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"THREATENED MEDICINAL PLANTS IN AYURVEDIC PRACTICE: A REVIEW OF CONSERVATION STATUS, TRADE PRESSURE AND SUBSTITUTION STRATEGIES FOR PHARMACOPOEIAL DRUGS"

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ABSTRACT
Ayurvedic manufacturing depends on a large volume of plant raw material, much of it collected from the wild. A national assessment recorded 1,178 medicinal plant species in trade in India, with an annual demand of about 512,000 tonnes in 2014–15. Of the 242 species traded at more than 100 tonnes per year, 173 (72%) were collected from the wild. Several drugs of high classical importance come from slow-growing Himalayan species whose roots or rhizomes are harvested, killing the plant. This review examines the conservation status of representative threatened Ayurvedic drugs and evaluates strategies to reduce pressure on them. Kushtha (*Saussurea costus*) is listed in CITES Appendix I and as Critically Endangered, and its wild collection is banned in India; cultivation has expanded but faces market and export barriers. Jatamansi (*Nardostachys jatamansi*) is assessed as Critically Endangered on the IUCN Red List. Katuki (*Picrorhiza kurroa*) is threatened mainly by overharvesting, with 300–400 plants uprooted per kilogram of dry rhizome. Ativisha (*Aconitum heterophyllum*) is a rare Himalayan plant for which the classical substitute Musta has shown phytochemical and pharmacological similarity. Four complementary strategies are discussed: validated pratinidhi substitution, cultivation with good agricultural and collection practices, substitution of renewable plant parts for roots, and biotechnological production. We recommend that the Ayurvedic Pharmacopoeia record conservation status and approved alternatives in monographs of threatened species, and that manufacturers report the source of these raw materials.

KEYWORDS: Threatened medicinal plants, conservation, IUCN Red List, CITES, *Saussurea costus*, *Nardostachys jatamansi*, *Picrorhiza kurroa*, substitution, Ayurvedic Pharmacopoeia

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INTRODUCTION

The growth of the Ayurvedic industry has greatly increased demand for medicinal plant raw materials. An earlier national assessment estimated demand for botanical raw drugs at 319,000 tonnes in 2005–06 and identified 960 species in trade.[1] A later assessment for the National Medicinal Plants Board recorded 1,178 traded species and an annual demand of about 512,000 tonnes in 2014–15.[2,3] Of the 242 species traded at more than 100 tonnes per year, 173, or 72%, were collected from the wild.[3] Wild collection is not sustainable for species that are slow-growing, narrowly distributed or harvested for their roots and rhizomes.

Several of these species supply drugs of central importance in classical formulations, including Kushtha, Jatamansi, Katuki and Ativisha. Their scarcity also drives substitution and adulteration in trade.[4] This review summarises the conservation status of representative threatened Ayurvedic drugs and evaluates strategies to reduce pressure on them.

METHODS

This is a critical narrative review. We consulted national assessments of medicinal plant trade, IUCN Red List and CITES listings, and published studies of selected threatened species used in Ayurveda.

REPRESENTATIVE THREATENED SPECIES

Table 1 summarises four examples.

Table 1. Conservation status and pressures for representative threatened Ayurvedic drugs.

Drug (species)	Status	Main pressures and observations	Strategy evidence
Kushtha (*Saussurea costus*)	CITES Appendix I; IUCN Critically Endangered; Schedule VI; wild collection banned in India[5]	Cultivated by farmers in Uttarakhand; declining prices; export barriers[5]	Cultivation established
Jatamansi (*Nardostachys jatamansi*)	IUCN Critically Endangered[6]	Rhizome harvested from alpine habitats	Cultivation and substitution need evaluation
Katuki (*Picrorhiza kurroa*)	Endangered to critically endangered in regional assessments[7]	Overharvesting; 300–400 plants uprooted per kg dry rhizome; habitat loss, grazing[7]	Habitat modelling identifies in situ conservation sites[7]
Ativisha (*Aconitum heterophyllum*)	Rare Himalayan species[8]	Tuber harvest	Classical substitute Musta validated in one study[8]

CITES, Convention on International Trade in Endangered Species of Wild Fauna and Flora; IUCN, International Union for Conservation of Nature.

Kushtha illustrates both the strength and the limits of regulation. *Saussurea costus* is listed in CITES Appendix I, rated Critically Endangered, and protected under Schedule VI of the Wild Life (Protection) Act, and its wild collection is banned in India.[5] A study of cultivators in Uttarakhand found that cultivation had expanded with government support, but that prices for dried roots had fallen and export was difficult under existing laws, limiting incentives.[5] Jatamansi, whose rhizome is used for its sedative and neuroprotective actions, has been assessed as Critically Endangered on the IUCN Red List.[6]

Katuki shows how harvesting practice determines pressure. Because the rhizome is the official part, harvesting uproots the whole plant, and 300 to 400 plants are needed for one kilogram of dry drug.[7] A survey of 30 alpine meadows in the Kumaun Himalaya found representative populations in only 15, and habitat modelling identified priority areas for in situ conservation.[7]

STRATEGIES TO REDUCE PRESSURE

Validated substitution

Classical texts provide for approved substitutes when a drug is unavailable.[9] Ativisha is an instructive example: Musta, a common weed, was found to share Dravyaguna properties, phytochemical features and antidiarrhoeal activity with Ativisha.[8] Where such equivalence has been shown for a given use, substitution can relieve pressure on threatened species. Unvalidated substitution, in contrast, is a form of adulteration.[4]

Cultivation

Cultivation can reduce wild collection, as the Kushtha example shows, but its success depends on stable markets, fair prices and supportive export policy.[5] Cultivated material must also be shown to match the chemical quality of wild material, since growing conditions can change constituent profiles.[10]

Plant-part substitution

For species harvested for roots or rhizomes, using renewable parts such as leaves or aerial stems would avoid killing the plant. This requires comparative evidence that the alternative part has equivalent constituents and activity for the intended use.

Biotechnological production

Cell, tissue and organ culture can in principle produce active constituents without harvesting wild plants, but these approaches yield isolated compounds or extracts that may differ from classical whole-drug preparations, and their equivalence must be established case by case.

A ROLE FOR THE PHARMACOPOEIA

The Ayurvedic Pharmacopoeia of India sets identity and quality standards for official drugs[11] but does not systematically indicate conservation status or approved alternatives. We propose that monographs for threatened species record their status under IUCN, CITES and national law; list approved pratinidhi or alternative parts with the evidence supporting them; and require manufacturers to declare whether material was cultivated or wild-collected. Such information would align quality standards with sustainability and guide manufacturers towards responsible sourcing.

A DRAVYAGUNA PERSPECTIVE

Classical texts include detailed guidance on the collection of medicinal plants, including the place, season and manner of collection, and the doctrine of pratinidhi shows that the tradition anticipated scarcity.[9] Conservation is therefore not foreign to Ayurveda. Applying these principles to today's scale of demand requires adding modern tools: conservation assessments, cultivation, chemical equivalence testing and regulation.

LIMITATIONS

This review discusses a small number of representative species and does not provide a complete cross-match of pharmacopoeial species with conservation lists. Conservation assessments are periodically revised, and the status of some species may have changed.

CONCLUSION

Ayurveda depends heavily on wild-collected plants, and several drugs of classical importance now come from threatened species. Validated substitution, cultivation, use of renewable plant parts and biotechnological production can reduce pressure on these species, provided each is supported by evidence of equivalence. Incorporating conservation status and approved alternatives into pharmacopoeial monographs would make sustainability part of the definition of quality.

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