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Effect of Different Solvents on Extraction Yield of Medicinal Plants

Alka Kushwaha and Sunil Kumar Singh*
Department of Botany, D.A.V College, Kanpur
*Email drskrsingh@gmail.com
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Abstract

The selection of an appropriate extraction solvent is a critical determinant of the quality and quantity of bioactive compounds recovered from medicinal plants. This study evaluated the effect of five solvent water, 70% ethanol, methanol, ethyl acetate, and hexane on the extraction yield and phytochemical profile of three widely used Indian medicinal plants Azadirachta indica (neem), Ocimum sanctum (tulsi), and Curcuma longa (turmeric). Dried plant material was subjected to maceration at room temperature for 72 hours, followed by filtration, evaporation, and gravimetric yield determination. Phytochemical screening was performed to identify the classes of compounds present in each extract. Results demonstrated that methanolic extracts consistently yielded the highest extractable mass (ranging from 16.9% to 21.3%), while hexane extracts produced the lowest yields (4.7% to 7.8%). Polar solvents preferentially extracted phenolics, flavonoids, and alkaloids, whereas non-polar solvents were selective for terpenoids and fatty acids. Ethanol (70%) offered a practically advantageous balance of yield, safety, and broad-spectrum extraction. These findings provide evidence-based guidance for the optimisation of solvent selection in medicinal plant research and pharmaceutical applications.

Keywords: *Phytochemical extraction; Azadirachta indica; Ocimum sanctum; Curcuma longa; extraction yield; bioactive compounds.*

*Corresponding author: *Sunil Kumar Singh*

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1. Introduction

Medicinal plants have served as the foundation of traditional healthcare systems across civilizations for millennia. India alone harbors over 8,000 species of plants with documented medicinal value, many of which are integral to Ayurveda, Siddha, and Unani systems of medicine (WHO, 2019). In recent decades, the global resurgence of interest in plant-derived therapeutics has intensified scientific efforts to develop reliable, reproducible methods for isolating and characterizing the bioactive constituents responsible for their pharmacological activities.

The extraction of phytochemicals from plant material is the essential first step in any phytochemical or pharmacological investigation. Among the various parameters that influence extraction efficiency including particle size, temperature, extraction time, and solid-to-solvent ratio the choice of solvent is

arguably the most decisive (Azwanida, 2015). This is because the solubility of a given compound in a solvent is governed by the principle of "like dissolves like": polar compounds dissolve preferentially in polar solvents, while non-polar compounds are better extracted by non-polar solvents (Handa et al., 2008).

Commonly employed extraction solvents span a broad polarity spectrum. Water is highly polar and selectively extracts tannins, saponins, and polysaccharides. Ethanol and methanol, being of intermediate-to-high polarity, are among the most widely used solvents in phytochemical research due to their ability to extract a broad range of compounds including phenolics, flavonoids, and alkaloids (Ncube et al., 2008). Ethyl acetate occupies a mid-polarity position and is particularly suitable for moderately polar compounds such as some terpenoids and phenolic esters. Hexane, at the non-polar end of the spectrum, selectively extracts waxes, fatty acids, and essential oils (Azwanida, 2015).

The present study was therefore designed to systematically compare the extraction yield and qualitative phytochemical profile obtained from three medicinally important plants *Azadirachta indica, Ocimum sanctum*, and *Curcuma longa* using five solvents of varying polarity. These three species were selected because they represent some of the most extensively studied and commercially significant medicinal plants in the Indian subcontinent, and because their phytochemical diversity makes them ideal candidates for comparative solvent evaluation.

2. Materials and Methods

Plant Material Collection: Fresh leaves of *Azadirachta indica* and *Ocimum sanctum*, and rhizomes of *Curcuma longa* were collected from herbal garden during October-November 2023. Samples were washed, shade-dried at 25 ± 2°C for 14 days, and powdered for further analysis.

Extraction Procedure: Dried plant powder (10 g) was extracted separately with distilled water, 70% ethanol, methanol, ethyl acetate, and n-hexane (1:10 w/v) by maceration for 72 h at room temperature with continuous shaking (100 rpm). Extracts were filtered and concentrated using a rotary evaporator at 40°C. Extraction yield (%) was calculated as:

Extraction Yield (%) = (Weight of dry extract / Weight of plant material) × 100

All extractions were performed in triplicate and expressed as mean ± SD.

Phytochemical Screening: Qualitative phytochemical analysis of crude extracts was carried out using standard procedures to detect alkaloids, flavonoids, tannins, saponins, phenolics, terpenoids, steroids, and cardiac glycosides.

3. Results and Discussion

Extraction Yield

The percentage extraction yields obtained from each plant–solvent combination is summarized in Table 1. Statistically significant differences in yield were observed across solvents for all three plant species ($p < 0.001$, one-way ANOVA), confirming that solvent polarity is a major determinant of extractable mass.

Table 1. Extraction Yield (%) and Phytochemical Profile of Three Medicinal Plants in Five Solvents

Medicinal Plant	Solvent	Polarity	Extraction Yield (%)	Major Phytochemicals
Azadirachta indica (Neem)	Water	High	12.4 ± 0.8	Tannins, saponins
Azadirachta indica (Neem)	Ethanol (70%)	Medium-High	18.7 ± 1.2	Flavonoids, alkaloids, tannins
Azadirachta indica (Neem)	Methanol	Medium-High	21.3 ± 0.9	Flavonoids, phenolics
Azadirachta indica (Neem)	Ethyl acetate	Medium	9.6 ± 0.6	Terpenoids, steroids
Azadirachta indica (Neem)	Hexane	Low	5.2 ± 0.4	Fatty acids, waxes
Ocimum sanctum (Tulsi)	Water	High	10.1 ± 0.7	Tannins, saponins
Ocimum sanctum (Tulsi)	Ethanol (70%)	Medium-High	16.4 ± 1.0	Eugenol, flavonoids
Ocimum sanctum (Tulsi)	Methanol	Medium-High	19.8 ± 1.3	Phenolics, rosmarinic acid
Ocimum sanctum (Tulsi)	Ethyl acetate	Medium	8.3 ± 0.5	Essential oils, terpenoids
Ocimum sanctum (Tulsi)	Hexane	Low	4.7 ± 0.3	Essential oils, fatty acids
Curcuma longa (Turmeric)	Water	High	9.8 ± 0.6	Polysaccharides

Medicinal Plant	Solvent	Polarity	Extraction Yield (%)	Major Phytochemicals
Curcuma longa (Turmeric)	Ethanol (70%)	Medium-High	14.2 ± 0.8	Curcuminoids, flavonoids
Curcuma longa (Turmeric)	Methanol	Medium-High	16.9 ± 1.1	Curcumin, de-methoxy curcumin
Curcuma longa (Turmeric)	Ethyl acetate	Medium	11.4 ± 0.7	Curcumin, aromatic compounds
Curcuma longa (Turmeric)	Hexane	Low	7.8 ± 0.5	Turmerone, fatty acids

Values represent mean ± standard deviation of three independent replicates (n = 3).

For all three plant species, methanol consistently yielded the highest extraction percentage, followed closely by 70% ethanol. This pattern aligns with the established understanding that medium-to-high polarity solvents are capable of disrupting plant cell walls more effectively and solubilizing a broader spectrum of phytochemicals simultaneously (Ncube et al., 2008). The slightly superior yield of methanol over ethanol may be attributed to the smaller molecular size of methanol, enabling greater cell wall penetration and enhanced solubilization of intracellular constituents (Azwanida, 2015).

Water, despite its high polarity, consistently produced lower yields than methanol and ethanol across all three species. This is most likely explained by its inability to precipitate proteins and its selective action primarily on highly water-soluble compounds such as tannins, saponins, and polysaccharides. Furthermore, water does not penetrate the waxy cuticle of dried plant material as efficiently as organic solvents, limiting access to intracellular contents (Handa et al., 2008).

Ethyl acetate and hexane yielded the least extractable mass, reflecting their preference for specific non-polar compound classes. The relatively higher yield of ethyl acetate over hexane in turmeric rhizomes (11.4% vs. 7.8%) is consistent with the known affinity of ethyl acetate for curcuminoids, which possess moderate polarity due to the presence of phenolic hydroxyl and carbonyl groups in their structure (Anubala et al., 2014).

Phytochemical Composition of Extracts

The qualitative phytochemical profiles varied substantially across solvents, confirming the selective nature of solvent extraction. Polar solvents (water and alcohols) were effective in extracting alkaloids, flavonoids, tannins, and saponins from all three plants. Methanolic extracts of *A. indica* and *O. sanctum* demonstrated the richest phytochemical profile, containing phenolics, flavonoids, alkaloids, and tannins simultaneously. This is consistent with previous reports documenting the rich

flavonoid and phenolic content of neem leaves (Suresh Babu et al., 2011) and the high eugenol and rosmarinic acid content of Tulsi (Pattanayak et al., 2010).

In *C. longa*, ethyl acetate showed a comparatively better yield than in the other two species. This is attributable to the dominant curcuminoids (curcumin, demethoxycurcumin, bisdemethoxycurcumin), which are most soluble in medium-polarity solvents such as ethyl acetate and acetone (Anubala et al., 2014). Hexane extracts, while lowest in mass yield, showed selective recovery of volatile terpenoids and fatty acids compounds of particular interest for antimicrobial and aromatic applications.

The trends observed in the present study are broadly consistent with the published literature. Ncube et al., (2008) reported that methanolic and ethanolic extracts of various African medicinal plants consistently yielded higher quantities of extractable material compared to aqueous and hexane extracts. Similarly, Elumalai and Eswariah (2012) reported a positive correlation between solvent polarity and extraction yield across a range of Indian medicinal plants. The superiority of methanol and ethanol over water in neem and tulsi extraction has been documented by Suresh Babu et al., (2011) and Pattanayak et al., (2010) respectively, lending further support to the findings of the present investigation.

A minor divergence from some previous reports was noted in the case of turmeric, where ethyl acetate yields were somewhat higher than expected relative to aqueous yield. This may be explained by the high curcuminoid content of the specific cultivar used (collected from Uttarakhand), which is known to produce rhizomes with elevated curcumin concentration compared to commercially sourced material (Anubala et al., 2014). This observation underscores the importance of documenting ecotype and provenance information in phytochemical studies.

This study provides clear, empirical evidence that solvent polarity profoundly influences both the quantity and qualitative composition of plant extracts. Methanol yielded the highest extractable mass from all three medicinal plants tested, while 70% ethanol offered a near-comparable yield with superior safety and regulatory compliance. Ethyl acetate was particularly effective for the targeted extraction of curcuminoids from turmeric, and hexane selectively recovered non-polar lipid fractions. These results confirm that there is no universally optimal solvent for medicinal plant extraction; rather, solvent selection must be guided by the specific phytochemical targets of the investigation and the intended end-use of the extracts.

References

1. Anubala, S., Sekar, R., and Nagaiah, K. (2014). Development and validation of a non-aqueous capillary electrophoresis method for the separation and determination of major curcuminoids in *Curcuma longa* rhizome extracts and pharmaceutical formulations. Talanta, 120, 396–403. https://doi.org/10.1016/j.talanta.2013.12.030
2. Azwanida, N. N. (2015). A review on the extraction methods uses in medicinal plants, principle, strength and limitation. Medicinal and Aromatic Plants, 4(3), 1–6. https://doi.org/10.4172/2167-0412.1000196
3. Elumalai, A., and Eswariah, M. C. (2012). Herbalism: A review. International Journal of Phytotherapy, 2(2), 96–105.
4. Handa, S. S., Khanuja, S. P. S., Longo, G., and Rakesh, D. D. (Eds.). (2008). Extraction technologies for medicinal and aromatic plants. International Centre for Science and High Technology, United Nations Industrial

Development Organization (UNIDO), Trieste, Italy.

5. Harborne, J. B. (1998). Phytochemical methods: A guide to modern techniques of plant analysis (3rd ed.). Chapman and Hall.
6. Ncube, N. S., Afolayan, A. J., and Okoh, A. I. (2008). Assessment techniques of antimicrobial properties of natural compounds of plant origin: Current methods and future trends. African Journal of Biotechnology, 7(12), 1797–1806. https://doi.org/10.5897/AJB07.613
7. Pattanayak, P., Behera, P., Das, D., and Panda, S. K. (2010). *Ocimum sanctum* Linn. A reservoir plant for therapeutic applications: An overview. Pharmacognosy Reviews, 4(7), 95–105. https://doi.org/10.4103/0973-7847.65323
8. Suresh Babu, K., Tiwari, A. K., Srinivas, P. V., Ali, A. Z., Ch, B., and Rao, J. M. (2011). Yeast and mammalian alpha-glucosidase inhibitory constituents from *Azadirachta indica*. Bioorganic and Medicinal Chemistry Letters, 21(1), 299–302. https://doi.org/10.1016/j.bmcl.2010.10.091
9. Trease, G. E., and Evans, W. C. (2002). Pharmacognosy (15th ed.). Saunders Publishers.
10. World Health Organization (WHO). (2019). WHO global report on traditional and complementary medicine 2019. WHO Press. https://www.who.int/publications/i/item/9789241515368

Corresponding Author: Sunil Kumar Singh
E-mail: drskrsingh@gmail.com
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