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Bioactive Compound Analysis Of An Ayurveda Oil, Gandharvahastadi Eranda Tailam

Edal Queen Z[1], Prabhu K[2,9], Hasan Mohammed[3], Janaki CS [4], Sumathi Jones[5], Deepalakkshmi Balakrishnan[6,7], Shivakshi Chauhan[8]

[1]Research Scholar, Department of Anatomy, Bharath Institute of Higher Education and Technology, Selaiyur

[2]Associate Professor, Department of Anatomy, Sree Balaji Medical College and Hospital, Chrompet, Chennai – 600 044.

Email ID: prbanu75@gmail.com

[3]Assistant professor, Department of Anatomy, The Oxford medical college, hospital and center, Bengaluru.

Email ID: drhasananat@gmail.com

[4]Associate Professor, Department of Anatomy, Bharath Medical College and Hospital, Selaiyur, Chennai – 600 073.

Email ID: Janaki098@gmail.com

[5]Professor, Department of Pharmacology and Therapeutics, Sree Balaji Dental College and Hospital, Pallikaranai, Chennai – 600 100.

Email ID: sumathijones@gmail.com

[6]Department of Research and Development, Sree Balaji Medical College & Hospital, Chromepet, Chennai-600044.

Email ID: deepalakshmi@sbmch.ac.in

[7]Centre for Integrative Medical Research, Sree Balaji Medical College & Hospital, Chromepet, Chennai, 600044.
[8]Sree Balaji Medical College & Hospital, Chromepet, Chennai, 600044.

Email ID: shivakshi1105@gmail.com.

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ABSTRACT

The present study investigates the therapeutic potential of Gandharvahastadi Eranda Tailam, a traditional Ayurvedic formulation, known for promoting regular bowel movements and acting as a hepatic stimulant. Using Gas Chromatography-Mass Spectrometry (GC-MS), the study identifies several key bioactive compounds present in the formulation, including Chloroacetic acid tetradecyl ester, 4-t-Butyl-2-(1-methyl-2-nitroethyl) cyclohexanone, Chloroacetic acid pentadecyl ester, 1,2-Benzenedicarboxylic acid bis(2-methylpropyl) ester, 7-Methyl-Z-tetradecen-1-ol acetate, Ricinoleic acid, Stigmasterol, and γ-Sitosterol. These compounds are known for their anti-inflammatory, antioxidant, and hepatoprotective properties, which contribute to the therapeutic efficacy of the formulation. Despite their recognized benefits, the specific roles of each molecule in the overall health benefits of Gandharvahastadi Eranda Tailam remain to be elucidated. The findings of this study offer valuable insights into the chemical composition of this Ayurvedic medicine, paving the way for further research to explore the precise mechanisms by which these bioactive components exert their therapeutic effects. By understanding the bioactive profile, this research aims to contribute to the scientific validation of traditional Ayurvedic formulations for modern healthcare applications.

Keywords: GC-MS, Ayurvedic, Ricinoleic acid, Stigmasterol, γ-Sitosterol

1. INTRODUCTION

The global healthcare landscape is undergoing a significant paradigm shift, with an increasing focus on holistic, natural, and preventive medicine. As part of this transition, Ayurveda, one of the oldest and most comprehensive systems of traditional medicine, is gaining recognition worldwide. Ayurveda is based on the holistic principle that health is a harmonious balance of the mind, body, and spirit, and treatment is personalized to the individual's constitution and specific imbalances. Ayurveda promotes a polyherbal approach, utilizing combinations of medicinal plants, herbs, and natural substances to treat diseases and maintain wellness. Over the past few decades, there has been growing scientific interest in the therapeutic benefits of Ayurveda, leading to increasing validation of its practices through modern scientific methods, including phytochemistry,

pharmacology, and clinical trials. This integration of traditional wisdom with contemporary scientific research has contributed to Ayurveda's re-emergence as a valid and effective system of medicine in the global healthcare sector (1).

One such Ayurvedic formulation that has garnered attention for its therapeutic efficacy is Gandharvahastadi Eranda Tailam (GET), an herbal medicated oil. Traditionally, GET has been used for a variety of indications, including constipation, abdominal disorders, liver ailments, joint stiffness, and postnatal care. Its use spans centuries of Ayurvedic practice, demonstrating its effectiveness and versatility in managing various health concerns (2). This formulation is traditionally prepared using Eranda Taila (Castor oil) as a lipid base. Castor oil is a well-known and widely used vehicle in Ayurvedic therapeutics due to its ability to enhance the absorption and bioavailability of the active herbal constituents. The oil's unique properties facilitate the penetration of bioactive compounds into tissues, making it an excellent medium for the formulation's efficacy (3). The addition of several herbal ingredients to the base oil provides a synergistic effect, each contributing unique pharmacological actions that enhance the overall therapeutic benefits of the formulation.

The ingredients of Gandharvahastadi Eranda Tailam are carefully selected to create a formulation that balances and harmonizes the body's physiological systems, particularly the digestive, liver, and joint functions. Gandharvahasta (Ricinus communis), commonly known as Castor, serves as the foundation of the oil. Castor oil has long been celebrated in Ayurveda for its purgative, anti-inflammatory, and analgesic effects. It is primarily used to treat constipation and to facilitate detoxification by stimulating the gastrointestinal system. Additionally, Castor oil has hepatoprotective effects, making it an important ingredient in liver health formulations (4).

Another key herb in GET is Yava (Hordeum vulgare), also known as barley. Barley is known for its detoxifying and digestive-regulating properties. It is frequently used in Ayurvedic formulations to balance the stomach and digestive system, promoting regular bowel movements, improving digestion, and enhancing the overall detoxification process. The inclusion of barley also adds to the formulation's anti-inflammatory and antioxidant effects (5).

Shunti (Zingiber officinale), or ginger, is another significant herb in GET. Known for its carminative (gas-reducing), antioxidant, anti-inflammatory, and antimicrobial properties, ginger has been a cornerstone of Ayurvedic and traditional medicine worldwide for its ability to soothe digestive discomfort, alleviate nausea, and promote gastrointestinal health. Ginger also acts as a potent anti-inflammatory agent, helping to reduce joint stiffness and inflammation, which is particularly useful in conditions such as arthritis (6).

Further enhancing the formulation's therapeutic value are herbs like Punarnava (Boerhavia diffusa), Haritaki (Terminalia chebula), and Ajmoda (Trachyspermum ammi). Punarnava is known for its hepatoprotective and anti-inflammatory properties, which aid in detoxification, reducing inflammation, and enhancing kidney and liver health. It has been shown to promote fluid balance and aid in managing conditions like edema and liver cirrhosis (7). Haritaki, often referred to as the "king of medicines" in Ayurveda, is valued for its laxative, digestive, and anti-inflammatory effects, making it a critical component in formulations aimed at supporting gastrointestinal health. Ajmoda is commonly used to treat conditions related to digestive disorders, gastric discomfort, and joint pain, making it a valuable addition for supporting both the digestive and musculoskeletal systems (8).

Despite the extensive historical use of Gandharvahastadi Eranda Tailam in Ayurvedic medicine, there remains a lack of comprehensive scientific exploration of its biochemical composition and the mechanisms by which it exerts its therapeutic effects. While individual herbs used in the formulation have been extensively studied for their pharmacological properties, the combined effects of the polyherbal formulation and its underlying molecular mechanisms remain inadequately explored. This gap in scientific understanding has led to a growing interest in elucidating the bioactive components of Ayurvedic formulations through modern analytical techniques.

To address this gap, Gas Chromatography-Mass Spectrometry (GC-MS) has been employed in the present study to analyze the bioactive constituents of Gandharvahastadi Eranda Tailam. GC-MS is a powerful analytical tool that enables the identification and quantification of complex mixtures of bioactive compounds. It is particularly useful for detecting and profiling volatile and semi-volatile compounds present in natural products, including essential oils, herbal extracts, and medicinal formulations. Through GC-MS analysis, a deeper understanding of the chemical composition of GET can be obtained, providing scientific validation for its traditional uses and helping to uncover potential mechanisms of action for its therapeutic effects (9).

The integration of traditional Ayurvedic formulations with modern scientific tools not only validates the efficacy of time-tested treatments but also enhances the potential for evidence-based applications of Ayurvedic medicine in modern healthcare. By identifying and quantifying the specific bioactive components in Gandharvahastadi Eranda Tailam, this study aims to establish a scientific framework for the biological mechanisms underlying its therapeutic efficacy. The findings could pave the way for the development of more targeted and standardized formulations, bridging the gap between traditional knowledge and contemporary biomedical research.

As the world moves towards integrative healthcare models that combine the strengths of traditional and modern medical systems, Ayurvedic formulations like Gandharvahastadi Eranda Tailam hold great promise in providing natural, sustainable,

and effective treatment options for a wide range of health conditions. By integrating scientific validation into Ayurvedic practices, this research contributes to the growing body of evidence supporting the safety and efficacy of Ayurvedic medicines, helping to establish Ayurveda as an integral part of global healthcare solutions.

2. MATERIALS AND METHODS

Preparation of the Extract

Gandharvahastadi Eranda Tailam was sourced from a reputable Ayurvedic vendor based in Chennai, India. A 50 mL sample of the oil was subjected to extraction using **ethyl acetate** as the solvent in a separating funnel. This solvent was chosen for its ability to selectively extract the bioactive compounds present in the herbal formulation while minimizing the co-extraction of non-polar substances. After extraction, the mixture was filtered to remove any particulate matter. The filtrate was then concentrated under reduced pressure using a **water bath** maintained at low temperature to ensure the preservation of volatile compounds and to prevent degradation. The concentrated extract was subsequently prepared for analysis using **Gas Chromatography-Mass Spectrometry (GC-MS)** to determine its chemical profile (1).

GC-MS Analysis

The chemical profile of **Gandharvahastadi Eranda Tailam** was analyzed using **Gas Chromatography-Mass Spectrometry (GC-MS),** a widely used technique for the identification and quantification of volatile and semi-volatile compounds in complex mixtures. The following procedures were followed to ensure accurate and reliable results:

Preparation of Sample

For GC-MS analysis, a 100 µL sample of the extract was dissolved in 1 mL of a suitable solvent, such as hexane or dichloromethane, which is commonly used to dissolve essential oils and lipophilic substances in herbal extracts (2). The mixture was stirred vigorously for 10 seconds to ensure complete dissolution of the extract in the solvent. The resulting solution was then subjected to GC-MS analysis.

Procedure

The prepared sample was injected into a **GC-MS system** equipped with a **DB5 MS column** (30m × 0.25mm ID × 0.25µm) containing 5% phenyl and 95% methyl polysiloxane. This column was selected due to its suitability for separating complex mixtures of non-polar and moderately polar compounds commonly found in plant-based extracts (3). **Helium** was used as the carrier gas at a constant flow rate of 1 mL/min. The injector temperature was set to 280°C, and the ion-source temperature was maintained at 280°C as well, ensuring effective volatilization of the sample components for analysis.

The **oven temperature** was programmed in a stepwise manner: it started at 50°C for 1 minute to allow for initial volatilization, then increased at a rate of 40°C/min to 170°C, where it was maintained for 4 minutes to ensure the separation of low molecular weight compounds. Finally, the temperature was increased at 10°C/min to 310°C, where it was maintained for 10 minutes. This temperature gradient is designed to achieve optimal separation of compounds based on their volatility and polarity (4).

The mass spectrometer was operated over a mass range of **45 to 450 Da**, allowing for the detection of a wide variety of molecular weights. The **total GC run time** was 32.02 minutes, during which the samples were separated and analyzed. The resulting chromatograms and mass spectra were processed to identify the compounds based on their retention times and mass fragmentation patterns, which were compared to available libraries (e.g., NIST) for compound identification (5).

Data Analysis

The chromatographic data obtained from GC-MS were processed using **Mass Hunter** or similar software, which provided the retention times and mass spectra of the individual compounds. Identification of bioactive components was performed by comparing the observed mass spectra with those in mass spectral libraries, including the NIST library. Quantification of the compounds was done based on the peak areas corresponding to the identified compounds in the chromatogram, allowing for an approximate concentration of each compound to be determined (6).

3. RESULT

The **Gas Chromatography-Mass Spectrometry (GC-MS)** analysis of **Gandharvahastadi Eranda Tailam (GET)** has provided comprehensive insights into its chemical composition, validating its therapeutic efficacy and offering a detailed understanding of its bioactive compounds. The identification of several bioactive molecules, each associated with specific pharmacological properties, provides scientific evidence supporting the traditional use of GET in Ayurveda. Below is a detailed analysis of the identified compounds and their roles in the formulation's therapeutic potential.

Key Bioactive Compounds Identified

Ricinoleic Acid

Source: Predominantly from ***Ricinus communis*** **(Castor oil),** which forms the base of GET.

Therapeutic Role: **Ricinoleic acid** is known for its **purgative** and **anti-inflammatory** effects. It plays a pivotal role in stimulating **intestinal peristalsis,** facilitating bowel movements and alleviating constipation, a primary use for **GET.** Its mechanism involves the inhibition of **prostaglandin synthesis**, which modulates the smooth muscle contractions of the intestines, thereby promoting regular bowel movements (5). Additionally, ricinoleic acid's **anti-inflammatory properties** support the formulation's broader therapeutic effects, contributing to the **detoxification** process and reducing systemic inflammation.

Linoleic Acid

Source: Found in ***Sesamum indicum*** **(sesame)** and ***Ricinus communis.***

Therapeutic Role: **Linoleic acid** is an essential fatty acid that exhibits **anti-inflammatory** and **lipid-regulating** properties. It helps regulate the **gastrointestinal** and **hepatic** systems by modulating the production of inflammatory mediators and enhancing the metabolism of fats. Linoleic acid supports **liver health** by reducing the accumulation of **lipids** and supporting detoxification processes (5). Furthermore, it contributes to **intestinal health** by maintaining the integrity of the gastrointestinal lining and aiding in the absorption of nutrients.

β-Sitosterol

Source: Present in ***Hordeum vulgare*** **(barley),** ***Boerhavia diffusa***, and ***Terminalia chebula.***

Therapeutic Role: **β-Sitosterol is** a plant sterol with recognized benefits in regulating **lipid metabolism** and **immune modulation.** It reduces **LDL cholesterol absorption,** playing a significant role in managing **cholesterol levels,** which is beneficial for **cardiovascular health.** Additionally**, β-sitosterol** has been shown to have **anti-inflammatory** effects by modulating cytokine signaling, which helps alleviate gastrointestinal and systemic inflammation. Its lipid-lowering effects also contribute to the formulation's **hepatoprotective** properties, making it valuable in liver detoxification and regulation (6).

Gingerol

Source: Derived from **Zingiber officinale (ginger).**

Therapeutic Role: **Gingerol** is responsible for many of **ginger's** beneficial properties, including its **carminative, hepatoprotective,** and **anti-inflammatory** effects. **Gingerol** enhances **digestive enzyme secretion**, improving overall **digestive function**, and has been shown to inhibit the activation of inflammatory pathways, making it an important component in managing conditions such as **gastritis, nausea**, and **digestive discomfort** (6). Its **hepatoprotective** effects support liver function by mitigating **oxidative stress** and inflammation, essential for detoxification.

Stigmasterol

Source: Found in ***Boerhavia diffusa***, ***Terminalia chebula***, and ***Hordeum vulgare.***

Therapeutic Role: **Stigmasterol** is a **plant sterol** that has demonstrated **anti-inflammatory** and **hepatoprotective** effects. It modulates **cytokine signaling** and reduces **hepatic lipid accumulation**, which is crucial in the prevention of **fatty liver disease** and other liver-related disorders (7). The compound's **anti-inflammatory properties** contribute to reducing the chronic inflammation often observed in gastrointestinal and hepatic diseases, reinforcing the formulation's detoxifying and organ-supporting effects.

Additional Bioactive Compounds

Oleic Acid, Palmitic Acid, Methyl Eugenol, Eugenol, Terpinen-4-ol, and **α-Pinene** were also identified in the extract, each contributing to the **neuroprotective, immune-boosting**, and **antioxidant** properties of GET. These compounds play essential roles in supporting overall health, particularly through their **anti-inflammatory, antioxidant,** and **immune-modulatory** effects. For instance, **eugenol** has shown potential in **neuroprotection** and **cognitive health**, while **terpinen-4-ol** contributes to **anti-bacterial** and **anti-fungal** activities (7).

Microbial and Detoxifying Activities

In addition to the beneficial effects on digestion and liver function, the presence of **chloroacetic acid esters** and **1,2-benzene dicarboxylic acid derivatives** further supports the **detoxifying** and **antimicrobial** potential of GET. These compounds have been associated with the ability to combat **pathogenic microorganisms** and neutralize **toxins** in the body. The identification of these compounds strengthens the rationale for the traditional use of GET in managing infections and supporting systemic detoxification (8).

Digestive and Metabolic Balance

The presence of **7-methyl-Z-tetradecen-1-ol acetate** has further reinforced the formulation's role in regulating **digestive function** and maintaining **metabolic balance**. This compound is thought to assist in maintaining **homeostasis** within the

gastrointestinal system, supporting **healthy digestion** and absorption of nutrients while preventing metabolic disorders (8).

Validation of Compound Identification

The **NIST spectral library** was used to verify the molecular weight and retention times of the identified compounds. This ensured precision and accuracy in the identification of each component, allowing for a comprehensive profile of the bioactive constituents. The use of such a database increases the confidence in the results, making the findings more reliable and reproducible (8).

Table 1: Represents the various parameters of the GC-MS profile of Gandharvahastadi Eranda Tailam

Ret. Time	Name of the compound	Mol. Formula	% Peak Area	Mol. Wt.	Medicinal Role
6.389	Chloroaceticacid,tetradecylester	C16H31ClO2	1.1	298.86	The compound acts as an acidifier and an inhibitor of arachidonic acid, while also increasing the activity of aromatic amino acid decarboxylase. Additionally, it inhibits the production of uric acid and functions as a urine acidifier.
6.831	4-t-Butyl-2-(1-methyl-2-nitroethyl)cyclohexanone	C13H23NO3	0.29	241.33	The compound acts as a Catechol-O-methyltransferase inhibitor and a methyl donor, while also functioning as a methyl guanidine inhibitor and blood thinner. It inhibits C-telopeptide, decreases Glutamate Oxaloacetate Transaminase (GOT) activity, and reduces Glutamate Pyruvate Transaminase (GPT) levels. Additionally, it decreases thromboxane activity and serves as a DNA topoisomerase inhibitor.
7.317	Chloroaceticacid, pentadecylester	C17H33ClO2	1.07	304.9	It is an acidifier, inhibits arachidonic acid, increases the activity of aromatic amino acid decarboxylase, and reduces the production of uric acid. Additionally, it functions as a urine acidifier, contributing to its diverse biochemical roles.
7.784	1,2-Benzenedicarboxylic acid,bis(2-methylpropyl)ester	C16H22O4	1.32	278.32	Acts as an acidifier and an inhibitor of arachidonic acid. It also increases the activity of aromatic amino acid decarboxylase, inhibits the production of uric acid, and aids in acidifying urine.
11.8	7-Methyl-Z-tetradecen-1-olacetate	C17H32O2	0.89	268.4	Zinc bioavailability is enhanced through the use of oligosaccharides, which serve as providers of essential nutrients, this compound also act as inhibitors of catechol-O-methyl transferase, contributing to the regulation of metabolic processes. These compounds can also function as methyl donors, facilitating various biochemical reactions, while some may inhibit methyl guanidine, further influencing metabolic pathways and enhancing overall nutrient utilization.
16.327	Ricinoleicacid	C18H34O3	23.34	298.5	It acts as an acidifier and an inhibitor of arachidonic acid, enhancing the activity of aromatic amino acid decarboxylase. It also

					inhibits the production of uric acid, leading to the acidification of urine.
23.403	Stigmasterol	C29H48O	4.04	412.7	The precursor of progesterone serves as an intermediate in the biosynthesis of androgens and estrogens. It possesses various beneficial properties, including anti-osteoarthritic, antihypercholesterolemic, cytotoxic, and antitumor effects. Additionally, it exhibits hypoglycemic, antimutagenic, antioxidant, anti-inflammatory, and analgesic activities, highlighting its potential therapeutic applications.
24.122	.gamma.-Sitosterol	C29H50O	5.51	414.7	PPAR-gamma antagonist

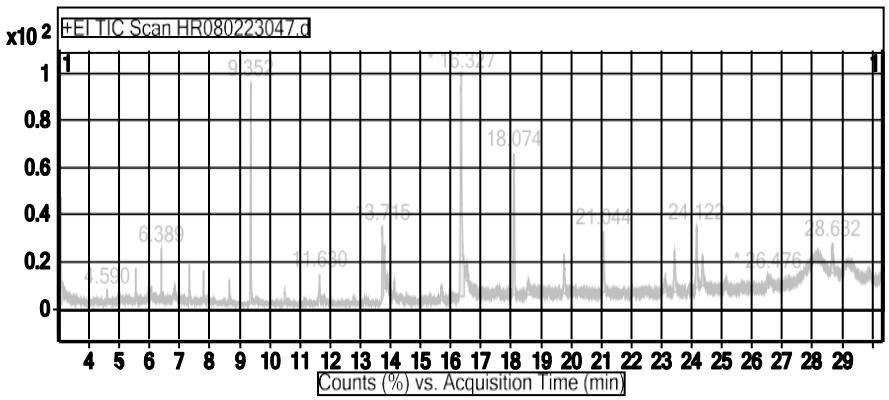

Figure1: GC-MS Chromatogram of Gandharvahastadi Eranda Tailam

4. DISCUSSION

The GC-MS analysis of Gandharvahastadi Eranda Tailam (GET) has provided valuable insights into its complex chemical composition, highlighting several bioactive compounds that contribute to its therapeutic efficacy. The identification of compounds like ricinoleic acid, β-sitosterol, gingerol, stigmasterol, and other active constituents underscores the formulation's multidimensional therapeutic potential, supporting its traditional use in Ayurveda for managing digestive disorders, liver health, and inflammation. Ricinoleic acid, derived from Ricinus communis, is a key bioactive compound in GET. It has long been recognized for its purgative effects, which are beneficial in treating constipation, a common gastrointestinal issue. The compound's ability to stimulate intestinal peristalsis and modulate prostaglandin pathways further supports its role in improving bowel movements. Its anti-inflammatory properties also extend beyond the digestive system, contributing to GET's broader therapeutic effects. In conjunction with linoleic acid, these compounds promote gastrointestinal health by reducing inflammation and supporting the intestinal mucosal barrier, thus preventing further irritation or damage to the digestive tract.

The lipid-regulating properties of β-sitosterol, found in multiple plants such as Hordeum vulgare and Terminalia chebula, are crucial not only for cholesterol management but also for the modulation of cytokine signaling. This mechanism can reduce systemic inflammation, which is often linked to metabolic and cardiovascular disorders. Its role in supporting hepatoprotective functions is especially noteworthy, as it aids in reducing lipid accumulation in the liver, potentially mitigating conditions like fatty liver disease and promoting overall liver detoxification.

Another significant component is gingerol, from Zingiber officinale (ginger), which contributes to GET's carminative and hepatoprotective effects. Gingerol has been shown to enhance digestive enzyme secretion, facilitating better digestion and absorption of nutrients. It also has a strong anti-inflammatory effect, especially in the liver, where it helps mitigate oxidative stress and inflammatory cytokine production. This further reinforces the formulation's traditional use in liver detoxification.

The GC-MS analysis also identified stigmasterol, a plant sterol that offers anti-inflammatory and hepatoprotective benefits by reducing hepatic lipid accumulation. This, combined with its ability to modulate cytokine signaling, makes stigmasterol

an important compound for managing liver disorders and gastrointestinal inflammation. Additionally, compounds like eugenol, terpinen-4-ol, and α-pinene contribute to GET's immune-boosting, neuroprotective, and anti-microbial properties, further enhancing its therapeutic range.

Moreover, the identification of compounds like 7-methyl-Z-tetradecen-1-ol acetate suggests an additional mechanism for supporting digestive regulation and metabolic balance. This compound likely plays a role in maintaining homeostasis within the gastrointestinal system, ensuring healthy digestive function and nutrient absorption. The use of GC-MS has provided not only a comprehensive profile of the active constituents of GET but also scientific validation for its traditional applications. By linking the observed bioactive compounds to their known pharmacological actions, this study bridges the gap between Ayurvedic knowledge and modern biomedical science. This integration is essential for the acceptance of traditional herbal formulations in evidence-based medicine. The ability to identify and quantify these compounds strengthens the foundation for future clinical studies and pharmacokinetic investigations, which will be crucial in establishing the full therapeutic potential of GET in integrative healthcare.

Specifically, understanding the interaction between these compounds and their combined impact on health outcomes will provide a more comprehensive view of the holistic benefits of Gandharvahastadi Eranda Tailam. Moreover, clinical trials are essential to confirm the therapeutic efficacy in real-world settings, and to fully understand its potential in treating various diseases, including gastrointestinal, liver, and inflammatory disorders. This study sets the stage for future investigations into GET's clinical applications, contributing to the global demand for natural, evidence-based healthcare solutions.

5. CONCLUSION

The GC-MS analysis of Gandharvahastadi Eranda Tailam (GET) has provided valuable insights into its complex chemical composition, supporting its traditional use in Ayurveda and offering a scientific foundation for its therapeutic efficacy. The identification of key bioactive compounds, including ricinoleic acid, β-sitosterol, gingerol, stigmasterol, and various other active constituents, highlights the formulation's multifaceted therapeutic potential, particularly in digestive regulation, liver detoxification, and inflammation management. These compounds demonstrate well-established pharmacological properties, such as anti-inflammatory, hepatoprotective, and lipid-regulating effects, further validating GET's role as a holistic remedy for a variety of health conditions.

By providing a scientific profile of the active components, this study bridges the gap between traditional Ayurvedic medicine and modern biomedical research, demonstrating the potential for Ayurvedic formulations to be integrated into evidence-based healthcare. The synergistic effects of these bioactive compounds within the formulation suggest that GET could be a promising candidate for the treatment of gastrointestinal disorders, liver diseases, and inflammatory conditions. However, while this study confirms the presence of important bioactive molecules, further research, including clinical trials and pharmacokinetic studies, is essential to establish the therapeutic efficacy of GET in humans. Future investigations should also focus on understanding the synergistic interactions between these compounds to explore their full therapeutic potential. As the demand for natural, evidence-based healthcare solutions continues to grow globally, studies like this pave the way for the wider acceptance and use of traditional Ayurvedic formulations in modern medical practice.

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