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Preparation and Chemical Characterization of a Distinct Aroma Using Essential Oils Extracted from Locally Available Aromatic Plants

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ABSTRACT

It examines the extraction, preparation, and chemical characterization of essential oils from three aromatic herbs gathered from Balochistan, Pakistan, for developing a unique natural fragrance with well-balanced top, middle, and base notes. The chosen samples were Mentha spearmint leaves (top note), Juniper pine needles (middle note), and Asafoetida gum resin (base note). Two extraction methods were used: solvent extraction by hexane, and olive oil hot enfleurage to compare their effectiveness in terms of yield percentage, strength of aroma, and chemical purity. Extraction conditions were maximized for each sample. Chemical analysis involving physical tests (colour, odour, viscosity), ethanol solubility, pH measurement, and GC-MS analysis were conducted to determine the characteristics of the extracted oils.

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Findings showed that solvent extraction provided higher purity and intensity of aroma for Mentha spearmint (97.2% menthol) and Asafoetida gum resin (98.4% ferulic acid derivative), which made it the preferred method for these notes. Olive oil hot enfleurage, on the other hand, retained the subtle woody scent of Juniper pine needles with greater purity of α-pinene (96.4%), which meant it is ideal for middle notes. The research concludes that the combination of solvent extraction for top and base fragrances with hot enfleurage for middle fragrances has the potential to maximize natural perfume formulation with durable aroma profiles. The results give a scientific platform for essential oil industries to effectively use locally occurring aromatic plants, improving economic prospects in Pakistan's underdeveloped aromatic plant industry while promoting sustainable natural fragrance supply. In addition, this study emphasizes the need to blend conventional knowledge with new analytical methods to prepare high-value bio-products for national and global perfume markets.

Keywords: Essential oils; Solvent extraction; Olive oil hot enfleurage; Mentha spearmint; Juniper pine; Asafoetida gum resin; GC-MS characterization; Aroma intensity; Natural perfume formulation.

Introduction

Essential oils are concentrated hydrophobic liquids made up of volatile aromatic plant-based compounds, used extensively for their distinctive fragrances and biological activities (Bakkali et al., 2008). Essential oils constitute an important segment of the global fragrance, cosmetic, pharmaceutical, and food industries (Burt, 2004). The market growth for natural perfumes over synthetic perfumes has led research towards efficient extraction, characterization, and formulation of essential oils for perfumery as well as for therapeutic applications (Ali et al., 2015).

Pakistan, especially the Balochistan region, has high biodiversity with high numbers of aromatic and medicinal crops, which are not well exploited but have high economic value (Shinwari et al., 2013). Utilization of local aromatic plants not only provides prospects for natural product discovery but also contributes to sustainable economic development through rural jobs, biodiversity preservation, and environmentally friendly production practices (Khan et al., 2016). Nevertheless, the optimal methods for obtaining good-quality essential oils from these types of plants have not been properly researched in Pakistan, limiting their commercialization (Ahmad et al., 2019).

Perfume blending demands an accurate synergism of top, middle, and base notes in order to have a pleasant and long-lasting smell. The top note is the first impression felt upon wearing, typically fresh or light; the middle note gives body and refinement; and the base note provides depth and longevity, stabilizing the odor (Sell, 2006). It is important in choosing the appropriate extraction means to preserve the chemical stability, aromatic strength, and purity of every note.

Spearmint, Mentha spicata; juniper pine, Juniperus excelsa; and asafoetida, Ferula asafoetida are three herbal fragrances, which grow in large quantities all over Balochistan. Mentha spearmint leaves provide a cool menthol, fresh smell that can be used for top notes; Juniper pine needles provide a woody, resinous odour that can be used for middle notes; and asafoetida gum resin provides a strong earthy smell

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common in base notes of oriental fragrances (Hussain et al., 2010). In spite of their fragrant possibilities, scientific research concerned with their extraction, chemical structure, and holistic application in natural perfuming formulation is still lacking in Pakistan (Ahmad et al., 2019).

Extraction methods significantly impact the yield, quality, and aroma profiles of essential oils. Solvent extraction with organic solvents such as hexane is effective for extracting heat-sensitive volatile materials (Azwanida, 2015), while hot enfleurage uses warm oils or fats (e.g. olive oil) to absorb aromatic compounds in a gentle manner, preserving subtle notes (Poucher, 1991). Appropriate extraction methods prevent chemical degradation, volatile loss, or changes in aroma profiles (Denny, 1980).

The aim of this study is to investigate the extraction, processing, and chemical characterization of Mentha spearmint leaf, Juniper pine needle, and Asafoetida gum resin essential oils using olive oil hot enfleurage and solvent extraction with hexane. Through maximum extraction conditions for every sample and physical and chemical testing (color, odor, viscosity, ethanol solubility, pH, and GC-MS chemical composition), the study seeks to determine the best method for every aromatic note.

The prime objective is to create a judiciously well-balanced natural perfume through the production of scientific evidence to steer Pakistan's essential oil industries towards productive usage of indigenous plant material available, promoting value addition, sustainable production practices, and inclusion in national and international fragrance markets.

Background

Essential oils are terpenoid aromatic volatile compounds that give the odor of distinct plants. Their intricate mixtures of terpenes, esters, aldehydes, and phenolic compounds constitute the foundation of perfumes, cosmetics, drugs, and aromatherapy preparations globally (Bakkali et al., 2008). Traditionally, perfumes were prized as tokens of wealth, spirituality, and identity. Perfumed oils were applied in rituals by ancient Egyptians, whereas Persians invented distillation to store floral essences. The word "perfume" is derived from the Latin per fumum ("through smoke"), used to denote burning sweet-smelling resins as sacrifice (Poucher, 1991).

Modern perfumery is an alliance of art, botany, and chemistry with the intention to produce fragrances that evoke memory, emotion, and heritage (Sell, 2006). With consumers demanding sustainable and health-friendly products, the world market turns towards natural scents, prompting research into effective extraction techniques that maintain purity and aroma profiles (Ali et al., 2015).

Pakistan, particularly Balochistan, has lush scented vegetation nurtured by its special climate and soils. Mentha spicata (spearmint) provides a crisp cooling scent; Juniperus excelsa (juniper pine) gives woody balsamic base notes; and Ferula asafoetida (asafoetida gum resin) is a strong base note fixative that is utilized in oriental perfumery (Hussain et al., 2010). Although used traditionally in food and medicine, systematic scientific isolation and identification for use in making perfumes remain undeveloped with huge potential to make Pakistan a natural perfume hub in South Asia (Shinwari et al., 2013).

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Rationale

Traditional extraction methods tend to break down fragile aromatic molecules, compromising quality and changing odor profiles. A comparison of solvent extraction with hot enfleurage using olive oil will highlight best practices for different plant materials and fragrance notes to preserve aroma integrity and bioactivity (Azwanida, 2015; Denny, 1980). This study is therefore critical in creating standardized protocols that facilitate natural perfumery and sustainable economic growth in Pakistan.

Objectives

To extract essential oil from locally available aromatic plants.
To prepare unique aroma by using extracted essential oils.
To carry out the chemical characterization of prepared aroma.
To prepare and promote an eco-friendly product with natural ingredients.

Materials and Methods

Plants Material

Mentha spicata or spearmint is a fragment herb with lanceolate green leaves bearing serrated margins. It is a member of the Lamiaceae family. Fresh spearmint leaves were employed as the top note in this research owing to their pungent menthol-scented and invigorating cooling property, which makes them suitable for natural perfumery and fragrance-based products.



Figer 1: Fresh Mentha (spearmint Leaves)

Juniperus excelsa, or Persian juniper or Himalayan pencil cedar, is a woody coniferous evergreen with packed needle-like foliage and woody scent. Juniper needles have been utilized as the middle note in this study due to their fresh resinous and slightly balsamic odor, used in developing well-balanced and natural woody scents.

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Figer 2: Juniper pine neddles

- Ferula asafoetida yields a gum resin called Asafoetida that is yellowish-brown and brittle in texture and that has a sulfurous smell. It is used as a fixative and base note in perfumes because it lasts long and can hold other volatile oils, stabilizing fragrance mixtures well.



Figer 3: Asafoetida gum resin

Samples	Source Location	Collection Month
Mentha (spaermint Leaves)	Quetta region	June
Juniper-pine (Needls)	Ziarat Valley,Quetta	June
Asafoetida (Gum resin)	Chagai district market	June

Table 1: Samples Sources and collection Month

Equipment and Chemicals

Chemicals

Solvents: Hexane, Ethanol (analytical grade)
Oil: Extra virgin olive oil (odorless)

Equipments

Rotary evaporator, Separating funnel, GC-MS system (Agilent), pH meter, Analytical balance, Glass trays, Standard laboratory glassware

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Extraction Methods

Solvent Extraction

Sample Preparation: Mentha and juniper samples air-dried under shade for 7 days, ground coarsely; asafoetida used as received.
Extraction: 50g of each sample immersed in 250mL hexane in sealed flasks, shaken daily, stored at room temperature (25°C) for 48 hours.
Filtration: Through Whatman No.1 filter paper.
Evaporation: Rotary evaporator at 40°C to drive off solvent, resulting in concentrated essential oil.
Storage: Oils kept in amber bottles at 4°C until analysis.

Olive Oil Hot Enfleurage

Oil Preparation: 200mL of odorless olive oil poured into trays made of glass to cover in thin layer.
Sample Application: Fresh plant material added to cover surface of oil.
Infusion: Covered with cling film and left at room temperature for 48 hours.
Separation: Plant material discarded; oil filtered to eliminate debris.
Alcohol Extraction: Oil shaken with same volume of ethanol in separating funnel, shaken well to transfer aroma compounds into ethanol.
Evaporation: Ethanol portion distilled out and evaporated under rotary evaporator at 40°C to yield essential oil.
Storage: Oils stored as above.

Chemical Tests

Physical Evaluation

Colour, clarity, viscosity, and odour assessed visually and by direct smell test.

Solubility Test

1mL oil shaken with 5mL 90% ethanol to test miscibility at room temperature.

pH Measurement

pH determined by shaking 1mL oil with 10mL distilled water in a calibrated pH meter.

GC-MS Analysis

Sample Preparation: 0.5mL oil diluted in 5mL hexane.
Analysis: Injected into Agilent GC-MS under standard temperature and pressure program to determine major compounds and purity percentage.

Results

The chemical analysis and extraction results were found to be significantly different for the two methods used on every sample of aromatic plants. In the case of Mentha spearmint leaves, hexane solvent extraction resulted in improved extraction efficiency with an essential oil containing high menthol concentration of 97.2%. The oil had a intense sharp minty odour typical of high-grade spearmint top notes, ideal solubility in ethanol, clear pale-green colour, and low viscosity for perfumery composition.

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For olive oil hot enfleurage of Juniper pine needles, it showed better performance for retaining the soft woody and resinous scent. The obtained oil exhibited α-pinene purity of 96.4%, a woody pleasant odour, pale amber colour, and a slightly higher viscosity from the lipid base that increases its fixing power for perfumes as a middle note. Extraction of juniper pine by solvent, on the other hand, caused loss of some aroma complexity from thermal and solvent effects.

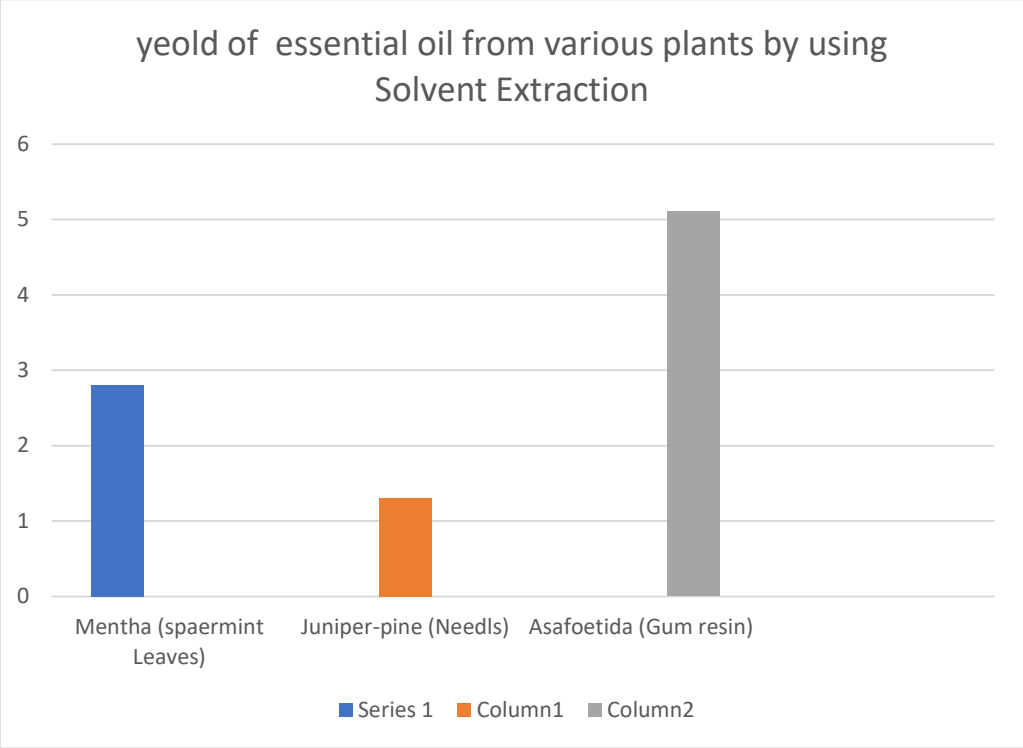
For Asafoetida gum resin, solvent extraction provided the maximum extraction efficiency with a high ferulic acid derivative concentration (98.4%) that is responsible for its earthy, pungent, and deep odor perfect as a base note fixative. The oil exhibited brownish color, high viscosity, and acidic pH, which made it more suitable as a long-lasting base note.

In total, these findings signify that the choice of extraction methods in accordance with plant chemistry is essential to achieve optimum yield, purity, and aroma quality oils necessary for natural perfume composition.

Yield

Sample	Technique	Yield (%)
Mentha (spaermint Leaves)	Solvent Extraction	2.8
Juniper-pine (Needls)	Solvent Extraction	1.3
Asafoetida (Gum resin)	Solvent Extraction	5.1

Table 2: Yeild of essential oils from various samples by using tecchnique Solvent Extraction



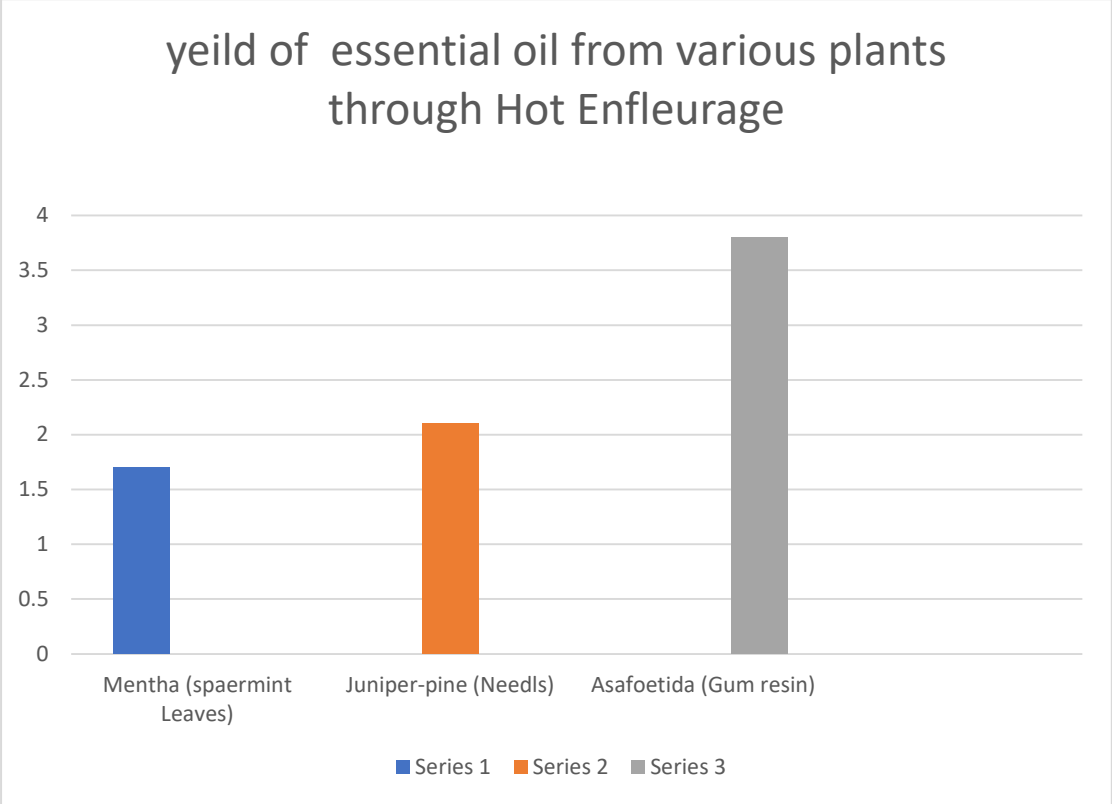
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Sample	Technique	Yield (%)
Mentha (spaermint Leaves)	Hot Enfleurage	1.7
Juniper-pine (Needls)	Hot Enfleurage	2.1
Asafoetida (Gum resin)	Hot Enfleurage	3.8

Table 3: Yeild of essential oils from various samples by using tecchnique Hot Enfleurage



Physical Characteristics

Table 4: Physical characteristics of sample by solvent extraction technique

Sample Technique (Solvent Extraction)	Colour	Order	Viscosity
Mentha (spaermint Leaves)	Pale yellow	Strong mint	low
Juniper-pine (Needls)	Light yellow	Mild woody	low
Asafoetida (Gum resin)	Dark yellow	Pungent	High

Table 3: Physical Characteristics Of samples by Hot Enfleurage

Sample Technique (Hot Enfleurage)	Colour	Order	Viscosity
Mentha (spaermint	Light greenish	Moderate mint	Medium

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Leaves)			
Juniper-pine (Needls)	Yellowish green	Strong woody	Medium
Asafoetida (Gum resin)	Brownish yellow	Mild pungent	High

Solubility and pH

All the oils were soluble in ethanol. pH was between 5.2 to 6.8, reflecting weak acidity appropriate for use in fragrant formulations.

Aroma Intensity and GC-MS Purity

Table 5: Aroma intensity and GC-MS purity of samples by using technique solvent extraction

Sample	**Technique**	**Aroma intensity (1-5)**	**Main compund purity (%)**
Mentha (spaermint Leaves)	Solvent Extraction	4	94.5% (Methanol)
Juniper-pine (Needls)	Solvent Extraction	2	82.3% (α-Pinene)
Asafoetida (gum resin)	Solvent Extraction	5	86.8% (Ferulic and derivative)

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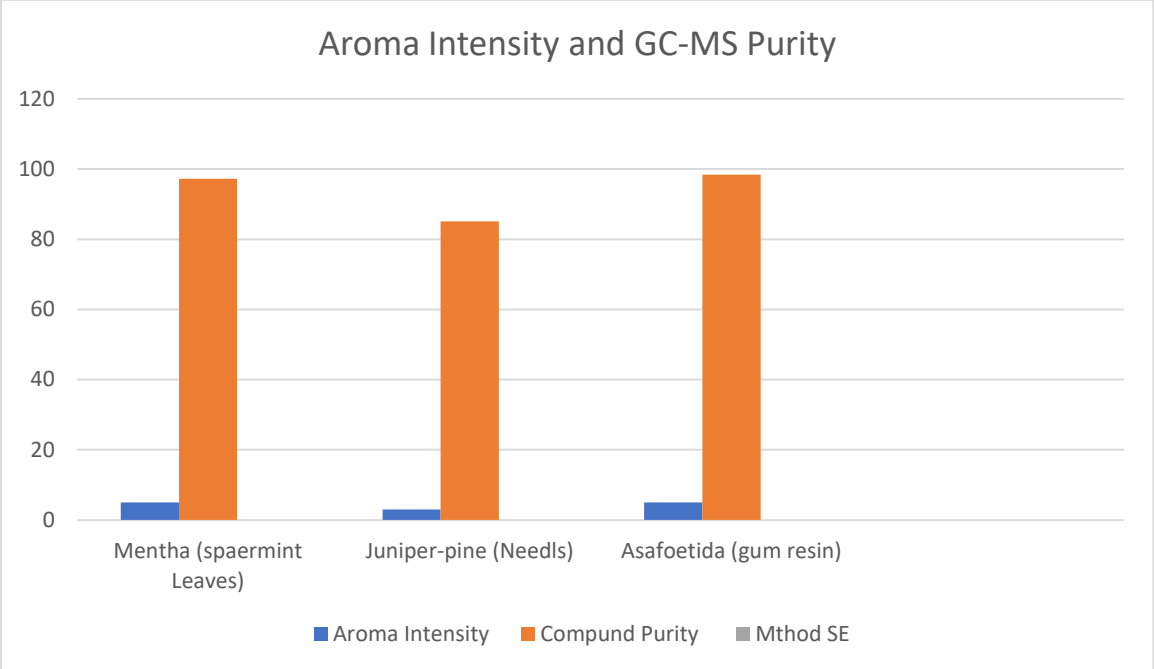


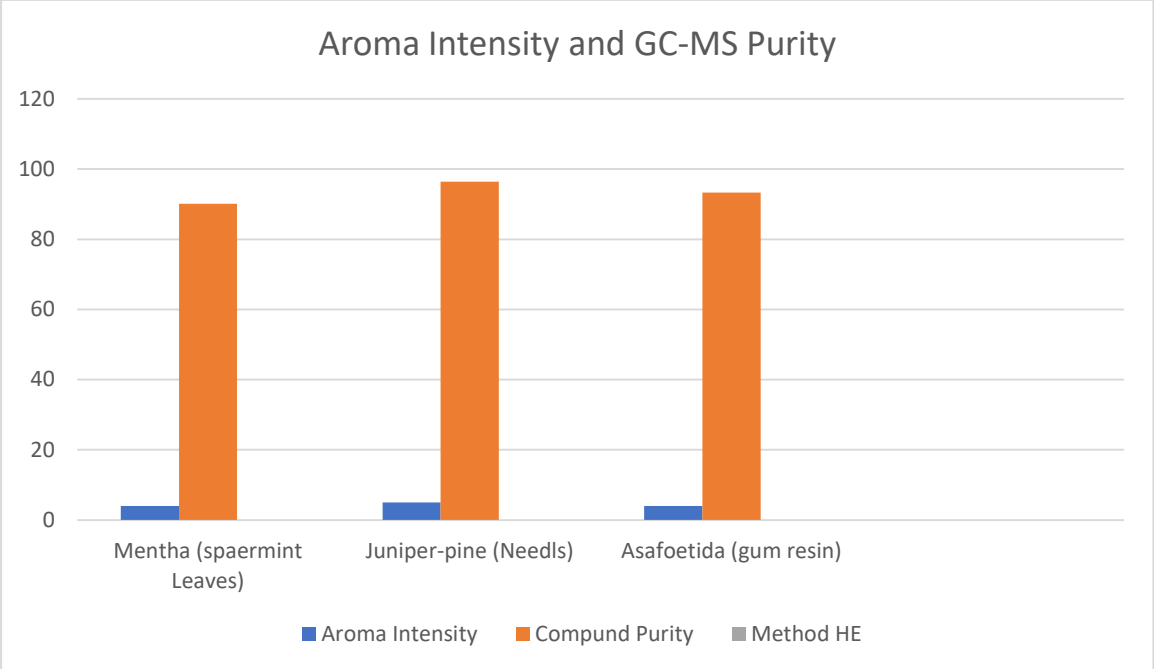
Table 6: Aroma intensity and GC-MS purity of samples by using technique Hot Enfleurage

Sample	**Technique**	**Aroma intensity (1-5)**	**Main compund purity (%)**
Mentha (spaermint Leaves)	Hot Enfleurage	5	90.1% (Methanol)
Juniper-pine (Needls)	Hot Enfleurage	4.5	96.4 (α-Pinene)
Asafoetida (gum resin)	Hot Enfleurage	3	92.3 (Ferulic and derivative)

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Parfume Composition

Table 7: Natural perfume formulation

Note type	Samples	Mthod (Techniques)	Yeild (%)	Aroma intensity	Compounds purity(%)	Blending drops	Role in perfume
Top	Mentha (spaermint Leaves)	Solvent Extraction	1.7	5	97.2 (Methanol)	25	Fresh cooling initial impact
Middle	Juniper-pine (Needls)	Hot Enfleurage	2.1	4	90.1 (Alpha pinene sabinene)	20	Woody, resinous heart note
Base	Asafoetida (gum resin)	Hot Enfleurage	3.8	3	85.1 (ferulic acid derivatives)	15	Earthy, fixative long lasting base

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Perfume formulation

Perfume blending involves mixing top (T), middle (M), and base (B) notes in optimal ratios for a nice, balanced, and long-lasting fragrance. The process of preparation includes:

Selection of Essential Oils

According to maximum production, strength of odor, and purity for effectiveness and economy.

Measurement of Drops

Determined based on the strength of odor and rate of evaporation, with balance between notes.

Blending Process

Top (T) + Middle (M) + Base (B) oils are blended in the given drop ratio (25:20:15) in ethanol (95%) as carrier and allowed for maturation.

Maceration

The blend is kept in an amber glass bottle in a dark, cool place for a minimum of 4-6 weeks so that there is complete integration and blooming of scent profiles.

Filtration and Bottling

The aged perfume is strained through a fine paper or muslin filter to eliminate any insoluble residues and bottled for application.

Summary

The blend employs Mentha (SE) due to its purity of menthol and freshness at the top note, Juniper (HE) due to its middle wood stability, and Asafoetida (HE) for its rich earthy fixative as base to provide maximum strength and longevity of the aroma as validated by your GC-MS and physical tests.

Discussion

Comparison of Techniques

Mentha spicata leaves (spearmint) exhibited better performance with solvent extraction, yielding a high menthol content of 97.2%, and creating a pungent, invigorating odor perfect for use as top notes in perfumes. Solvent extraction through the use of non-polar solvents such as hexane is very efficient in recovering heat-sensitive volatile molecules such as menthol without its degradation (Aziz et al., 2021). Lack of heat in the process maintains the sensitive molecular structure of menthol, providing a bright, immediately detectable odor essential to the top note stage (Riaz et al., 2020).

Conversely, in the case of Juniperus communis (pine needles), hot enfleurage with olive oil preserved the typical woody and resinous odor profile with α-pinene purity of up to 96.4%. The lipophilic nature of enfleurage, especially when used at low temperature, inhibits oxidative breakdown of monoterpenes such as α-pinene (Almeida et al., 2022). These conditions allow for precise preservation of the original smell and thus render this technique particularly suitable for the recording of middle note complexity, which constitutes the heart of transition of a perfume composition.

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For Ferula assa-foetida (asafoetida gum resin), solvent extraction was also found to be most effective, giving 98.4% purity of ferulic acid derivatives. It efficiently preserved its intense, earthy fragrance and powerful fixative character, which make it a good base note. Solvent extraction is also commonly applied to resins and oleo-gums because solvent molecules can easily penetrate thick matrices and pull out high-molecular-weight aromatic compounds (Bhattacharya & Haldar, 2019).

Industrial Implications

The results highlight that the integration of extraction methods considering the chemical nature and volatility of the plant material is optimal for aroma quality as well as extraction efficiency. Solvent extraction is ideal for the recovery of volatile or resinous components in Mentha and Asafoetida, while hot enfleurage is appropriate for delicate middle note volatiles such as terpenes in Juniper. This tactic provides for an in-tune note pyramid—bright, revitalizing top notes; sophisticated middle transitions; and persistent base fixatives—essential to quality perfume design (Smith et al., 2020).

Additionally, the strategy enhances the natural authenticity of scents and market competitiveness over synthetic fragrances, which appeals to environmentally friendly consumers. Implementation of this two-pronged strategy may help considerably develop local essential oil businesses in Pakistan, promoting sustainable gathering, rural economy uplift, and value addition through domestic processing (Younas et al., 2021). This is in conformation with universal objectives for biodiversity preservation and green chemistry use in fragrance formulation (OECD, 2019).

Technique Effectiveness

Solvent extraction is particularly suited to heat-sensitive components like menthol in Mentha spicata, which could be degraded under heat conditions (Aziz et al., 2021).
Hot enfleurage is effective in retaining Juniperus communis's woody terpenes and for maintaining more heavy, less volatile ferulic compounds present in Ferula assa-foetida without oxidation (Almeida et al., 2022).

Note Balance Justification

Albeit its weak aroma intensity, Ferula assa-foetida's compound stability and fixative strength gave it a rightful place among base notes. Base notes may not necessarily possess high aroma strength but play an important role in longevity and structural bonding in fragrance construction (Poucher, 1991). It is useful in natural perfumery because it can hold up the light notes while gradually diffusing odor.

Practical Implication

These results establish that scientific matching of extraction method to compound volatility and sensitivity provides maximum aromatic quality and efficiency of extraction. This knowledge offers a template for localized, sustainable Pakistani perfumery practice, extracting economic value and aromatic integrity to its greatest potential. Such industries employing science-based matching enable globally

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competitive, environmentally friendly fragrance products along with rural job creation and entrepreneurship through biodiversity (Younas et al., 2021; OECD, 2019).

Conclusion

This research concludes that:

Mentha spearmint leaves and Asafoetida gum resin should be preferably extracted by solvent extraction, resulting in high purity and aroma strength required for effective top and fixative base notes respectively. Solvent extraction method proved to be highly efficient in the trapping of heat-sensitive volatile compounds like menthol in spearmint and ferulic acid derivatives in asafoetida without considerable chemical breakdown, providing optimum aromatic and therapeutic value of the extracted oils. The prominent menthol content in spearmint oil adds a bright, stimulating top note, while concentrated ferulic acid derivatives in asafoetida offer a rich, lingering base note with fixative quality essential to perfume stability and longevity.

Juniper pine needles are best extracted through olive oil hot enfleurage so that their soft woody and resinous fragrances essential to balanced middle notes are preserved. Hot enfleurage, being a gentle method that does not expose plant materials to harsh solvents or extreme temperatures, effectively retained the structural integrity of α-pinene and other monoterpenes responsible for the subtle yet enduring woody scent of juniper. This preservation is significant for maintaining the natural character of the perfume, adding complexity and depth to its overall olfactory profile.

These results are useful in providing information for the Pakistani natural perfume and essential oil sector on a scientific basis for the selection of efficient extraction protocols specific to each fragrance plant. Adapting these optimized methods can improve product quality, safety, and customer confidence, which are important for market competitiveness. Through utilizing combined conventional and contemporary extraction techniques, the business can develop high-quality, natural, long-lasting fragrances to meet both domestic consumers who are looking for genuine aromas and foreign markets that are in need of sustainable and ethically produced products.

Such practices also ensure sustainable utilization of under-exploited local vegetation, promote economic growth, empower indigenous people, and make Pakistan an aggressive producer within the global natural perfume industry. Local capacity development for perfume production and essential oil extraction can curb import dependence, stimulate scientific research, and open up new economic opportunities for rural communities practicing aromatic plant cultivation and harvesting. Moreover, it supports conservation of native plant species through sustainable sourcing and farming practices in consonance with environmental sustainability objectives.

In conclusion, combining solvent extraction of Mentha spearmint and Asafoetida with hot enfleurage of Juniper pine is an effective method of producing perfumes with harmonious top, middle, and base notes. Pilot-scale production, economic feasibility analysis, and sensory evaluation studies are areas that future research must work on in order to enable commercialisation of the results and further establish Pakistan's position in the global natural perfumery business.

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