

## REVIEW ARTICLE

# Mitigation Plan for Adulterated Ayurvedic Herbs/Herbal Raw Drugs

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## ARTICLE INFO

### Article history:

Received on: 02-03-2025

Accepted on: 26-03-2025

Published on: 31-03-2025

### Key words:

Ayurvedic adulteration,  
Extracts,  
Herbs,  
Mitigation,  
Raw Drugs

## ABSTRACT

**Introduction:** Adulteration of herbal raw drugs compromises efficacy and safety. This practice generally involves from substitution or inferior, unrelated, or harmful raw drugs/raw materials (RM), often driven by various factors like scarcity of authentic materials, economic gain, or misidentification due to similar plant morphology. Nowadays, it is a significant concern in herbal medicine. Addressing adulteration requires a collaborative effort among regulatory bodies, industry stakeholders, and consumers to ensure the safety and efficacy.

**Material and Methods:** Marketed samples were analyzed since a decade using modern tools (Taxonomy, Anatomy, Powder Microscopy, and Chemometrics) as physical markers for the identification and validation. Available published literature, compendium, floras, and monographs were extensively studied to mitigate the misidentification of herbal raw drugs.

**Results and Discussion:** Out of 77 raw drugs/RM, 23 herbs, 10 climbers, 23 shrubs, and 22 tree species were identified as marketed adulteration. Among the plant part use/raw drugs, 29 root, 06 stem bark, 05 whole plant, 05 rhizomes, 05 flowers, 03 heartwood, 03 leaves, 03 tubers, and rest were recorded as aerial part, bark, seeds, galls, resin, and stamens, respectively. Strengthening stringent regulations and quality control measures can help to prevent Ayurvedic adulteration. Educating all stakeholders, for example, aggregators, collectors, suppliers, manufacturers, and consumers about the importance of commercial cultivation and using the authentic herbal raw drugs/extracts. Mitigation plan has been suggested as commercial cultivation (54 species), alternative plant part use approvals (09 spp), alternative plant species approvals (06 spp), and regulatory approvals (08 spp) from Ayurvedic Pharmacopoeia of India.

## 1. INTRODUCTION

Himalayas, Western Ghats, Indo-Burma, and Sundarbans are the Biodiversity Hotspots in India. Indus plain, Gangetic plain, Western and Eastern Himalaya, Western coasts of Malabar, Central India, Deccan, Assam and Bay Islands of Andaman and Nicobar are the important phytogeography regions. Due to the high amount of rainfall, Andaman and Nicobar, Lakshadweep, Western Malabar, and south Assam characterize tropical wet climate regions (Anonymous). The tropical wet region comprises the wettest in the country that maintains the humidity round the year and provides favorable habitats for many

medicinal and aromatic plants (MAPs). Definitely, India is home to an amazing variability of climatic regions, ranging from tropical in the south to temperate and alpine in north regions. The high altitude regions sustained usual winter, waterfalls, and seasonal snowfall for suitability of the habitats of sub-alpine and alpine vegetation. The alpine/nival zone extends from the upper limit of the temperate zone of about 5,000 m or even higher (Kanchenjunga and Nanda Devi). Leh (Ladakh) and Kinnaur (Himachal Pradesh) represents the cold desert. Subsequently, Thar desert is an arid region in the north-western part as home of hot subtropical desert for some unique MAPs. Native plant parts (such as roots, stem, bark, leaves, fruits, flowers, seeds, and exudates) have been used in different localities from prehistoric times for food, fiber, fuel, fodder, shelter, and traditional/Ayurvedic medicines [Tables 1-4].

The Indian herbal raw drugs/extract market is huge and many large and small companies are actively involved in sustainable sourcing from

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wilds, commercial cultivation, extraction, and distribution of herbal products.<sup>[1]</sup> The herbal raw drugs/extracts/raw materials (RM) industry in India has the potential to lead the global market with its rich cultural heritage and diverse flora and fauna.<sup>[2]</sup> The herbal industry in India has witnessed tremendous growth in the last decades and it has accelerated after Corona Pandemic (Anonymous). There has been an increasing demand for herbal raw drugs/RM/extracts for nature based organic substances in the Ayurvedic industry, cosmetics, pharmaceuticals, nutraceuticals and certain food supplements.<sup>[3,4]</sup> However, this growth (increasing demand and supply) has also brought various inappropriate practices that threaten the integrity, quality, and efficacy of herbal products (cosmetics and foods) and herbal medicines.<sup>[5]</sup> The lack of specification and inspection has led to large-scale malpractices, including adulteration (intentional and unintentional) and so-called substitution (interspecies and intraspecies) of herbal raw drugs/RM. These substitutes and adulterants may have varying pharmacological effects and may cause adverse reaction too.<sup>[6]</sup> The lack of stringent regulations and complexity of detecting adulteration this not only compromise the quality and efficacy of the herbal products but also may retain serious health risk to the innocent consumers. Again, adulteration and substitution leads to loss of consumers trust in herbal products and the industry as a whole (Anonymous).

India has the unique peculiarity of having five recognized alternative systems of medicine; Ayurveda, Siddha, Unani, Naturopathy and Homoeopathy. The word Ayurveda is a combination of two words; Ayu and Veda, which means life and science, so Ayurveda is a science of life to live until last breath. Ancient Acharyas were firm and suggested substitute drugs (that may be particular plant species/part use) in place of the text referred in case unavailability. Substitution of the herbal raw drugs/plants have achieved goals of the conservation and application through the basic idea on Rasa (taste), Guna (nature), Veerya (potency), Vipaka (results) and Prabhava (action).<sup>[7-10]</sup> Substitution of the plants has been in practice for a long time, which was implemented by the Ayurvedic practitioners, users and different manufacturers. Ayush Kwath/powder (*Tulsi, Cinnamon, Ginger, Black Pepper*); Brahmi Bati (*Brahmi*); Chirayata churna (*Chirayita*); Giloy Ghan Batti (*Giloy*); Chyawanprash (40 herbal ingredients); Dasmoolaristha (*Bilva, Agnimontha, Shyonaka, Patala, Gambhari, Saliparani, Prishnparanai, Brihati, Kantkari and Gokhurua*); Asokhristha (*Asoka*); Talishadi churna (*Talishpatra*); Sitopladi churna (*Vanslochan, Pippali, Dalchini, Elachi*); Trikatu (*Pippali, Sunthi, Maricha*); Triphala (*Haritaki, Bhibhitaki, Amla*); Avipattikara churna (*Sunthi, Maricha, Pippali, Haritaki, Bhibhitaki, Amla, Musta*); Ashwagandha churna (*Ashwagandha*) and Mahamanjisthadi kwath (*Anantmool, Daruharidra, Manjistha*) are the important ethical Ayurvedic formulation which may be deceit due to constant substitution and adulteration.<sup>[11-19]</sup>

Having morphological resemblance with same herbs, different inferior commercial varieties/RMs are available in market at low price or as an adulterant which may or may not have any therapeutic properties as like Grantha-based genuine drugs, for example, Talishpatra (*Abies webbiana* vs. *Taxus wallichiana*) and Guduchi (*Tinospora cordifolia* vs. *Tinospora sinensis*) the genuine RM and alternative/substitute herbal raw drugs.<sup>[20]</sup> Identification tools, for example, taxonomy; is the scientific study of naming, defining, and classifying group of biological organisms/MAPs. Chemotaxonomy (chemosystematics); is the attempt to classify and identify organisms (original species/subspecies or variety, if any) according to confirmable similarities and dissimilarity in their biochemical (markers) composition. Macroscopy; which describes intact texture, color, shape, and size of raw drugs/

RM. Microscopy; which views objects and areas (dermal, ground, and vascular tissues) that cannot be seen with the naked eyes. Powder microscopy is an evaluation/quality control method, which is used to identify plant parts/raw drugs cell size and shapes using specific microscopic key characters to validate herbal medicine available in powder forms.<sup>[21-24]</sup>

Herbal medicine/raw drugs/extracts will have the therapeutic property on human body and may be harmful (long-term consumption), if not used correctly as per Grantha (textual) or as per Ayurvedic Pharmacopoeia of India (API). Molecular docking could play an important role in the field of network pharmacology of herbal raw drugs/RM, but these modern and sophisticated studies may be questionable, if extracts/raw drugs/RM have not been used with the identification and quantification of biological active markers. RM/raw drugs must be intact, dried/crude form, unprocessed, and without supercritical (SC-CO<sub>2</sub>) fluid and extraction.<sup>[25]</sup> We, as a part of this wellness industry, there is a need felt to address above concerns and provide steady solution, and advocate better practices for humanity. Some concrete mitigation plan is required to protect the integrity of herbal raw drugs/extracts/final products and ensure satisfaction of the consumer health. Mitigation should be taken as solid action to eliminate unintentional substitution and intentional adulteration. Mitigation plan (commercial cultivation, alternates, and regulatory approvals) and long-term management are urgently required with emerging standard guidelines on Agrotech protocols for the individual MAPs [Tables 1-4].

Keeping the all above facts in mind the present study has been conducted to identify the gaps of misidentification of MAPs and herbal raw drugs/RM and to mitigate the problems for future because people of the nation still believe in Ayurveda owing emotion, culture, and traditions.

## 2. MATERIALS AND METHODS

Ayurvedic raw drugs/RM/extracts/samples were collected from different Jadibuti store/retailers, for example, Bada Bazar (Kolkata), Khari Bowli (Delhi), Panchkula (Chandigarh), Saharanpur (Uttar Pradesh), Tanakpur (Uttarakhand), Neemuch (Madhya Pradesh), Pan India and India Mart (online access) during the years 2014–2024. Authentic plants and plant parts for in-house standard raw drugs were also collected from different phytogeography from Alpine to Tropical region.

Marketed samples/RM/raw drugs were analyzed for the identification, validation, and authentication with the help of Taxonomy, Chemotaxonomy, Anatomy, Powder Microscopy, Macroscopy, and Microscopy. Herbarium specimens have also been prepared and identified from Botanical Survey of India, Dehradun, and Kolkata. Sometimes Phytochemicals and biological active marker compounds were also studied and compared with the published Pharmacological docking literature. Microtome sections and Powder Microscopy were done following the usual micro-techniques.<sup>[26]</sup> The available literature, data, published papers, compendium, floras, and monographs were extensively studied to mitigate/revamp the misidentification of plant species/herbal raw drugs.<sup>[21,27]</sup>

## 3. RESULTS

In the present study, 77 raw drugs/RMs out of 500 and random raw drug samples were studied. Out of 77 raw drugs/RM/species, 23 herbs, 10 climbers, 23 shrubs, and 21 tree species were identified as per their habit and habitats. Among the plant part use/raw drugs, 29 root, 05 whole plant parts, 06 stem bark, 05 flowers, 05 heartwood, 05 rhizomes, 03 leaves, 03 tuberous roots, and rest were recorded as aerial

part, bark, seeds, flower buds, galls, resin, and stamens respectively. It has noticed that adulteration of different plant parts of the same genera and sometimes entirely different species was available in the market for auction (interstate and intrastate) and to final vending (through vendors). Mitigation plan for future has been suggested for the regulatory approval (08), commercial cultivation (54), alternative plant species approval (06), and alternative plant part use approval (09) of the botanicals in API.

Out of 23 herbs as raw drugs, 14 (*Anacyclus pyrethrum*, *Aconitum heterophyllum*, *Andrographis paniculata*, *Arnebia nobilis/A. euchroma*, *Centella asiatica*, *Fumaria parviflora*, *Hedychium spicatum*, *Nelumbo nucifera*, *Nymphaea stellata*, *Onosma bracteatum*, *Phaseolus trilobus*, *Pluchea lanceolata*, *Teramnus labialis* and *Tribulus terrestris*) were recorded with the interspecies adulteration. Moreover 09 (*Aconitum chasmantium*, *Chlorophytum tuberosum*, *Cyperus rotundus*, *Inula racemosa*, *Nardostachys grandiflora*, *Ocimum sanctum*, *Picrorhiza kurrooa*, *Pluchea lanceolata* and *Viola odorata*) RM were found with intraspecies adulteration [Table 1].

Out of 10 climbers as raw drugs, 03 (*Embelia ribes*, *Hemidesmus indicus*, and *Ipomoea digitata*) were traced with interspecies adulteration. And, 07 herbal raw drugs (*Argyreia nervosa*, *Cissampelos pariera*, *Leptadenia reticulata*, *Marsdenia tenacissima*, *Piper retrofractum*, *Rubia cordifolia*, and *Tinospora cordifolia*) were detected with intraspecies adulteration [Table 2].

Out of 23 shrubs/undershrubs as raw drugs, 11 (*Berberis aristata*, *Boerhavia verticillata*, *B. diffusa*, *Commiphora wightii*, *Hibiscus rosa-sinensis*, *Leonotis nepetifolia*, *Nerium indicum*, *Sida cordifolia*, *Solanum indicum*, *Swertia chirayita* and *Uraria picta*) RM were found as interspecies adulteration. A total of 12 herbal raw drugs (*Adhatoda zeylanicum*, *Caesalpinia sappan*, *Callicarpa macrophylla*, *Desmodium gangeticum*, *Jasminum officinale*, *Plumbago zeylanica*, *Rauwolfia serpentina*, *Ricinus communis*, *Rotheeca serrata*, *Salacia oblonga*, *Withania somnifera* and *Zanthoxylum armatum*) were recorded with intraspecies adulteration [Table 3].

Out of 21 tree species as source of raw drugs, 08 (*Abies webbiana*, *Garcinia pedunculata*, *Holarhena antidysenterica/Wrightia antidysenterica*, *Mesua ferrea*, *Pistacia integerrima*, *Saraca asoca*, *Stereospermum suaveolens*, and *Tecomella undulata*) were observed with interspecies adulteration. Moreover, 13 herbal raw drugs (*Bauhinia variegata*, *Aegle marmelos*, *Cinnamomum tamala*, *C. zeylanicum*, *Crateva nurvala*, *Ficus benghalensis*, *Gmelina arborea*, *Oroxylum indicum*, *Prunus cerasoides*, *Pterocarpus marsupium*, *Pterocarpus santalinus*, *Santalum album* and *Symplocos racemosa*) were found being intraspecies adulteration [Table 4].

Surprisingly, for volatile oil and aromatic incense, an extraction (either CO<sub>2</sub> or supercritical fluid extraction) is also observed among a few marketed spices/raw drugs/RM. Sunthi (*Zingiber officinale*), Jatamansi (*Nardostachys grandiflora*), Ratanjot (*Arnebia euchroma*), Haldi (*Curcuma longa*), Lavang (*Syzygium aromaticum*), Sandalwood (*Santalum album*), Almond (*Prunus dulcis*) and Nutmeg (*Myristica fragrans*) were found somewhere as an extracted biomass. Definitely, it is in practice due to higher price, non-availability, and high industrial demands.

#### 4. DISCUSSION

About 776 herbal raw drugs/RM are used in major and small herbal industries.<sup>[4]</sup> At present, intentional adulteration of herbal raw drugs is

a burning issue due to high price, unavailability, regulatory issue, and quality compliances.<sup>[5-11]</sup> The most common problem is unintentional replacement of genuine species/RM due to multiple reasons such as higher cost of cultivation, unfair trade, illegal collection, and poor identification tools.<sup>[11]</sup> The method of standardization for individual herbs that has been described in the monographs/pharmacopoeia cannot be applied as a quality control (QC) tools.<sup>[23]</sup> The visual evaluation followed by HPLC/HPTLC method described by various Pharmacopoeias should be accomplished using chemometrics method too.<sup>[23]</sup> If the quality markers have not been yet specified for each of the raw drugs/herbs then chemical profiling or DNA fingerprinting method may be the choice for performing QC tools.<sup>[23,24]</sup> To find similarities/differences of genuine and adulterated RM, chemical fingerprints can be used to evaluate the quality of extracts and finished products.<sup>[20,23,24]</sup>

The API is the master for the regulatory, quality, purity, and strengthen of herbal raw drugs that have been formulated and sold as finished goods by the licensed manufacturers. Due to inflated demand of RM and depleting key resources, yields as per gestation periods, yields as per plants and as per acres are now dwindling to fulfill the high demand of raw drugs for the herbal industry at national and global levels.<sup>[1]</sup> Moreover, the price of raw drugs/RM is constantly rising, which restricts availability, quality, and application as herbal medicines. There is a high need to rethink, making policy and mitigation plans for the industrial MAPs.<sup>[11]</sup> Cultivated source needs commercial cultivation immediately to sustain quality and regulatory compliances.<sup>[28,29]</sup> Identification tests should be specific for the herbal raw drugs/RM and that must be alliance with macroscopic, microscopic characters, chromatographic procedures, and chemical markers.<sup>[11]</sup> API parameters and specifications are still very simple (except vol. IX) and confined with the extractive and ash values instead of biologically active marker compounds or any physical and chemical key markers, for example, identification of Marmelosin and Aegeline may be an example for Bilva (*Aegle marmelos*). Same example may be quantification of Kutkoside or Picroside with rhizomes, stolons and aerial plant parts of Kutki (*Picrorhiza kurrooa*). Supercritical extraction or any others extraction should be properly checked for aromatic plants/raw drugs/spices, for example, Sunthi (*Z. officinalis*), Jatamansi (*N. grandiflora*), Ratanjot (*Arnebia* spp), Haldi (*C. longa*), Lavang (*S. aromaticum*), Sandalwood (*S. album*), Almond (*P. dulcis*), Keshar (*C. sativus*) and Nutmeg (*M. fragrans*).

Ayurvedic industries are using a few herbal extracts of the IUCN red-listed MAPs. Notably, when plant species/raw drugs/RM availability is already questionable in the local herbal market then how can an extract available with the adequate volume and quality.<sup>[17]</sup> Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), and Critically Endangered (CE) are the sequences that how plant species are being extinct in the available wild habitats or in a particular district, state and country.<sup>[30,31]</sup> If some species are, LC as per IUCN red list category that does not mean it is currently not of concern to worry about the availability of raw drugs/RM. Meanwhile, CR/CE does not mean that RM is critical in terms of availability in local/regional market or habitats for the commercialization. Local population and nativity of the same shall matter for the available trade, demand, and supply.<sup>[11]</sup> Definitely, if a sustainable conservation or commercial cultivation plan is under practice, no doubt species/RM will be available/sustainable for a long time.<sup>[28]</sup>

Commercial cultivation of Atis (*A. heteropyllum*), Kutki (*P. kurrooa*), Pushkara (*I. racemosa*), Kuth (*S. costus*) is under practice since many decades in the higher Himalayan states e.g., Uttarakhand, Himachal

Pradesh and Jammu and Kashmir, Leh, Ladakh, Sikkim and Arunachal Pradesh.<sup>[29]</sup> Biological markers like Atisine in Atis (*A. heterophyllum*), aconitine in Vatsnabha (*A. balfourii*), picroside and kutkoside in Kutki (*P. kurroa*), inulin and alantolactone in Pushkara (*I. racemosa*) and saussurine in Kuth (*S. costus*) have generally recorded with low concentration.<sup>[28,32,33]</sup> The marker compounds or chemical constituents of cultivated species have altered due to compromised habitats.<sup>[29]</sup> The leading herbal industries and extract manufacturers such as Natural Remedies, Phyto Life sciences, Octavirous Pharma, Herbal Creations, Aethon International, Bioveda, Dabur, Emami, Baidyanath, Patanjali, Himalaya, Charak, Kottakkal, Sandu and Swastik should come forward with cultivation plan immediately, otherwise, industry will lose Grantha based/genuine, ethical formulation even when the World Health Organization is coming in front to promote traditional knowledge/medicine. National Medicinal Plant Board, State Medicinal Plants Boards, Department of Science and Technology, Department of Biotechnology, Ministry of Environment, Forest and Climate Change, and Central Drug Research Institute are also required for intervention and promotion of cultivation and protection [Tables 1-4].

If we see Google-based literature on pharmacology docking of the key ingredients then we will see a drastic downfall of the potential and quality/efficacy of herbal medicines due to continuous adulteration and inferior substitutions. Bilva (*A. marmelos*) highlights its potential as therapeutic properties due to its antioxidant and anti-inflammatory actions. Phytochemical constituents such as auraptene, imperatorin, luvangetin, and psoralen show promising pharmacokinetic profiles.<sup>[34]</sup> Physical markers (powder microscopy) and chemical markers (key active ingredients) the two smallest particle or molecule may be interlinked with Quantum Physics/Quantum Entanglement. At submission, everything is mass and energy; perhaps, human body may consume the mass with energy of the actual raw drugs responsible for different therapeutic actions.

## 5. CONCLUSION

Following identification tools are must for the authentication of herbal raw drugs/RM. (1) Etymology (physical and historical characterization of plants part name and uses). (2) Organoleptic characterization (shape, size, color, texture, taste of intact and powdered material). (3) Classical taxonomy (identification, classification, description, and documentation). (4) Chemotaxonomy (chemical markers or biologically active marker compound, that is, coumarin (<0.3%) in Dalchini (*Cinnamomum zeylanicum*), Taxol in Yew (*Taxus baccata*) and abestin in Talishpatra (*Abies webbiana*). (5) Macroscopy (physical description) and anatomy (dermal, ground, and vascular tissues) of RM. (6) Powder Microscopy (shape/size of specific cells) and (7) Targeted pharmacology/molecular docking (therapeutic property).

Commercial cultivation of the important MAPs can be defined as farming that focuses on producing agricultural products to sale in the available herbal market. Aam (*M. indica*), Amla (*P. emblica*), Atis (*A. heteropyllum*), Ashwagandha (*W. somnifera*), Brahmi (*B. monnierii*), Chandan (*S. album*), Isabgol (*Plantago ovata*), Keshar (*C. sativus*), Kutki (*P. kurroa*), Kuth (*S. costus*), Moringa (*M. oleifera*), Mushali (*C. arundinaceum*), Pushkarmool (*I. racemosa*), Rose (*R. centifolia*), Shatavari (*A. racemosus*), Tejpatra (*C. tamala*), Tulsi (*O. sanctum*) and Tobacco (*N. tabacum*) are the best example of sustained commercial/industrial cultivation which were earlier in the list of non-available RM. Immediately, we have to adopt the same for all marketed adulterated and substituted species/raw drugs/RM.

## 6. ACKNOWLEDGMENTS

We appreciate Govt. officials of CNH, Howrah (herbarium division), BSI, Dehradun, and Garhwal University Herbarium (GUH), Srinagar Garhwal for identification of the Herbarium specimens. We are also grateful to our seniors and colleagues for their kind support at Zandu Advanced Ayurvedic Research Centre (ZAARC), Emami Limited, Kolkata. CSR is always obliged to Prof. (Retd.) R. D. Gaur for their endless guidance in plant taxonomy.

## 7. AUTHORS CONTRIBUTIONS

Written by Charan Singh and reviewed by Dr. Rajiv Kumar.

## 8. FUNDING

Nil.

## 9. ETHICAL APPROVALS

This study does not require ethical approval.

## 10. CONFLICTS OF INTEREST

Nil.

## 11. DATA AVAILABILITY

This is an original manuscript and all data are available for only research purpose from principal investigators.

## 12. PUBLISHERS NOTE

This journal remains neutral with regard to jurisdictional claims in published institutional affiliation.

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#### How to cite this article:

Rana CS, Rai RK. Mitigation Plan for Adulterated Ayurvedic Herbs/Herbal Raw Drugs. IRJAY. [online] 2025;8(3):81-87.

Available from: <https://irjay.com>

DOI link- <https://doi.org/10.48165/IRJAY.2025.80314>

**Table 1:** List of herbal raw drugs/raw material, associated with herbaceous species

<b>Raw drugs as per API</b>	<b>Scientific/botanical identification</b>	<b>Plant part used</b>	<b>Adulteration in practice</b>	<b>Mitigation plan</b>
Akarakarabha	<i>Anacyclus pyrethrum</i> DC.	Root	<i>Spilanthes</i> spp.*	Regulatory approvals
Ativisha/Atis	<i>Aconitum heterophyllum</i> Wall. ex Royle	Tuberous root	<i>Chaerophyllum</i> spp./ <i>Delphinium</i> spp.	Commercial cultivation
Banapsha	<i>Viola odorata</i> Linn.	Flowers	<i>Viola</i> spp.	Commercial cultivation
Gojiva	<i>Onosma bracteatum</i> Wall.	Aerial part	<i>Borago officinalis</i>	Alternative plant species approvals
Gokshura	<i>Tribulus terrestris</i> Linn.	Fruit	<i>Pedalium murex</i> * <sup>#</sup>	Alternative plant species approvals
Jatamansi	<i>Nardostachys jatamansi</i> DC.	Rhizome	CO <sub>2</sub> extraction	Regulatory approvals
Kalamegha	<i>Andrographis paniculata</i> Burm.f.	Aerial part	<i>Swertia</i> spp.	Commercial cultivation
Kamala/Padma	<i>Nelumbo nucifera</i> Gaertn.	Flowers	<i>Nymphaea stellata</i>	Commercial cultivation
Katuka	<i>Picrorhiza kurroa</i> Royle ex Benth.	Rhizome	Aerial Plant Part	Commercial cultivation
Mandukaparni	<i>Centella asiatica</i> (Linn.) Urban.	Whole plant	<i>Hydrocotyle</i> spp.	Commercial cultivation
Masaparni	<i>Teramnus labialis</i> Spreng.	Whole plant	<i>Vigna</i> spp.	Commercial cultivation
Mudgaparni	<i>Phaseolus trilobus</i> Ait.	Seed	<i>Vigna</i> spp.	Commercial cultivation
Musta/Mustaka	<i>Cyperus rotundus</i> Linn.	Rhizome	<i>Cyperus scariosus</i>	Regulatory approvals
Parpataka	<i>Fumaria parviflora</i> Lam.	Whole plant	<i>Chenopodium</i> spp.	Commercial cultivation
Puskara	<i>Inula racemosa</i> Hook. f.	Root	<i>Inula helenium</i>	Commercial cultivation
Rasnamool	<i>Pluchea lanceolata</i> Oliver and Hiern.	Root	<i>Dendrobium</i> spp.	Commercial cultivation
Rasnapatra	<i>Pluchea lanceolata</i> Oliver and Hiern	Leaf	<i>Vanda</i> spp.	Commercial cultivation
Ratanjot*	<i>Arnebia euchroma</i> (Royle ex Benth) I.M.Johnst.	Rhizome	<i>Onosma hispida</i> /CO <sub>2</sub> extraction	Alternative plant species approvals
Safed Musli*	<i>Chlorophytum tuberosum</i> (Roxb.) Baker	Tuberous root	<i>C. borivilianum</i>	Commercial cultivation
Sati	<i>Hedychium spicatum</i> Buch.-Ham.	Rhizome	<i>Curcuma zeydoaria</i>	Commercial cultivation
Tulsi	<i>Ocimum sanctum</i> Linn.	Whole plant	<i>Ocimum basilicum</i>	Commercial cultivation
Utpala/Nilakamala	<i>Nymphaea stellata</i> Willd.	Flower	<i>Nelumbo nucifera</i>	Commercial cultivation
Vatsanabha	<i>Aconitum chasmanthum</i> Stapf. ex Holmes	Root	<i>A. balfourii</i>	Commercial cultivation

\*Non API. API: Ayurvedic Pharmacopoeia of India

**Table 2:** List of herbal raw drugs/raw material, associated with Climber species

<b>Raw drugs as per API</b>	<b>Scientific/botanical identification</b>	<b>Plant part used</b>	<b>Adulteration in practice</b>	<b>Mitigation plan</b>
Bastantri/Vidharamool	<i>Argyreia nervosa</i> (Burm.f.) Boj	Root	Stem	Alternative part use approvals
Cavika/Chavya	<i>Piper retrofractum</i> Vahl.	Root	Stem	Commercial cultivation
Guduchi/Giloy	<i>Tinospora cordifolia</i> (Willd.) Miers ex Hk. f. and Thomson	Stem	<i>Tinospora sinensis</i>	Commercial cultivation
Jivanti	<i>Leptadenia reticulata</i> (Retz.)	Root	Stem	Commercial cultivation
Kshiravidari/Vidari	<i>Ipomoea digitata</i> L.	Root/Tuber	<i>Cycas</i> spp.	Commercial cultivation
Manjistha	<i>Rubia cordifolia</i> Linn.	Root/Stem	<i>Rubia tinctorum</i> L.	Regulatory approvals
Murva/Madhurasra	<i>Marsdenia tenacissima</i> (Roxb.) Moon	Root	Stem	Alternative part use approvals
Patha/Laghu Patha	<i>Cissampelos pareira</i> Linn.	Root	Stem	Alternative part use approvals
Sariva/Anantmula	<i>Hemidesmus indicus</i> (L.) R. Br.	Root	<i>Decalepis hamiltonii</i>	Regulatory approvals
Vidanga/Krimighna	<i>Embelia ribes</i> Burm. f.	Fruit	<i>Myrsine</i> spp.	Commercial cultivation

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**Table 3:** List of herbal raw drugs/raw material, associated with Shrub species

<b>Raw drugs as per API</b>	<b>Scientific/botanical identification</b>	<b>Plant part used</b>	<b>Adulteration in practice</b>	<b>Mitigation plan</b>
Ashwagandha	<i>Withania somnifera</i> (Linn.) Dunal	Root	Stem	Commercial cultivation
Bala	<i>Sida cordifolia</i> Linn.	Root	Aerial Part	Alternative part use approvals
Beejband	<i>Sida cordifolia</i> Linn.	Seed	<i>Abutilon indicum</i>	Alternative plant species approvals
Bharangi	<i>Rotheeca serrata</i> (L.) Steane and Mabb.	Root	Stem/Bark	Commercial cultivation
Brihati	<i>Solanum indicum</i> Linn.	Root	<i>Holoptelea integrifolia</i>	Commercial cultivation
Chitraka/Chitrakmul	<i>Plumbago zeylanica</i> Linn.	Root	Stem	Commercial cultivation
Danti	<i>Baliospermum montanum</i> Muell.-Arg.	Root	Stem	Commercial cultivation
Daruharidra	<i>Berberis aristata</i> DC.	Stem/Root	<i>Mahonia</i> spp.	Commercial cultivation
Eranda	<i>Ricinus communis</i> L.	Root	Stem	Regulatory approvals
Granthiparna	<i>Leonotis nepetifolia</i> (L.) R. Br.	Root	<i>Ficus</i> spp.	Commercial cultivation
Guggulu	<i>Commiphora wightii</i> (Arn.) Bhandari	Gum Resin	<i>Boswellia serrata</i>	Commercial cultivation
Japapushpa	<i>Hibiscus rosa-sinensis</i> Linn	Flower	<i>Rhododendron</i> spp.	Commercial cultivation
Karavira	<i>Nerium oleander</i> L.	Root	<i>Gloriosa superba</i>	Regulatory approvals
Kirata/Chirata	<i>Swertia chirata</i> Buch.-Ham.	Whole plant	<i>Andrographis</i> spp.	Commercial cultivation
Pitika/Saptranga	<i>Salacia oblonga</i> Wall.*	Heartwood	Stem	Commercial cultivation
Priyangu	<i>Callicarpa macrophylla</i> Vahl	Flowers	Seeds	Regulatory approvals
Prishnaparani	<i>Uraria picta</i> (Jacq.) Desv. ex DC.	Aerial Part	<i>Desmodium</i> spp.	Commercial cultivation
Punarnava	<i>Boerhavia diffusa</i> Linn.	Whole Plant	<i>T. portulacastrum</i>	Commercial cultivation
Salaparni/Anshumati	<i>Desmodium gangeticum</i> DC	Root	Stem	Commercial cultivation
Sarpagandha	<i>Rauvolfia serpentina</i> (L.) Benth. ex Kurz	Root	<i>R. tetraphylla</i>	Commercial cultivation
Svetpunarnava	<i>Boerhavia verticillata</i> Boiss.*	Root	<i>T. portulacastrum</i>	Commercial cultivation
Tejovati/Tomar	<i>Zanthoxylum armatum</i> DC	Bark/Fruit	<i>Z. rhetsa</i> (Roxb.) DC.	Commercial Cultivation
Vasaka/Adusi	<i>Justicia adhatoda</i> L.	Root	Stem	Commercial cultivation

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**Table 4:** List of herbal raw drugs/raw material, associated with tree species

<b>Raw drugs as per API</b>	<b>Scientific/botanical identification</b>	<b>Plant part used</b>	<b>Adulteration in practice</b>	<b>Mitigation plan</b>
Amlavetas	<i>Garcinia pedunculata</i> Roxb.	Fruit Rind	<i>Rheum</i> spp.	Commercial cultivation
Asana/Vijoysar	<i>Pterocarpus marsupium</i> Roxb.	Heartwood	Sapwood	Commercial cultivation
Ashoka	<i>Saraca asoca</i> (Roxb.) De Wilde.	Stem Bark	<i>Shorea robusta</i>	Commercial cultivation
Batjata	<i>Ficus benghalensis</i> L.	Aerial Root	Stem	Alternative part use approvals
Bilva/Bael	<i>Aegle marmelos</i> Corr.	Root	Stem Bark	Alternative part use approvals
Gambhari	<i>Gmelina arborea</i> Roxb.	Root	Stem	Alternative part use approvals
Indrajava/Kutaj	<i>Holarrhena pubescens</i> Wall. ex G. Don	Bark/Seed	<i>Wrightia tinctoria</i>	Commercial cultivation
Kanchanara	<i>Bauhinia variegata</i> Blume	Stem Bark	<i>Bauhinia purpurea</i>	Alternative plant species approvals
Karkatshringi	<i>Pistacia integerrima</i> Stew.	Gall	<i>Rhus chinensis</i>	Alternative part use approvals
Lodhra	<i>Symplocos racemosa</i> Roxb.	Stem Bark	<i>S. paniculata</i>	Alternative part use approvals
Nagakesara	<i>Mesua ferrea</i> Linn.	Stamens	<i>Couroupita/Ochrocarpus</i> spp.	Alternative plant species approvals
Padmaka/Padamkast	<i>Prunus cerasoides</i> D. Don	Heartwood	Stem	Commercial cultivation
Patala	<i>Stereospermum suaveolens</i> (Roxb.) DC.	Root	<i>Dalbergia</i> spp.	Commercial cultivation
Raktacandana	<i>Pterocarpus santalinus</i> L.f.	Heartwood	Sapwood	Commercial cultivation
Rohitaka	<i>Tecomella undulata</i> (Sm.) Seem.	Stem Bark	<i>Terminalia arjuna</i>	Commercial cultivation
Swetacandana/Chandan	<i>Santalum album</i> L.	Heartwood	Sapwood	Commercial cultivation
Shyonaka	<i>Oroxylum indicum</i> (Linn.) Vent.	Root	Stem	Commercial cultivation
Talispatra	<i>Abies webbiana</i> Linn	Leaf	<i>Taxus wallichiana</i>	Commercial cultivation
Tvak/Dalchini	<i>Cinnamomum zeylanicum</i> Blume.	Stem Bark	<i>Cinnamomum cassia</i>	Commercial cultivation
Tvakpatra/Tamalapatra	<i>Cinnamomum tamala</i> Nees and Eberm.	Leaf	<i>Cinnamomum cassia</i>	Commercial cultivation
Varuna/Barun	<i>Crateva magna</i> (Lour.) DC.	Stem Bark	Stem	Commercial cultivation

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