Instrument

GC-MS analysis of SGT was carried out using a Shimadzu GCMS-QP2020 system, which is extensively employed for accurate qualitative and quantitative analysis due to its high sensitivity and analytical reliability.

Sample Preparation

Hexane Extraction-1 µL of hexane was used to extract 1 g of the taila sample. A clear solution was obtained after the removal of solid residue by filtering the extract.

Procedure

A 1 µL aliquot of the SGT sample was dissolved appropriately in HPLC-grade hexane, and 1 µL of this solution was injected into the system in split mode (split ratio 20:1). Helium was employed as the carrier gas at a constant flow rate of 1.0 mL/min. The injector temperature was maintained at 280°C. The oven temperature program was set as follows: initial temperature 70°C, ramped at 8°C/min to 260°C with a 2-min hold, followed by a second ramp of 4°C/min to 280°C with a final hold of 5 min. The ion source temperature was maintained at 220°C, and the interface temperature at 280°C. A solvent cut time of 3.10 min was applied. Mass spectra were recorded in scan mode over an m/z range of 50–500 with a scan speed of 1666 scans/s. Identification of analytes was carried out by comparing mass spectral fragmentation patterns with those in the NIST 2020 library, and compounds were accepted based on high Similarity Index (SI) scores and consistency of characteristic ions.

Ethical Statement

Ethical approval was not required for this study as it involved only the phytochemical analysis of a herbal formulation and did not involve human or animal subjects.

Statistical Analysis

There is no specific subsection for statistical analysis. The study relies on quantitative analysis (area percentage) and Similarity Indices (SI ≥90%) rather than hypothesis testing statistics.

RESULTS

The Total Ion Chromatograph (Figure 1) shows 12 major peaks between 6.03 and 35.24 min. The most abundant compound is Cholesterol (49.06% area) at RT 34.292 min. Second major compound: 2,6-Bis(3,4-methylenedioxyphenyl)-3,7-dioxabicyclo (3.3.0) octane (32.69%) at RT 35.246 min. The name of the compounds detected, their retention time, area, height, area/height ratio and structure has been detailed in Table 3.

DISCUSSION

Shatapaka Guduchi Taila is prepared based on the *Chakradutta Vataraktam Chikitsa* reference, utilising *Guduchi* (*Tinospora cordifolia* [Willd.] Miers), *Tila Taila* (*Sesamum indicum* L.), and *Goksheera* (Cow Milk). *Guduchi Taila* is an oleaginous compound formulation that comprises *Guduchi* (*Kalka Dravya*), *Tila Taila* (*Sneha Dravya*), and *Goksheera* (*Drava Dravya*). It is prepared as per the principles of *Sneha Kalpana* as outlined in the *Sharangdhara Samhita*. In Ayurveda, there exists a

Table 1: **Ingredients of Shatapaka Guduchi Taila.**

Sl. No.	Ingredient	Drug	Latin Name	Part Used	Proportion
1.	*Kalka Dravya* (Paste Drug)	Guduchi	*Tinospora cordifolia* [Willd.] Miers	Stem	¼ Parts
2.	*Sneha Dravya* (Oil base)	Tila Taila	*Sesamum indicum*	Oil	1 Part
3.	Drava Dravya (Kashaya-Decoction)	Guduchi Kashaya	*Tinospora cordifolia* [Willd.] Miers	Stem	4 Part
4.	*Avapa Drava Dravya* (Added Drug)	Goksheera	Cow milk	Milk	1 part

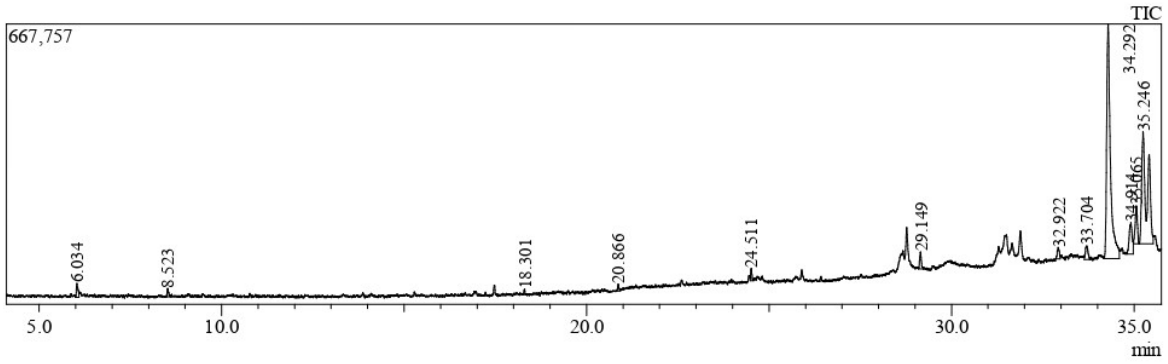


Figure 1: The Chromatogram of GC-MS Analysis of SGT.

methodology known as *Aavartana*, which involves the repeated processing of substances. The *Guduchi Taila* is processed for one hundred cycles (*Aavartana*) to enhance its bioavailability, reduce the required dosage, and provide *Rasayana* (rejuvenative and therapeutic) effects, to get *Shatapaka Guduchi Taila* (Sharma *et al*., 2024). *Guduchi* is regarded as the best drug for the management of *Vataraktam* (ED-8 Rheumatoid Arthritis) (Sharma *et al*., 2024). Multiple formulations have been described in *Ayurveda* texts that contain *Guduchi* as the main ingredient or as a constituent. There are 98 references available for the indication of *Guduchi* in *Vataraktam*, where the maximum used dosage form is *Kashaya/Kwatha* (decoction) with 41 formulations (Sharma *et al*., 2024; Shedbale *et al*., 2025). Properties of *Tila Taila* help to combat the vitiated *Vata* and *Rakta*. (Bhavaprakasha Nighantu, n.d.; Madanapala Nighantu n.d.) The *ushna* (hot) *veerya* (potency) pacifies the *Vata*, and *madhura vipaka* (biotransformation) works on *Rakta* vitiation. It also possesses properties of *balya* (strengthening), *chakshushya* (promotes eyesight), *Deepana* (promotes digestion), *keshya* (strengthens hair), etc., (Sharma *et al*., 2024). *Goksheera* (cow milk) is commonly utilised as a dietary source in all age groups. *Ayurveda* advises *Goksheera* be taken daily and regards it as the *Rasayana* (rejuvenating) based upon its properties (Sharma *et al*., 2025). It pacifies the *Vata* and *Pitta Dosha, Vata* and *Rakta*, enhances the complexion, and is an immuno-regulator (Sharma *et al*., 2024). This mode of action, which is based on *rasa, guna, veerya, vipaka*, and *karma*, supports the efficacy of SGT in treating *Vataraktam* on the lines of Ayurveda fundamentals. Moreover, this study aims to provide evidence based on the mode of action of phytochemical compounds, thereby contributing to the validation of traditional knowledge in the context of ED-8 Rheumatoid Arthritis and other related disorders.

Table 2: **Organoleptic and Physico-Chemical Parameters of SGT Documented.**

Parameters	Characters
Description	Pale yellow white colour, oily, unctuous, viscous liquid; ghee-like odour; taste- bitter taste
Colour under UV Rays	Whitish blue
Colour with solvent under UV (Petroleum ether)	Whitish blue
Loss on drying at 105°C	0.2693%
Refractive index	1.4609 @ 24.9°C
Specific gravity	0.9152
Acid value	1.4655 mg/KOH

The GC-MS analysis of Shatapaka Guduchi Taila reveals 12 total compounds, as listed in Table 3. This analysis of the sample revealed a complex phytochemical and lipid-based profile comprising aldehydes, lactones, fatty acid esters, terpenoids, sterols, and polyphenolic derivatives. Compound identification

was accomplished through comparison with the NIST 20 mass spectral library, yielding high similarity indices (SI ≥ 90), thereby confirming the reliability of identification. The predominance of bioactive compounds with reported antioxidant, anti-inflammatory, immunomodulatory and chemo-preventive properties suggest potential pharmacological relevance of the analysed sample. The common activity of the compounds is reported in Table 4.

In this GC-MS analysis, Cholesterol, 2,6-Bis(3,4-methylenedioxyphenyl)-3,7-dioxabicyclo (3.3.0) octane, Laurin, 2-capri-1,3-di-, and Beta-Sitosterol acetate, has the highest area and height ratio, which is linked to the highest concentration of the phytochemical in the compound in SGT.

Cholesterol is essential for cellular integrity, immune regulation, and inflammatory balance. It maintains membrane stability and signalling and serves as a precursor for steroid hormones, bile acids, and vitamin D, supporting physiological homeostasis (Cortes *et al.*, 2014). Balanced cholesterol levels regulate immune cell activity, whereas dysregulated metabolism promotes macrophage activation and chronic inflammation (Tall *et al.*, 2015; Aguilar-Ballester *et al.*, 2020). In rheumatoid arthritis and related inflammatory joint disorders, cholesterol imbalance is associated with disease progression and inflammatory burden (Lei *et al.*, 2023; Robinson *et al.*, 2022). From an Ayurvedic perspective, these functions are parallel to *sneha* and *meda dhatu* metabolism, which supports *Vata* alleviation and joint lubrication (*sandhi snehana*) (Agnivesha, 1983). Thus, physiological cholesterol balance can help in inflammatory modulation in *Vataraktam*-like conditions, while excess or oxidised cholesterol may contribute to *Rakta* vitiation and disease aggravation (Susruta, 2001; Agnivesha, 1983).

2,6-Bis(3,4-methylenedioxyphenyl)-3,7-dioxabicyclo (3.3.0) octane

A furofuran lignan, has demonstrated antioxidant activity due to its catechol-like structure. Related sesamin metabolites with the same 3,7-dioxabicyclo (3.3.0) octane core effectively scavenge reactive oxygen species, highlighting their potential to modulate oxidative stress (Nakai *et al.*, 2003). Since oxidative stress contributes to rheumatoid arthritis pathogenesis by promoting inflammation and joint damage, antioxidants like this compound may help reduce inflammatory cascades and tissue injury in RA (Robinson *et al.*, 2022).

Laurin, 2-capri-1,3-di- (Monolaurin (glycerol monolaurate)), a derivative of lauric acid, has demonstrated broad-spectrum antimicrobial activity against Gram-positive and Gram-negative bacteria isolated from skin infections, with strong sensitivity and low resistance rates *in vitro* (Carpo *et al.*, 2007). Also showing inhibition of antibiotic-resistant *Staphylococcus aureus* in atopic dermatitis without cytotoxicity, suggesting potential value in treating resistant skin disorders (Laowansiri *et al.*, 2025). Additionally, it exhibits antibiofilm activity, which is critical for managing chronic or wound-associated bacterial colonisation (Hassan *et al.*, 2024). Although no direct studies have examined monolaurin in rheumatoid arthritis, the pathophysiology of RA involves significant oxidative stress and immune dysregulation, and antioxidant interventions have shown moderate benefits in reducing oxidative damage and inflammation in RA contexts (Djordjevic *et al.*, 2023). These findings support the broader concept that compounds combining antimicrobial and antioxidant activities may have relevance in inflammatory and immune-mediated disorders.

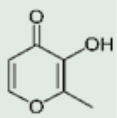
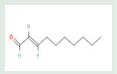
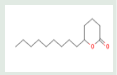
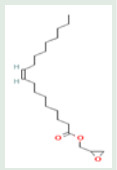
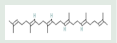
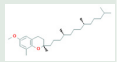
Beta-Sitosterol acetate or β-Sitosterol

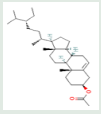
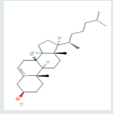
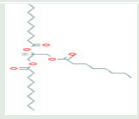
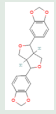
A common plant phytosterol, has widely reported its antiinflammatory and antioxidant properties. In cellular and animal models, it has shown suppression of key inflammatory mediators such as TNFα, IL1β, and IL6, inhibit inflammasome activation and NFκB signalling, and reduces reactive oxygen species, demonstrating its capacity to downregulate inflammatory responses and oxidative stress in vitro and in vivo. It reduced oxidative stress and neutrophil recruitment in a zebrafish inflammation model by increasing antioxidant enzymes like sod and gpx4b, while decreasing pro-inflammatory genes such as il-8 and myd88, highlighting its strong antioxidant and anti-inflammatory in inflammatory disorders (Zhang *et al.*, 2023). Additionally, in RA, βsitosterol has exhibited antiarthritic actions by inhibiting synovial angiogenesis, reducing joint swelling and cartilage damage, suppressing VEGF signalling, and improving redox balance in collageninduced arthritis models, suggesting therapeutic potential for RA. These findings support the idea that β-sitosterol and its derivatives may mitigate inflammation and oxidative stress mechanisms involved in RA pathogenesis (Qian *et al.*, 2022).

Antioxidant Potentials of Identified Compounds

Oxidative stress plays a crucial role in the pathogenesis of metabolic and chronic inflammatory disorders like RA and cancer. Several compounds identified in GC–MS analysis of SGT are well documented for their antioxidant properties. Maltol, a pyranone derivative detected in the early elution phase, is known for its potent free radical scavenging ability and inhibition of lipid peroxidation (Halliwell *et al.*, 1994). Squalene, a triterpenoid hydrocarbon identified with high confidence, functions as a chain-breaking antioxidant that protects cellular membranes from oxidative damage (Hien *et al.*, 2017; Abuobeid *et al.*, 2022). Tocopherol-related chroman derivatives identified in the sample further enhance antioxidant defence by neutralising Reactive Oxygen Species (ROS) and preventing oxidative degradation of polyunsaturated fatty acids (Lakkadi *et al.*, 2024). Methylenedioxyphenyl-containing compounds, which formed a significant proportion of the chromatographic area, are reported to exert strong antioxidant effects through modulation

Table 3: Details of Compounds detected in GCMS analysis with their Retention Time and their Activity.

Sl. No.	Name of the compound	Retention time	Area	Area%	Height	Height%	A/H	Structure	Chemical Formula	Compound Class	Activity of Compound
1.	Maltol	6.034	104767	1.29	33543	2.79	3.12		$C_6H_6O_3$	Phenol Derivative	Antioxidant (Song *et al.*, 2015), Anticancer, (Han *et al.*, 2023), Anti-Inflammatory (Li *et al.*, 2024), Hepatoprotective (Liu *et al.*, 2018), Cardioprotective (Xing *et al.*, 2022).
2.	2-Decenal, (E)	8.523	50282	0.62	19158	1.59	2.62		$C_{10}H_{18}O$	Unsaturated Aldehyde	Antileishmanial (Donega *et al.*, 2014), Anticancer (Vijayakumar *et al.*, 2025).
3.	2H-Pyran-2-one, tetrahydro-6-nonyl-	18.301	24109	0.30	13062	1.09	1.85		$C_{14}H_{26}O_2$	Tetrahydropyranone	Antibacterial, Antiviral, and Anti-Inflammatory (Nazari *et al.*, 2019), Anti-Alzheimer's (Almalki *et al.*, 2023).
4.	2H-Pyran-2-one, tetrahydro-6-tridecyl	20.866	41957	0.52	16268	1.35	2.58		$C_{18}H_{34}O_2$	Tetrahydropyranone	Anticancer And Antioxidant (Mashrai *et al.*, 2013).
5.	9-Octadecenoic acid (Z)-, oxiranylmethyl ester	24.511	69919	0.86	29088	2.42	2.40		$C_{21}H_{38}O_3$	Fatty Acid Ester	Antioxidant, Anti-Inflammatory, Antimicrobial & Cytotoxic (Sharaf *et al.*, 2021).
6.	Squalene	29.149	124916	1.54	40722	3.39	3.07		$C_{30}H_{50}$	Triterpene Hydrocarbon	Hypocholesterolemic (Hien *et al.*, 2017), Anti-Inflammatory and Anti-Cancer (Abuobeid *et al.*, 2022).
7.	(R)-6-Methoxy-2,8-dimethyl-2-((4R,8R)-4,8,12-trimethyltridecyl) chroman	32.922	103652	1.28	27459	2.29	3.77		$C_{29}H_{50}O_2$	Tocopherol/ Chroman Derivative	Anti-Cancerous (Das *et al.*, 2016; Saavedra *et al.*, 2020; Birringer *et al.*, 2003), Antiepileptic (Rawat *et al.*, 2016), Antioxidant, (Lakkadi *et al.*, 2024), Anti-Inflammatory (Jiang *et al.*, 2014; Reiter *et al.*, 2007).

Sl. No.	Name of the compound	Retention time	Area	Area%	Height	Height%	A/H	Structure	Chemical Formula	Compound Class	Activity of Compound
8.	Beta-Sitosterol acetate	33.704	158159	1.95	32422	2.70	4.88		$C_{31}H_{52}O_2$	Sitosterol	Anti-Inflammatory, Antioxidant (Hidayathulla *et al.*, 2018), Anti-Gastro-ulcer (Xiao *et al.*, 1992), Analgesic (Villasenor *et al.*, 2002).
9.	Cholesterol	34.292	3982353	49.06	558685	46.51	7.13		$C_{27}H_{46}O$	Cholestanoids	Immune Regulation, Inflammatory (Hien *et al.*, 2017).
10.	Laurin, 2-capri-1,3-di-	34.292	425863	5.25	74662	6.22	5.70		$C_{37}H_{70}O_9$	Glycerol Ester	Antimicrobial, (Matsue *et al.*, 2019), Antioxidant (Ameena *et al.*, 2024).
11.	3-(Octanoyloxy) propane-1,2-diyl bis(decanoate)	35.065	376975	4.64	89862	7.48	4.20		$C_{31}H_{58}O_9$	Triglycerols	Anti-Inflammatory, Anti-Oxidant (Ratheesh *et al.*, 2022).
12.	2,6-Bis (3,4- methylenedioxyphenyl)-3,7-dioxabicyclo (3.3.0) octane	35.246	2653550	32.69	266198	22.16	9.97		$C_{20}H_{18}O_6$	Phenylpropanoid Dimers	Antioxidant (Nakai *et al.*, 2003).

of redox-sensitive pathways and metal chelation. Collectively, the abundance of these antioxidant constituents suggests that the sample possesses substantial oxidative stress-modulating potential, which is particularly relevant in inflammation-driven disorders (Halliwell *et al.*, 2006).

Anti-Inflammatory Potentials of Identified Compounds

Inflammation is a central pathological feature underlying rheumatoid arthritis, and other metabolic diseases. Phytosterols such as β-sitosterol acetate identified in the present study are widely reported to suppress inflammatory mediators, including Cyclooxygenase-2 (COX-2), TNF-α, and interleukins (Loizou *et al.*, 2010; Vilahur *et al.*, 2019; Marahatha *et al.*, 2021). Squalene has also been shown to attenuate inflammatory signalling by modulating NF-κB activation and reducing oxidative inflammation (Ibrahim *et al.*, 2021). Additionally, lactone derivatives such as tetrahydro-2H-pyran-2-one analogues contribute to anti-inflammatory activity by inhibiting nitric oxide synthesis and prostaglandin release. The cumulative presence of these compounds suggests that the sample may exert multi-targeted anti-inflammatory effects, supporting its relevance in chronic inflammatory conditions (Gan *et al.*, 2019).

Anticancer and Chemopreventive Potentials of Identified Compounds

Several compounds identified in the GC-MS profile of SGT, like Maltol, 2-Decenal, (E)-, Squalene, 2H-Pyran-2-one, and tetrahydro-6-tridecyl have been associated with anticancer or chemopreventive activities. Squalene has been extensively studied for its ability to inhibit tumour progression, enhance immune surveillance, and reduce oxidative DNA damage (Abuobeid *et al.*, 2022). Methylenedioxyphenyl derivatives are structurally linked to apoptosis induction and inhibition of carcinogen-activating enzymes. Tocopherol analogues further contribute by protecting cellular DNA from oxidative mutations (Woyengo *et al.*, 2009). Although direct anticancer activity cannot be concluded from chemical profiling alone, the presence of these compounds provides a scientific basis for further in vitro and in vivo investigations aimed at evaluating the chemopreventive potential of the sample.

In summary, the GC-MS analysis of compounds of SGT, collectively confers antioxidant, anti-inflammatory, antimicrobial, and potential chemopreventive benefits, aligning with Ayurvedic principles of *Vataraktam* modulation while paralleling ED-8 RA pathogenesis management through ROS scavenging, cytokine suppression, and membrane stabilisation. This phytochemical synergy positions SGT as a promising candidate for further validation in inflammatory disorders, bridging traditional formulation wisdom with evidence-based therapeutic potentials.

Table 4: Common Activity of the Compounds.

Sl. No.	Activity	Number	Name of the Compound
1.	Anti-Oxidant	6	Maltol; 9-Octadecenoic acid (Z)-, oxiranylmethyl ester; (R)-6-Methoxy-2,8-dimethyl-2-((4R,8R)-4,8,12-trimethyltridecyl) chroman; Beta-Sitosterol acetate; 3-(Octanoyloxy) propane-1,2-diyl bis(decanoate); 2,6-Bis(3,4-methylenedioxyphenyl)-3,7-dioxabicyclo (3.3.0) octane
2.	Anti-Cancerous	4	2-Decenal, (E); Maltol; 2H-Pyran-2-one, tetrahydro-6-tridecyl; Squalene
3.	Anti-Inflammatory	7	Maltol; 2H-Pyran-2-one, tetrahydro-6-nonyl-; 9-Octadecenoic acid (Z)-; oxiranylmethyl ester; Squalene; (R)-6-Methoxy-2,8-dimethyl-2-((4R,8R)-4,8,12-trimethyltridecyl) chroman; Beta-Sitosterol acetate; 3-(Octanoyloxy) propane-1,2-diyl bis(decanoate)
4.	Anti-Bacterial	4	Laurin, 2-capri-1,3-di-; 9-Octadecenoic acid (Z)-; oxiranylmethyl ester

CONCLUSION

The GC-MS profiling of *Shatapaka Guduchi Taila* (SGT) identified 12 bioactive compounds, predominantly cholesterol (49.06%), 2,6-Bis(3,4-methylenedioxyphenyl)-3,7-dioxabicyclo (3.3.0) octane (32.69%), and β-sitosterol acetate, revealing a rich lipid matrix with antioxidant, anti-inflammatory, anti-cancer and antimicrobial potentials. These phytoconstituents align with Ayurvedic principles of *Vataraktam* management through *sneha guna* and *dhatu* nourishment, paralleling RA pathogenesis management via ROS scavenging, cytokine suppression, immuno-modulation and membrane stabilisation. SGT thus emerges as a promising *Rasayana* (rejuvenative and therapeutic) candidate bridging classical wisdom with evidence-based rheumatological therapeutics, warranting advanced in vitro/in vivo validation.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to The Indian Medical Practitioner's Co-operative Pharmacy Stores Ltd., Chennai, Tamil Nadu, for their support in the preparation, authentication, and physicochemical analysis of Shatapaka Guduchi Taila as per Ayurveda Pharmacopoeia standards. The authors also acknowledge the Centre for Analytical Instrumentation, Kerala Forest Research Institute, Peechi, Thrissur District, Kerala, for facilitating the GC-MS analysis of the formulation samples.

ABBREVIATIONS

RA: Rheumatoid Arthritis; **NAMC:** National Ayurveda Morbidity Code; **GC-MS:** Gas Chromatography–Mass Spectrometry; **GMP:** Good Manufacturing Practice; **SGT:** Shatapaka Guduchi Taila; **RT:** Retention Time; **A/H:** Area/Height Ratio; **ROS:** Reactive Oxygen Species; **TNF-α:** Tumour Necrosis Factor-alpha; **IL-1β:** Interleukin-1 beta; **IL-6:** Interleukin-6; **NF-κB:** Nuclear Factor kappa B; **COX-2:** Cyclooxygenase-2; **VEGF:** Vascular Endothelial Growth Factor; **NIST:** National Institute of Standards and Technology; **HPLC:** High-Performance Liquid Chromatography; **WHO:** World Health Organization; **ITA:** International Terminology of Ayurveda.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

PS: A-F; PPH: A-F; SKS: E; AC: E; SAD: C-D; SST: C, E; VS: B-D; SDK: D, F.

SUMMARY

This study provides the first scientific profiling of *Shatapaka Guduchi Taila* using GC-MS analysis. Twelve bioactive compounds were identified, including cholesterol and antioxidants. These findings validate the traditional use of this formulation in managing *Vataraktam* (ED-8 Rheumatoid Arthritis) by providing a scientific basis for its anti-inflammatory and immunomodulatory properties.

REFRENCES

Abuobeid, R., Sánchez-Marco, J., Felices, M. J., Arnal, C., Burillo, J. C., Lasheras, R., ... [Author List Continued]. (2022). Squalene through its post-squalene metabolites is a modulator of hepatic transcriptome in rabbits. *Antioxidants, 11*(4), Article 728.

Acharya, V. J. T. (Ed.). (2006). *Charaka Samhita* (Agnivesa, Auth.). Chowkhamba Krishnadas Academy.

Aguilar-Ballester, M., Herrero-Cervera, A., Vinué, Á., Martínez-Hervás, S., & González-Navarro, H. (2020). Impact of cholesterol metabolism in immune cell function and atherosclerosis. *Nutrients, 12*(7), Article 2021. https://doi.org/10.3390/nu12072021

Almalki, F. A. (2023). An overview of structure-based activity outcomes of pyran derivatives against Alzheimer's disease. *Saudi Pharmaceutical Journal, 31*(6), Article 101595. https://doi.org/10.1016/j.jsps.2023.101595

Ameena, M., Meignana Arumugham, I., Ramalingam, K., & Shanmugam, R. (2024). Biomedical applications of lauric acid: A narrative review. *Cureus, 16*(6), Article e62641. https://doi.org/10.7759/cureus.62641

Bhavaprakasha Nighantu. (n.d.). National Institute of Indian Medical Herbs. Retrieved February 10, 2026, from https://niimh.nic.in/ebooks/e-Nighantu/bhavaprakashanighantu/?mod=read

Birringer, M., EyTina, J. H., Salvatore, B. A., & Neuzil, J. (2003). Vitamin E analogues as inducers of apoptosis: Structure-function relation. *British Journal of Cancer, 88*(10), 1565–1573. https://doi.org/10.1038/sj.bjc.6601960

Carpo, B. G., Verallo-Rowell, V. M., & Kabara, J. (2007). Novel antibacterial activity of monolaurin compared with conventional antibiotics against organisms from skin infections: An in vitro study. *Journal of Drugs in Dermatology, 6*(10), 991–998.

Cortes, V. A., Busso, D., Maiz, A., Arteaga, A., Nervi, F., & Rigotti, A. (2014). Physiological and pathological implications of cholesterol. *Frontiers in Bioscience (Landmark Edition), 19*(3), 416–428. https://doi.org/10.2741/416

Das Gupta, S., & Suh, N. (2016). Tocopherols in cancer: An update. *Molecular Nutrition & Food Research, 60*(6), 1129–1146. https://doi.org/10.1002/mnfr.201500975

Djordjevic, K., Milojevic Samanovic, A., Veselinovic, M., Zivkovic, V., Mikhaylovsky, V., ... [Author List Continued]. (2023). Oxidative stress mediated therapy in patients with rheumatoid arthritis: A systematic review and meta-analysis. *Antioxidants, 12*(11), Article 1938. https://doi.org/10.3390/antiox12111938

Donega, M. A., Mello, S. C., Moraes, R. M., Jain, S. K., Tekwani, B. L., & Cantrell, C. L. (2014). Pharmacological activities of cilantro's aliphatic aldehydes against *Leishmania donovani. Planta Medica, 80*(18), 1777–1781. https://doi.org/10.1055/s-0034-1383183

Gan, L., Zheng, Y., Deng, L., Sun, P., Ye, J., Wei, X., ... Zhang, W. (2019). Diterpenoid lactones with anti-inflammatory effects from the aerial parts of *Andrographis paniculata. Molecules, 24*(15), Article 2726. https://doi.org/10.3390/molecules24152726

GBD 2021 Rheumatoid Arthritis Collaborators. (2023). Global, regional, and national burden of rheumatoid arthritis, 1990–2020, and projections to 2050: A systematic analysis of the Global Burden of Disease Study 2021. *The Lancet Rheumatology, 5*(10), e594–e610. https://doi.org/10.1016/S2665-9913(23)00211-4

Halliwell, B. (1994). Free radicals and antioxidants: A personal view. *Nutrition Reviews, 52*(8 Pt 1), 253–265. https://doi.org/10.1111/j.1753-4887.1994.tb01453.x

Halliwell, B. (2006). Reactive species and antioxidants: Redox biology is a fundamental theme of aerobic life. *Plant Physiology, 141*(2), 312–322. https://doi.org/10.1104/pp.106.077073

Han, N. R., Park, H. J., Ko, S. G., & Moon, P. D. (2023). Maltol has anti-cancer effects via modulating PD-L1 signaling pathway in B16F10 cells. *Frontiers in Pharmacology, 14*, Article 1255586. https://doi.org/10.3389/fphar.2023.1255586

Hassan Abd El-Ghany, S. S., Azmy, F. F., Osama El-Gendy, A., Abd El-Baky, R. M., Mustafa, A., ... [Author List Continued]. (2024). Antimicrobial and antibiofilm activity of monolaurin against methicillin-resistant *Staphylococcus aureus* isolated from wound infections. *International Journal of Microbiology, 2024*, Article 7518368. https://doi.org/10.1155/2024/7518368

Hidayathulla, S., Shahat, A. A., Ahamad, S. R., Al Moqbil, A. A. N., Alsaid, M. S., & Divakar, D. D. (2018). GC/MS analysis and characterization of 2-Hexadecen-1-ol and beta sitosterol from *Schimpera arabica* extract for its bioactive potential as antioxidant and antimicrobial. *Journal of Applied Microbiology, 124*(5), 1082–1091. https://doi.org/10.1111/jam.13678

Hien, H. T. M., Ha, N. C., Thom, L. T., & Hong, D. D. (2017). Squalene promotes cholesterol homeostasis in macrophage and hepatocyte cells via activation of liver X receptor (LXR) α and β. *Biotechnology Letters, 39*(8), 1101–1107. https://doi.org/10.1007/s10529-017-2358-8

Ibrahim, N., & Naina Mohamed, I. (2021). Interdependence of anti-inflammatory and antioxidant properties of squalene—Implication for cardiovascular health. *Life, 11*(2), Article 103. https://doi.org/10.3390/life11020103

Jiang, Q. (2014). Natural forms of vitamin E: Metabolism, antioxidant and anti-inflammatory activities and the role in disease prevention and therapy. *Free Radical Biology & Medicine, 72*, 76–90. https://doi.org/10.1016/j.freeradbiomed.2014.03.018

Kanthal, L., Dey, A., Satyavathi, K., & Bhojaraju, P. (2014). GC-MS analysis of bio-active compounds in methanolic extract of *Lactuca runcinata* DC. *Pharmacognosy Research, 6*(1), 58–61. https://doi.org/10.4103/0974-8490.122919

Lakkadi, A., Vuppala, S., Nampally, V., Kim, J., Kim, K., Jang, J., ... [Author List Continued]. (2024). Development of novel chromones as antioxidant COX2 inhibitors: In vitro, QSAR, DFT, molecular docking, and molecular dynamics studies. *Journal of Biomolecular Structure and Dynamics, 42*(6), 2793–2808. https://doi.org/10.1080/07391102.2023.2196201

Laowansiri, M., Suwanchote, S., Wannigama, D. L., Badavath, V. N., Hongsing, P., Edwards, S. W., ... [Author List Continued]. (2025). Monolaurin inhibits antibiotic-resistant *Staphylococcus aureus* in patients with atopic dermatitis. *Scientific Reports, 15*(1), Article 23180. https://doi.org/10.1038/s41598-025-05667-w

Lawrence, J. S. (1977). *Rheumatism in populations*. Heinemann.

Lei, Q., Yang, J., Li, L., Zhao, N., Lu, C., Lu, A., & He, X. (2023). Lipid metabolism and rheumatoid arthritis. *Frontiers in Immunology, 14*, Article 1190607. https://doi.org/10.3389/fimmu.2023.1190607

Li, J., Liu, Q., Liu, S., Xin, H., Zhang, X., & Guo, N. (2024). Maltol improves peripheral nerve function by inhibiting Schwann cell apoptosis via the PERK/eIF2α/CHOP pathway and MME upregulation in diabetic peripheral neuropathy. *Pharmaceuticals, 17*(9), Article 1145. https://doi.org/10.3390/ph17091145

Liu, W., Wang, Z., Hou, J. G., Zhou, Y. D., He, Y. F., Jiang, S., ... Li, W. (2018). The liver protection effects of maltol, a flavoring agent, on carbon tetrachloride-induced acute liver injury in mice via inhibiting apoptosis and inflammatory response. *Molecules, 23*(9), Article 2120. https://doi.org/10.3390/molecules23092120

Loizou, S., Lekakis, I., Chrousos, G. P., & Moutsatsou, P. (2010). Beta-sitosterol exhibits anti-inflammatory activity in human aortic endothelial cells. *Molecular Nutrition & Food Research, 54*(4), 551–558. https://doi.org/10.1002/mnfr.200900012

Madanapala Nighantu. (n.d.). National Institute of Indian Medical Herbs. Retrieved February 10, 2026, from https://niimh.nic.in/ebooks/e-Nighantu/madanapalanighantu/?mod=read

Malaviya, A. N., Kapoor, S. K., Singh, R. R., Kumar, A., & Pande, I. (1993). Prevalence of rheumatoid arthritis in the adult Indian population. *Rheumatology International, 13*(4), 131–134. https://doi.org/10.1007/BF00301258

Marahatha, R., Gyawali, K., Sharma, K., Gyawali, N., Tandan, P., Adhikari, A., ... Parajuli, N. (2021). Pharmacologic activities of phytosteroids in inflammatory diseases: Mechanism of action and therapeutic potentials. *Phytotherapy Research, 35*(9), 5103–5124. https://doi.org/10.1002/ptr.7138

Mashrai, A., Darwish, S., Albassri, N., Sultana, N., Rahman, S., Abualnaja, M., ... [Author List Continued]. (2013). Green synthesis and biological evaluation of steroidal 2H-pyrans as anticancer and antioxidant agents. *Journal of the Saudi Chemical Society, 17*(1), 85–91.

Matsue, M., Mori, Y., Nagase, S., ... [Author List Continued]. (2019). Measuring the antimicrobial activity of lauric acid against various bacteria in human gut microbiota using a new method. *Cell Transplantation, 28*(12), 1526–1535. https://doi.org/10.1177/0963689719875961

Nakai, M., Harada, M., Nakahara, K., Akimoto, K., Fujiwara, H., Kiso, Y., ... [Author List Continued]. (2003). Novel antioxidative metabolites in rat liver with ingested sesamin. *Journal of Agricultural and Food Chemistry, 51*(6), 1666–1670. https://doi.org/10.1021/jf021028a

Nazari, P., Bazi, A., Ayatollahi, S. A. M., Dolati, H., Mahdavi, S. M., Rafighdoost, L., & Amirmostofian, M. (2019). Synthesis and evaluation of the antimicrobial activity of spiro-4H-pyran derivatives on some gram positive and gram negative bacteria. *Iranian Journal of Pharmaceutical Research, 18*(2), 1029–1038. https://doi.org/10.22037/ijpr.2019.11215.13226

Qian, K., Zheng, X. X., Wang, C., Huang, W. G., Liu, X. B., Xu, S. D., ... [Author List Continued]. (2022). β-Sitosterol inhibits rheumatoid synovial angiogenesis through suppressing VEGF signaling pathway. *Frontiers in Pharmacology, 12*, Article 816477. https://doi.org/10.3389/fphar.2021.816477

Ratheesh, M., Sunil, S., Sheethal, S., ... [Author List Continued]. (2022). Anti-inflammatory and anti-COVID-19 effect of a novel polyherbal formulation (Imusil) via modulating oxidative stress, inflammatory mediators and cytokine storm. *Inflammopharmacology, 30*(3), 855–868. https://doi.org/10.1007/s10787-022-00970-0

Rawat, P., & Verma, S. M. (2016). Design and synthesis of chroman derivatives with dual anti-breast cancer and antiepileptic activities. *Drug Design, Development and Therapy, 10*, 3275–3289. https://doi.org/10.2147/DDDT.S112966

Reiter, E., Bettinger, S., Boscoe, A., ... [Author List Continued]. (2007). Anti-inflammatory properties of alpha- and gamma-tocopherol. *Molecular Aspects of Medicine, 28*(5-6), 668–691. https://doi.org/10.1016/j.mam.2007.01.003

Robinson, G., Pineda-Torra, I., Ciurtin, C., & Jury, E. C. (2022). Lipid metabolism in autoimmune rheumatic disease: Implications for modern and conventional therapies. *The Journal of Clinical Investigation, 132*(2), Article e148552. https://doi.org/10.1172/JCI148552

Saavedra, E., Del Rosario, H., Brouard, I., Hernández-Garcés, J., García, C., Quintana, J., ... [Author List Continued]. (2020). The synthetic flavanone 6-methoxy-2-(naphthalen-1-yl)chroman-4-one induces apoptosis and activation of the MAPK pathway in human U-937 leukaemia cells. *Bioorganic Chemistry, 94*, Article 103450. https://doi.org/10.1016/j.bioorg.2019.103450

Sharaf, M. H., Abdelaziz, A. M., Kalaba, M. H., Radwan, A. A., & Hashem, A. H. (2021). Antimicrobial, antioxidant, cytotoxic activities and phytochemical analysis of fungal endophytes isolated from *Ocimum basilicum. Antibiotics, 10*(10), Article 1201. https://doi.org/10.3390/antibiotics10101201

Sharma, A. (Ed.). (2001). *Susruta Samhita* (Vol. 2, Susruta, Auth.). Chaukhamba Surbharati Prakashan.

Sharma, P. V. (Ed.). (1983). *Charaka Samhita* (Vol. 1 & 2, Agnivesha, Auth.). Chaukhamba Orientalia.

Sharma, P., & Kumar Shetty, S. (2025). Short-term evaluation of Shatapaka Guduchi Taila in rheumatoid arthritis – A case series. *Journal of Ayurveda and Holistic Medicine, 13*(7), 60–68.

Sharma, P., & Shetty, S. K. (2024). Therapeutic and rejuvenating potential of Guduchi Taila in the purview of rheumatoid arthritis: A review. *Journal of Drug Research in Ayurvedic Sciences, 9*(Suppl 2), S184–S191. https://doi.org/10.4103/jdras.jdras_177_24

Sharma, P., & Shetty, S. K. (2025). Pharmaceutico-analytical and Ayurvedic pharmacological profile of Simhanada Guggulu in purview of Vataraktam (ED-8 Rheumatoid Arthritis). *International Journal of Research in Ayurveda and Pharmacy, 16*(3), 64–67.

Shedbale, S. D., Shetty, S. K., Sharma, P., & Mithraa, M. K. (2025). Immunomodulatory and therapeutic profile of *Tinospora cordifolia* Linn. (Guduchi): A phytopharmacological review. *International Research Journal of Ayurveda and Yoga, 8*(6), 16–21.

Song, Y., Hong, S., Iizuka, Y., Kim, C. Y., & Seong, G. J. (2015). The neuroprotective effect of maltol against oxidative stress on rat retinal neuronal cells. *Korean Journal of Ophthalmology, 29*(1), 58–65. https://doi.org/10.3341/kjo.2015.29.1.58

Tall, A. R., & Yvan-Charvet, L. (2015). Cholesterol, inflammation and innate immunity. *Nature Reviews Immunology, 15*(2), 104–116. https://doi.org/10.1038/nri3793

Venkataramanan, V., & Kamat. (2023). Gas chromatography mass spectrometry (GC-MS) profiling of Arjunarishta. *International Journal of Ayurveda and Medicine, 14*(2). https://doi.org/10.47552/ijam.v14i2.3644

Vijayakumar, S., González-Sánchez, Z. I., Anbu, P., Divya, M., Sonamuthu, J., ... Li, M. (2025). Asafoetida gum-wrapped ZnO nanoparticles: Synthesis, characterization, and anticancer potential against gastric carcinoma. *International Journal of Biological Macromolecules, 257*(Pt 1), Article 128583. https://doi.org/10.1016/j.ijbiomac.2024.128583

Vilahur, G., Ben-Aicha, S., Diaz-Riera, E., Badimon, L., & Padró, T. (2019). Phytosterols and inflammation. *Current Medicinal Chemistry, 26*(37), 6724–6734. https://doi.org/10.2174/0929867325666180622151438

Villaseñor, I. M., Angelada, J., Canlas, A. P., & Echegoyen, D. (2002). Bioactivity studies on beta-sitosterol and its glucoside. *Phytotherapy Research, 16*(5), 417–421.

Woyengo, T. A., Ramprasath, V. R., & Jones, P. J. (2009). Anticancer effects of phytosterols. *European Journal of Clinical Nutrition, 63*(7), 813–820. https://doi.org/10.1038/ejcn.2009.29

Xiao, M., Yang, Z., Jiu, M., You, J., & Xiao, R. (1992). The antigastroulcerative activity of beta-sitosterol-beta-D-glucoside and its aglycone in rats. *Hua Xi Yi Ke Da Xue Xue Bao, 23*(2), 169–173.

Xing, J. J., Mi, X. J., Hou, J. G., Cai, E. B., Zheng, S. W., ... Li, W. (2022). Maltol mitigates cisplatin-evoked cardiotoxicity via inhibiting the PI3K/Akt signaling pathway in rodents in vivo and in vitro. *Phytotherapy Research, 36*(4), 1724–1737. https://doi.org/10.1002/ptr.7405

Zhang, P., Liu, N., Xue, M., Zhang, M., Liu, W., Xu, C., ... [Author List Continued]. (2023). Anti-inflammatory and antioxidant properties of β-sitosterol in copper sulfate-induced inflammation in zebrafish (*Danio rerio*). *Antioxidants, 12*(2), Article 391. https://doi.org/10.3390/antiox12020391

Cite this article: Hemke PP, Sharma P, Shetty SK, Chougale A, Dixit SA, Thakur SS, *et al*. GC-MS Phytochemical Profiling of *Shatapaka Guduchi Taila* with Therapeutic Insights into *Vataraktam* (ED-8 Rheumatoid Arthritis). Pharmacog Res. 2026;18(4):1386-94.