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REVIEW

Cultivation and conservation of underutilized medicinal and agricultural plants in India

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Abstract In the current era, the increased demand of healthy food rich in antioxidants, vitamins and minerals and those having therapeutic value has led to over-exploitation of major agricultural and medicinal plants. This overburden can be reduced by an efficient utilization of underutilized plants with nutritional and medicinal importance. These underutilized plants are neglected or undervalued 'minor' crops having low production and sale. These less documented and less studied group of underutilized plants are considered as a rich source of various phytochemicals and secondary metabolites having bioactive compounds. These underutilized wild herbs that have not gained much attention from commercial as well as scientific community were selected for the present study. The present review elucidates the significance of these plants and recent biotechnological methods to conserve them. The present study on such food and medically important herbs would contribute in a wide recognition of their benefits for our society.

Keywords Underutilized · Medicinal · Agricultural plants · Cultivation · Conservation

Increased demand of healthy food rich in antioxidants, vitamins and minerals has led to over-exploitation of major agricultural and medicinal plants. The present study would contribute in a wide recognition of their benefits for our society.

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Introduction

The present COVID-19 pandemic has caused a potential threat to global health and economy and this has led to an increased attention toward medicinal plants and nutritional food rich in vitamins and minerals as about 30–50% of current pharmaceuticals drugs are plant-derived [1] Enhanced demand of major food and medicinal crops may lead to their over-exploitation which can be another threat to our floral biodiversity. Therefore, there is an urgent requirement to take necessary steps that can reduce the burden on major crops and fulfil the increased demand of supply. There are certain plant species which get little attention by the researchers and breeders and fall into the category of 'underutilized' and neglected species. In order to be categorized as an underutilized plant, the plant must possess certain characteristics like having a scientific proof of food and/or medicinal value, weak supply of seeds, being cultivated in the past and presently less cultivated, getting little attention from farmers, researchers and policy-makers.

Potential of underutilized plants

Recently, the significance of a large number of 'minor' plants having medicinal and agricultural importance came to limelight with a view to secure the livelihood of people across the world. These neglected/underutilized plants are likely to increase the sources of food, nutrition, medicines and economic growth of their native countries. Efficient utilization of these neglected natural resources may add to the available herbal medicines and plant-based drugs for the welfare of the present and future generations. In addition to this, their cultivation may contribute to an additional

source of rural income, future supply of foods and conservation of genetic resources of minor plant species. Underutilized food crops have the potential to tackle social issues like poverty, malnutrition and may contribute to nation's economic growth through enhanced employment both in urban and rural environments. Their resourceful use can reduce the burden on major crops in high demand. Varieties of underutilized vegetables are rich in nutritional value and well acclimatized to low-input cultivation methods. Their consumption can help in combating the nutritional deficiencies in rural low-income and other weak social groups. Apart from food and medicinal value, these plants may contribute to the ecosystem stability as they are well adapted to fragile environments like mountains, tropical forests and arid, semiarid lands. They possess tolerance to many biotic and abiotic stresses like drought, high salinity, pests, playing an important role in preserving our fauna diversity.

Geographical distribution

India has a rich diversity of biotic resources covering about 2.4% of global area and 8% of world's biodiversity [2]. All the three levels of biodiversity including species, genetic and habitat diversity make our country rich in medicinal plant diversity. India has an elite system of its own recognized traditional medicine including Ayurveda, Yoga, Unani, Siddha, and Homoeopathy (AYUSH), with Gujarat, Madhya Pradesh, Maharashtra, Uttar Pradesh, Rajasthan, Himalayas, Western Peninsula, Tamil Nadu, Bengal, Bihar, Assam, Karnataka being important states for the cultivation of medicinal plants [3]. There are two main regions of India's biodiversity, the Western Ghats and the Eastern Himalayas. UNESCO World Heritage Site list, 2012 includes the Western Ghats as one of the most diverse eight biodiversity hot spots across the planet. In the Indian Western Ghats, one of 36 worldwide biodiversity hot spots, over 4000 medicinal plant species have been identified, keeping it at fifth position with respect to economic potential of biological resources [4]. The Indian Himalayan region is home to 1,748 medicinal plant species most of which are highly endemic to the region [5]. Few significant underutilized medicinal plants from Indian Western Ghats include *Strychnos nuxvomica* (nux vomica), *Abrus precatorius* (crab's eye), *Leptadenia reticulata* (jivanti), *Terminalia chebula* (black myrobalan), *Nothapodytes nimmoniana* (ghanera), *Aristolochia indica* (Indian birthwort), *Achyranthes aspera* (prickly chaff) [6].

The resource pool of such medicinal plants is plentiful in our forests but with increased anthropogenic pressure, commercial collection, unsustainable harvesting and habitat loss, these reserves are dwindling fast. Therefore, in order to keep our traditional system of medicine revived, an uninterrupted supply of new/ underutilized/ threatened medicinal plants is very important. Most threatened medicinal plants are found in Jammu and Kashmir, followed by Sikkim, Himachal Pradesh, Arunachal Pradesh and Uttarakhand. Some of these endangered medicinal plants found in Himalayan region are *Coptis teeta* having anti-tumor and antibacterial activities, *Gymnocladus assamicus* used for treating swelling and abscesses, *Illicium griffithii*, an antifungal agent and food preservative, *Lilium polyphyllum* used for treating bronchial asthma and cough and *Nardostachys jatamansi* for epilepsy, and mental weakness [7–11]. Table 1 enlists some underutilized plants with both medicinal and agricultural benefits along with their geographical location in India.

Biotechnological techniques to cultivate and conserve underutilized plants

With increasing cost and side effects of allopathic medicines, plant-based herbal medicines are getting more popular owing to their long-term benefits with minimum side effects. However, over-exploitation, low seed viability, inappropriate management practices and uncontrolled ayurveda practices have put a large number of medicinal plant species on the verge of extinction. Global utilization of these plants for their herbal products with insufficient means of their cultivation and conservation are making them disappear at a high pace. Underutilized vegetable crops including lettuce, Amaranthus, Leek are also considered to be possessing high nutritional value due to their high content of micro- and macronutrients, vitamins, protein, antioxidants. These underutilized food crops have potential for income generation and national food security.

The conservation of these plants through cultivation and modern propagation techniques is of prime importance. Although sexual propagation via seeds is common but for commercial scale applications, alternative vegetative methods like multiplication by cuttings, bulbs, etc., along with advanced biotechnological propagation techniques of in vitro cultures, clonal propagation, callus-mediated organogenesis, etc., have to be routinely utilized for production of massive number of identical medicinal plants. Both in situ conservations and *ex-situ* conservations are

Table 1 List of important underutilized Indian food plants with medicinal value

S. No	Scientific name	Common name	Geographical location	Uses	References
1	*Alternanthera sessilis*	Sessile joyweed, dwarf copperleaf	Widespread in moist places, river banks, swampy marshy areas, Bongaigaon, Barak Valley, Darrang (Assam)	Used as food, and in treatment of fever, diarrhoea, anaemia, liver diseases	[21]
2	*Sesbania grandiflora*	Vegetable hummingbird, West Indian pea, Agathi, or katurai	Marshy and wet places in Assam, Maharashtra, Tamil Nadu, Uttar Pradesh	Remedy for headache, fever, congestion, sore throat and eaten as cooked vegetable or salad, and to treat headache, stuffy nose head congestion	[22]
3	*Nymphaea* spp	Water lily, pond lily	Meghalaya	Remedy for diabetes, liver and urinary disorders, menstruation problem	[23]
4	*Portulaca oleracea*	Purslane	throughout India ascending Himalayas	Rich in β carotene, folic acid, Vitamin C and essential fatty acids, used in treatment of treatment of osteoporosis and psoriasis	[24]
5	*Talinum triangulare*	Water leaf	Karnataka, Tamil Nadu, Kerala	used as diuretic, in gastrointestinal disorders, high blood pressure, anemia	[25]
6	*Ipomoea aquatica*	Water spinach	Kerala and Tamil Nadu	against piles, nosebleeds, and high blood pressure	[26]
7	*Sauropus androgynus*	Chekurmanis	Sikkim, Himalayas, Khasi, Abor and Aka hills and in the Western Ghats of Kerala	high nutritive value, rich in protein, minerals and vitamin A, B, C and antioxidants	[27]
8	*Solanum torvum*	Turkey berry, Wild eggplant	Tamil Nadu, Tripura, Northeast India	treatment of fever, wounds, tooth decay, reproductive problems and hypertension	[28]
9	*Vigna umbelata*	Rice bean, Climbing bean, Mountain bean	Northeastern hills and the Western and Eastern Ghats	Multipurpose legume eaten as vegetable, rich in vitamins and proteins,	[29]
10	*Dendrocalamus strictus*	Male bamboo, solid bamboo, and Calcutta bamboo	eastern and northeast part of India	therapy for cold, cough and fever	[30]

recommended for conservation of genetic diversity of these plants.

In situ conservation

These methods include build up of wild nurseries and natural reserves maintaining the efficacy of traditional medicinal plants in their natural habitats. Preserving these endemic plants under their natural environments help sustain their medicinal properties with efficient production of secondary metabolites. Globally, greater than 12,700 protected natural reserves have been set up covering around 8.81% of the world's land area [12]. These reserves play a significant role in protection and restoration of plants biodiversity. Wild nurseries also provide an efficient way to conserve medicinal plants which are in-demand, endemic and rare, especially those which cannot be maintained under natural reserves owing to lack of land space or cost considerations.

Ex-situ conservation

They include techniques related to protection and conservation of a biodiversity outside its natural habitat. Various biotechnological tools are now employed for regeneration and genetic transformation of medicinal plants to enhance their in vitro secondary metabolite production. These modern techniques are important for selection, multiplication and conservation of the crucial genotypes of traditional medicinal plants [13].

In vitro regeneration

In vitro regeneration of medicinal plants, through micropropagation, metabolic engineering, cell cultures, callus cultures and genetic manipulations, permits the production of pathogen-free plants with an increased multiplication rate. These advanced techniques are considered to be the most important especially in case of plant species which

are difficult to be propagated in vivo [14]. Other modern tools to preserve the gene pool of rare and endangered plant species with medicinal properties are creation of seed banks, pollen storage and genetic material banks [15].

Micropropagation

One of the in vitro culture methods involving the production and multiplication of identical plant species and recalcitrant seeds under controlled aseptic conditions is micropropagation. This method employs addition of plant growth regulators like auxins, gibberellins, cytokinins, etc., to culture medium to induce the growth of plant parts from explants. In vitro regeneration aids in the production of high-quality, disease-free plant species with great medicinal values in addition to efficient production of standard phyto-drugs. Micropropagation also benefits in conservation of plants into their natural habitat by establishment of regenerated plantlets directly into the environment. Anand and Jeyachandran et al. [16] established the micropropagation of *Zehneria scabra* (wild cucumber) used for treating diarrhea, fever, skin rashes, etc. Plant tissue culture techniques such as callus-mediated organogenesis and subsequent regeneration of traditional medicinal plants prove to be promising in rapid mass proliferation, germplasm preservation and production of secondary metabolites including drugs and other industrially important products. An efficient regeneration protocol for a medicinal plant *A. precatorius* (Crabs eye) through callus-mediated organogenesis has been established by Biswas et al. [17].

Cryopreservation

A long-term conservation method with minimum maintenance to preserve plant materials at ultra-low temperature (− 196 °C) under liquid nitrogen is cryopreservation. At such low temperature, most of the biochemical and physical processes inside a cell are arrested, which help in extended storage and preservation of plant germplasm. An important step for successful cryopreservation is vitrification process that involves rapid freezing to inhibit the formation of intracellular ice-crystal formation at this temperature. Two plant species with huge medicinal effects, *Holostemma annulare* and *Dioscorea bulbifera,* were cryopreserved for plant regeneration by Kumar and Anand et al. [18]. Researchers also reported cryopreservation of the zygotic embryos of *Celastrus paniculatus* through desiccation [19].

Seed banks

Seed banks are the preservation centers where seeds of rare plant species with medicinal and agricultural benefits are stored for future use. These banks are established to maintain and conserve plants diversity without damaging their genetic characteristics. These seed banks ensure continuous cultivation of plants in case seed reserves are not accessible to the farmers at required quantities. Indian Council for Agricultural Research (ICAR) and State agricultural universities are actively involved in production and distribution of seeds. Other voluntary or private organizations have also established seed banks across the country like Navdanya, Green foundation, Annadana Seed and Soil Savers, etc. [20]

Conclusion

Despite their recognized significance, minor plants are underutilized because of lack of awareness about their planting material and cultivation techniques. Therefore, there is an immediate need to highlight the implications and utilization of these underutilized plants and conserve their genetic resources to ensure nutritional and therapeutic supply for future generation. These tools for in vitro regeneration of medicinal plants possess incredible potential for the production of secondary metabolites in cell suspension cultures. The key for successful commercial production of secondary metabolites by plant biotechnology approach is the establishment of bioreactors. Production of genetically modified plants, especially through *Agrobacterium*-mediated transformations, further enhances the production of novel secondary metabolites from traditional medicinal plants. All these integrated approaches will provide a base for the future production of secured, efficient, and best-quality products for consumption.

Authors' contribution RG, AN and RK have contributed equally in drafting the article and critical revision for its intellectual content before submission.

Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

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