

# *The Science Behind Extracting Crude Drugs from India's Medicinal Plants*

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**OPEN ACCESS**

**Keywords**

Medicinal plants, Crude drugs, Pharmacy, Extraction

*How to cite this article:*

Rao, M. S., Ramanjineyu, M. and Sathish, B. R. 2026. The Science Behind Extracting Crude Drugs from India's Medicinal Plants. *Vigyan Varta* 7 (04): 154-159.

## **ABSTRACT**

India harbours over 7,500 medicinal plant species - the richest proportion of any nation on Earth. Crude drug extraction, the foundational step that converts raw plant material into therapeutically potent medicines, is at the heart of India's booming herbal industry, now valued at over ₹90,000 crore. This article traces the journey from field to pharmacy: what crude drugs are, how they are collected and classified, the classical and modern extraction techniques used from simple maceration to cutting-edge supercritical fluid extraction and why the choice of method directly determines the safety, efficacy and commercial viability of the final product. It also highlights key Indian plants whose extraction has shaped both traditional and modern pharmacology.

## **INTRODUCTION**

**W**alk into any Ayurvedic pharmacy in Andhra Pradesh or a small herbal shop in Kerala and the shelves tell a quiet story stretching back thousands of years. Behind every oil, powder, or tincture sits a plant - often harvested from the forests, dried under the sun and processed

through methods that have been refined over generations. The raw, unprocessed plant material that forms the starting point of this journey is what pharmacognosy calls a crude drug. It is, in essence, nature's raw material - waiting to be unlocked.

India's relationship with medicinal plants is unmatched anywhere in the world. Of the approximately 17,000 species of higher plants documented across the subcontinent, around 7,500 are recognized for their medicinal value (Sharma *et al.*, 2024). The World Health Organization (WHO) has long affirmed that roughly 80% of the global population in developing countries relies on traditional, plant-based remedies for primary healthcare. In India, that reliance runs even deeper - woven into Ayurveda, Siddha, Unani and countless tribal healing traditions practiced across 6,49,481 villages.

So, what exactly happens between the plant growing in the wild and the finished medicine on a shelf? The answer lies in a disciplined, step-by-step process: collection, drying, classification and - most critically - extraction. This article walks you through that process, explains the science behind it and shows why getting it right matters more than most people realise.

### What Is a Crude Drug?

The term “crude drug” does not mean impure or inferior. In pharmacological parlance, it simply refers to a plant or animal-derived material that has not yet been chemically refined - it has undergone only the basic processing essential to prevent decay, such as drying or packing. A crude drug could be a dried root, a leaf, a bark, a seed, a resin, or even an essential oil trapped inside plant tissue. What makes it valuable is the presence of *active compounds* - molecules that produce a measurable therapeutic effect in the human body.

Pharmacognosy classifies crude drugs into two broad categories. **Organised crude drugs** come from a specific, identifiable organ of the plant - leaves, roots, flowers, seeds, or bark - each retaining its distinct tissue structure.

**Unorganised crude drugs**, on the other hand, are derived from undifferentiated plant parts or secretions: think balsams, resins, gums and volatile oils. The type of crude drug directly influences which extraction technique will work best and yield the highest concentration of active compounds.

### Collection and Preparation of Crude Drugs

Before any extraction can begin, the crude drug must be properly collected and prepared. This stage - often overlooked in popular accounts - is actually where quality is won or lost. Harvesting at the wrong season, using the wrong plant part, or storing material carelessly can render an entire batch therapeutically useless.

The Ayurvedic Pharmacopoeia of India mandates a series of quality benchmarks before a crude drug is deemed fit for processing. These include tests for total ash content, acid-insoluble ash, moisture levels and the proportion of alcohol-soluble and water-soluble extracts - all designed to ensure the material is free from contamination and has not deteriorated (Kumar *et al.*, 2024). For instance, the roots of *Withania somnifera* (Ashwagandha) - one of India's most commercially important medicinal plants - are ideally harvested between January and March, then shade-dried for several days. The dried roots retain full therapeutic potency for up to two years; beyond that, their withanolide content degrades significantly.

Once collected and verified, the crude drug is typically dried, coarsely powdered or chopped to a standard size and stored in well-labelled containers away from light, moisture and pests. The particle size of the powdered material is not arbitrary - it directly affects how efficiently solvents can penetrate the plant tissue during extraction.

## Classical Extraction Methods

The extraction of active compounds from crude drugs is fundamentally a process of dissolving those compounds into a suitable liquid - called a *menstruum* or solvent - and then separating them from the inert plant material. The choice of solvent (water, ethanol, methanol, or others) depends on the chemical nature of the target compounds: polar compounds like alkaloids and glycosides dissolve well in water or ethanol, while non-polar compounds such as essential oils and waxes require solvents like hexane or petroleum ether (Rasul *et al.*, 2019).

### Three classical methods have remained the workhorses of extraction for centuries:

**Maceration** is the simplest and oldest approach. The powdered crude drug is placed in a closed vessel, a solvent is added and the mixture is allowed to sit at room temperature - typically for three to seven days - with periodic stirring. Over time, the soluble constituents dissolve into the menstruum. Maceration works well for heat-sensitive compounds but is slow and the extraction yield can be uneven (Rasul *et al.*, 2019).

**Percolation** is a step up in efficiency. Here, the crude drug is placed in a percolator - a funnel-shaped vessel - and the solvent is allowed to trickle through the plant material continuously. Because the solvent is always fresh and in contact with the drug, extraction is more thorough and faster than maceration. This method is particularly suited for expensive crude drugs like *Zingiber officinale* (ginger), where maximum recovery of active material is economically important.

**Decoction** - known in Ayurveda as *kwatha* - involves boiling the crude drug in water for a fixed duration, then cooling and straining. The traditional Ayurvedic ratio is well defined: one part drug to four parts water for soft plant

materials, one to eight for moderately hard material (such as woody roots) and one to sixteen for very hard barks. Decoction is ideal for extracting heat-stable, water-soluble compounds from tough, fibrous material (Rasul *et al.*, 2019).

### The Soxhlet Advantage

When classical methods are not thorough enough, the *Soxhlet extraction apparatus* enters the picture. Invented in the 19th century, this elegant piece of glassware uses a cycle of heating and condensation to repeatedly wash the crude drug with solvent - automatically, without manual intervention. The result is near-complete extraction of all soluble material, using remarkably little solvent compared to repeated maceration (Islam *et al.*, 2023). In Indian pharmaceutical laboratories, Soxhlet extraction is commonly used to isolate withanolides from *Withania somnifera* and azadirachtin from *Azadirachta indica* (Neem), among many others.

### Modern Extraction Technologies

Classical methods, for all their reliability, have real limitations: long extraction times, high solvent consumption and the risk of degrading heat-sensitive compounds. Over the past two decades, a suite of advanced, environmentally friendlier techniques has emerged - often grouped under the banner of *green extraction*. Three of the most significant for India's herbal pharmaceutical industry are:

**Ultrasound-Assisted Extraction (UAE)** uses high-frequency sound waves (typically 20 kHz to 10 MHz) to disrupt plant cell walls, dramatically increasing the surface area available to the solvent. Extraction times that would take days under maceration can be reduced to minutes. Studies have shown UAE can improve oil yields by over 80% compared to conventional solvent extraction, while using significantly less energy (Islam *et al.*, 2023).

### **Microwave-Assisted Extraction (MAE)**

harnesses the rapid, uniform heating provided by microwave radiation to accelerate the release of active compounds from plant tissue. MAE is particularly effective for extracting polyphenols and flavonoids and it can cut extraction time from hours to just one to four minutes (Islam *et al.*, 2023). Indian research institutions, including those under the Council of Scientific and Industrial Research (CSIR), have actively explored MAE for standardising extracts from *Ocimum sanctum* (Tulsi) and *Tinospora cordifolia* (Giloy).

### **Supercritical Fluid Extraction (SFE)**

is perhaps the most sophisticated method now available. It uses carbon dioxide (CO<sub>2</sub>) at pressures above 73.8 bar and temperatures above 31.1 °C - conditions under which CO<sub>2</sub> behaves simultaneously as a gas and a liquid, penetrating plant tissue with extraordinary efficiency. The key advantage: once extraction is complete and the pressure is released, the CO<sub>2</sub> simply evaporates, leaving behind a pure, solvent-free extract. SFE is ideal for thermolabile compounds and is already being adopted by leading Indian herbal manufacturers seeking to meet international quality benchmarks (Chemat *et al.*, 2020).

### **India's Star Players**

India's botanical wealth is staggering - over 7,500 species with documented medicinal use, spread across four biodiversity hotspots. A handful of these have become the backbone of the country's herbal pharmaceutical exports and domestic Ayurvedic market. Understanding their extraction requirements helps illustrate why method selection is so critical.

Ashwagandha (*Withania somnifera*) is arguably India's most commercially significant adaptogenic herb. Its roots contain withanolides - a family of steroidal lactones - that are responsible for its anti-inflammatory,

immunomodulatory and neuroprotective properties. Ethanol-water maceration and Soxhlet extraction are traditionally used, but recent studies published in 2024-2025 have demonstrated that UAE and SFE yield higher concentrations of withanolides with fewer impurities (Singirala *et al.*, 2025). The global market for ashwagandha extracts alone has been growing at a compound annual growth rate (CAGR) of over 8%, driven strongly by Indian producers.

Neem (*Azadirachta indica*) is a treasure chest of bioactive compounds, most notably azadirachtin, a potent biopesticide and anti-inflammatory agent. Successive Soxhlet extraction - first with petroleum ether, then ethyl acetate, then methanol - is the standard laboratory protocol for isolating different compound classes from neem leaves. India exports neem-derived products worth hundreds of crores of rupees annually, with Andhra Pradesh and Tamil Nadu being major production centres.

Tulsi (*Ocimum sanctum*) may be the most revered plant in India's traditional medicine chest. Its essential oil - rich in eugenol, rosmarinic acid and various flavonoids - is extracted predominantly through steam distillation and hydrodistillation. Simple infusion (steeping dried leaves in hot water) is sufficient for everyday medicinal use, but pharmaceutical-grade extraction demands Soxhlet or MAE for consistent, standardised output.

### **Why the Method Matters**

Choosing the wrong extraction method does not just reduce yield - it can produce a product that is ineffective or, worse, potentially harmful. Several factors determine which method is appropriate for any given crude drug:

The *chemical nature of the target compound* is the first consideration. Heat-sensitive

molecules like certain flavonoids and withanolides will degrade under prolonged boiling; they require low-temperature methods like maceration, UAE, or SFE. The *physical structure of the plant material* is the second: tough barks and woody roots demand decoction or Soxhlet, while soft leaves can be processed with simple infusion. *Cost and scale* also play a role - maceration is inexpensive and suitable for small batches, while SFE requires significant capital investment but delivers premium-grade extracts suited to export markets.

A 2024 WHO assessment found that nearly 18% of herbal products circulating in India contained detectable levels of heavy metals or pesticide residues - a figure that underscores the importance of rigorous quality control at every stage, from raw material sourcing to final extraction. The Indian government has responded by allocating over ₹4,300 crore to the Ministry of AYUSH in the 2024-25 budget, a 20% increase over previous years, with a clear mandate to strengthen standardisation and research in herbal drug manufacturing.

### India's Herbal Economy

The numbers tell a compelling story. India's medicinal plant extracts market was valued at approximately ₹6,250 crore (USD 750 million) in 2024 and it is projected to grow at a CAGR of 8.03% through 2035 (Market Research Future *et al.*, 2024). The broader herbal medicine market - encompassing Ayurvedic formulations, dietary supplements and personal care products - stood at around ₹38,000 crore (USD 4.56 billion) the same year, with projections crossing ₹60,000 crore by 2032. Exports of Ayurvedic and herbal products from India reached approximately ₹5,400 crore (USD 651 million) in the 2023-24 fiscal year, with demand surging from Europe, the United States and Japan.

Major players driving this growth include Dabur India Ltd., Himalaya Wellness, Patanjali Ayurved Limited and Baidyanath Group - all of whom have invested heavily in modernising their extraction infrastructure while staying rooted in Ayurvedic traditions. The National Medicinal Plants Board (NMPB) continues to offer subsidies of up to 75% to farmers cultivating priority medicinal plant species and has established 72 conservation and development areas covering over 10,935 hectares across 13 states.

### CONCLUSION

Crude drug extraction is far more than a laboratory procedure - it is the bridge between India's ancient botanical wisdom and the demands of a modern pharmaceutical world. From the shade-dried roots of *Withania somnifera* to the resin-rich bark of *Azadirachta indica*, each plant demands a method tailored to its chemistry, its structure and its intended use. As India's herbal industry continues to expand - powered by government investment, rising global demand and advances in green extraction technology - mastering this science is not optional. It is essential to turning nature's raw promise into medicine that works.

### REFERENCES

- Chemat, F., Viguier, R., Godeau, R. M., Oghbani, M., & Escobar, A. (2020). Green extraction technologies for non-food applications of essential oils. *Molecules*, 25(23), 5579.
- Islam, M., Malakar, S., Rao, M. V., Kumar, N., & Sahu, J. K. (2023). Recent advancement in ultrasound-assisted novel technologies for the extraction of bioactive compounds from herbal plants: A review. *Food Science and Biotechnology*, 32(13), 1763-1782.
- Kumar, R., Patel, A., & Mehta, S. (2024). Collection and preservation of crude

- drugs: An overview. *International Journal of Advanced Biochemistry Research*, 8(11), 33-39.
- National Medicinal Plants Board (NMPB), Ministry of AYUSH <https://www.nmpb.nic.in/>
- Rasul, M. G. (2019). Conventional extraction methods used in medicinal plants, their advantages and disadvantages. *International Journal of Basic Sciences and Applied Computing*, 2(6).
- Sharma, N., Pandey, R., & Shakya, S. (2024). Status and consolidated list of threatened medicinal plants of India. *Journal of Ethnobiology and Ethnomedicine*, 20(1), 14.
- Singirala, S. K., Reddy, A. R., & Vasantha, B. (2025). Extraction of bioactive compounds from *Withania somnifera*: The biological activities and potential application in the food industry. *International Journal of Food Science*, 2025, 9922626.