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EXTRACTION AND YIELD PROFILING OF ESSENTIAL OILS FROM *HEDYCHIUM SPICATUM*, *ELETTARIA CARDAMOMUM* AND *OCIMUM SANCTUM* WITH ETHNOPHARMACOLOGICAL RELEVANCE

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ABSTRACT: Essential oils are volatile, aromatic compounds derived from medicinal plants and valued in both Ayurveda and modern medicine for their diverse pharmacological activities. *Hedychium spicatum* (Shati), *Elettaria cardamomum* (Ela), and *Ocimum sanctum* (Tulsi) are classical Ayurvedic herbs mentioned under the *Swasahara Mahakashaya* group in the *Charaka Samhita*, traditionally prescribed for respiratory ailments. The present study aimed to extract and compare the essential oil yields from these botanicals, providing a preliminary scientific basis for evaluating their ethnopharmacological relevance. Dried, powdered samples (40 g each) of *H. spicatum*, *E. cardamomum*, and *O. sanctum* were subjected to hydro-distillation using a Clevenger apparatus with 400 mL distilled water for 4–6 hours. The extracted oils were separated with n-hexane, dried over anhydrous sodium sulfate and stored at 4 °C for further analysis. The yields obtained were 0.34 g (0.85%) for *H. spicatum*, 1.46 g (3.65%) for *E. cardamomum*, and 0.38 g (0.95%) for *O. sanctum*, with *E. cardamomum* demonstrating the highest yield among the three. The study confirms the effectiveness of hydro-distillation for isolating essential oils from Ayurvedic botanicals. This establishes a comparative yield profile that can serve as a foundation for future phytochemical and pharmacological investigations.

INTRODUCTION: Essential oils are concentrated, volatile compounds from medicinal plants with diverse bioactivities, including antimicrobial, anti-inflammatory, and antioxidant properties [1, 2]. Essential oils are believed to contain over 200 different compounds. In recent years, they have gained widespread recognition across multiple industries - including aromatherapy, food flavouring, and natural therapeutics - owing to their diverse applications, key bioactive constituents, and associated pharmacological properties [3, 4].

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Hedychium spicatum (*Shati*), *Elettaria cardamomum* (*Ela*), and *Ocimum sanctum* (*Tulsi*) are classified under *Swasahara Mahakashaya* in the *Charaka Samhita*, traditionally used for respiratory and immune disorders [5, 6]. Hydro-distillation using a Clevenger apparatus remains a standard, cost-effective method for extracting essential oils [7]. Despite their known benefits, comparative yield profiling of these herbs remains underreported. This study aims to extract and compare essential oil yields of *Shati*, *Ela*, and *Tulsi*, providing baseline data to support future pharmacognostic and formulation research.

MATERIALS AND METHODS:

Plant Material Collection and Authentication: *Shati*, *Ela*, and *Tulsi* were selected for essential oil extraction based on their classical Ayurvedic and therapeutic relevance.

The dried crude drugs were procured from an authentic Ayurvedic pharmacy in Mumbai, Maharashtra. Botanical authentication was conducted at Alarsin Pharmaceuticals, Mumbai, and the shade-dried plant parts were stored in air-tight containers for further use, as shown in **Fig. 1.**

FIG. 1: CRUDE DRIED A) *HEDYCHIUM SPICATUM* (*SHATI*), B) *ELETTARIA CARDAMOMUM* (*ELA*), C) *OCIMUM SANCTUM* (*TULSI*) - 40 G each

Sample Preparation: All raw drugs were thoroughly washed with distilled water to remove any adhering impurities and then shade-dried under ambient conditions. The dried materials were coarsely powdered and used for hydro-distillation as shown in **Fig. 2**.

FIG. 2: COARSELY POWDERED A) *HEDYCHIUM SPICATUM* (*SHATI*), B) *ELETTARIA CARDAMOMUM* (*ELA*), C) *OCIMUM SANCTUM* (*TULSI*)- 40GMS EACH

Essential Oil Extraction by Hydro-Distillation: Essential oils were extracted using a Clevenger-type glass apparatus fitted with a 1000 mL round-bottom flask and a vertical condenser. For each sample, 40 g of plant powder was mixed with 400 mL of distilled water (1:10 w/v ratio). The hydro-distillation process was carried out individually for each plant. *Shati* (*H. spicatum*): 5 hours 35 min *Ela* (*E. cardamomum*): 6 hours 10 min *Tulsi* (*O. sanctum*): 4 hours 20 mins as shown in **Fig. 3.**

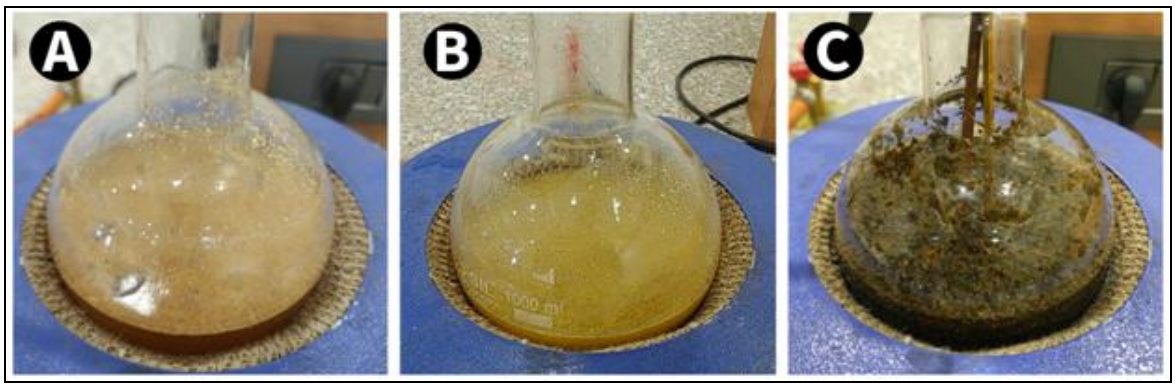

FIG. 3: 40G OF EACH A) *SHATI,* B) *ELA,* C) *TULSI* MIXED WITH 400 ML OF DISTILLED WATER IN A 1000ML ROUND-BOTTOM FLASK

The initial temperature was maintained at 30 °C, gradually increased by 10 °C every 10 minutes until reaching 70 °C, which was maintained for the rest of the process. The volatile oil fractions were collected from the oil trap of the apparatus, as shown in **Fig. 4** and **5.**

FIG. 4: CLEVENGER APPARATUS SETUP

FIG. 5: VOLATILE OIL COLLECTED IN A GRADUATED TUBE OF THE APPARATUS

Oil Recovery and Purification: Following hydro-distillation, the essential oil that appeared as a separate oily layer above the hydrosol was collected using a separating funnel. To ensure efficient separation and reduce oil loss, n-hexane, a nonpolar solvent, was added to the distillate. Hexane selectively dissolved the essential oil, allowing easier collection from the aqueous layer as shown in **Fig. 6.** Then anhydrous sodium sulfate (Na_2SO_4), a drying agent, was added to the hexane-oil mixture and then filtered to remove any residual water content. This step is crucial to prevent degradation or microbial contamination during storage (**Fig. 7**).

FIG. 6: HEXANE (UPPER) AND HYDROSOL (LOWER) LAYER IN THE SEPARATING FUNNEL

FIG. 7: ADDITION OF ANHYDROUS SODIUM SULFATE TO THE HEXANE-OIL MIXTURE TO REMOVE ANY RESIDUAL WATER CONTENT

After drying, the hexane was removed by gentle evaporation under reduced pressure at low temperatures to avoid thermal decomposition of volatile oil components. The resulting extract was a

concentrated, purified essential oil with a characteristic aroma and appearance specific to each plant, as shown in **Fig. 8.** The samples were stored in vials at 4 °C until further use.

Yield Estimation: The yield of essential oil was calculated as a percentage of the initial dry weight of the plant material.

RESULT: The essential oils of *H. spicatum* (*Shati*), *E. cardamomum* (*Ela*), and *O. sanctum* (*Tulsi*) were extracted by hydro-distillation using a Clevenger apparatus, as shown in **Fig. 8.**

The observations made during and after the distillation process are compiled in **Table 1**.

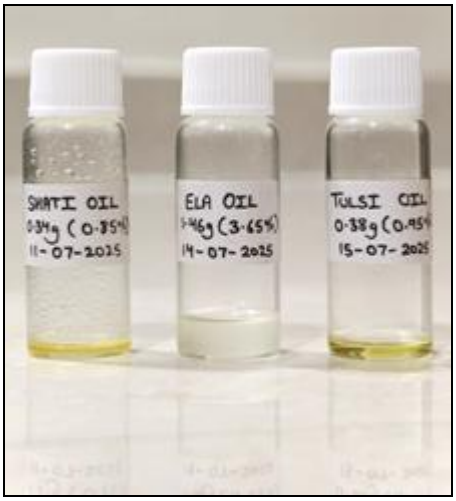

FIG. 8: ESSENTIAL OILS COLLECTED FROM SHATI (0.34G), ELA (1.46G), AND TULSI (0.38G)

TABLE 1: SUMMARY OF EXTRACTION PARAMETERS AND ESSENTIAL OIL YIELDS

Plant Name & Part used	Botanical Name	Drug Qty (g)	Water volume (mL)	Duration (hrs)	Yield (g)	Yield (%)	Color
Shati Rhizome	*Hedychium spicatum*	40	400 (+200 added later)	5.35	0.34	0.85%	Yellow
Ela Fruit	*Elettaria cardamomum*	40	400	6.10	1.46	3.65%	Colorless
Tulsi Whole Plant	*Ocimum sanctum*	40	400	4.20	0.38	0.95%	Pale yellow

DISCUSSION: Due to their low yield and high pharmacological potential, essential oils are often referred to as high-value phytoconstituents. Essential oils are characterised by their rapid onset of action and high therapeutic potency, even in minimal quantities. This is largely attributed to their volatile, lipophilic, and low molecular weight nature, which allows them to permeate biological membranes and exert systemic effects quickly. From an Ayurvedic standpoint, this aligns with the *Teekshna* (penetrative), *Sukshma* (subtle), and *Vyavayi* (diffusible) properties attributed to such substances, enabling them to bypass the gastrointestinal tract and deliver swift pharmacodynamic responses. Unlike bulk herbal decoctions or powders, essential oils act at lower doses yet exhibit enhanced bioavailability and targeted action, particularly in conditions involving the respiratory, nervous, and immune systems. Their concentrated nature makes them ideal candidates for formulation into inhalers, balms, or emulsions where rapid relief is desired. The hydro-distillation process using the Clevenger apparatus successfully yielded essential oils from *H. spicatum* (*Shati*), *E. cardamomum* (*Ela*), and *O. sanctum* (*Tulsi*), with notable differences in both yield and organoleptic properties. Among the three, *Ela* produced the highest yield of essential oil at 3.65%, followed by *Tulsi* (0.95%) and *Shati* (0.85%).

Practical Observation: During the distillation of Shati, a thick paste-like residue was formed of a thick, paste-like residue formed in the round-bottom flask, particularly toward the end of the extraction process. This was likely due to the starch content of the rhizome, which gelatinised upon prolonged heating. To prevent charring or sticking to the glass surface, an additional 200 mL of water was introduced midway. This highlights the need for flexibility in fluid volume when processing starch-rich botanicals to ensure continuous and efficient oil separation. While the essential oil profiles of *H. spicatum*, *E. cardamomum* and *O. sanctum* have been previously explored in literature, the present study was conducted to generate standardised extraction data under uniform laboratory conditions using authenticated Ayurvedic raw materials. Such comparative yield profiling not only aids in validating classical references but also contributes practical insights for reproducibility and formulation relevance in contemporary Ayurvedic applications.

Ethnopharmacological Relevance: The concept of extracting volatile and aromatic components from medicinal plants is not new to Ayurveda. *Arka Kalpana*, a classical Ayurvedic dosage form described in the *Arka Prakash*, involves the distillation of medicinal herbs using water to obtain a clear, fragrant liquid known as *Arka*. This distillate contains the *sukshma* (subtle), *teekshna* (sharp), and *vyavayi* (quickly spreading) constituents of the drug, similar to the volatile fractions obtained in essential oil extraction. While *Arka* primarily represents the aqueous distillate (hydrosol), the *essential oil* corresponds to the more lipophilic fraction often discarded in traditional practice. However, both preparations capture the volatile principles responsible for therapeutic actions like *Shwasahara* (respiratory support), *Krimighna* (antimicrobial), and *Deepana* (digestive stimulant).

Hedychium spicatum, long esteemed in Ayurvedic, Tibetan, and folk traditions, is traditionally used in respiratory disorders (*via Shwasahara* formulations), as well as for alleviating inflammation, pain, and digestive discomfort. Hedychium spicatum essential oil showed potent anticancer activity, especially against prostate cancer (PC-3) cells, by inducing apoptosis and cell cycle arrest. The oil's rich phytochemical profile (193 compounds) and mechanisms involving ROS generation, mitochondrial depolarisation, and caspase activation highlight its chemotherapeutic potential [8].

Moreover, its essential oil and extracts possess broad-spectrum antimicrobial activity against both bacterial and fungal pathogens, corroborating its use in wound healing and skin ailments. It contained 38 compounds, mainly Ethyl p-methoxy-cinnamate (50.1%), Ethyl cinnamate (26.22%), and Eucalyptol (5.68%). It exhibited significant antimicrobial activity against various human pathogens, showing strong inhibition comparable to Ciprofloxacin and Amphotericin B [9]. The array of bioactivities is attributed to its rich phytochemical profile especially monoterpenoids like 1,8-cineole and camphor, and diterpenes such as hedychenone which collectively underpin its ethnomedical importance and relevance in Ayurvedic therapeutics [10]. *Elettaria cardamomum* (*Ela*), traditionally acclaimed in Ayurveda for supporting digestion, relieving cough, and balancing the doshas, is also prescribed for colic, bad breath, and as an expectorant. Modern research validates several of these applications: animal models demonstrate their gastroprotective effects, significantly reducing peptic ulcer indices and enhancing gastric mucosal defence [11]. Its essential oil and key constituents like 1,8-cineole and α-terpinyl acetate have shown potent antimicrobial and antioxidant activity, supporting its traditional use for respiratory and digestive health [12].

Ocimum sanctum (*Tulsi*), revered in Ayurveda as *"Elixir of Life"* and a *Rasayana* herb, is traditionally employed for respiratory, metabolic, and infectious disorders. It is commonly prescribed for asthma, bronchitis, fever, and wound healing, and also holds a sacred status in Indian ethnomedicine. Modern studies corroborate these uses, with extracts exhibiting immunomodulatory, adaptogenic, and anti-stress effects via cortisol regulation and antioxidant defence. *Ocimum sanctum* essential oil (OsEO) exhibited potent antibacterial activity against multidrug-resistant bacterial vaginosis (BV) pathogens, including *Streptococcus pyogenes*, *Staphylococcus aureus*, and *E. coli*. BV isolates showed high antibiotic resistance (>60%) and strong biofilm and hemolytic activity, indicating severe infection potential. OsEO metabolites such as cyclohexene and methanoazulene demonstrated significant inhibitory effects, suggesting their potential use in topical antimicrobial formulations for BV treatment [13]. Its essential oil, rich in eugenol and methyl eugenol, demonstrates significant antimicrobial, antiviral, and anti-inflammatory activity, validating its ethnomedical role in infectious and inflammatory conditions [14]. Furthermore, studies report its antidiabetic and cardioprotective potential, extending its traditional application into modern integrative medicine [15].

CONCLUSION: The present study successfully demonstrated the hydro-distillation-based extraction and yield profiling of essential oils from *Hedychium spicatum* (*Shati*), *Elettaria cardamomum* (*Ela*), and *Ocimum sanctum* (*Tulsi*) using a Clevenger apparatus. Among the three, *E. cardamomum* yielded the highest amount of essential oil, followed by *O. sanctum* and *H. spicatum*. Minor procedural adjustments, such as

increasing water volume for *H. spicatum*, were found essential for efficient extraction. These findings provide foundational data for further exploration into the standardisation and therapeutic evaluation of essential oils from traditionally significant Ayurvedic botanicals.

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