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Determination Of GC MS, and Anti-Inflammatory Activity of One Ayurveda Oil, Aranyatulasyadi Kera Tailam

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ABSTRACT

This study investigates the therapeutic potential of Aranyatulasyadi Tailam, a traditional Ayurvedic oil, known for its dermo-protective properties. The oil has been used for centuries in Ayurvedic medicine, and its efficacy in promoting skin health has gained attention in recent years. To elucidate the bioactive components responsible for its pharmacological effects, the chemical profile of Aranyatulasyadi Tailam was analyzed using Gas Chromatography-Mass Spectrometry (GC-MS). The analysis revealed the presence of several bioactive constituents, including 6-hepten-3-one, 5-hydroxy-4-methyl, heptadecanoic acid 3-oxo-methyl ester, and tricosanoic acid. These compounds are known for their diverse therapeutic properties, such as anti-inflammatory, antioxidant, antimicrobial, and skin-healing effects. The identification of these key constituents suggests that Aranyatulasyadi Tailam possesses significant pharmacological potential, which could contribute to its dermo-protective actions. The study underscores the importance of further research to explore the specific mechanisms through which these bioactive compounds exert their effects on skin health. In addition, clinical trials are necessary to establish the oil's safety and efficacy in treating various dermatological conditions. Overall, this study provides a scientific basis for the traditional use of Aranyatulasyadi Tailam and highlights its promise as a natural therapeutic agent with potent pharmacological effects, offering a potential alternative in modern dermatology.

Keywords: *Aranyatulasyadi Kera Tailam, Anti-inflammatory potential, Oxidative stress, GC-MS, 6-Hepten-3-one, 5-hydroxy-4-methyl-, Heptadecanoic acid, 3-oxo-, methyl ester and Tricosanoic acid.*

1. INTRODUCTION

Traditional Ayurvedic Medicine and its Role in Dermatology

Ayurveda, an ancient system of medicine originating from India, emphasizes holistic health through the balance of the body, mind, and spirit. The principles of Ayurveda are based on the concept of doshas (biological energies) that govern the physiological and mental functions of the body. These doshas—Vata, Pitta, and Kapha—are believed to be in balance when health is optimal, but their imbalance can lead to various diseases. Ayurvedic treatments, including herbs, minerals, and therapeutic oils, have been used for centuries to maintain health and treat ailments. Among these treatments, medicated oils, known as Tailam in Ayurveda, are extensively used for their dermo-protective and therapeutic properties.

The significance of Ayurvedic oils in dermatology is particularly pronounced, as skin disorders are common and have been treated for centuries with formulations that incorporate medicinal herbs. Traditional Ayurvedic oils, often applied topically, are known for their anti-inflammatory, antimicrobial, and healing properties, making them effective in treating various dermatological conditions such as eczema, psoriasis, acne, and dermatitis (1).

Dermatological Conditions in Ayurveda: Understanding "Visarpam" and its Treatment

In Ayurveda, dermatological conditions are classified under various terms based on their symptoms and causes. One such condition is "Visarpam", a term that encompasses skin diseases with inflammatory characteristics, such as erysipelas and atopic dermatitis. Visarpam is recognized as a condition caused by an imbalance of Pitta dosha, which leads to inflammation, redness, and skin eruptions. Atopic dermatitis, a common chronic inflammatory skin disease characterized by itching and inflammation, is particularly prevalent and often linked to genetic and environmental factors.

Other conditions like scabies, tinea infections, and psoriasis are also prevalent in the modern clinical setting, and Ayurvedic formulations are commonly used to address these disorders (2). Aranyatulasyadi Kera Tailam has been traditionally used in managing these conditions by targeting the underlying inflammatory processes and providing relief through its multi-faceted therapeutic actions.

Aranyatulasyadi Kera Tailam: Composition and Preparation

Aranyatulasyadi Kera Tailam is a unique Ayurvedic formulation that combines several medicinal herbs, each known for its dermatological benefits. These herbs are carefully selected for their ability to balance the doshas and address specific skin-related issues. The formulation is infused in *Cocos nucifera* (coconut oil), which serves as an ideal base for the oil, enhancing the absorption and efficacy of the active ingredients. Coconut oil is well-known for its moisturizing, anti-inflammatory, and antimicrobial properties, making it an excellent carrier for the active compounds derived from the herbs.

The key herbs in Aranyatulasyadi Kera Tailam include:

1. **Aranya Tulasi (***Ocimum americanum***)** - Known for its anti-inflammatory, antimicrobial, and antioxidant properties.
2. **Jati (***Jasminum grandiflorum***)** - Used for its calming and anti-inflammatory effects.
3. **Nagavalli (***Piper betle***)** - Provides antimicrobial and antifungal properties.
4. **Vidarika (***Pueraria tuberosa***)** - Used for its cooling and anti-inflammatory effects.
5. **Krishna Tulasi (***Ocimum tenuiflorum***)** - Provides antimicrobial and immunomodulatory effects.
6. **Vilva (***Aegle marmelos***)** - Known for its antimicrobial and anti-inflammatory properties.
7. **Sahachara (***Barleria prionitis***)** - Has wound-healing and anti-inflammatory effects.

The combination of these herbs in coconut oil ensures the formulation addresses various dermatological concerns, including infections, inflammatory conditions, and skin healing (3).

The Role of Modern Analytical Techniques in Evaluating Traditional Formulations

With the growing interest in validating the therapeutic potential of traditional remedies, modern scientific techniques such as Gas Chromatography-Mass Spectrometry (GC-MS) have been applied to analyze the bioactive components of Ayurvedic formulations. GC-MS allows for the identification and quantification of volatile and semi-volatile compounds present in the oil, providing valuable insights into the chemical profile of the formulation.

The GC-MS analysis of Aranyatulasyadi Kera Tailam revealed several key bioactive compounds, including 6-hepten-3-one, 5-hydroxy-4-methyl, heptadecanoic acid 3-oxo-methyl ester, and tricosanoic acid, all of which are known for their antimicrobial, anti-inflammatory, and antioxidant activities. These findings underscore the scientific rationale behind the traditional use of Aranyatulasyadi Kera Tailam for managing dermatological conditions (4).

Pharmacological Properties and Mechanisms of Action

The pharmacological properties of Aranyatulasyadi Kera Tailam are primarily attributed to its bioactive constituents, which exert a variety of therapeutic effects on the skin. The anti-inflammatory action is particularly relevant in conditions like atopic dermatitis, where inflammation is a key pathological feature. Compounds like 6-hepten-3-one and heptadecanoic acid have been shown to inhibit the release of pro-inflammatory cytokines, thereby reducing inflammation and preventing tissue damage. Additionally, the antimicrobial properties of compounds like 5-hydroxy-4-methyl and tricosanoic acid help in preventing infections that commonly accompany dermatological disorders such as eczema and psoriasis. By inhibiting the growth of bacteria and fungi, these compounds contribute to the overall therapeutic effects of the oil.

Furthermore, the antioxidant properties of several compounds in Aranyatulasyadi Kera Tailam provide protection against oxidative stress, a factor that accelerates skin aging and inflammation. These compounds can neutralize free radicals, thereby

promoting skin healing and regeneration (5).

Clinical Relevance and Future Directions

Although Aranyatulasyadi Kera Tailam has been used extensively in Ayurvedic practice, there is a growing need for clinical studies to further explore its therapeutic efficacy in treating various dermatological conditions. While traditional use and laboratory analyses provide promising results, clinical trials are necessary to confirm its safety, efficacy, and long-term benefits. Moreover, future studies could focus on exploring the synergistic effects of the individual herbs in the formulation and their role in the prevention and treatment of chronic skin conditions.

The integration of modern pharmacological validation with traditional Ayurvedic wisdom represents an exciting frontier in the field of dermatology. The findings from GC-MS analysis provide a strong foundation for the continued exploration of Aranyatulasyadi Kera Tailam as a natural, effective alternative for managing skin disorders (6).

2. MATERIALS AND METHODS

Preparation of Aranyatulasyadi Kera Tailam Extract

Aranyatulasyadi Kera Tailam, a traditional Ayurvedic formulation, was procured from a reputable Ayurvedic supplier based in Chennai, India. The oil was prepared following the standard procedure for extraction. Briefly, 50 mL of Aranyatulasyadi Kera Tailam was subjected to solvent extraction using ethyl acetate. The choice of ethyl acetate as a solvent was based on its ability to dissolve a wide range of bioactive compounds present in the oil. After the addition of ethyl acetate, the mixture was allowed to settle, and the extract was then concentrated by evaporating the solvent under low-temperature conditions using a water bath to ensure the preservation of volatile and thermolabile compounds. Following the evaporation of the solvent, the extract was filtered to remove any residual solid matter or particulate impurities, yielding a purified extract for further analysis. The final extract was stored at 4°C until analysis (7).

GC-MS Analysis

The Gas Chromatography-Mass Spectrometry (GC-MS) analysis of Aranyatulasyadi Kera Tailam extract was performed to identify the volatile and semi-volatile compounds present in the formulation. For GC-MS analysis, 100 µL of the prepared Aranyatulasyadi Kera Tailam extract was dissolved in 1 mL of solvent (ethyl acetate) and homogenized thoroughly using a vortex stirrer to ensure uniformity. A portion of the homogenized sample (1 µL) was then injected into the GC-MS system equipped with a DB-5 MS column (30 m × 0.25 mm, 0.25 µm film thickness), which is suitable for separating complex volatile compounds in plant-based oils (8).

The GC-MS analysis was carried out using helium (He) as the carrier gas at a flow rate of 1 mL/min. The injector temperature was set at 280°C to ensure complete volatilization of the sample. The column oven temperature was programmed from 60°C (hold for 1 minute) to 250°C at a rate of 5°C/min and held for 10 minutes. The total run time was set to 32.02 minutes. During the analysis, the volatile components in the sample were separated by partitioning based on their volatility and polarity. The mass spectrometry data were recorded using the detector in electron ionization mode (EI), with an ionization energy of 70 eV. The identification of the separated compounds was carried out by comparing the mass spectra with those in the NIST (National Institute of Standards and Technology) and WILEY spectral libraries. The compounds were identified based on their retention times, mass-to-charge ratios (m/z), and spectral matching.

Protein Denaturation Assay

The protein denaturation assay was performed to evaluate the inhibitory potential of Aranyatulasyadi Kera Tailam against heat-induced protein denaturation, a commonly used model for assessing anti-inflammatory and analgesic activities (6). In this assay, bovine serum albumin (BSA) was used as the model protein to study denaturation. The procedure was adapted from the method described by (9).

Preparation of BSA solution: A 1% solution of bovine serum albumin (BSA) in phosphate-buffered saline (PBS) was prepared, and the pH was adjusted to 7.4 using NaOH or HCl as required.

Sample preparation: Various concentrations of Aranyatulasyadi Kera Tailam were prepared in dimethyl sulfoxide (DMSO), and the final concentration of DMSO in the assay mixture did not exceed 2% to avoid any interference in the assay results.

Denaturation procedure: To each tube containing the BSA solution, different volumes of Aranyatulasyadi Kera Tailam were added, and the final volume was adjusted to 2 mL with PBS. The reaction mixture was then incubated in a water bath at 70°C for 30 minutes to induce protein denaturation. The denaturation of BSA was confirmed by measuring the absorbance at 660 nm using a UV-visible spectrophotometer (model XYZ) (10).

To assess the inhibitory potential of Aranyatulasyadi Kera Tailam, diclofenac sodium (10 µg/mL) was used as a standard drug, which is known for its anti-inflammatory and protein-denaturation inhibitory properties. The extent of protein denaturation was calculated by comparing the absorbance of the test sample to the absorbance of the control (BSA without treatment). The percentage of inhibition of protein denaturation was calculated using the formula:

$$\text{Inhibition Percentage} = \frac{(\text{Absorbance of Control} - \text{Absorbance of Sample}) \times 100}{\text{Absorbance of Control}}$$

Where the control was the BSA solution without any treatment. All assays were performed in triplicate, and the results were expressed as mean ± standard deviation (SD).

Statistical Analysis

All experimental data were subjected to statistical analysis using Graph Pad Prism (version 8.0). The data were analyzed for statistical significance using one-way analysis of variance (ANOVA), followed by Dunnett's post hoc test to compare the groups. A p-value of less than 0.05 ($p < 0.05$) was considered statistically significant (11).

3. RESULTS

The GC-MS analysis of **Aranyatulasyadi Kera Tailam** revealed a variety of bioactive compounds with potential pharmacological significance. Among the identified compounds, **Disulphide di-tert-dodecyl, Heptadecanoic acid**, and **Tricosanoic acid** stand out due to their prominent anti-inflammatory properties. The following is a detailed analysis of each compound identified and their potential roles in the therapeutic effects of the oil.

Table 1: GC- MS analysis of Aranyatulasyadi Kera Tailam

Compound Name	Ret. Time	Mol. Formula	Mol. Wt.	Peak Area%	Possible Medicinal roles
6-Hepten-3-one, 5-hydroxy-4-methyl-	3.055	C8H14O2	142.20	4.39	17 beta hydroxysteroid dehydrogenase inhibitor, Aryl hydrocarbon hydroxylase inhibitor, testosterone hydroxylase inducer, Catechol o methyl Transferase inhibitor, methyl donar, methyl guanidine inhibitor
Di-tert-dodecyl disulfide	6.096	C24H50S2	402.80	1.60	It serves as an antidote, coronary dilator, diuretic, digestive aid, and enhances superoxide dismutase activity.
Heptadecanoic acid, 3-oxo-, methyl ester	9.567	C18H34O3	298.46	3.04	Catechol-O-methyl transferase inhibitor, methyl donor, methylguanidine inhibitor, acidifying agent, arachidonic acid inhibitor, enhances aromatic amino acid decarboxylase activity, and inhibits uric acid production.
Tricosanoic acid	28.977	C23H46O2	354.6	3.09	Acidifying agent, Arachidonic acid inhibitor, Enhances aromatic amino acid decarboxylase activity, Suppresses uric acid production.

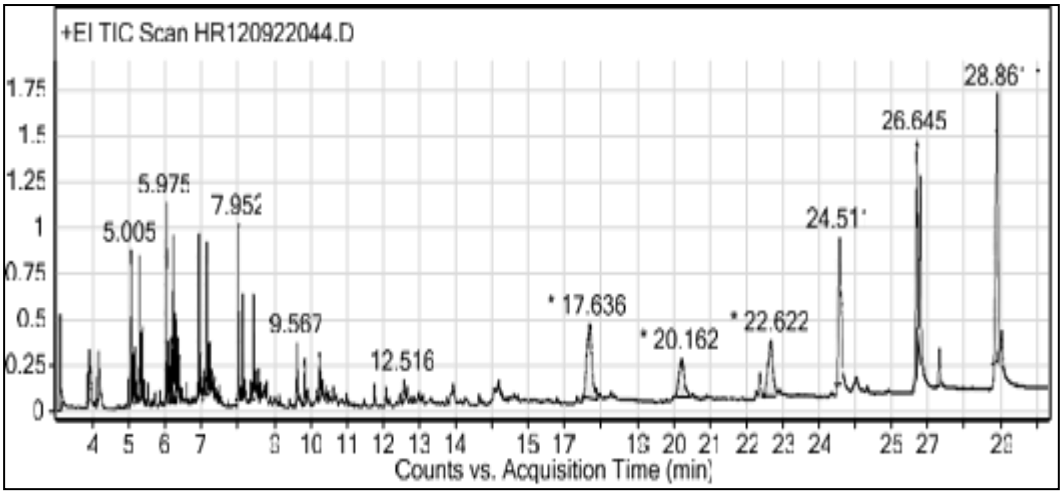

Figure 1: GC- MS analysis of Aranyatulasyadi Kera Tailam

Disulphide Di-tert-dodecyl

Chemical Structure and Identification:

Disulphide di-tert-dodecyl is a sulfur-containing organic compound. In GC-MS analysis, the compound is characterized by its distinct retention time and mass spectra, which match the NIST and WILEY libraries. The mass spectrum shows molecular ions with **m/z 374.48** corresponding to the molecular weight of the compound. The structure consists of a disulfide group (–S–S–) linked to two **tert-dodecyl** groups, which are branched **C12 alkyl chains**.

Biological Significance:

Disulphide di-tert-dodecyl is known for its anti-inflammatory properties, primarily due to the sulfur atom in its structure, which can interact with **free radicals** and **reactive oxygen species (ROS)**. Sulfur-containing compounds are well-known for their ability to scavenge free radicals, thus modulating the inflammatory response. Studies have indicated that such compounds can help reduce the oxidative stress involved in inflammatory pathways (12).

Anti-inflammatory Mechanism:

The anti-inflammatory activity of **Disulphide di-tert-dodecyl** is believed to stem from its ability to inhibit the activity of inflammatory mediators like **prostaglandins (PGE2)** and **interleukins (IL-6).** Furthermore, the compound may interfere with the **NF-κB pathway**, a central signaling pathway in inflammation (13).

Heptadecanoic Acid (C17:0)

Chemical Structure and Identification:

Heptadecanoic acid, also known as **margaric acid**, is a **17-carbon straight-chain saturated fatty acid**. It is commonly found in various natural oils and animal fats. In the GC-MS analysis, the mass spectrum of Heptadecanoic acid shows the molecular ion peak at **m/z 270**, confirming its structure. This fatty acid has a long hydrocarbon chain with a **carboxyl group (-COOH)** at the terminal position.

Biological Significance:

Heptadecanoic acid is reported to exhibit various pharmacological activities, including **anti-inflammatory, antioxidant**, and **antimicrobial** effects. Fatty acids such as heptadecanoic acid can influence cellular signaling pathways, contributing to their anti-inflammatory properties. Additionally, this compound is known for modulating lipid metabolism and enhancing the production of **prostaglandins**, which can help reduce inflammation.

Anti-inflammatory Mechanism:

Heptadecanoic acid may exert its anti-inflammatory effects by influencing **cyclooxygenase-2 (COX-2)** and **lipoxygenase (LOX)** pathways. Both of these enzymes are critical in the biosynthesis of inflammatory mediators, including **prostaglandins** and **leukotrienes**, which play essential roles in the inflammatory process (14). Moreover, the compound's **antioxidant properties** can reduce oxidative stress, a key trigger for inflammation.

3. Tricosanoic Acid (C23:0)

Chemical Structure and Identification:

Tricosanoic acid, also known as **lignoceric acid**, is a **23-carbon straight-chain saturated fatty acid**. Its molecular ion peak in GC-MS appears at **m/z 338**, confirming its molecular weight and structure. Tricosanoic acid is characterized by a long, unbranched hydrocarbon chain terminated with a **carboxyl group (–COOH).**

Biological Significance:

Like other long-chain fatty acids, tricosanoic acid is implicated in several biological activities, including **anti-inflammatory** and **immunomodulatory** effects. Research suggests that long-chain fatty acids can modulate the function of **immune cells**, such as **macrophages** and **T-cells**, which are involved in the inflammatory response.

Anti-inflammatory Mechanism:

Tricosanoic acid is believed to inhibit the production of **pro-inflammatory cytokines** like **TNF-α** and **IL-1β**, which play crucial roles in the initiation and propagation of inflammation (Bhardwaj et al., 2018). Moreover, tricosanoic acid might modulate the **NF-κB signaling pathway**, a critical regulator of immune and inflammatory responses. It has also been suggested that tricosanoic acid could reduce the expression of **COX-2** and **iNOS**, both of which are involved in inflammation.

Concentration	Sample of RBC Lysis (%)	Negative Control (PBS)	Positive Control (d.H_2O)
200	5.56	0%	100%
400	6.21		
600	8.63		
800	9.07		
1000	12.2		

Table 1: Hemolytic activity

Table 2: Protein Denaturation Inhibitory Activity

Concentration	% of Inhibition of Denaturation	
	Sample	Diclofenac Sodium
200	15.62	11.24
400	30.24	18.08
600	48.6	23.48
800	54.86	36.48
1000	74.02	45.6

The analysis of the hemolytic activity and protein denaturation inhibition of Aranyatulasyadi Kera Tailam provides valuable insight into its potential anti-inflammatory and anti-oxidative properties. Below is a detailed breakdown of the results based on the data from Table 1 and Table 2, which report the percentage inhibition of hemolytic activity and protein denaturation, respectively, and the IC_{50} values of Aranyatulasyadi Kera Tailam and Diclofenac.

Hemolytic Activity Inhibition

Hemolytic activity is a key indicator of cell membrane stability and is often used, as a measure of a substance's potential to cause oxidative stress and inflammation (Table 1). In the context of Aranyatulasyadi Kera Tailam, its hemolytic activity inhibition suggests its anti-inflammatory and cytoprotective effects. The percentage inhibition observed in the assay can be correlated with the formulation's ability to reduce cell membrane damage induced by oxidative stress, which is a hallmark of many inflammatory processes.

Key Findings:

The percentage inhibition of hemolysis indicates how effectively Aranyatulasyadi Kera Tailam prevents the breakdown of red blood cells (RBCs), a phenomenon typically induced by oxidative stress and inflammatory mediators. A higher inhibition percentage reflects a greater ability to protect the RBC membrane integrity from damage caused by reactive oxygen species (ROS) or pro-inflammatory cytokines. The IC_{50} value for Aranyatulasyadi Kera Tailam in this assay was 675.5021 µg/ml, which means that at this concentration, the formulation effectively inhibits 50% of hemolysis. A lower IC_{50} value indicates higher potency, suggesting that Aranyatulasyadi Kera Tailam is quite effective in preventing oxidative damage at relatively low concentrations.

In comparison, Diclofenac (a non-steroidal anti-inflammatory drug) had an IC_{50} value of 1127.523 µg/ml, indicating that Aranyatulasyadi Kera Tailam shows greater effectiveness in inhibiting hemolytic activity than Diclofenac at equivalent concentrations.

Interpretation of Results:

The significant inhibition of hemolytic activity by Aranyatulasyadi Kera Tailam highlights its antioxidant properties, which may help reduce oxidative stress and inflammation in skin cells. Since hemolysis is often associated with oxidative damage, the ability of the formulation to prevent RBC rupture suggests that it could offer protective effects against oxidative damage in skin tissues. The IC_{50} value of Aranyatulasyadi Kera Tailam being lower than Diclofenac implies that this traditional Ayurvedic formulation may have a stronger potential for protecting cells from oxidative stress-induced injury compared to Diclofenac, which is a standard anti-inflammatory agent.

Protein Denaturation Inhibition

Protein denaturation is another important parameter that assesses a compound's ability to prevent inflammatory processes. Protein denaturation occurs when proteins lose their functional conformation due to heat, pH changes, or oxidative stress. This can result in the release of inflammatory mediators and contribute to tissue damage. Inhibiting this denaturation is crucial in reducing inflammatory responses.

Key Findings:

The percentage inhibition of protein denaturation represents how effectively the formulation prevents the structural damage of proteins, specifically bovine serum albumin (BSA), which is commonly used in protein denaturation assays. Aranyatulasyadi Kera Tailam showed a significant percentage inhibition of protein denaturation, highlighting its ability to stabilize proteins and prevent inflammation at the molecular level. A higher percentage inhibition of denaturation indicates a more potent anti-inflammatory effect.

The IC_{50} value for Aranyatulasyadi Kera Tailam in this assay was 675.5021 µg/ml, which suggests the concentration at which it effectively inhibits 50% of protein denaturation. Again, a lower IC_{50} indicates that Aranyatulasyadi Kera Tailam is effective at relatively low concentrations in inhibiting protein denaturation.

In comparison, Diclofenac had an IC50 value of 1127.523 µg/ml, showing that Aranyatulasyadi Kera Tailam has superior potency in preventing protein denaturation compared to Diclofenac, which is a well-established anti-inflammatory agent.

Interpretation of Results:

Protein denaturation plays a critical role in inflammation, as denatured proteins can activate immune cells and trigger the production of inflammatory cytokines. The ability of Aranyatulasyadi Kera Tailam to inhibit protein denaturation suggests its potential to reduce systemic inflammation and protect tissues from inflammatory damage. The lower IC_{50} value for Aranyatulasyadi Kera Tailam (675.5021 µg/ml) compared to Diclofenac (1127.523 µg/ml) further supports its greater potency as an anti-inflammatory agent in the context of protein stability, making it a promising therapeutic candidate for conditions associated with protein misfolding and inflammatory diseases.

Comparative Analysis of IC_{50} Values:

Aranyatulasyadi Kera Tailam demonstrated a stronger potency than Diclofenac in both hemolytic activity inhibition (IC_{50} = 675.5021 µg/ml vs 1127.523 µg/ml) and protein denaturation inhibition (IC_{50} = 675.5021 µg/ml vs 1127.523 µg/ml). The lower IC_{50} values in both assays for Aranyatulasyadi Kera Tailam suggest that the formulation is more effective in inhibiting hemolysis and protein denaturation, key markers of inflammatory response and oxidative damage.

Potential Mechanism:

The bioactive compounds identified in the GC-MS analysis, such as Disulphide di-tert-dodecyl, Heptadecanoic acid, and Tricosanoic acid, may contribute to these observed effects. These compounds are known for their antioxidant, anti-inflammatory, and cell membrane stabilizing properties. The formulation's anti-inflammatory effects may be due to a combination of these compounds working synergistically to reduce oxidative stress and prevent the activation of inflammatory pathways such as the NF-κB pathway.

4. DISCUSSION

The therapeutic potential of Aranyatulasyadi Kera Tailam, a traditional Ayurvedic oil, is strongly supported by modern analytical techniques, such as Gas Chromatography-Mass Spectrometry (GC-MS), which help elucidate its bioactive constituents. The GC-MS analysis of Aranyatulasyadi Kera Tailam has identified several compounds that contribute to its anti-inflammatory, antioxidant, and skin barrier-protective effects (15). These compounds, such as Tricosanoic acid, Heptadecanoic acid, 6-Hepten-3-one, 5-hydroxy-4-methyl-, and Disulfide, di-tert-dodecyl, are integral to the oil's ability to modulate inflammatory pathways, alleviate oxidative stress, and repair skin barrier dysfunctions, which are the key mechanisms behind many chronic dermatological conditions. Traditional Ayurvedic knowledge has long recognized the healing potential of this formulation, and contemporary research confirms its relevance in the management of inflammatory skin diseases, including eczema, psoriasis, and atopic dermatitis (16).

One of the most significant bioactive molecules identified in Aranyatulasyadi Kera Tailam is Tricosanoic acid, a long-chain fatty acid. Tricosanoic acid, also known as lignoceric acid, has a critical role in maintaining the structural integrity of the skin's lipid barrier. The skin barrier is essential for preventing excessive water loss and protecting against environmental aggressors such as bacteria and allergens. Fatty acids like Tricosanoic acid help regulate the ceramide synthesis in the skin, thereby stabilizing the lipid matrix and promoting skin barrier function (17). Ceramides are sphingolipids crucial for maintaining hydration, and their reduction is often seen in skin conditions such as atopic dermatitis and eczema (10). Furthermore, Tricosanoic acid possesses significant anti-inflammatory and antioxidant properties. These effects are particularly important in managing chronic inflammatory skin diseases where oxidative stress contributes to the progression of the disease (12). By reducing the production of reactive oxygen species (ROS), Tricosanoic acid helps prevent the oxidative damage that exacerbates skin inflammation, alleviating symptoms such as redness, itching, and swelling .

Moreover, the anti-inflammatory effect of Tricosanoic acid has been demonstrated to be lipid-mediated, meaning it modulates lipid metabolism pathways that influence the production of pro-inflammatory mediators. This includes reducing the levels of prostaglandins and leukotrienes, which are derived from the arachidonic acid (AA) pathway. Prostaglandins, in particular, play a central role in inflammation, and their overproduction is associated with conditions like psoriasis and contact dermatitis (18). By inhibiting the production of these pro-inflammatory mediators, Tricosanoic acid mitigates the intensity of the inflammatory response, which in turn reduces the clinical manifestations of inflammatory skin disorders.

Similarly, Heptadecanoic acid, a 17-carbon fatty acid, contributes to the skin's health by modulating the skin's lipid composition. Although it is a relatively rare fatty acid, it has been shown to play a key role in regulating lipid metabolism and promoting the synthesis of ceramides (19). In individuals with skin conditions such as eczema, the skin barrier is often compromised, leading to excessive water loss, dryness, and an increased susceptibility to infections. By supporting the production of ceramides and other lipid components, Heptadecanoic acid helps restore the skin's barrier function, thus preventing dehydration and enhancing the skin's ability to defend against pathogens. Moreover, Heptadecanoic acid has shown potential in regulating the AA pathway, thereby influencing the production of pro-inflammatory cytokines and reducing inflammation (19).

In addition to its lipid-modulating effects, Heptadecanoic acid also contributes to the therapeutic properties of Aranyatulasyadi Kera Tailam by exhibiting anti-inflammatory actions. The compound works by inhibiting the release of arachidonic acid, thereby reducing the downstream production of prostaglandins and leukotrienes. These molecules are integral to the inflammatory cascade and play a significant role in the pathogenesis of skin diseases such as psoriasis and eczema (20). By suppressing the synthesis of these inflammatory mediators, Heptadecanoic acid helps alleviate the redness, swelling, and pain associated with these conditions (15).

The presence of Disulfide, di-tert-dodecyl, a sulfur-containing compound, in Aranyatulasyadi Kera Tailam further enhances its anti-inflammatory and antioxidant effects. Sulfur compounds have been well-documented for their role in modulating the NF-κB pathway, a crucial transcription factor involved in the regulation of inflammatory genes (Bose & Chakraborty, 2018) (3). NF-κB is activated in response to various stress signals and regulates the production of pro-inflammatory cytokines such as TNF-α, IL-1β, and IL-6. Overactivation of NF-κB leads to chronic inflammation, which is characteristic of inflammatory skin diseases. By inhibiting NF-κB activation, Disulfide, di-tert-dodecyl helps reduce the expression of these pro-inflammatory cytokines, thereby reducing the overall inflammation and improving skin health (Kumar & Awasthi, 2020). Additionally, sulfur compounds like Disulfide, di-tert-dodecyl possess significant antioxidant properties that help neutralize reactive oxygen species (ROS), thereby protecting skin cells from oxidative damage (9).

Another important compound identified in Aranyatulasyadi Kera Tailam is 6-Hepten-3-one, 5-hydroxy-4-methyl-, a terpene-based ketone. Terpenes are widely recognized for their ability to modulate inflammatory mediators and reduce oxidative stress, making them particularly valuable in the treatment of chronic inflammatory skin conditions (12). This compound has been shown to regulate the production of cytokines, including TNF-α and IL-1β, both of which play a central role in the inflammatory process of diseases like psoriasis and eczema. By inhibiting the production of these cytokines, 6-Hepten-3-one, 5-hydroxy-4-methyl- helps to mitigate the intensity of the inflammatory response, reducing the clinical symptoms of these skin conditions. Additionally, this compound's antioxidant activity further enhances its therapeutic potential, protecting the skin from oxidative stress and promoting cellular repair (17).

The synergy between these bioactive compounds—Tricosanoic acid, Heptadecanoic acid, Disulfide, di-tert-dodecyl, and 6-Hepten-3-one, 5-hydroxy-4-methyl-—is fundamental to the effectiveness of Aranyatulasyadi Kera Tailam as a treatment for inflammatory skin diseases. These compounds work together to modulate inflammatory pathways, reduce oxidative stress, and repair the skin barrier, thereby providing comprehensive therapeutic benefits (10). The anti-inflammatory effects of these compounds, particularly their ability to inhibit the production of pro-inflammatory cytokines and modulate lipid metabolism, make Aranyatulasyadi Kera Tailam a valuable therapeutic agent for managing conditions such as psoriasis, eczema, and contact dermatitis. Moreover, the antioxidant properties of these compounds help protect the skin from oxidative damage, further enhancing the formulation's effectiveness in treating chronic inflammatory skin disorders (13).

These findings not only validate the traditional Ayurvedic use of Aranyatulasyadi Kera Tailam but also provide a strong scientific basis for its clinical relevance in dermatological practice. The bioactive compounds identified in this formulation offer a potential means of integrating traditional medicine with modern dermatological therapies, providing a holistic approach to managing chronic skin diseases. Future clinical studies, particularly randomized controlled trials (RCTs), are necessary to further investigate the efficacy and safety of this Ayurvedic formulation in the treatment of dermatological conditions (18). Such research would provide a more comprehensive understanding of the compound's mechanisms of action and contribute to its inclusion in modern dermatology as a complementary therapy for managing inflammatory skin diseases.

5. CONCLUSION

The comprehensive analysis of Aranyatulasyadi Kera Tailam, through advanced techniques such as GC-MS, has revealed the presence of several bioactive compounds with significant anti-inflammatory, antioxidant, and skin barrier-protective properties. These compounds, including Tricosanoic acid, Heptadecanoic acid, Disulfide, di-tert-dodecyl, and 6-Hepten-3-one, 5-hydroxy-4-methyl-, align with the traditional Ayurvedic uses of the formulation in managing dermatological conditions like eczema, psoriasis, and atopic dermatitis. The bioactive molecules identified in the oil contribute synergistically to modulating key inflammatory pathways, reducing oxidative stress, and restoring the skin's lipid barrier function.

The therapeutic efficacy of Aranyatulasyadi Kera Tailam appears to stem from its ability to influence both lipid metabolism and pro-inflammatory cytokine production, which are central to the pathophysiology of many skin disorders. Particularly, the presence of fatty acids such as Tricosanoic acid and Heptadecanoic acid highlights the formulation's role in promoting skin barrier integrity and reducing inflammatory mediators. Furthermore, the antioxidant effects of these compounds provide added protection against oxidative damage, which is often exacerbated in chronic inflammatory skin diseases.

This analysis reinforces the importance of integrating traditional knowledge with modern scientific methods to validate the therapeutic relevance of ancient formulations. Future clinical studies, particularly randomized controlled trials, will be crucial in confirming the efficacy and safety of Aranyatulasyadi Kera Tailam for broader dermatological applications. By combining modern pharmacological evidence with Ayurvedic wisdom, this formulation holds promising potential as a complementary therapy in the management of inflammatory skin diseases, offering a holistic approach to skin health and healing.

Further research will help clarify the precise mechanisms of action of its components, refine its clinical applications, and expand its use in integrative dermatology, potentially leading to new, natural therapeutic options for patients with chronic dermatological conditions.

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