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ICAR

INDIAN Horticulture

May–June 2020

Diverse World of
Indigenous and Minor Vegetables




Diverse World of

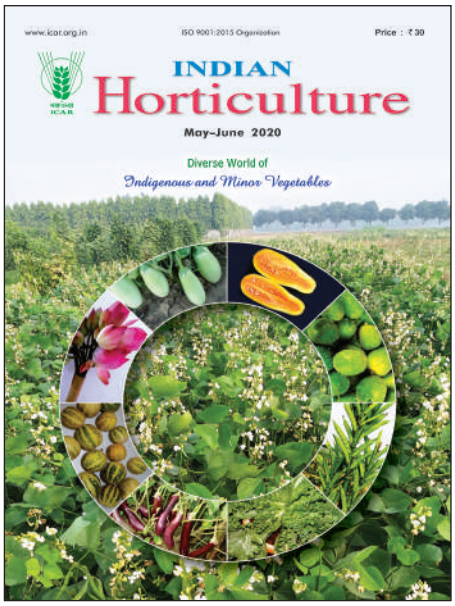
Indigenous and Minor Vegetables

The Indian subcontinent represents one of the richest emporia of 2,500 diverse plant species used as food sources. Global diversity in vegetable crops is estimated at about 400 species, with about 80 species of major and minor vegetables reported to have originated in India. Indigenous and minor vegetables are increasingly being recognized as essential source for food and nutritional security. Indigenous and minor vegetables are valuable source of genes for genetic improvement of cultivated species especially for pests and diseases resistance.






This special issue of *Indian Horticulture* on *Diverse World of Indigenous and Minor Vegetables* emphasis on the production, processing and marketing of Indigenous and Minor Vegetables which offer potential opportunities for higher gains to the growers. Despite these values, these vegetables have been neglected for many years by researchers and policy makers and there is a great need not only to conserve their germplasm but also to improve their production. It is high time to prioritize investments, providing increased economic opportunities for smallholder farmers and providing healthy diets for all. The era of Nutritional Security Revolution has begun, it's high time to realize the potential of these incredible vegetables in alleviating hunger, malnutrition and providing a thrust to their production and consumption among stakeholders.



Cover : Indigenous and Minor Vegetables

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TRILOCHAN MOHAPATRA, Ph.D.
Secretary & Director General

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THE global diversity of vegetable crops is estimated to be around 400 species, of which about 80 species of major and minor vegetables are reported to have originated in India. These indigenous and minor vegetables are primary candidates for greater use of crop biodiversity in horticulture as they are consumed locally and can be produced profitably in both rural and urban environments. Increasing use of these vegetables will lead to diversification in agricultural production system; will increase crop heterogeneity which eventually will result into better crop resilience against biotic and abiotic stresses under the changing climatic scenario. There are examples of successful pest and disease suppression and buffering against climate variability triggered by looming climate change in more diverse agro-ecosystems where indigenous and minor vegetables are likely to play greater role. To enhance food diversity and quality diets with local nutritious food including vegetables, a two-pronged approach of increasing nutrition awareness and consumer demand along with interventions to increase agricultural production and year-round supplies is required.

There is an enormous ecological diversity prevailing in our country, therefore, huge potential exists for identification, domestication and commercialisation of unique indigenous vegetables in these biodiversity rich regions. The Indian subcontinent has been one of the rich emporia of plant species used in indigenous treatment and as food sources. The vegetables described in this special issue are often more nutrient-denser than global vegetables in terms of vitamins, minerals and other health promoting phytochemicals and thus need to play as immediate and crucial role in the continuing struggle for alleviating hunger, malnutrition and improving health. As we are presently pushing the Nutritional Security Revolution; the current special issue would provide a bid thrust to the production and consumption of indigenous and minor vegetables among the stakeholders. An effort has been made by the Horticulture Division of ICAR to collate and document the genetic resources that are available in indigenous and minor vegetable crops in this special issue of the *Indian Horticulture*.

I compliment the ICAR-Indian Institute of Vegetable Research, Varanasi, for this initiative and all the contributors for their enduring efforts to bring forward this meticulous compilation.

Krishi Bhawan
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(Trilochan Mohapatra)

Message

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INDIGENOUS (traditional) vegetables are best defined as species that are locally important for the sustainability of human nutrition, health and social systems – but which have yet to attain global recognition to the same extent as major vegetable commodities. About hundreds of indigenous vegetables are consumed worldwide. These species deserve greater recognition and investment for research and development. Indigenous vegetables are primary candidates for greater use as crop biodiversity in horticulture. Variety of such vegetables are grown in respective agro-ecology for local consumption with variety of reasons. Demand for such vegetables are rising from urban areas, therefore, more acreage under such crops is expected in near future.

Indigenous and minor vegetables show very substantive biodiversity, are adapted to specific marginal soil and climatic conditions, and often can be grown with minimal external inputs. Diversifying current production systems with traditional vegetables will increase their heterogeneity and will subsequently lead to better resilience to abiotic and biotic stresses. Research is needed to understand the potential opportunities and perceived constraints faced by poor smallholder farmers in cultivating indigenous vegetables to be able to devise adoption and dissemination strategies to best meet their needs. Relatively nutrient-dense indigenous vegetables have a potential role in improving human nutrition. Amongst indigenous vegetables, specifically brinjal, cucumber, snake gourd, snap melon, ridge gourd, sponge gourd, satputia, spine gourd, bitter gourd, Indian lotus, Indian bean, cluster bean and many other leafy vegetables are important indigenous vegetable in the tropics and possess good nutrient density and are a rich source of a number of antioxidant phytochemicals and other micronutrients, viz. β-carotene, vitamin C, folic acid, magnesium, phosphorus and potassium and are often used in folk medicine. Indigenous and minor vegetables play a significant role in addressing malnutrition problems and maintaining biodiversity and ensuring incomes for poor farmers. In many parts of our country locally, adapted landraces are known as "farmer varieties" and these still contribute significantly to sustainable food production, household nutrition and increased incomes.

The vegetables covered in this special issue of *Indian Horticulture* are often more nutrient dense than commonly consumed vegetables in terms of vitamins A, C, folic acid, iron, zinc, etc. and may play a crucial role in the continuing struggle to handle micronutrient malnutrition problem widely prevalent in this country. There is a need to look at an optimal diet within a food system. An approach is needed to capture the constituents of food and the richness of taste, texture, aroma together with the cultural significance that food brings to our lives compared to supplementing the diet simply with pills, powder and pastes. As we are in the beginning of Nutritional Security Revolution and I hope the present special issue of the Indian Horticulture on **"Indigenous and minor vegetables"** will give a big push to the production and consumption of traditional vegetables. I congratulate, Dr. T. Janakiram, ADG (Hort.), ICAR and Dr. Jagdish Singh, Director (Actg.), ICAR-IIVR, Varanasi and his team for a very useful compilation.

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INDIGENOUS foods and dietary diversity within an ecosystem can be powerful sources for improving food and nutritional security. Despite this, the use of indigenous vegetables has declined due to the non-availability of these vegetables. The indigenous and minor vegetable crops have been largely ignored by commercial farming, research and development, thus becoming less competitive than well-established major vegetable crops, and gradually losing their diversity and the associated traditional knowledge. Surveys indicate that there are over 7000 plant species across the world that are cultivated or harvested from the wild for food. These underutilized species play a crucial role in food security, income generation, food culture and can contribute to nutrient requirements. Provision of and access to these food sources may be declining as natural habitats come under increasing pressure from development, conservation exclusions and agricultural expansion. In India the consumption pattern is highly variable and depends on geographic location with highest consumption mainly in rural areas. Many people consumed indigenous and local vegetables they believe would reduce some risk of certain diseases. Many rural communities have access to indigenous and traditional vegetable crops that are rich in micronutrients, which are likely to serve as a long-term strategy to eliminate food insecurity and contribute to nutrient requirements. Modern science has isolated many natural products with active principles of medicinal importance from many indigenous and minor vegetable crops. For example, *Brassica* species have been shown to contain glucosinolates, and isothiocyanates which are highly effective against cancer and heart diseases. The indigenous vegetable species are also adapted to many tropical conditions, pests and diseases. Therefore, they can be very good sources of genes for genetic improvement of cultivated species especially in pests and diseases resistance. Also, the indigenous vegetable species can be improved by introducing desirable traits from cultivated species into them.

Despite these values, these vegetables have been neglected for many years by researchers, policy makers and funding agencies and there is a great need not only to conserve their germplasm but also to improve their production.

I am confident that this special issue of *Indian Horticulture* on **"Indigenous and minor vegetables"** will help further spread of scientific knowledge on Indigenous vegetables for further improvement in traditional and minor vegetables in Indian context wherever increasing population and falling cultivable land pose impending threat to food & nutritional security. I am sure this compilation will help us to identify potential areas and plan suitable measures to achieve our targets for the future.

(T. Janakiram)
ADG (Hort.)
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Indigenous and minor vegetables of India

INDIGENOUS plant species provide a variety of products like food, medicines, raw materials and are also an important source of renewable energy. The Indian subcontinent has been one of the rich emporia of 2,500 plant species used in indigenous treatments and are utilized as food sources. The Indian subcontinent represents one of the richest diverse genetic resources. Of the estimated 2,50,000 species of flowering plants at global level, about 3,000 are regarded as food source, in which only 200 species have been domesticated. Global diversity in vegetable crops is estimated at about 400 species, with about 80 species of major and minor vegetables are reported to have originated in India. The U.N. Food and Agriculture Organization (FAO) reports that approximately 75% of the Earth's genetic resources are now extinct, and another third of plant biodiversity is predicted to disappear by the year 2050.

Indigenous (traditional) vegetables are best defined as species that are locally important for the sustainability of economies, human nutrition, health and social systems – but which are yet to attain global recognition to the same extent as major vegetable commodities. In general, vegetables are the key component of balanced human diet and are also the main drivers in achieving nutritional security by providing essential micronutrients, vitamins and minerals such as potassium, vitamin C, Vitamin-B6. In addition, They are an important source of an array of phytochemicals that play important role as antioxidants, phytoestrogens and anti-inflammatory agents and through various protective mechanisms protects the human body from a number of lifestyle diseases. Spectacular growth in vegetable production has been achieved, which was possible due to development of improved varieties/hybrids as well as production and protection technologies through systematic research coupled with large scale adoption by the farmers. However, this remarkable production was contributed by only few major vegetables. Endowed with a wide diversity of agro-climatic conditions, India is virtually a herbarium of the world. This diverse agro-climate in the country permits to grow more than 60 cultivated and about 30 lesser known vegetable crops which are not all indigenous. Many rural households including people residing in the tribal areas still depend on the traditional leafy vegetables to a great extent for their food security strategies. Traditional leafy crops are important fresh crops during the rainy season and are especially important in dried form during winter and spring seasons as a source of cheap protein. Bitter gourd, despite its distinctive appearance and bitter taste, originally from the Indian subcontinent, is popular in a number of Asian countries. The triterpenoid momordicin, responsible for the bitterness of this vegetable, has been demonstrated to have anti-diabetic activities. Another triterpenoid from wild bitter gourd has been shown to inhibit breast cancer cells.

Although, some of these indigenous vegetables are widely harvested and consumed, but there is an increasing concern that their use is declining in the rural areas. The importance of these indigenous vegetables in the food security strategies is being limited due to loss of the biodiversity and the associated indigenous knowledge. Their potential contribution to food security, nutrition, health, income generation, and ecosystem services for the wellbeing of mankind is still largely under-exploited.

Indigenous vegetables are primary candidates for greater use of crop biodiversity in horticulture as they are already consumed and enjoyed locally and can be produced profitably in both rural and urban environments. Conservation and sustainable use of the genetic resources of indigenous vegetable crops offer a tremendous tool for addressing the problem of food security – both inadequate quality and quantity – at national and household levels. The food base for the rural population, especially in the marginal and semi-arid areas, has become narrower, leaving communities more vulnerable to food shortages and nutrient-deficiency diseases. Wild and weedy species, commonly used as vegetables in the past, are disappearing as a result of changes in customs and land use. Local knowledge about the cultivation and management of these species is on decline as well. At the same time, producers lack knowledge of more efficient, intensive production and management techniques. There is also a lack of knowledge about nutritive value and cooking methods that minimize nutrient leaching during food preparation.

Thus, there is a need to promote the use of indigenous and minor vegetables, and hence their production, by carrying out research on nutritive value, agronomy and value addition, in particular focusing on the role of vegetables in alleviating malnutrition among certain vulnerable groups in the community.

This issue highlights important indigenous and minor vegetables and their use in alleviating hunger, malnutrition and improving health. Besides, it can serve as an important bunch of information to academicians, researchers and agrarian communities.

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A K Singh, T Janakiram and
Jagdish Singh

Status of indigenous and minor vegetables Research – Way forward

NUTRITION has captured the international spotlight in an unprecedented way as persistent global hunger and under nutrition has underscored the need for urgent action. One in eight people around the world still suffer from hunger, and more than double that number are victims of hidden hunger. Indigenous (traditional) Indian vegetables can make an important contribution to food and nutritional security and can enhance the livelihood of marginal and smallholder farmers. In comparison with globally important vegetables, indigenous vegetables have been shown to be rich in micronutrients such as iron, zinc, pro vitamin A and phytochemicals that help protect people against non-communicable diseases. In addition to their nutritional and medicinal importance, indigenous (traditional) vegetables are considered valuable because of their ability to fit into year-round production systems. Many indigenous vegetables have high yields within a short period of growth, are easy to harvest with minimum labor and have widely acceptable taste. Despite the wealth of agronomic, economic and nutritional benefits, indigenous vegetables provide, the production and marketing of these crops are constrained by factors such as poor quality and availability of quality seeds and other production-related risks, lack of appropriate market information and support systems (e.g., cold storage), high postharvest losses – all of which prevent farmers from exploiting the opportunities indigenous vegetable crops present. This partly stems from the fact that most past and some ongoing efforts to address food security have concentrated on the provision of calories by enhancing the availability of staples, particularly cereals, and root and tuber crops, rather than placing emphasis on appropriate nutritional elements that can be attained from a balanced diet. Awareness of the importance of nutrition has recently increased in many parts of our country, which should create new opportunities for indigenous (traditional) vegetables. Research is needed to better understand the potential opportunities and perceived critical bottlenecks faced by smallholder farmers in their decisions to produce and consume indigenous vegetables to devise effective dissemination and adoption strategies. The underlying factors on the supply side of vegetable consumption outcomes seem to be quite well understood, but the socioeconomic behavioral constructs of producers and their perceptions of the nutritional benefits of indigenous vegetables from the demand side require further evidence. Since plants were first domesticated, our Indian societies have used indigenous vegetables to meet their nutritional needs. Depending on the region considered, most of these indigenous vegetables are found as weeds in wild and/or cultivated areas, are semi-cultivated, or are grown as crops that require very little management or additional inputs. It is generally believed that Indian indigenous vegetables are old-fashioned foods used mainly by 'backward' rural people and destined to be superseded by "more modern" vegetable species. However, the evidence shows that these plants are rich in micronutrients, are crucial to the household food security of millions of low income people,

Brinjal – Ramnagar Gaint

Dudaim melon

and are emerging as cash crops as demand increases. In nearly two-third of the households in NEH region, for example, leafy vegetables are prepared four to seven times a week. Nutritional studies have shown that most indigenous vegetables have higher levels of protein, vitamins (A and C), carotene and minerals, compared to cereals and fruits. Moreover, numerous studies have shown that indigenous vegetables are important for both subsistence production and income generation, especially in urban and peri-urban cropping systems. Despite the contribution of indigenous vegetables to food security, nutrition and income, the lack of resources allocated for the development of the vegetable sector has meant that in our country they have not received the attention they deserve. Until recently, most research and development efforts have focused on improving production systems for exotic vegetables, and have ignored the more diverse and abundant indigenous species and varieties and the ways in which they are used.

Indigenous vegetables are increasingly recognized as essential for food and nutrition security. Indigenous vegetables production provides a promising economic opportunity for reducing rural poverty and unemployment and is a key component of farm diversification strategies. Today, neither the economic nor nutritional power of indigenous vegetables is sufficiently realized. To tap the economic power of indigenous vegetables, governments will need to increase their investment in farm productivity (including improved varieties, alternatives to chemical pesticides, and the use of protected cultivation), good postharvest management, food safety, and market access. To tap the nutritional power of indigenous vegetables, consumers need to know how these vegetables contribute to health, and find them at affordable prices or be able to grow them themselves. Indigenous vegetables consumption must therefore be nurtured through a combination of supply-side interventions and behavioral change communication emphasizing the importance of eating vegetables for good nutrition and health. To fully tap the economic and nutritional power of indigenous vegetables, governments and donors will need to give indigenous vegetables much greater priority than they currently receive. Now is the time to prioritize investments in indigenous vegetables, providing increased economic opportunities for smallholder farmers and providing healthy diets for all. Food security has long been associated with a vision of an abundance of grains, roots, and tubers – the staple crops that provide affordable sources of dietary energy. But this picture is changing as the concept of nutritional security has become embedded in that of food security and the importance of dietary diversity for good health has moved to the fore. Healthy, high-quality diets require the consumption of a wide range of food categories in the right quantities. Globally, the prevalence of hunger has declined, indicating progress in ensuring adequate access to staple foods as measured in terms of calorie intake. But an estimated 2 billion people are affected by insufficient intakes of micronutrients (WHO, 2016) and a further 2.1 billion people are overweight or obese. Potassium in indigenous vegetables helps to maintain healthy blood pressure, their dietary fiber content reduces blood cholesterol levels and may lower the risk of heart disease, folate (folic acid) reduces the risks of neural tube defects, and vitamin A keeps eyes and skin healthy, while vitamin C not only keeps teeth and gums healthy but also aids in iron absorption and supply needed micronutrients (especially calcium, iron, iodine, vitamin A and zinc). Indigenous vegetables also typically provide more employment per hectare than cereals; on an average 297 labour-days per hectare per season against 116 labour-days for cereal production. Particularly for youth, indigenous vegetable farming may offer a profitable business opportunity. Indigenous vegetables including traditional vegetables production, processing and marketing offer potential opportunities that can be especially attractive to youth: production requires only small amounts of land, is technology-sauvy, and high profits can be obtained in a relatively short period of time. Public investments in infrastructure, training and subsidies in support of value chains could advance such employment. The potential of indigenous vegetables to generate positive economic and nutritional impacts, however, has been limited by the relatively low levels of support that national governments and international donors direct to public sector vegetable research and development. Public and private investments in agriculture are still largely focused on staple crops and

Dark purple brinjal

Greenish purple brinjal

oil crops, not on commodities rich in micronutrients. There are indications of underinvestment in indigenous vegetable research, especially by the public sector and in improving 'indigenous' or 'traditional' vegetables that primarily reach local and regional markets.

Indigenous vegetable crops

The indigenous vegetable crops are popular and culturally known native varieties. Every region of our country has unique traditional vegetables that are widely consumed by a group of people, or by a particular community. The traditional vegetables and based products that once occupied a part of the regular Indian diet are lost in time due to the emphasis on mono-cropping post-Green Revolution. The revival of indigenous vegetable crops is necessary, measures should be carried out to conserve the indigenous vegetables of the nation and also to carry knowledge to the future generations by reviving the crops back into cultivation. The government of India may initiate the acquisition and management of germplasm of all indigenous vegetables by the Indian National Genebank at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi. Furthermore, the primary factors that contribute to the revival of indigenous vegetable crops include the passion of farmers, administrative measures initiated by the stakeholders, and the marketing strategies of vendors. Additionally, the knowledge about the health benefits of indigenous vegetable crops may also prevent its extinction and ensure the availability of these foods in local markets and the methods of cooking for future generations. Nevertheless, the revival of indigenous vegetables crops is possible only when all the stakeholders define and bring these crops under a special category similar to the one initiated in Kyoto, Japan. In Kyoto Prefecture, the "native varieties" are categorized into "Kyo-no-dento-yasai," and outside the prefecture, it is called "Brand-Kyo-yasai". Additionally, traditional vegetables led-food products of India may be collectively registered with the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) Food Heritages as Intangible Cultural Heritage of Humanity similar to the registrations obtained for the washoku, a traditional dietary culture of Japan; the kimjang and kimchi of Republic of Korea; the Le repas gastronomique des Français (the gastronomic meal) of France; the Mediterranean diet; traditional Mexican foods; and the ceremonial keşkek of Turkey. India may also adopt a geological indication (GI) for the traditional products like the one followed in the European Union and Japan.

Traditional health perceptions

Though Indigenous (traditional) vegetables were predominantly used as food source but some of them also got acclaimed for their medicinal properties. Local people use them for curing the health problems like anemia, vision, skin problems, digestive irregularities, scurvy, wound healing, intestinal worms etc. The indigenous vegetables of islands have manifold traditional health perception. *Ipomea aquatica* for heat strokes and *Enhydra flactuans* for small pox. Tribes also use leaf paste on face and hands to prevent from sun burn or UV rays.

Stress tolerance of indigenous vegetables

The indigenous vegetables have better tolerance to biotic and abiotic stresses which reduce the use of chemical inputs and favour ecosystem concept. Biotic tolerance could be due to their phytochemical profiles which contribute in insect repellence or inhibit establishment or growth of microbes. Abiotic stress tolerance is also inherent in their genetic makeup which is established by the natural selection process. These species face two contrast climatic extremities like drought, high incidence of ultra-violet (UV) rays and high canopy temperature during dry months, and water logging, high humidity (>90%), low sun light, weed competence, poor soil conditions during prolonged rainy season. These indigenous vegetables might have common or different survival mechanisms in such stress situations which is an investigable issue.

Household fortification with indigenous vegetables: a new concept

The indigenous vegetables have less preference among children particularly in rich and educated rural and urban households than exotic vegetables. Thus, high content of micronutrients in these vegetables can be supplied to children through household fortification of their staple foods or fast food items like biscuits, *idli*, *vada*, *pakora*, sandwich, chutney, *paratha*, *kurkure* etc at household or *aganwadi* or school (mid day meal scheme) levels. This concept will help in increase in intake of essential micronutrients like Ca, Zn, Fe, β-carotene and ascorbic acid contribute by these vegetables. The concept will assist in targeting the micronutrient malnutrition along with food security schemes in marginal communities. The powder of drumstick, palak and broad dhaniya is used for supplementing the dietary items for pregnant women and children in health conscious households. Amongst other indigenous vegetables, cucurbits, specifically bitter gourds (*Momordica charantia*) which are important indigenous vegetables in the tropics and possess good nutrient density. Bitter gourd fruits are a rich source of β-carotene, vitamin C, folic acid, magnesium, phosphorus and potassium. The fruits are often used in folk medicine to treat type

Large deep purple brinjal

Summer Squash

II diabetes, a rapidly spreading non-communicable disease that afflicts millions of people. In addition to the fruits, which are eaten stir-fried, in soups, pickled or raw, the young tender shoots of bitter gourd also can be consumed.

Rescue, conservation and utilization of the genetic diversity of cultivated and wild forms of Indigenous vegetables under threat of genetic erosion

Competition for the ever-shrinking land area available and suitable for horticultural crop cultivation is increasing due to rapid human population growth. Indigenous vegetables and other neglected and underutilized plant species compete for land, water and labour resources with other crops and with many other human activities, especially in peri urban areas. Genetic biodiversity in all cropping systems and in home gardens is under constant threat from habitat loss, overexploitation of land for commercial or subsistence reasons, the introduction of exotic species, and rapid urbanization. These factors discount the importance of many indigenous vegetables as mainstays of a number of local communities for food, nutrition, income and for their medicinal value. For example, while still holding only a niche market in NEH region, indigenous vegetables are regularly produced and gathered for home use and also sold fresh or in semi-processed form at both local open markets and urban supermarkets. The market share of indigenous vegetables in our country has been going up recently, accounting for about 35% of overall vegetable sales. Likewise, the consumption of indigenous leafy vegetables has been increasing in several parts of country. Similarly, in region of eastern ghats, western ghats and north west Himalayan region of India many indigenous vegetables are either collected from the wild or are cultivated. The products are sold fresh in the harvesting season, dried and used in home consumption during 'hungry months', or sold in markets for income generation. Regional demand for vegetable crops of underutilized indigenous species needs to be better identified, particularly for the collection of those species showing traits of high yield, good quality, resistance to diseases and pests, or tolerance to abiotic factors. Nevertheless, research and development funding for indigenous vegetable crops is chronically deficient – a situation that demands urgent attention. The factors likely to predetermine support for research and development funding for these crops are, first, an enhancement of descriptors of the socio-economic and cultural value of indigenous vegetables; second, actions to counteract their perceived stigma as 'famine foods' among the general public, and third, better provision of the evidence of their potential for wide use in overcoming malnutrition through effective, balanced diets. Indigenous vegetables often are the principal sources of essential micronutrients especially for the poorest people, as shown from surveys of people across a wide range of incomes in different part of the country. More research is needed to strengthen the case of the value to society of indigenous vegetables, such as indigenous vegetables also holds high levels of anti-inflammatory phytochemicals such as flavonoids and other antioxidants that are of value to human health. Our indigenous vegetables play a significant role in addressing increasing incomes, reducing malnutrition and maintaining biodiversity. Traditional leafy vegetable diversity is an important part of bio-cultural heritage, particularly with regard to food security, nutrition and health. In many part of our country locally adapted landraces are known as 'farmer varieties' and these still contribute significantly to sustainable food production, household nutrition and increased incomes. Typically, landraces are mainly grown for family use or for the local market. Indigenous leafy vegetables can provide a substantial contribution not only to poverty reduction but also to increasing food security and maintaining health in vulnerable communities, as indigenous leafy vegetable production can often be done with little capital investment. These indigenous vegetable crops have been neglected by researchers, policy makers and funding agencies and are currently threatened with extinction, which would mean a substantive reduction in biodiversity. Indian indigenous vegetables have yet to be fully integrated into the mainstream of agricultural production. The introduction of new vegetable varieties into traditional agro-ecosystems is one of the major factors driving genetic erosion, can lead to loss of landraces and associated local knowledge. The main objective is to conserve indigenous vegetable germplasm and to provide seeds of the crops that are vital to meet the nutritional needs of the Indian population and to determine whether

Round Summer Squash

such crops have opportunities for expansion at a national level. Opportunities remain in Indian environments for *in-situ* strategies for vegetable species to conserve crop evolutionary processes and provide scope for ongoing evolution, particularly in response to environmental changes, and pathogen and pest pressures which fluctuate in numbers and genetic composition. The preservation and utilization of crop genetic diversity is of particular importance in the more marginal, diverse agricultural environments where modern plant breeding has had much less success. Moringa (*Moringa* spp.) is a well-known, very versatile, high-nutrient density vegetable crop in most tropical countries, and is most commonly produced in home gardens rather than in cultivated field situations. The few existing breeding programs have yet to produce consistent success. National gene banks need support and encouragement to increase and fully categorize their collections of local indigenous vegetable germplasm now and into the future.

How can the lack of quality seed be overcome?

Lack of a sustainable supply of quality seeds is the main bottleneck in the development of indigenous vegetables, with more than 75% of seeds being supplied through informal sources. Until very recently farmers were the sole sources of such seeds with informal supply systems remaining important, particularly for indigenous vegetable crops. More recently private seed companies have been encouraged to help in the role of public organizations as a formal approach to seed systems, but with varying levels of success in the indigenous vegetables sector. Community seed production and storage systems must be set up in villages, where growers can be trained to produce reasonably genetically pure seed to store in low relative humidity conditions after drying. The availability of quality seed for indigenous vegetables can be increased through the development of primary and elite seed production facilities in research institutes and by the private sector. Training farmers to develop specialized skills for seed multiplication and encouraging them to become contract seed growers for the private sector would be a major factor in overcoming the present poor and irregular seed supply. Farmer training to improve efficiency in pesticide use, harvesting, seed extraction, and seed marketing has shown that seed yields can be increased substantially. The mounting interest in consumption and use of indigenous vegetables demands that this situation now be addressed effectively. The breeding programmes for indigenous vegetables are in its infancy; selections are made from within existing natural populations (landraces) and gene bank accessions. The public sector has released a few improved cultivars of these crops, but may not produce enough seed for wide distribution. Some exceptions exist, such as the Indian Institute for Horticultural Research in Bengaluru, which has its own seed production and distribution agency. Other actors in the seed production sector can include non-governmental organizations (NGOs) involved in agricultural development, disaster relief and rehabilitation. World vegetable center, in collaboration with a local NGO in the eastern part of India, started producing superior home garden seed for year-round production of vegetables, including indigenous vegetables such as green leafy types (Malabar spinach and kangkong) and gourd species (bitter, bottle, ridge, etc.). A range of indigenous local vegetables are being tested for year-round cultivation such as kangkong, Indian spinach, bitter gourd, ridge gourd, snake gourd and eggplants. Ensuring the availability of quality seed is a key issue to assure the sustainability of home gardens with indigenous vegetables. Private sector seed companies and large NGOs have expressed keen interest in this new market and seed packs for small-scale home gardens which can now be purchased widely in the country. The nutrient-dense nature of many indigenous vegetables and their adaptation to local environments makes them most appropriate for NGOs that address problems of hunger and malnutrition. Collaboration between the research system, extension, seed (formal and informal seed systems) and NGOs is very important if the potential of indigenous vegetables is to be adequately exploited to improve nutrition, food security and income generation. Community seed production projects that can be classified as a semi-formal system have become quite common to address the widely known spatial, time, information and value gaps which inhibit development of the seed sector, provision of emergency seed relief, or simply the generation of income, but they often require external support with corresponding challenges regarding their sustainability.

Plant insect interactions

Information on the major insect and mite pests constraining indigenous vegetable production is scanty.

Jack bean pods

Snap melon

Monitoring the incidence and infestation of various insect and mite pests on selected indigenous vegetables is being carried out by entomologists at different ICAR institutes. Aphids are common in nightshade (*Solanum nigrum*) and on mint (*Mentha* spp.), reducing the quality of the produce. *Solanum torvum* fruits are readily infected by the eggplant fruit and shoot borer (*Leucinodes orbonalis*) and act as reservoir for the pest in entire India. Changing climate, especially increased carbon dioxide (CO_2) concentration and rising temperatures, may substantially alter the status of a pest species. Besides CO^2, temperature also impacts insect pest species. Climate change may also modify the performance of natural enemies under field conditions. Understanding the population dynamics of different phytophagous insects and their natural enemies in indigenous vegetable production systems will become a major scientific issue as the world warms rapidly.

Developing integrated pest management strategies

(i) Host plant resistance offers great scope for avoiding pest damage on indigenous vegetables.

(ii) Sticky traps have been widely used in the management of sucking insects such as thrips, whiteflies and leafhoppers. However, recent findings have shown that use of kairomones (volatile chemicals from host plants) increased trapping of some thrips species up to six-fold. This strategy can be combined with the use of entomopathogens has effectively controlled thrips. These novel strategies could be validated for use against the sucking insects on different indigenous vegetables.

(iii) Pheromones are widely used as monitoring and/or mass-trapping tools in integrated pest management programs. Effective pheromone lures are commercially available for pests such as *H. armigera*, *S. litura* and *P. xylostella*, and are being used in pest monitoring.

(iv) Given the short harvest intervals of most indigenous vegetables, biopesticides are highly suitable for pest management as they leave no residues and thus have no requirements for pre harvest intervals. Several commercial *B. thuringiensis*, nuclear polyhedrosis virus (NPV), *M. anisopliae*, *B. bassiana* and neem (*Azadirachta indica*) products have been registered for the control of *S. litura*, *H. armigera*, *P. xylostella*. These biocontrol agents may have a much greater role in the future for defending indigenous vegetables against key pests globally. Formulated essential oils from the neem and tea trees (*Melaleuca alternifolia*) were tested for their toxicity against *A. gossypii*.

Importance of plant diseases on sustainable production of indigenous vegetables

Information about yield losses of indigenous vegetables caused by plant diseases is very limited. This is largely due to the meager research efforts devoted to such neglected crops. Nevertheless, potential yield losses have been indicated from the results of surveys conducted by different agencies. Farmer knowledge of plant diseases of indigenous vegetables is insufficient. Damage caused by less conspicuous problems, such as viruses, nematodes, and wilting were not regarded by farmers as diseases but as issues caused primarily by climatic factors. Their knowledge of diseases affecting global crops was better than that for indigenous vegetables. The need to enhance the capacity of both scientists and farmers at the national level on disease diagnosis and management, as well as the different management options, is urgent.

Can postharvest management be improved, thus making market chains more effective and profitable?

Like other horticultural crops, indigenous vegetables are very often perishable and are easily damaged by poor handling. Careful attention must be given to handling at harvest, during transportation, during value addition, transport to market, and in storage. In most cases this requires considerable investment in ensuring good grower/packer knowledge of suitable postharvest handling techniques, the availability of appropriate on-site or nearby cooling facilities, suitable good quality packaging, and effective transport and storage infrastructure. Postharvest problems that occur during handling and storage include loss of moisture, which leads to weight loss and thus value of the product at market. Many indigenous vegetables are leafy types, and are very susceptible to wilting and weight loss. Quantitative information on the extent of postharvest losses of indigenous vegetables is limited, but some studies indicate that up to 23% of brinjal is lost on farm. Optimum storage temperature regimes have been elaborated for most crops; information on oxygen and carbon dioxide levels for modified atmosphere storage require further development. Optimum temperature for bitter gourd has been worked out to be 12-13°C. Postharvest methods suitable for resource poor farmers are being developed to prolong the shelf life of indigenous vegetables, such as the use of ice in bottles packed with leafy vegetables – a modification of the top icing treatment for greens. Low cost treatments such as the use of 2% bicarbonate wash to reduce microbial contamination have been developed and tested and are being promoted by ICAR-IIVR, Varanasi for suitable indigenous vegetables. It is generally recommended to place vegetable crops in a cool environment to prolong their shelf life. The use of cold rooms and cooling equipment that are mechanically powered is now widespread and very effective, but many smallholder producers do not have

Basella – bush type

access to such equipment and the necessary infrastructure such as a regular electricity supply may not be available. Evaporative cooling principles can be employed using various materials such as using shade and covering vegetables with moist hessian sacks or using charcoal/ moist brick walled structures to provide lower cost cooling options. Effectiveness will depend on the ambient humidity but results from trials show temperatures can be reduced by about 4°C and can thus help provide a longer useful storage period even in high humidity environments. The use of these methods will allow smallholders to deliver a higher quality product. These value chain linkages have used the methods highlighted above, including evaporative coolers and improved packaging such as plastic crates for transporting the crop, and have enabled growers to deliver a higher quality product to market. Improvements in knowledge of postharvest handling requirements for vegetable crops and use of the opportunities for better market linkages mean that growers and traders should be able to increase their income from the production and marketing of indigenous vegetables as demand for these crops increases among consumers.

Can greater consumption of such diverse and nutritious indigenous vegetables be encouraged, knowing that changing dietary habits is a difficult exercise?

A growing population is now conscious of the need for healthy diets. This enhanced awareness may increase the consumption of indigenous vegetables, as seems to be the case in many parts of the country. Sharing and disseminating information about the different indigenous vegetable types and species, their nutritional value for health, and how they can be source of income generation can be done through extension events (farmer days, women's groups and youth training, recipe formulation, preparation and testing) and exposure in the mass media in which indigenous vegetables can be further popularized. Consumption of an important, health-promoting indigenous vegetable such as bitter gourd can be encouraged by breeding non-bitter or less bitter cultivars that may be more palatable to different consumers and developing bitter gourd recipes that increase phyto nutrient retention but moderate the bitter taste. However, this must not compromise the anti diabetic and deworming qualities of the vegetable, which may be associated with its bitter chemistry. In addition to policy makers, the public needs to be well-informed about accessible and affordable sources of micronutrients and antioxidants. A strong promotional campaign is required at the national level to enhance consumption and better understanding of the benefits of nutrient-dense indigenous vegetable crops. This need for popularization should go beyond traditional dissemination activities to reach larger number of people as quickly as possible. Studies that can provide more in-depth information and knowledge about the nutritional value of indigenous vegetables will also help to enhance their use. Many factors have limited greater consumption of indigenous vegetables, including (1) loss of traditional knowledge and skills in their utilization, especially following large-scale urban migration; (2) low priority given to research on improvement of local indigenous vegetable landraces to meet production and market requirements; (3) the highly perishable nature of leafy indigenous vegetables compared to cabbage, onions and eggplants; (4) altered or changing consumption patterns and food habits; and (5) food systems characterized by easier (physical and economic) access to foods of low nutritional quality. Factors influencing food systems (from agricultural inputs to market and consumption factors) and nutritional outcomes need to be taken into consideration in problem analysis, research and design of possible interventions. Strategies can be incorporated into programmes to enhance public awareness and increase consumer knowledge about the benefits of healthy, balanced diets, eventually leading to sustainable behavior changes that will increase demand for more local nutritious food, which will include indigenous vegetables. Changing diets is difficult but can occur, as has been observed over the last decade with the success of moringa as a vegetable in our country, where this little-known seasonal crop is sold throughout the year in principal markets and is recognized as a highly nutritious and valued vegetable.

Developing capacity in research, teaching, policymaking, trading and farming of indigenous vegetables

The entire agricultural sector needs to recognize the importance of indigenous vegetables and to protect

and conserve traditional knowledge about indigenous vegetables for future generations. This means training farmers and other groups along value chains, for example, crop management, producing good quality seed, selecting varieties, intercropping systems, managing soil health, adding value and developing products, packaging and marketing. Training is particularly important for women as it empowers them to play an important role in taking indigenous vegetables to markets. Broadening agricultural curricula to include the conservation and use of indigenous vegetables along with the staple crops will encourage young scientists to take food and nutritional approaches to agricultural development. Information campaigns can help convince policymakers of the need for incentives and support for programmes promoting the use of indigenous vegetables. Supporting the development of infrastructure and institutions, such as providing better cultivation tools, processing machinery and storage facilities, will also be important.

Put in place legal frameworks, policies and financial incentives to promote indigenous vegetables and encourage agricultural diversification

Policies, such as including indigenous vegetables in school feeding programmes and promoting them as components in sustainable diets, enriching food aid with nutritious indigenous vegetables and subsidizing cultivation and marketing of indigenous vegetables, can encourage their use. Incentives can support farmers to grow and conserve indigenous vegetables on-farm, and can be complemented by incentives to conserve indigenous vegetables *ex situ*. Governments can mainstream indigenous vegetables best practices, methods and tools into routine operations. Financial support can take the form of schemes such as payment for conserving agro biodiversity. At the international level, including indigenous vegetables in the International Treaty on Plant Genetic Resources for Food and Agriculture will be important.

Undertake more research on indigenous vegetables, particularly with regard to their adaptive qualities and the links between indigenous vegetables and nutrition and livelihood

Investing in research on indigenous vegetables will help realize the full potential of these crops. Properly documenting, characterizing and collecting and sharing data on indigenous vegetables are essential. In particular, research on the nutritional aspects of indigenous vegetables, and their adaptive traits are important. Research will need to include molecular work to identify indigenous vegetables material suitable for breeding. Links between scientific and traditional knowledge systems will need to be created and inter-disciplinary research networks established.

Encourage collaboration in research, promoting, conserving and sustainably using indigenous vegetables and coordinate activities and multi stakeholder platforms across sectors

More needs to be done to ensure that indigenous vegetables are no longer ignored and neglected by researchers and markets. This means strengthening cooperation among stakeholders and creating synergies at national, regional and international levels. Coordination to promote indigenous vegetables at different levels and in different areas will help establish common approaches, such as standard methods for documenting and monitoring on-farm conservation and international policies for trading indigenous vegetables. The current lack of interaction across sectors (agriculture, nutrition, health, education) and stakeholder groups (farmers, researchers, value chain actors, decision makers) limits the potential of indigenous vegetables. Mechanisms and processes that facilitate strategic synergies among national, regional and international networks, and collaborative platforms, need to be encouraged and supported. Indigenous vegetables are nutritional powerhouses, key sources of micronutrients needed for good health. Indigenous vegetables add diversity, flavor, and nutritional quality to diets. A strengthened focus on indigenous vegetables may be the most direct and most affordable way to deliver better nutrition for all. Indigenous vegetables are also economic engines for productive, profitable agricultural economies. Intensified indigenous vegetables production has the potential to generate more income and employment than other segments of the agricultural economy, making indigenous vegetables an important element of any agricultural growth strategy. Today, however, neither the economic nor the nutritional power of indigenous vegetables is sufficiently realized. Governments and donors need to raise the priority given to increasing the productivity of indigenous vegetables production systems, reducing postharvest losses, and increasing affordability and market access. With a growing understanding of the linkages between dietary quality and health, policymakers must also be prepared to support additional interventions to promote indigenous vegetables consumption.

Involve the full range of stakeholders in participatory partnerships to promote and conserve indigenous vegetables, particularly farmer and women's organizations

Addressing challenges, needs and opportunities related to promoting indigenous vegetables calls for active collaboration with local communities and mainstreaming gender-sensitive approaches. Through each step of the research and development processes, stakeholders – from smallholder farmers to policymakers – must be consulted and involved through open participatory processes. Farmer organizations and traditional seed systems can help make programmes to promote the relevance and effectiveness of indigenous vegetables more effective.

Find innovative ways to upgrade indigenous vegetables market chains and develop and market value-added products

Key priorities in marketing indigenous vegetables are improving access to markets, adding value and stimulating demand. Because new technologies developed for commercial crops are not always suited to traditional indigenous vegetables, this means finding innovative

Basella alba

solutions to simplify processing, create new products and establish multi-stakeholder platforms for indigenous vegetables value chains. Top chefs, restaurants and food retailers can play a leading role in promoting the use of indigenous vegetables in gastronomy and food systems.

Conservation plans for the indigenous vegetables

Setting up national indigenous vegetables conservation programmes will strengthen *in situ* conservation of wild species and *ex situ* conservation in gene banks. A combination of *in situ* and *ex situ* approaches will empower local farmers, particularly women. To do this, local, national, regional and international agencies can finance programmes to conserve and use indigenous vegetables, and leverage existing mechanisms and programmes that focus on major staples and commodity crops.

Genetic erosion constitutes great threat to human survival. The extent and impact of the erosion may not be visible to the present generation. Future generations will have to pay dearly for the carelessness of the earlier generations. In order to prevent this future disaster, the following step-wise conservation plans are suggested for the indigenous leaf vegetables and fruits. With the realization of the threat to plant diversity, the first step in the conservation effort should be a collection mission of samples of the remaining useful indigenous plants as a matter of urgency. It is imperative therefore that the diversity within the gene pools, including the wild relatives are adequately collected, conserved and used in the broadening of the genetic base in crop improvement programmes. India is well endowed with a wide diversity of indigenous useful plants and there is a dire need for greater investment in their conservation and sustainable utilization in order to broaden the base of agriculture and improve food security. Seeds are the most convenient part of plant for storage, with the exception of a few species that have recalcitrant behaviour. In storage, under good temperature and humidity regimes, seeds can be stored for several years. Therefore, following collection, reliable seed banks must be put in place for conservation of the collected samples. It must be emphasized that regular checks are carried out to test the viability of the stored seeds periodically. The seed bank will serve as a major insurance against permanent loss of any species that had been previously collected.

Crop type collection center (CTC)

This is also called 'Field gene banks'. Field gene banks are the most suitable for species that do not produce seeds easily and those with recalcitrant seed behavior. At the CTC, collected plant species are planted out in orderly manner – species by species, variants by variants and family by family. The CTC should be well guarded against fire as this can lead to a total loss of the conserved species. The management and maintenance of the CTC should also be accorded high priority because it is capital intensive. There must be reliable source of water especially during the dry season when water is limiting.

Conservation in natural ecosystem

The objectives of conservation in natural areas have been to protect a representative sample of each ecosystem and to establish a world network of plant reserves in their natural ecosystem. In this way, landraces of the indigenous

vegetables are protected in their natural habitat. This practice is as old as the beginning of live. The forests are indirectly serving plant conservation purposes. Therefore our interest as scientists should be in how many rare species we could find and collect in these forests. To ensure a successful conservation in natural ecosystem, there must be enabling laws and willing government in place to deal with illegal exploitation of the conserved species.

Cryopreservation

The best answer for long-term conservation of germplasm *in vitro* lies in cryopreservation i.e. the storage of frozen tissue cultures at very low temperatures in liquid nitrogen at –196^{0}C, which virtually stops all biological activity. This process puts the cells in suspended animation where they can retain their viability indefinitely. This method is also the best for handling the storage of recalcitrant seeds and is also suitable for species that do not form seed and those that are propagated from bulbs and rhizomes.

Application of novel technologies

India must be able to develop and adapt scientific procedures and technologies that can solve her problems. For example, the Geographic Information System (GIS) applications could contribute significantly to the understanding of inter-specific diversity and its spatial distribution thereby enabling scientists to develop more articulate *in situ* and *ex situ* conservation strategies. Other novel technologies in the public domain and from which India can derive maximum benefits are the application of molecular marker technology in the assessment of intra-specific diversity, germplasm characterization and evaluation, development of core collections, marker assisted selection, gene mining and functional genomics among others. The responsibility is therefore on Indian continent to acquire and develop the necessary human resources to make the best use of these technologies. Indian government should as a matter of urgency demonstrate seriousness by rising to protect what is left of our plant heritage. To achieve this, we need development of enabling legal and policies framework, capacity and infrastructural building and reasonable financial investment to develop our plant genetic resources for the improved livelihood of our people, well being of our citizen and economic development of our continent. The world is going through a stage of conservation and biotechnological revolution and we in India must not be left behind. Institutional, groups and individual intervention to save what is left of our natural resources. To achieve this, the following suggestions are made.

Capacity building

Inadequate expertise in the science of plant genetic resources is at the moment posing serious problems for the ability of India to embark on serious plant conservation programme. For a well-organized plant conservation programme, there is the need for molecular geneticist, biochemist, horticulturist, physiologist, pathologist, entomologist, ecologist, statistician and ethno botanist. It is therefore an urgent task for India to strengthen the technical capacity for *in situ* and *ex situ* conservation and utilization of plant genetic resources at the sub-regional and national levels, with a special focus on human resources development and development of the necessary institutional conservation infrastructures. For conservation efforts to succeed there must be material/ financial resources and human expertise. Therefore in India, especially the Eastern, Western and North west Himalyan region need to invest more in human resources development to be able to face the challenges of conservation of plant resources.

Strategies for the promotion of Indigenous vegetables

A strategy for the promotion of Indigenous vegetables must include appropriate measures to increase both production and consumption. This is because it would be futile to try to promote consumption without ensuring adequate supply. In the same vein, sufficient availability without market demand will create gluts and thus act as a disincentive to further production. Success of promotion programmes, therefore, will depend on how these factors can be synchronized. To achieve this objective, a promotional strategy must include the following:

(i) Adequate baseline data to quantify the contribution of indigenous vegetables in ensuring national food security, to help identify the constraints to their further development, and to forecast future demands and potentials. It should also help to determine the type of policies, programmes and support that would be necessary for promotional activities.

(ii) A strong advocacy to obtain political commitment and government support to long-term programmes of promotion.

(iii) A well-planned research and extension programme and development of appropriate technologies for increasing production, marketing and preservation. High priority should be given to the development of new recipes that will increase market value and competitiveness against exotic species. Recipe-driven increases in demand are exemplified by industrial processing of many indigenous vegetable products.

(iv) Measures to increase public awareness on nutritive value, economic benefits and social prestige in the national diet.

(v) The long-term aim of the promotion programme for indigenous vegetables is to improve the food security and nutritional status of the rural and urban poor, and in so doing recognize the pivotal role played in the rural areas by women in their dual capacity as subsistence food producers and processors.

Selection criteria and future strategy

Indigenous vegetables fulfill multiple roles in the diet, not just as unique carriers of certain nutrients, but also adding flavour, colour and texture that relieve the monotony of an otherwise bland starchy diet. As a group they provide improved nutrition for people of all economic levels and are important sources of income for small farmers. Vegetable production and marketing, particularly of the indigenous vegetables, frequently offer income-generating opportunities for women. Some species

of indigenous vegetables are fully domesticated, others partially domesticated and others almost untouched. Yet among the partially domesticated and the untouched, there may be some with great potential either with or without further improvement. For those species that cannot play major roles, there may be special niches where they can be useful. The discovery of appropriate roles for little-known plant species will depend on careful examination of promising types in many localities. For this purpose, comparative evaluation criteria could be applied. An indigenous vegetable diversification programme should include carefully chosen traditional species to meet the criteria and specific needs of the potential beneficiaries - producers and consumers in various ecological settings. Secondary food crops do not always remain secondary, and as all food plants were gathered at one time before man learned to domesticate them, it is the role of the agricultural and allied sciences to re-examine potential species hitherto neglected.

Utilization strategies

(i) Development/identification of high yielding, disease and pest resistant varieties of indigenous vegetables.

(ii) Develop a platform to exchange and conserve information and materials, identify key task and relevant lead centres for networking of research and development activities to address key knowledge gaps and resource needs for nutritional security, climate change associated stresses, heat tolerance, flooding and salinity tolerance by participatory approach with indigenous and advance knowledge for promising indigenous vegetables.

(iii) The efforts on collection and conservation of indigenous vegetables germplasm need to be strengthened by developing *ex-situ* conservation block or through participatory approach.

(iv) Experiments for establishing the role of indigenous vegetables in improving micronutrient in human.

(v) Selective habitat enrichment for identified indigenous vegetables and their promotion.

Conclusion and policy considerations

Collect, preserve, and effectively characterize traits of those indigenous and traditional species in gene banks using modern molecular characterization. Characterization is the first step in new breeding programs for indigenous vegetable crops, and should be initiated. It is likely to be a myth that these crops are more permanently 'resistant to pests and diseases' than conventional field crops or global vegetable crops. Thus, defensive strategies through breeding, grafting, integrated pest management and good agronomic practices will be required for a sufficient quantity and quality of crops to be produced on-farm in a profitable and efficient manner. Better regimes for shading, cooling, packaging, transporting and storing will be required along the value chain from field to kitchen, particularly in the case of nutrient dense leafy green vegetables with an apparently short shelf life. Many of indigenous vegetables are preferred by consumers for their taste, appearance and vitamin and mineral content. Packaging and marketing to ensure food wholesomeness, cooking to ensure taste and nutrient bioavailability, and attractive meal presentation are all crucial aspects for acceptance of these food products by consumers. The present compilation highlighted the often ignored demand-side factors guiding smallholders' decision to cultivate nutrition-sensitive crops such as indigenous vegetables and their contributions in addressing the nutritional aspects of food security within the household. There are several challenges in the indigenous vegetable value chain (mainly due to high perishability of produce, particularly of leafy types) that are important to all actors in the sub-sector, yet interactions among them are hampered by information asymmetry that results in farmers neglecting or evading recommended practices. The following recommendations are offered: Householders seem to be aware of the higher farm gate values for indigenous vegetables per unit area. They also understand the importance of indigenous vegetables for nutrition – a main driver of their production decisions. Detailed measurements of indigenous vegetables, staples and other food items consumed by households are required to understand other psychological constructs. Family labour size is positively and significantly related to crop concentration on traditional vegetable cultivation. This is an indication of the preference allocation of more labour resources for the cultivation of indigenous vegetables as compared to other crops, perhaps because of their relatively higher farm gate values and household nutrition needs.

- There are marked regional differences in indigenous vegetable preferences that need to be noted for targeting future interventions.
- Since female-headed households involved in indigenous vegetable production are more intensively engaged in it than male-headed households, it is necessary to provide adequate farm management training and knowledge to female farmers to upgrade the value chain. However, a study of decision making on indigenous vegetable production by females within male-headed households would be an interesting area for future research, to better understand gender roles and division of labour in the supply chain, and to explore options to empower women via indigenous vegetable value chains.

It is also important for government to implement enabling policies to enhance timely availability for indigenous vegetable seeds and to avoid spatial gaps, as farmers tend to grow less indigenous vegetables when they perceive that seed is not available in time for cultivation. As a complement, advocacy for enabling collaborative policies that will encourage public–private partnerships can enhance timely availability of seeds to smallholders to bridge the spatial and time gaps in seed systems.

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Management of indigenous vegetable genetic resources

India being the primary centre of origin and secondary centre of diversity of many vegetable crops also possesses large variability in many important introduced vegetable crops. The success and pace of the development depends on the efficient use of plant genetic resources, viz. landraces, traditional varieties, wild, weedy and other related species constituting primary, secondary and tertiary gene pools. Wild relatives are incredible genetic resources carrying several desirable attributes like nutritional quality parameters, resistance to biotic and abiotic stresses that are generally lacking in the cultivated allies. ICAR-National Bureau of Plant Genetic Resources, New Delhi is the nodal agency for the management of national wealth of VGR, specially working for collections, characterization, identification and documentation of new germplasm.

INDIA is the centre of origin for a number of indigenous vegetable crops like brinjal, cucumber, ridge gourd, sponge gourd, pointed gourd and snap melon, etc. It also possesses rich diversity for vegetable crops like cowpea, okra, chilli and water melon for which it is the secondary centre. A large number of wild species have not only contributed towards food but are also rich gene pool for important traits. North-eastern region including Assam is rich in solanaceous vegetables, leafy vegetables, lesser-known legume vegetables (winged bean, jack bean, sword bean) and cucurbits (cucumber, ridge gourd, coccinia, etc.). The northern plains/ gangetic plains including *tarai* region is considered to exhibit variability in cucurbits and other aquatic leafy vegetables. The north western/Indus plain region is rich in diversity particularly in amaranth, chenopods, *Cucumis, Momordica* and *Citrullus*. The central region/plateau has more diversity in cucurbits like melon, bitter gourd, pointed gourd and ridged gourd. Western and eastern peninsular regions have considerable diversity in regionally important species like snake gourd, sponge gourd, ridged gourd and *Moringa*. The distribution of important wild relatives of vegetable crops in different phyto-geographical zones (Arora and Nayar 1984) are presented in Table 1.

Table 1. Phyto-geographical zones and distribution of wild relatives

Phyto-geographical zones	Distribution of wild relatives of vegetable crops
Western Himalaya	*Abelmoschus tetraphyllus, Cucumis hardwickii, C. trigonus, Luffa echinata, L. graveolens, Solanum indicum, S. lasiocarpum, Trichosanthes multiloba, T. himalensis*
Eastern Himalaya	*Abelmoschus manihot, Cucumis trigonus, Luffa graveolens, Neoluffa sikkimensis*
North-eastern region	*Abelmoschus tetraphyllus, Alocasia macrorhiza, Amorphophallus bulbifer, Colocasia esculenta, Cucumis hystrix, C. trigonus, Dioscorea alata, Luffa graveolens, Moghania vestita, Momordica dioica, M. cochinchinensis, M. macrophylla, M. subangulata, Solanum indicum, Trichosanthes cucumerina, T. dioica, T. khasiana, T. ovata, T. truncata*
Gangetic plains	*Abelmoschus tuberculatus, A. tetraphyllus, Luffa echinata, Momordica cymbalaria, M. dioica, M. cochinchinesis, Solanum incanum, S. indicum Indus plains: Momordica balsamina, Citrullus colocynthis, Cucumis prophetarum*
Western peninsular region	*Abelmoschus angulosus, A. moschatus, A. tetraphyllus (pungens forms), A. ficulneus, Amorphophallus campanulatus, Cucumis setosus, C. trigonus, Luffa graveolens, Momordica cochinchinensis, M. subangulata, Solanum indicum, Trichosanthes anamalaiensis, T. bracteata, T. cuspidata, T. perottitiana, T. villosa*
Eastern peninsular region	*Amorphophallus campanulatus, Abelmoschus tetraphyllus (manihot forms), A. moschatus, Colocasia antiquorum, Cucumis hystrix, C. setosus, Luffa acutangula var. amara, L. graveolens, L. umbellata, Momordica cymbalaria, M. denticulata, M. dioica, M. cochinchinesis, M. subangulata, Solanum indicum, S. melongena (insanum types), Trichosanthes bracteata, T. cordata, T. lepiniana, T. himalensis*

Domestication of vegetables crops

About 1,500 wild species have been originally involved in the process of domestication of cultivated vegetable crops at global levels. The Indian subcontinent has contributed to about 20-25 species of domesticated vegetables. Many species in this region are still in the process of domestication. Some important examples are creeping cucumber (*Solena amplexicaulis*) a cucurbit from Indian subcontinent (tropical Asian) under cultivation in the tribal pockets of Odisha (a delicacy vegetable), otherwise found wild in disturbed habitats. Same is true for many wild species of *Momordica* and *Amaranthus*. *M. subangulata* ssp. *renigera*, often confused with *M. cochinchinesis* and *M. dioica* is a semi-domesticated vegetables native of Assam-Mayanmar region. Fruit (are less bitter than bitter gourd) and leaves are used as vegetable. An Asian species *Colocasia gigantea* occurs wild throughout India; it is cultivated in Hawaii for export of petioles/leaves to United States of America. It is primarily used for leaves but tubers are inedible.

Germplasm collection

Global diversity in vegetable crops is represented by around 400 species. The regions with maximum diversity are tropical America, Asia and Mediterranean region. Indian subcontinent being one of the Vavilovian centres of origin of crop plants possesses a lot of diversity in several important vegetable crops. It represents great diversity of cultivated and wild species of vegetable crops with the occurrence of around 80 species of major and minor importance. Indian subcontinent is endowed with morphological diversity owing to center of origin of several vegetable crops namely brinjal, cucumber, ridge gourd, sponge gourd, *Trichosanthes* and *Momordica,* lablab bean etc. There are about 100 species of cucurbitacae family are reported to occur in India including 34 endemic species viz. *Cucumis hardwickii, C. trigonus, C. prophetarum, C. setosus, C. hystrix, Luffa graveolens, L. acutangula* var. *amara, L. cylindrica, L. tuberosa*, *L. echinata, L. umbellata*, *Trichosanthes anguina, T. dioica, T. dicaeleosperma, T. khasiana, T. ovata, T. truncata, T. multiloba,T. anamalaeiensis, T. bracteata, T. cuspidata, T. nervifolia, T. perotteliana*, *T. himalensis*, *Momordica cochinchinensis, M. macrophylla, M. subangulata, M. cymbalaria, M. dioica, M. cymbalaria, M. denticulata*, *M. balasamina*, *Neoluffa sikkimensis* and *Citrullus colocynthis*. However, there are several areas which need to be explored for augmentation of un-tapped variability. Some of the potential areas are given in Table 2.

Brinjal (IC 354698)

Table 2. Indigenous vegetable crops with their maximum diversity areas

Crop	Areas/region to be explored
Cucumber	Indo-Gangetic plains, sub-Himalayan tract, Western Ghats and eastern peninsular tract
Cucumis sp	J.K., H.P., U.P., Rajasthan, A.P. and Karnataka
Pointed gourd	Bihar, West Bengal and Assam
Ivy gourd	Eastern Madhya Pradesh, West Bengal, North Eastern hill region, Uttar Pradesh, Bihar
Sponge and Ridge gourd	Indo-Gangetic plains, Tarai region and North Eastern plains
Snake gourd	Southern peninsular tract and Kerala
Lablab bean	Bihar, Orissa, Gujarat, Maharashtra, Goa and Eastern peninsula
Taro	Kerala, Andhra Pradesh, Orissa, Bihar, Uttar Pradesh, West Bengal, North East region, Nilgiri and Anamalai hills

Some of the important indigenous vegetable collections made in the recent years are as follows:

- Orange fleshed (carotenoid-rich) cucumber from Manipur and Mizoram
- Brown-netted cold tolerant cucumber from Meghalaya
- Scented ash gourd from Arunachal Pradesh, Mizoram and Tripura
- Linear-elongate ash gourd with small seeds from Manipur
- Distinct form of *Momordica cochinchinensis* for many floral characters from middle Andaman Island is named as *Momordica cochinchinensis* subsp. *andamanica* Kattuk
- Primitive brinjal (JPJ/18-060) a rare collection from Andaman and Nicobar Islands
- Highly pungent bird-eye chilli from Mizoram

Germplasm characterization and evaluation

Characterization essentially means the recording of the observations on highly heritable traits, can be observed and expressed across the environment where as evaluation refers to recording of potential agronomic traits including biotic and abiotic stresses, and quality traits for its use in specific purposes and in specific environment. Besides, morphological characterization, germplasm is also characterized for biochemical (protein/ isozyme) and molecular (DNA based) markers. The evaluation of germplasm is pre-requisite for their effective utilization in vegetable improvement programme. Most of the desirable traits are polygenic in nature and are influenced by the environments. Therefore, it is better to evaluate the germplasm at multi-locations to draw unbiased conclusion about their genetic potential. In indigenous vegetable crops, a large number of germplasm have been

evaluated for different agro morphological traits and have been documented in the form of catalogues. For detailed evaluation of vegetable crops, the following parameters need attention for effective utilization:

(a) Evaluation of indigenous vegetable germplasm for agronomic, biotic and abiotic stresses, and quality parameters
(b) Evaluation of promising germplasm through biochemical and molecular markers
c) Documentation of vegetable germplasm along with characterization and evaluation data
(d) Pre breeding/genetic enhancement in indigenous vegetables using primary, secondary and tertiary gene pools

More than 12,000 accessions of vegetable crops germplasm have been characterized and evaluated and a number of promising lines have been identified and utilized in improvement programme by various researchers. Based on the information on characterization and evaluation of vegetable crops germplasm, catalogues were published. Besides this, annual report on characterization and evaluation of agri-horticultural crops are being regularly published. Recently multi-location evaluation of vegetable crops germplasm in brinjal ond okra germplasm has been initiated in collaboration with AICRP (Vegetable crops) under Consortium Research Platform (CRP) on Agro-biodiversity.

Brinjal *(Solanum melongena)*

India, being a primary center of origin, possesses large variability for growth habit; leaf blade lobing; calyx colour; fruit shape, size, and colour; and colour distribution. The region across India and Indo-China is considered the center of diversity for brinjal. The *Solanum melongena* complex has three species, namely, the *S. melongena, S. incanum* and *S. insanum.* Wild relatives of *Solanum* viz. *Solanum torvum, S. indicum, S. insanum, S. surattense, S. pubescens, S. gilo, and S. khasianum* are widely distributed in South India, Shivalik hills and North-eastern region.

A core set of 181 accessions has been developed in brinjal from the entire collection available in the National Gene bank on the basis of agro-morphological (qualitative and quantitative) descriptors. Presently, the research objectives are focussed on development of brinjal fruit and shoot borer resistant pre-bred lines using wild species *S. incanum.*

Brinjal (IC 090785)

Brinjal (IC 265251)

Legumes

The rich legume biodiversity of India with 167 genera and 1,141 species hold great promise in this regard. *Lablab purpureus*, referred to as country bean is one such lesser known legumes and its tender pod is a popular vegetable in North East India, although the seeds are also consumed. In India, it is grown in North East India, Eastern and Southern India, but it is in North East India that high degree of genetic variability exists. A large number of indigenous land races are found scattered all over North East India, distinguished primarily on the basis of pod morphology and pod colouration. Wide variability is also reported from Tamil Nadu and the accessions were distinguished smoothly on the basis of pod morphology and pod, seed colouration. Analysis of North East Indian landraces of country bean for nutritive values and seed protein profile revealed that the tender pods contain good amount of crude protein (16.44 to 21.47%), total carbohydrate (14.53 to 19.61%), lipid content (0.43 to 0.96%). Whereas the protein and carbohydrate content of mature seeds of these land races are higher than the corresponding values for tender pods. Dolichos bean is an important legume crop with multiple benefits. In India, it is popularly grown in south, east and north east parts of the country. It is the major source of protein in the South Indian diet. It is grown either in pure stand or

Table 3. Qualitative characters of Dolichos bean genotypes

Genotype	Plant type	Flower colour	Pod colour	Pod curvature	Seed colour
Pusa Early Prolific	Pole	White	Light green	Intermediate	Red
BCDB – 2	Pole	Purple	Light green	Flat	Black
SEMVAR– 8	Pole	White	Green	Flat	Yellow
KDB – 413	Pole	White	Green	Slightly curved	Brown
JIB(V)16	Pole	Purple	Green	Flat	Brown
Swarna Utkrist	Pole	Purple	green	Flat	Brown
KDB – 415	Pole	Violet	Green	Slightly curved	Reddish
BCDB – 1	Pole	Purple	Purple	Flat	Black
RCMDL – 1	Pole	White	Light green	Slightly curved	Black
HADB – 4	Pole	Purple	Light	Green Flat	Brown
HADB – 3	Pole	White	Creamy white	Flat	Brown
Gomchi Green	Semi pole	White	Green	Straight	Orange

Brinjal fruit diversity

Sponge gourd fruit

intercropped with cereals like finger millet, pearl millet, corn and sorghum, and with other crops like groundnut, castor in rainfed ecosystems. It prefers comparatively cool season, and moreover majority of traditional cultivars are temperature-and photoperiod-sensitive and requires short days for flowering. Its green delicious immature pods and seeds are consumed as vegetable. It is very good source of protein (20-25%), amino acids (like lysine, usually lack in cereals), vitamins (A, C and riboflavin) and minerals (Ca, Fe, Mg, S, Na and P). Moreover, immature pods and seeds are rich in dietary fibre and low carbohydrates and lipids.

Cucurbits

India is the home of a large number of cucurbits including cucumber (*Cucumis sativus*), sponge gourd (*Luffa cylindrica*), ridge gourd (*Luffa acutangula*), spine gourd (*Momordica dioica),* pointed gourd (*Trichosanthes dioica*), snake gourd (*Trichosanthes anguina*), snapmelon (*Cucumis melo* var. *momordica*), ivy gourd (*Coccinia indica*). Luffa has rich diversity in Indian gene centre. Out of 9 species, 7 are native to India. *Luffa acutangula* and *L. cylindrica* have rich diversity throughout India, particularly North eastern parts including Sikkim, West Bengal, western, central and southern India. *Luffa* spp are growing in natural habitat in North-eastern region of India. A high yielding variety of the ridge gourd with bisexual flowers and smaller fruits in clusters, viz. *Luffa acutangula* var. *hermaphrodita,* (Hindi-meaning seven children) is also known in cultivation in the states of Bihar, Uttar Pradesh, West Bengal, Jharkhand, Chhattisgarh, Andhra Pradesh, Gujarat and Rajasthan. *L. acutangula* var. *amara* occurs in Peninsular India and *L. echinata* in the western Himalaya and upper Gangetic plains. Another important species, *L. graveolens* occurs in Bihar, Sikkim, and Tamil Nadu.

The domesticated cucumber *Cucumis sativus* var. *sativus* L. originated from its wild progenitor *Cucumis sativus* var. *hardwickii* (Royle) Alef. which is found in foothills of Himalayas. In Indian sub-continent, besides the common cultivars there are several landraces under cultivation viz. 'Sikkimensis type' (*C. sativus* var. *sikkimensis* Hook. f.) prevalent in Sikkim and adjoining hilly areas with reddish-

Cucumis callosus

Orange fleshed cucumber from Manipur

orange hard skinned, 'Hill cucumbers (gigantic khira)', 'Silentvalley type' (*C. sativus* var. *silentvalley*) commonly consumed in Kerala, 'Madras cucumber', 'Mulsouthe' landrace in Karnataka with gigantic fruit, and round cucumber in Assam.

A number of carotenoid rich accessions' viz. IC420405, IC420422, AZMC-1, KP-1291, EOM-400, IC420446, KP-1293, JB-11/91, JB-11/69, have been reported from north eastern part of India particularly, Mizoram and Manipur. The carotenoid rich germplasm has high potential for enriching food and alleviating vitamin A deficiency in the country.

Phoot (snapmelon) designated as *Cucumis melo* var. *momordica* Duthie and Fullar is an important type with a wide distribution in North India. It has been found resistance to powdery mildew (*Sphaerotheca fuliginea*) and downy mildew (*Pseudoperonspora cubensis*) and cucumber green mottle mosaic virus (CGMMV). Besides, there are a number of indigenous cucurbits which are not yet exploited for their potential. Bankunari (*Solena amplexicaulis*) is a dioecious cucurbit, bears edible fruits which are used for vegetable as well as salad. Ripe red coloured fruits are used as dessert, tender shoots and leaves are used as a leafy vegetable while dry powder of tubers is used in several Ayurvedic medicines. Solena is found in wild state in Bihar, Uttarakhand, Assam, Tripura, Garo hills in Meghalaya, Konkan and Deccan areas.

Leafy vegetables

India is the home of a large number of leafy vegetables including Indian spinach (*Basella alba*), drumstick (*Moringa oleifera*), curry leaf (*Murraya koenigii*), etc. and a number of lesser known leafy vegetables, which are available seasonally and are grown in small pockets. A number of underutilized leafy vegetables which are generally used as day to day vegetables with small area of cultivation. Apart from this a number of species like *Bacopa monnieri, Boerhavia diffusa, Centella asiatica* etc. are also used as leafy vegetables basically for therapeutic value. Rural people from North-eastern parts of India prefer non-traditional vegetables like runner and petioles of *Colocasia* spp and *Xanthosoma* spp, bamboo shoots, elephant foot yam petiole, and leafy vegetables like fern shoot (*Ceratopteris*), poi (*Basella alba*). The majority of the indigenous leafy vegetables are grown in wild, semi-wild or stray conditions but are the main source of vitamins and minerals to the rural and tribal communities. Concentration of genetic diversity comprising native species and landraces occurs more in Werstern ghats, Eastern ghats and North-eastern Himalayas.

Table 4. Distribution of cucurbitaceous species including rare/endangered species in India

Species	Distribution
Cucumis hardwickii, Cucumis trigonus, Luffa graveolens, Trichosanthes multiloba, Trichosanthes himalensis	Western Himalaya
Cucumis trigonus, Luffa graveolens, Neoluffa sikkimensis	Eastern Himalaya
Cucumis hystrix, C. trigonus, Luffa graveolens, Momordica cochinchinensis, M. macrophylla, M. subangulata, Trichosanthes anguina, T. dioica, T. dicaleosperma, T. khasiana, T. ovata, T. truncata	North-eastern region
Luffa echinata, Momordica cymbalaria, M. dioica, M. cochinchinensis	Gangetic plains
Momordica balasamina, Citrullus colocynthis, Cucumis prophetarum	Indus plains
Cucumis setosus, C. trigonus, Luffa graveolens, Momordica cochinchinenis, M. subangulata, Trichosanthes anamalaeiensis, T. bracteata, T. cuspidata, T. horsfieldii, T. perottitiana, T. nerifocia, T. villosa	Western peninsular tract
Cucumis hystrix, C. setosus, Luffa acutangula var. amara, Luffa graveolens, Luffa umbellata Momordic cymbalurea, M. denticulata, M. dioica, M. cochinchinenis, Trichosanthes bracteata, T. cordata, T. lepiniana, T. himalensis, T. multiloba.	Eastern peninsular tract
Rare and endangered species	
Coralloocarpus gracillipes (Naud.) Cogn.	Western Ghats
Gomphogyne macrocarpa Cogn.	Eastern Himalaya
Indofevillea khasiana Chatterjee	North Eastern Region
Luffa umbellata (Kleir) Roem	Western Ghats
Melothria amplexicaulis Cogn.	Deccan Plateau
Momordica subangulata	Deccan Plateau, Western Ghats
Trichosanthes lepiniana (Naud) Cogn.	Deccan Plateau, Western Ghats
Trichosanthes perrotteliana Cogn.	Western Ghats
Trichosanthes villosula Cogn.	Deccan Plateau, Western Ghats

Table 5. Promising accessions of indigenous vegetables

Crop	Trait(s)	Promising accession
Brinjal	Long deep purple	IC126879, NIC5938, EC304992
	Purple Long	IC90764, IC112312, IC90975, IC126869, IC144084
	Green Long	IC74209A, IC136142, IC144083, NIC4573
	Deep Purple Oblong	IC14405, NIC13009
	Purple oblong	IC90957, IC127239, IC113802, IC112821
	White with purple stripe oblong	IC127163
	Creamy white oblong	IC137748, IC144078, IC136328
	Early flowering (<60 days)	IC89953, IC99676, IC137770
	Dwarf (<40 cm)	IC89964, IC112588, IC112692
	Cluster bearing	EC304951, IC99747, NIC5904
	Long fruit (>35 cm)	IC90102, IC90157, IC11384
	Fruit and shoot borer resistance	*Solanum incanum:* IC256181, IC203595-C, IC541208-A, IC241664-A, IC531754-A, IC531769, IC539833, IC421594
	Fruit weight (≥120 g) at TNAU and IIHR	IC433547, IC316201, IC090871
	Yield per plant (≥2.15 kg) at TNAU and HARP	IC261843, IC374904, IC354546, IC090907
	Bacterial wilt survival of plants at 90 DAT (>80%) at HARP and IIHR	IC305048, IC545931
	Resistance to fruit and shoot borer (>85%) at TNAU	IC354546, IC112736
	Fruit and shoot borer	EC385380, EC038474, EC383372, EC316294, IC074196, IC089929-A, IC090144, IC090785, IC111415, IC111439, IC249319, IC383195, IC394877, IC279555 (<10% infestation)
Cucumber	Extended shelf life	IC203838, IC203839
	Early and determinate	EC398030
	Gynoecious line	EC382739, EC 382739
	High yielding	EC 237658, IC 203838, VJ/98-176, VJ/98-151
	Anthracnose resistance	PI 197087, Poinsett
	Downy mildew resistance	PI 197087
	Powdery mildew resistance	Poinsett, Yomaki, PI 79376
	Cucumber scab resistance	Wisconsin SMR 9
	Angular leaf spot resistance	Poinsett, MSU 9402, PI 169400
	Bacterial wilt resistance	PI 200815, PI 200818
	Cucumber green mottle mosaic virus resistance	*Cucumis anguria, C. africanus, C. ficifolius*
	White fly resistance	*Cucumis asper, C. dinteri, C. sagittatus*
	Carotenoid content (>20 µg/g fresh pulp)	IC420405, IC420422, IC420446, KP-1291
Pointed gourd	High yielder	VRPG-13, VRPG-44, VRPG-70, VRPG-72, VRPG-93
	Number of fruit/plant	VRPG-13, VRPG-44, VRPG-70, VRPG-72, VRPG-88, VRPG-93, VRPG-113
	Heat tolerance	VRPG-72, VRPG-99, VRPG-19, U-34/BP/DR/07, VRPG-110, VRPG-110A, VRPG-110B
	Resistance to gall forming nematode	U-34/BP/DR/44, VRPG-72, VRPG-18, VRPG-96
Ivy gourd	High yielder	VRK-05, VRK-10, VRK-20, VRK-3
	Stem diameter	U-325/DA/DR/20, 325/DA/DR/36
	Internode length	U-35/DA/DR/48
	Resistance to mosaic virus	VRK-05, VRK-10, VRK-20, VRK-35
	Resistance to leaf miner	VRK-01, VRK-06, VRK-22, VRK-04, VRK-31, VRK-33, VRK-55

Crop	Trait(s)	Promising accession
Sponge gourd	Early types	IC92779, IC92797, IC92604, IC93445, IC3367601, IC 284897 NIC1023, NIC 13236, NIC 110235, NIC 597
	High yielding	NIC 23288, NIC 23291, NIC 23292
	Long and heavy fruits	EC305688, IC201217, IC 201229, IC92721, IC92727, IC92475, IC92751
	High primary branches (>11)	IC417970, IC284767
	Fruit weight (>512 g)	IC342824, IC355635
	Node no. at which first female flower appears (<11)	IC284844, IC398578, IC284767, IC398538
	Fruit length (>36 cm)	IC264897, IC411904, IC411891
Ridge gourd	Early types	NIC20402
	High yielding	IC93399, IC12136, NIC957, NIC10216, NIC10224, NIC20213
	Cluster bearing	NIC10222, NIC10232, NIC10288, NIC10213, NIC10215
	Node no. at which 1st female flower appear (<14)	IC427676, IC424548, IC418476, IC424549
	Fruit length (>20 cm)	IC427163, IC427131, NIC22409
	Primary branches (>12.9)	IC417716
	Fruit weight (>187g)	IC276403, IC893393

Variability in flower and pod colour of *Dolichos*

Genomic resources of vegetable crops

Genomic resources are whole or parts of the genome (DNA) or its functional unit (RNA) of actual or potential value. Genomic resources for model horticultural crops are increasing with great pace, however many of them are still not being exploited. Genomic resources are available in the form of genomic, mitochondrial or chloroplast DNA, RNA, DNA markers, probes, primers, whole genome sequence, ESTs, large-insert genomic libraries and high-density genetic maps in a range of vegetable crops. These resources have been used for sequencing and annotation, mapping and cloning of genes or quantitative trait loci (QTL), and marker assisted selection (MAS) in important vegetable crops. Advances in technologies for identifying accurate genetic polymorphisms have accelerated the discovery of molecular markers. The most popular markers developed from the genomic resources include SSR, SNP and conserved ortholog set (COS) markers. SSR and EST markers have been developed in a number of indigenous vegetable crops including brinjal and

Fruit variability in Okra

cucumber that can be used for studying synteny between distantly related species and breeders can take advantage of these findings to identify markers for traits of interest in their specialist crops. Markers tightly linked to major genes responsible for the expression of important traits have been developed in many horticultural crops and are being used for marker assisted selection. A large number of indigenous vegetable genetic resources are being conserved in National Genebank, New Delhi which caters the need of various vegetable breeders throughout NARS for their germplasm requirement. The status of NGB is presented in Table 6.

Table 6. Status of indigenous vegetables in National gene bank

Crop	No. of accssions. available
Brinjal (*Solanum melongena*)	3739
Wild Brinjal (*Solanum* spp)	412
Cucumber	624
Ridge gourd	326
Sponge gourd	408
Luffa spp	95
Trichosanthes spp	274
Snap melon	206
Ivy gourd	34
Solena amplexicaulis	08
Basella	88
Portulaca oleracea	23
Ipomoea aquatica	15
Diplazium esculentum	01
Lasia spinosa	04
Colocasia esculenta	2410
Oxalis corniculata	16
Moringa oleifera	197
Murraya koenigii	24
Lasia spinosa	04

Table 7. List of registered germplasm conserved at NBPGR, New Delhi

Crop	Accs.	Unique character(s)
Brinjal	6	Bacterial wilt resistance, Better ratooning and semi-spreading
Sponge gourd	2	Cluster bearing fruiting, Highly resistant to TLCNDV
Cucumber	3	Long fruit, Small fruit, High carotenoid content
Snap melon	3	Drought hardy and high yielding, downy mildew resistance
Kachri	2	Salad type, pickle type
Pointed gourd	1	Obligate parthenocarpic and seedless fruit
Sword bean	1	Drought tolerant

Small fruited Cucumber (INGR 18030)

Fruit variability in Cucumber

SUMMARY

There is lot of vegetable crops diversity available in India. Over the years this diversity in major vegetable crops has been captured, augmented, characterized, evaluated and conserved through systematic PGR management. There is still need to explore the indigenous minor vegetable crops (under-utilized vegetable crops used locally) especially leafy vegetable crops as well as on trait-specific germplasm. The characterization and evaluation of major vegetable crops need to be strengthened in a network mode involving multi-disciplinary approaches on priority. In the context of climate change, the wild relatives play an important source for genes/gene complex, need to be evaluated and utilized with suitable tools and techniques. To increase the germplasm utilization, more importance needs to be given from trait specific evaluation to trait discovery.

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Hari Har Ram, Sunita Kushwaha and
Rakesh Kumar Dubey

A glimpse of indigenous and minor vegetables of India

Indigenous (traditional) vegetables are best defined as species that are locally important for the sustainability of economies, human nutrition and health, and social systems but which have yet to attain global recognition to the same extent as major vegetable commodities such as tomato or cabbage. Indigenous vegetables - plant species consumed in specific locations as part of traditional diets - have the potential to diversify cropping systems, increase farm income, and add a range of vital micronutrients to diets. Given the hundreds of indigenous vegetables consumed worldwide, their accumulated value for mankind is considerable. These species deserve much greater recognition and investment in agricultural research and development than they have received presently.

INDIGENOUS vegetables are primary candidates for greater use of crop biodiversity in horticulture as they are already consumed and enjoyed locally and can be produced profitably in both rural and urban environments. Yet many such species have received little scientific attention to date. More effort in research and development would likely produce rewarding results, as productivity increase in these neglected crops are much easier to realize than for intensively researched staple cereals. Questions therefore are: 1) How can we rescue, conserve and utilize the genetic diversity of cultivated and wild forms of indigenous vegetables under threat of genetic erosion with reference to India?; 2) How can the lack of quality seed of these neglected but important vegetable crops can be overcome?; 3) Given the increased levels of biotic and abiotic stresses driven by climate change, as well as existing rural-urban migration trends, how can these indigenous vegetables help produce sufficient quantities of quality food?; and 4) Can greater consumption of such diverse and nutritious indigenous vegetables of India be encouraged, knowing that changing dietary habits is a difficult exercise? This article addresses some of these issues in Indian context.

Indigenous vegetables

Precise definition and explanation of the term 'Indigenous Vegetables' is required in the beginning itself to avoid any confusion and to make the reader comfortable while dealing with indigenous vegetables. Indigenous vegetables are traditional vegetables which are locally important for local food dishes, are rich in nutritional contents, and are part of the social systems but have remained neglected in terms of concerted efforts towards research and development and have yet not received global recognition. This is illustrated from the fact that global public spending on agricultural research and development reached USD 31.7 billion in 2008 and has increased at average annual rate of 2.4% since 2000, mostly driven by China, India and United States. Although, data are not disaggregated by crop, it would be safer to say that very little of this money has been spent on fruits and vegetables and virtually none of it goes into the improvement of indigenous vegetables. The term indigenous is altogether different from another obscure but seemingly related term that is 'landraces'. Although, the term landrace was first used in 1890, it was not in common use until the twentieth century. Early user of the term landrace defined it as a variety that had been grown in a certain locality for a long time and which had become adapted to local growing conditions through natural selection, usually with no intentional selection by farmers. Thus the term landrace reflected seed management in pre-industrial Europe as commonly practiced in wheat and barley. Landraces at this time were often named after a farm or a locality. Some authors used the term 'folk variety' as a substitute for landrace. Folk variety is usually defined as a 'farmers' variety' that is selected and maintained for one or more distinctive properties. They consist of mixture of genotypes all of which are reasonably adapted to the region in which they evolved but which differ in details as to specific adaptations to particular conditions within the environment. They differ in reaction to diseases and pests, some lines being resistant or tolerant to certain races of pathogens and some to other races, but not all and no particular race of pathogen is likely to build up to epiphytotic proportions because there are always resistant plants in the populations. Landraces tend to be rather low yielding but dependable. They are adapted to rather crude land preparation, seeding, weeding, and harvesting procedures


Amaranthus


Brinjal in nursery


Cluster bean


Elephant foot yam


Brinjal

of traditional agriculture. They are also adapted to low soil fertility, they are not very demanding, partly because they do not produce very much. Farmer bred varieties are better termed as folk varieties. This, the term landrace/folk variety is in relation to the term 'modern variety' which is understood as a variety that is improved by a formal breeding programme. The use of the term modern variety vs. landrace/folk variety/farmer's variety depends upon whether the product has been derived through formal breeding or has been derived through informal breeding under natural selection or through limited intervention by the farmers and these landraces/folk varieties/farmers' varieties survive alongside of modern varieties if they are characterized by distinctive traits that make them relevant in the farming system or demanded in the market. Thus, if an indigenous vegetable is subjected to modern breeding, the resulting cultivar will certainly be a modern variety and not the landrace/folk variety/farmer's variety. Another way of understanding indigenous vegetable crops is that these crops are not global but are essentially local and traditional types.

Indigenous vegetables and their importance in global context

Indigenous vegetables do not show substantial biodiversity, are adapted to local niche characterized by marginal soils and climatic conditions, and are often grown without much of external agro-inputs. Increasing use of indigenous vegetables will lead to diversification in agricultural production system; will increase crop heterogeneity which ultimately will result into better crop resilience against biotic and abiotic stresses. There are examples of successful pest and disease suppression and buffering against climate variability triggered by looming climate change in more diverse agro-ecosystems where indigenous vegetables are likely to play greater role than what is happening now. These crops are of great relevance to rural, poor, small-holder farmers with limited land resources and agronomic inputs. Relatively nutrient-dense indigenous vegetables have potential to play significant role in improving human nutrition. For example, bitter gourd (*Momordica charantia*) and tropical pumpkin (*Cucurbita moschata*) which are important indigenous vegetables in tropics possess good nutrient density. Bitter gourd fruits are rich sources of β carotene, vitamin C, folic acid, magnesium, phosphorus and potassium. Many indigenous vegetable species such as moringa (*Moringa oleifera*), amaranth (*Amaranthus* spp.), sweet potato (*Ipomea batatas*) leaves and spider plant (*Cleome gynandra*) also have high levels of anti-inflammatory phyto-chemicals, namely, flavonoids and other antioxidants that are of vital importance to human health and wellness.

Conservation and utilization of genetic diversity of cultivated and wild forms of indigenous vegetables

Indigenous vegetables have not got due attention by researchers, policy makers and funding agencies. Because of these neglects, these vegetables are threatened with extinction which may lead to reduction in biodiversity. These crops have not been fully integrated into the main agricultural production system, are grown generally on small scale using traditional technologies/indigenous technical knowhow (ITKs). *Moringa* is well known, very versatile, high nutrient density vegetable crop and commonly grown in home gardens and is not popular as a crop to be grown on large scale on commercial farms. Work on *Moringa* breeding has made good progress in southern part of India where several clonal selections have been commercialized and are popular among the farmers. These varieties from public sector research institutions include KM-1, PKM-1 (Bhagya), PKM-2, GKVK 1, 2, 3, Dhanraj, Bhagya, Konkan, Ruchira, Anupama, and Rohit 1. ICAR-Indian Institute of Vegetable Research, Varanasi has made some beginning in north India by block planting of annual and perennial *Moringa* as field gene bank and characterization, hybridization and documentation has been initiated using these types to put a full-fledged breeding programme in place. Germplasm collection of 257 accessions of *Moringa* including wild types are being maintained at NBPGR, New Delhi/its regional stations. The World Vegetable Centre, Shanhua, Taiwan's Eastern and Southern Africa seed repository conserves about 2,500 accessions of 20 indigenous crops plus some older traditional varieties of global crops. Wealth of information in genetic resources of Indian snapmelon landraces for resistance to fungal and viral diseases, nematodes and insects, tolerance to drought and salinity, genes for unique flavours, and status of genetic diversity of snapmelon in different parts of India are reported from various researchers. Snapmelon, commonly called 'phut' which means split, is native to India which is considered the centre of domestication of melon by some researchers with the earliest melons remains at the Indus valley site Harappa dated between 2300 and 1600

Flowering and fruiting in Cowpea

Fruiting in King Chilli

Jack bean

Pointed gourd-Bower system

BC. Immature fruits are cooked or eaten raw. Global breeding programmes have transferred many of these qualities into open-pollinated and hybrid cultivars of sweet melons. Snapmelon is a source of high fruit acidity, a trait that has been utilized to breed uniquely flavoured melon cultivars. Resistance genes to combat pathogens and pests and to strengthen crop resilience against climate change have been identified in snapmelon collections from various parts of India. More effort is needed to collect, characterize, evaluate, and preserve Indian snapmelon diversity in gene banks. There is urgent need on part of national gene banks to fully characterize their collections of local indigenous vegetable germplasm. The complex taxonomy of many of these species and need for accurate identification are areas where capacity building is needed.

Quality seed issues in indigenous vegetables

Quality seed supply in the required quantity of the indigenous vegetables is the major bottle neck in the development of these crops. Since research itself on these crops is meager or non-existent, the formal seed production and supply naturally remains almost non-existent. Public sector seed producing organizations are pre-occupied with seed production and distribution of major food crops where bulk seed handling is involved. Private seed companies too are not very enthusiastic to take up these crops in their formal seed business because the seed demand for these crops is scattered and that too in low volumes where seed business does not work. Accordingly, more than 75% of seed of these crops is supplied through informal sources involving farmers saved own seed, recycled seeds, gifts or exchange with other farmers. Small farmers face the problem of scientific seed production methods. For development of a more effective seed supply system, all sectors, including individual farmers, farmer groups, public seed enterprises, research and development organizations and local and multinational seed company will have to play a key role in harmony with each other to improve quality seed production and distribution of indigenous vegetables so that their impact in terms of nutritional security could be fully realized. In India, indigenous vegetable seed is sold by small private seed companies that produce and package local landraces of crops such as Malabar spinach (*Basella* spp.), kangkong (*Ipomea aquatica*) and amaranth.

Indigenous vegetables in India

The Indian subcontinent represents one of the richest diverse genetic resources. Of the estimated 2,50,000 species of flowering plants at global level, about 3,000 are regarded as food source, in which only 200 species have been domesticated. Global diversity in vegetable crops is estimated at about 400 species, with about 80 species of major and minor vegetables reported to have originated in India. However, with the advent of cut-and-burn agriculture and green revolution/ commercialized agriculture, the development project areas and related activities of these diverse resources are declining at a fast pace. Overgrazing, deforestation, and over exploitation of native resources under changed situations have eroded the biodiversity from this unique ecosystem. Moreover, traditional knowledge about these important indigenous plant species has also decreased in the younger generation influenced by urbanization. Indigenous plant species provide a variety of products like food, medicines and raw materials. They are also an important source of renewable energy. The Indian subcontinent has been one of the rich emporia of 2,500 plant species used in indigenous treatment and food sources.

Brief botanical description, distribution/diversity and uses, etc. of individual indigenous vegetable crops commonly grown in India are discussed below.

Kulfa (Purslane, *Portulaca oleracea*)

It is highly popular all over the world. It is found growing as weed in the waste land. The plant is used as vegetable, spice and for medicinal purposes. It is annual succulent plant spreading over the surface of the land. In India, it is commonly available in summer season. It has prostrate stem with reddish yellow green colour due to presence of betalain alkaloid pigment and beta xanthins. Its stem contains white milky juice. It is succulent spongy plant and contains gum like substances. Leave are small and clustered at the end of the stem. It bears yellow colour 4-5 flowers which contain hundreds of black coloured tiny seeds in ovoid capsule shape structures. It is broadly distributed throughout the world. It is successfully grown in America, India, Malaysia and Australia. It is usually self-pollinated but substantial cross-pollination also occurs. It belongs to family Portulaceae. It is rich source of omega-3- fatty acid, vitamins (A, B and C) and minerals (calcium, magnesium, iron). Stems, leaves, flower buds, all are edible. It is consumed as fresh salad, stir-fried or cooked as spinach. Having mucilaginous quality, it is used in soups also.

Shiranti (Joy weed, *Alternanthera sessilis*)

Joy weed/dwarf copper leaf belonging to family

Promising variety of Cucumber

Seedling production in polybag

Multivitamin vegetable

Variation in Lai saag leaf

Amaranthaceae is locally known as *Shiranti* in Bihar and *Sanchi* in West Bengal. This is tropical weed of shady, damp soils in cultivated and barren waste areas. In general, it is available on road sides, waste lands, irrigation canals, dykes, and fallow land. It is typically found in wetland areas having deep water up to 1 m in India, it is found as weed throughout warmer parts of country to an altitude of 1,200 m in the Himalayas. Fresh and immature shoots and leaves are eaten as cooked vegetable or in soups in many countries. It is perennial herb/weed with having 0.2 to 1 m height and strong tap roots. The stems are generally prostrate, creeping, often rooting at nodes, cylindrical with straight branches. The leaves are simple fleshy, short, petiolate, broadly lanceolate, 0.6 to 5 cm long, and 0.3 to 1 cm wide. The apex is rounded and the base cuneate. The flowers are inconspicuous, white, borne in small axillary heads; bracts are ovate, 1 mm long. The inflorescence is dense, silvery white clusters of compressed spikes on axils of leaves. Bracts are ovate, shorter, persistent, sub-equal, 1 to 1.5 mm long. Sepals are 2-3 mm long, white or purplish glabrous with hairs and strong mid-rib. Fruits are indehiscent, small, flattened, ovate, 2-2.5 mm long. Seeds are dark brown to black, hairy, shining with 1 mm diameter. Average number of seed per plant is up to 2,000. It is present throughout old world tropics, tropical Africa, southern and eastern Asia and Australia with China and south-eastern Asia as probable native places. It is propagated by seeds which fall down on the soil and germinate on onset of monsoon. The plant is rich in vitamin, C, riboflavin, calcium, iron and sugars. It is primarily consumed as cooked vegetable. In tribal belt of Jharkhand, its juice is used as medicine.

Jangali chaulai (Wild amaranth, *Amaranthus spinosus*)

Amaranth, commonly known as *Chaulai*, belonging to family Amaranthaceae in India comes under leafy vegetables. Few wild species are edible and are found growing in wild in most parts of India. The cultivated types are grown for nutritious grains and foliage. Its two species, *A. spinosus* and *A. viridis* are edible. They are annuals. It is easily available from June to November. Plants are tolerant to height and drought but cannot tolerate temperature below 8°C. Wild amaranth gets best vegetative growth in temperature range of 25 to 35°C. It has about 60 species, all annual with small seeds (approximately 0.07 g/100 seeds). In India, cultivated and wild, both species are found. *A. spinosus*, commonly known as spiny amaranth, prickly amaranth or spiny pig weed is noxious weed in rice fields. *A. viridis*, known as slender amaranth or green amaranth is commonly found in northern part of India. In rural India, it is used as vegetable on large scale in Uttar Pradesh, Bihar, Jharkhand, and West Bengal. Tribal belts of Jharkhand and Odisha use this species as best source of minerals. Grain amaranth species (*A. hypochondriacus, A. caudatus, A. cruentus*) have several health benefits. They are effectively gluten free, have a variety of medically active compounds. Amaranth oil is the best plant based source of squalene, which is a strong anti-oxidant, protecting the skin from pre-mature aging by preventing cell damage. Grain amaranth has particularly favourable composition in essential amino acids and its protein quality is much higher than conventional food sources such as wheat, barley and corn. The sum of essential amino acids in grain amaranth has been reported to range from 31.22 to 44.88 g/100 g protein, making amaranth a good source of high quality protein and nutritive substitute for some cereals in functional foods. It has C_4 photosynthetic pathway also. Wild amaranth is widely spread in India, Mexico, Guatemala, Peru, China and Nepal. Wild types do not have released cultivars. Propagation is through seed. These are highly adapted to stress conditions.

Keu (Crepe ginger, *Cheilocostus speciosus*)

Crepe ginger (family Cotaceae) is native to India. It is considered a potential invasive plant in Fiji and Hawaii. It is tall and ornamental plant used in landscaping. It can grow up to 10 feet in forest areas but typically it is a potted plant. In India, it has medicinal uses. It is a tall plant with large leaves (up to 18 cm long), dark green leaves arranged in spiral on the stalk. Flowers appear in late summer and they are remarkable in look. They form on glossy red cone-shaped bracts which stay red till flowers are finished. From each cone, 3-4 pure white crinkle flowers appear, one at a time. The attractive red-cone shaped bracts remain even after the flowers are gone. The fruits are red capsule and they contain black seeds with white fleshy aril. This is propagated by division of clumps, stem cuttings or pieces of rhizomes that are similar in appearance to thick fleshy ginger roots. It is a rich source of carbohydrates and proteins. Its rhizomes and new stems are used as vegetables in the tribal areas of Chhattisgarh, Madhya Pradesh, and Jharkhand. Rhizomes are boiled with water and the same are used as vegetables. The plant has many historical uses in Ayurveda.

Bichho grass (Nettle leaf, *Urtica dioica*)

Nettle leaf (family Urticaceae) is herbaceous perennial plant grown in hilly areas of Uttarakhand, Himachal

Pradesh, Sikkim, Meghalaya and Mizoram. The plant bears spines on the stem. The spines contain acetylcholine, histamine, 5 HT or formic acid which is responsible for itching and rashes on skin. It prefers rocks for its growth. It is found in autumn season from February to March. It is dioecious perennial plant (3.5 – 6 feet height). Soft green leaves are borne on erect stem. The plant bears brownish colour, many flowers on axillary inflorescences. Leaves and stem are hairy. The hairs on the leaves secrete chemicals during touch and cause sensation. Flowering starts in May and is completed by October. Seeds remain viable for a long time. Insects with long proboscis are pollinating agents. It is propagated via seeds and stolon. In India, it is available in hilly areas and forests and not cultivated commercially. Fresh green leaves contain proteins, vitamins (A and C), iron, calcium, potassium, manganese, fat and carbohydrates. Mature leaves contain about 40% alpha linolenic acid and omega -3-fatty acid. Spring shoots (leaf tips) are consumed like spinach. Younger tender shoots may be eaten as such or made into juice. In Uttarakhand, the plant is boiled, converted into fine pulp, cooked slowly and garnished with butter. Leaf juice mixed with water and sugar can be taken as a drink also.

Sahjan (Drumstick, *Moringa oleifera*)

Drumstick (family Moringaceae) is widely grown but on limited scale all over India except western part states like Rajasthan, Punjab and western UP, etc. In India, its young seeded pods and leaves are consumed as vegetables. It thrives well in semi-arid tropical and sub-tropical areas. *Moringa* is sun and heat loving plant and does not tolerate frost. It is dry-region crop and can be grown without expensive irrigation facilities. Flowering begins within the first six months after planting. In cool reasons, flowering occurs only once a year between February and March. In southern parts of India, few cultivars flower round the year. It is a fast growing deciduous tree which obtains 11-13 m height and trunk diameter of about 40-50 cm. Flowers are hermaphrodite with yellowish-white petals. The flowers are about 1-1.5 cm long and 2.0 cm broad. The flowers are hairy and the pods are green with hairy surface in the beginning but later on, pods get ridges with rough surface. Pods are 25-30 cm in length and contain winged seeds. Pods are drooping in nature. It is a fast growing tree, native to the southern foothills of the Himalayas in north western India and widely grown in tropical and sub-tropical areas. Leading *Moringa* growing states in India are Andhra Pradesh, Karnataka and Tamil Nadu. It is self-pollinated and propagated by seed and cuttings. Best germination of seed occurs in June-July. Cuttings of 1 m length and diameter of 4 cm are used in propagation. One third of cutting must be buried in the soil, preferably from June to August. Plants raised from cuttings, produce fruits within six months. Leaves are the most nutritious part of the plant being rich source of vitamins A, B, C and K along with manganese and protein. Leaves are cooked and used like spinach. Additionally, leaves are dried and crushed into a powder which is used in soups and sauces. Seed-pods are also a rich source of vitamin C, dietary fiber, and minerals like potassium, magnesium and manganese. Seeds sometimes removed from mature pods are eaten like peas and roasted like nuts and provide high levels of vitamin C and dietary minerals.

Sanai (Sunnhemp, *Crotalaria juncea*)

Sunnhemp is a multi-purpose tropical and sub-tropical legume grown in many parts of India. It is mainly known for fibre and fodder but flowers are used as vegetables also. Another species, *Crotalaria tetragona,* also locally knows as 'Tum Thang' has been collected from Mizoram, North-east hill region of India. It is also known as eastern rattle pod. Flowers are sold by tribal communities in local markets. Buds and flowers are cooked as vegetables and used in garnishing of local food preparations especially in non-vegetarian recipes. It is basically rainy season crop. It belongs to family Fabaceae. The plant is branched, erect, herbaceous, shrubby annual growing 3-9 feet high with bright green simple elliptical leaves. Leaves are simple, oblong (15-20 cm × 1-2 cm), carried on about 4 mm long stalks. Flowers are borne in racemes at branch ends or leaf-opposed. The flower is typical papilionaceous, as in peas, etc. It originated in India and is now widely cultivated in Brazil, Bangladesh and other Asian countries. In India, it is found in Mizoram, Meghalaya, Uttarakhand, Uttar Pradesh, Bihar, West Bengal and Assam. The other species, *tetragona* is found in Himalayas from Kumaon to Bhutan, south-east Asia and China. It is generally reported to be self-incompatible and cross-pollination is extensive. It is propagated by seed. Flowers are rich in dietary fibre, and calcium and iron. Pods and seeds have been reported to contain some toxic alkaloids but the same have not been reported in flowers. Vegetables from buds and flowers are commonly consumed in Uttar Pradesh, Bihar and West Bengal.

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Flowers always make people better, happier, and more helpful; they are sunshine, food and medicine for the soul.

– Luther Burbank

Rakesh Kumar Dubey, Vikas Singh,
Jyoti Devi, P M Singh and Jagdish Singh

Indigenous aquatic and minor vegetables

Indigenous vegetables have made an important contribution to food and nutritional security and also enhanced the livelihoods of marginal and smallholder farmers. Indigenous vegetables have been shown to be rich in micronutrients such as iron, zinc, pro-vitamin A and phytochemicals that help protect people against non-communicable diseases. Indigenous aquatic vegetables are predominantly in vogue where they are naturally available in plenty. Areas rich in water bodies like lakes, lagoons, ponds, ditches, marshy wet places are natural abode of most of the aquatic vegetables. Communities dominated in the wetland areas of the India do not only get their requirements of vegetables completed, it has been indispensable part of their life.

WATER spinach, water convolvulus, Kang Kong and swamp cabbage are some alternative names in English or kalmi saag in Hindi; originated in India and is member of morning glory family. It is a semi aquatic, tropical plant, grown as a leafy vegetable for its tender shoots and leaves. The leaves are good source of minerals, vitamins and also considered a possible source of food protein. The plant serves as high nutritive green fodder, fish food and feed for broilers. It has long, jointed and hollow stems, which allow the vines to float on water or creep across muddy ground. Adventitious roots are formed at nodes which are in contact with water or moist soil. They exude a milky juice and leaves are white or green, depending on variable forms. Leaves are 1-2.5 cm wide and 20-30 cm long and broad leaves are up to 5-7.5 cm wide and 15-25 cm long. Stems are 1- 2 meters long, rooting at the nodes, and they are hollow and can float. Water spinach easily forms new plants when fragments of stem break off and take root. The leaves are usually green and arrow-head or lanceolate in shape. The leaves grow alternately on the stem of the plant. The margins are entire or angular and sub lobed. The flowers peduncles are erect, 2.5 to 5.0 cm long, with 1-2 flowers, borne in the axils of the leaves. Typically look like "morning glory" flowers. They are trumpet shaped and showy, white to pale pink or lilac in colour and grow singly or in small groups. Sepals are green, oblong, about 8.0 mm long. Corolla is narrowing bell-shaped, about 5.0 cm long, and purplish; limb nearly white or pale pink purple, about 5 cm in diameter, the tube deeper purple inside. Capsules are smooth and ovoid, about 1.0 cm long. Fruits are an oval or spherical capsule, woody at maturity, 1.27 cm wide, each capsule holds 1-4 grayish seeds, about 4-5 cm in diameter. The pods and seeds can easily float and travel to spread new plants.

Table 1. Nutritional value of water spinach, Indian palak and spinach (per 100 g of raw)

Water spinach		Indian Palak	Spinach
Energy	19.0 kcal	46.0 kcal	23.0 kcal
Carbohydrates	3.14 g	6.5 g	3.63 g
Dietary fiber	2.1 g	0.7 g	2.2 g
Fat	0.2 g	0.8 g	0.39 g
Protein	2.6 g	3.4 g	2.86 g
Vitamins			
Vitamin A equiv.	1890.0 µg	1758.6 µg	469.0 µg
Thiamine (B1)	0.03 mg	0.26 mg	0.078 mg
Riboflavin (B2)	0.1 mg	0.56 mg	0.189 mg
Niacin (B3)	0.9 mg	3.3 mg	0.724 mg
Vitamin C	55.0 mg	70.0 mg	28.1 mg
Minerals			
Calcium	77.0 mg	380.0 mg	99.0 mg
Iron	1.67 mg	16.2 mg	2.71 mg
Phosphorus	39.0 mg	30.0 mg	49.0 mg

Health benefits of water spinach

It is an excellent option to lose weight and reduce cholesterol naturally. Research has proved that consumption of water spinach results in the reduction of cholesterol level and triglycoside. Water spinach has been used in Ayurvedic medicine for the treatment of jaundice and liver problems by its modulation of detoxification enzymes; antioxidant and free radical scavenger properties. Being rich in iron, the new water spinach leaves are extremely beneficial for anemia as well as pregnant women who require iron in their diets. Water spinach is rich in fiber and hence, it aids in digestion, providing relief from different digestive disorders. Juice from boiled water spinach can loosen constipation and also used in the treatment of intestinal worm infestation. It contains latex which is used as a purgative agent. It has been found that regular consumption of water spinach helps in developing resistance against diabetes induced

oxidative stress. The nutrients present in water spinach act as antioxidants to reduce free radicals in the body, thus preventing cholesterol from becoming oxidized. Besides, folate contained in water spinach helps to convert a potentially dangerous chemical called homocysteine, which in high levels can lead to heart attack. Magnesium lowers blood pressure and provides protection against heart disease as well. Being loaded with 13 different types of antioxidant compounds, water spinach is a perfect diet for prevention of cancer. Water spinach is said to be most beneficial in the prevention of colo-rectal and stomach cancers as well as skin and breast cancers and making the skin cells more resistant from damage from exposure to the sun and minimizing wrinkling to a significant extent. Regular consumption of this vegetable can prevent and reverse ageing. Water spinach has a high content of carotenoids, vitamin A and lutein. These nutrients are vital for eye health and also boosts glutathione levels, which play an important role in preventing cataracts. Being a storehouse of nutrients, this leafy green vegetable is an inexpensive and natural way of boosting the body's immunity in comparison to vitamin C supplements. Consumption of this green leafy vegetable on a regular basis boosts your body's immune system and promotes healthy development of bones. Drinking of water spinach juice is extremely beneficial for skin health as it keeps skin ever rejuvenated by eliminating harmful toxins from the body. The wide array of nutrients contained in water spinach is beneficial for hair and prevents hair loss besides improving the quality and texture of hair. In addition to the benefits discussed above, water spinach is effective in treating ulcers, menstrual pains, toothache, launched urination, nosebleed etc. It acts as a sedative for people who have insomnia or sleeping difficulty. The juice of water spinach mixed with water is used as a cold compress to treat fever. Being anti-venom, it is used to promote vomiting in case of poisoning.

Uses of water spinach

Young shoots and leaves can be eaten as raw in salads or cooked with other vegetables, spices and meat. Stir-fried (stir-fried water spinach with garlic) water spinach is a popular vegetable dish. In the South India, the water spinach is julienned into thin strips and eaten with many kinds of noodles. It is also commonly cooked in sour soup with tomatoes and other vegetables. Water spinach is also eaten raw or parboiled along with other vegetables in dip dishes. In the Philippines, the tender shoots are cut into segments and cooked together with the leaves in fish and meat stews. In Singapore and Malaysia, the tender shoots along with the leaves are usually stir-fried with chili pepper, garlic, ginger and other spices. In West Bengal, it is known as kolmishak and stir-fried preparation of the leaves is a very popular dish.

Genetic resources

Water spinach is extremely widespread and not in danger of genetic erosion. Diverse germplasm collections are being maintained at ICAR- Indian Institute of Vegetables Research, Varanasi, Uttar Pradesh with holdings of more than 30 diverse genotypes. World Vegetable Center, Taiwan and National Research Institutes, South-East Asia are holding many genotypes of water spinach.

Crop improvement

Consumers have specific preferences with regard to the quality of the product, viz. number of leaves, stem length, percentage of fibre and taste. ICAR-IIVR, Varanasi has selected superior genotype from landraces for different horticultural traits and rapid development. The genotype VRWS-1 with broad leaves and grown year-round and is suitable for multiple harvesting indentified at ICAR-IIVR, Varanasi. Important variants on the basis of leaf size, colour and growing habits are as follows:

Light green: Plants of this group have light green stem. The shoots are tender, soft and glabrous with ovate, oblong and lanceolate leaves and spread densely in shallow water.

Green red: Stems of this group of plants are green red. Shoots are tender, soft and glabrous with thick leaves, mostly hastate. The plants spread and produce long trailing branches. It is the most common type.

Red stem : Stem of this plant group possesses dark red colour and they are soft, glabrous with a diameter thinner than of the other varieties.

Climatic and soil requirement

Water spinach responds well at optimal temperature of 20-30°C. Flowering occurs under short-day conditions. It tolerates very high rainfall, but not frost. It prefers full sun but where summer temperatures are very high, it is sometimes grown as a ground cover beneath climbing plants. Water spinach should be sheltered from strong winds. It requires fertile soil rich in organic matter with soil pH of 5.5 to 7.0.

Sowing and planting

In moist soil culture, the crop is grown on raised beds 60-100 cm wide. Seeds are sown directly or nursery grown seedlings are transplanted. Seed should not be more than 2 years old and can be soaked for 24 hours before sowing to encourage germination. Seed should be sown 5-10 mm

Variation in shape, size and colour in water spinach grown at ICAR-IIVR, Varanasi

deep in trays with potting mix deep enough to allow the plants to develop a good root system. Transplanting should take place when plants are 10-15 cm high with four true leaves. Highest yields are obtained by spacing plants at 20 × 15 cm. They can also be grown in rows about 20 cm apart with plants at 15 cm spacing within rows. Water spinach can be grown as an upland field crop. The 1000 - seed weight is about 50-60 g. The seed rate of 60–100 kg is found to be sufficient for a hectare sowing. Final plant densities may range from 3,00,000-17,00,000 plants/ hectare. Upland field water spinach is more productive and has a better market quality.

Propagation from cuttings

Water spinach can also be raised from stem cuttings 30-40 cm long, taken from the young growth just below a node and planted about 5.0 cm deep. For aquatic culture, cuttings from the broad leaved cultivars are transplanted in puddled soil.

ICAR-IIVR, Varanasi developed package of practices for upland field water spinach

Water spinach is commonly grown in waterlogged areas. However, such cultivation requires cumbersome practices for plant protection measures and harvesting. This also invites water pollutants harmful for human health. Therefore, an attempt was made for cultivation of water spinach in upland field conditions and promising results were obtained for the same. This technology can prove to be simple and be cultivated round the year which can serve as boon for the socio-economic upliftment of farmers.

Cultivation of water spinach in upland field condition at ICAR-IIVR, Varanasi

Advantages of upland field–water spinach

- Multiple cuttings.
- Can be grown throughout the year.
- Can be grown in upland field condition, submerged condition is not necessary.
- Produce may be free from water pollutants.
- Technology promises “Safe Biomass” as “Upland Water Spinach”.
- Promotion of cultivars VRWS-1 for socioeconomic prosperity among growers.

Crop management

Before transplanting, the crop must be given sufficient nutrients to produce quality water spinach. Plants respond well to nitrogen but over-feeding must be avoided because it can result in high nitrate concentrations in the leaves and stems which is undesirable. A general fertilizer recommendation includes manure applied before sowing/ transplanting at the rate of 30 t/ha with N 50.0 kg/ hectare, P 30.0 kg/ha and K 40.0 kg/ha. This is followed by three top dressing at 10 days interval with N at a rate of 30, 8 and 8 kg/ha. In case of multiple cuttings, which is most desirable in home gardens, additional top dressing is recommended after each cutting. Application of large amounts of nitrogen fertilizer increases yield and leaf/stem ratio, but also the nitrate content, whereas the dry matter content decreases. In wet cultivation the water level is raised in accordance with the development of the crop, reaching a depth of 15–20 cm. Fertilizer application is similar to upland cultivation, also with a top dressing of nitrogen after each cutting.

Harvesting, yield and post harvest management

Water spinach should be harvested before it flowers. Crop becomes ready for harvesting 50-60 days after sowing and 35-40 days after planting. Many harvests can be taken if shoots are cut above ground level; allowing secondary shoots to grow from nodes below the cut in upland field condition. The frequency of harvesting will depend on the growth rate of the crop. The upper part of the main shoot, about 30 cm long is cut about 5 cm above water level. About 35-40 tonnes/hectare fresh greens can be harvested from three or more cuttings. Rapid and careful post-harvest handling is required to minimize damage to the crop, especially due to wilting caused by moisture loss. To prevent this, the plants should be harvested during the coolest part of the day. After bunching, a fine spray of cold water should be applied and the leaves kept in a cool place away from the wind. Leaves are usually sold in 500 g bunches in the markets at the rate of ₹ 60-80/kg.

For long-distance transport and supermarkets, water spinach bundles are packed in layers of 15 cm in bamboo crates with crushed ice in between. Water spinach harvested from upland field has a longer shelf life because the leaf area of the young shoots is small.

Prospects

Upland field water spinach is an excellent vegetable, worth promoting in tropical Indian lowland areas. The popularization of improved germplasm line VRWS-

Leaf bundle of water spinach

1 developed by ICAR-Indian Institute of Vegetable Research, Varanasi for upland field water spinach might be successful especially in areas where sweet potato leaves are traditionally consumed. Research should focus on the improvement of fertilizer application and non-chemical control of insect damage. Breeding efforts should concentrate on cultivars/germplasm lines adapted to specific environments and resistant to biotic and abiotic stresses.

Indian lotus (*Nelumbo nucifera*)

Lotus is also known as Kamal, Padma, sacred lotus, Indian lotus, East Indian lotus, Oriental lotus, Lily of Nile and Bean of India. Young leaves, petioles and flowers are eaten as vegetables. Rhizome (Kamal-Kakadi) is edible and sold as vegetable. Fresh rhizomes are eaten after boiling and fried slices are used in curry or fried as chips. Fresh rhizomes can be preserved in frozen conditions and used as precooked food. Generally two types of rhizomes, white and red are available. Rhizomes varied 60-120 cm in length and 6-9 cm in diameter, white to buff orange in colour and possess a few large cavities in cross section. The leaves are used as a flavouring agent and to wrap sweet and spicy mixtures for steaming.

Nutritive and medicinal value

Fresh rhizomes contains moisture 83%, crude protein 2.7%, fat 0.11%, reducing sugar 1.56%, sucrose 0.41%, starch 9.25%, fiber 0.80%, Ash 1.10%, calcium 0.06%, thiamine 0.22 mg, riboflavin 0.06 mg, niacin 2.1 mg and ascorbic acid 15.0 mg. Decoction of its leave significantly reduces the serum triglyceride and cholesterol levels. Lotus has been found to have 77% antioxidant activity. Rhizome of lotus is known for its hypoglycemic, antipyretic, anti diarrheal, antibacterial and anti-inflammatory activity.

Description of Indian lotus plant

Apart from its aesthetic value, the entire lotus plant is of considerable economic and medicinal value as well. Every part of the plant is consumable. The petals are often used for ornamental purposes. The mature leaves are often used for packaging as well as serving food. The rhizome and leaf stalks are used as vegetables in most of the East Asian countries like China, Korea and Indonesia. The rhizome is boiled, sliced and fried, used in salads and pickled in vinegar. It is rich in fiber, contains vitamins B_1, B_2, B_6, and C and minerals like potassium, manganese, phosphorous and copper. The lotus seed are also quite popular as nuts and are often eaten raw. They may also be fried or dry roasted to produce a sort of popcorn. The lotus has several curative properties in traditional medicine. The lotus tea brewed using the flower is used to relieve cardiac ailments. It also has detoxifying properties and helps stop blood flow in injuries. The lotus rhizome is good for the general wellness of stomach and reproductive organs. It is good for healthy development of foetus during pregnancy. The lotus leaves are used for wrapping other food items and it helps preserve their freshness.

The lotus stem remains underground in the muddy soil at the bottom of the inhabiting water body. It modifies into a structure known as the rhizome which serves as both an anchoring device and storage organ. Roots are short and fibrous, growing out in bunches from the stem internodes. The lotus plants have simple leaves meaning one per leaf stalk. The stalks emerge upwards from the rhizomatous stem – are green, long, round and hollow. The vasculature is porous enabling the stems and stalks to remain afloat in water. The upper surface of the leaves is waxy and impervious to water. The flowers are the key focus of the plant, and are large and showy, predominantly pink. The cone shaped central female reproductive structure is termed the thalamus which is framed by the delicate petals. The lotus bud resembles the shape of a tear-drop with pointy tip and tightly packed petals. The petals are translucent and open in overlapping spiral pattern. The flowers open in the morning and bloom for three days. The petals close after sunset trapping in the pollinating agents. The central yellow receptacle of the spongy thalamus contains the ovaries which develop into seeds after fertilization and are embedded in single chambers. Seeds are hard, oval in shape and dark brown in colour.

Cultural importance

The lotus flower is deeply imbibed with symbolism of Indian philosophy. In his essay "The Secret of Work", Swami Vivekananda impressed upon the significance of lotus leaves as a symbol of spiritual detachment by saying, "Just as water cannot wet the lotus leaf, so work cannot bind the unselfish man by giving rise to attachment to results." The lotus plant itself is evocative of this powerful imagery symbolizing this spiritually desired way of life; the way it grows among mud and murk yet remain pristine and upholds something of immense beauty. It is considered sacred in both Hinduism and Buddhism. Many Hindu deities like Brahma, Lakshmi and Saraswati are depicted to be seated on a lotus flower. In Buddhist philosophy, the lotus represents the preserved ability of purity of one's soul amidst the grime of mortal life. The lotus flower is a symbol of divine beauty and is often used as a simile to describe someone with pure and delicate attribute.

Distribution of Indian lotus

Indian lotus distribution ranges throughout the semi-tropical climatic condition. It is predominant in the India, Bangladesh, and Myanmar; but also very common in other

south-east Asian countries like Bali, Indonesia, Malaysia etc. It is cultivated in Australia as well as in European countries for its aesthetic value. The national flower of India is Lotus and has been an integral part of the Indian culture from time immemorial. A prominent feature of the Indian mythology, the lotus is one with the Indian identity and represents the core values of Indian psyche. The Indian lotus symbolizes spirituality, fruitfulness, wealth, knowledge and illumination. The leaves and flowers have long stems that contain air spaces in them. The Indian lotus flowers have many petals overlapping in a proportional pattern.

Propagation

In general, lotus is grown from seeds or rhizomes. For one hectare planting, 10-12 kg of seed is required to raise seedling. To propagate through the seeds; first step is Scar the seeds. If we do not scar the seed, it will not grow and may rot. The seeds should be placed into a glass of warm water. The water should not be chlorinated and must be changed every day until the lotus seeds sprout. After the first day of soaking, the seeds should swell to nearly twice their original size. Seeds that float are almost always infertile. If these seeds do not swell like the others, discard them to avoid letting them cloud up the water. Growth should start after four or five days of soaking and wait until the seedling is at least 15-20 cm long before transplanting. For propagation through rhizomes; rhizomes are cut into small pieces and planted with eyes above the soil surface in March-April. Rhizomes should not be exposed to direct sunlight or freezing temperatures. Plant the lotus within a few weeks after the rhizomes sprouts. Plant will be ready for deeper water once the growing tips show leaves. Smaller types of lotus need only 1 to 15 cm of water covering the top of the soil, but larger varieties may need up to 1 m of water.

Propagation technique of Indian lotus through leafy stem cutting standardized at ICAR-IIVR, Varanasi

Lotus is usually propagated by the seed or division of enlarged rhizomes. Vegetative propagation allows the cloning of superior individuals and enables nurseries to supply uniform planting stock to growers. Since enlarged rhizomes are divided and planted for propagation in late March, before the sprouting of terminal buds, the propagation of lotus is limited to a relatively short period of the year when lotus does not grow actively. During the growth period in early summer, farmers who cultivate edible lotus generally use rhizome straps with enlarged rhizomes as materials for propagation. They consider that rhizome straps without enlarged rhizomes would not be suitable as materials. However, excavation of enlarged rhizomes from lower depths in soil is laborious and the buds often break vigorously in response to heavy pruning. Rhizome straps without enlarged rhizomes may have the potential to produce many roots, and it could be possible to develop a propagation method that uses rhizome straps. Thus rigorous studies were undertaken at ICAR-IIVR, Varanasi to determine whether lotus could be propagated through some other plant parts than seeds or rhizomes and also their survival rate evaluation. Large number of plants could be raised by leaf-stem cuttings for vegetative propagation. Through this method, we could produce true to characters as of source material within a very short period of time and plant survival rate was also found to be more than 90%. The present finding encourages for rapid multiplication technique of lotus and proven as easy and most effective method of propagation of lotus over seed /rhizome propagation methods.

Standard agrotechniques

Rhizome yield with tune of 250-350 quintal per hectare could be obtained by application of 270 kg N, 120 kg K_2O and 15 kg B per hectare. It is found that lotus is more responsive to B application. Harvested rhizome of lotus is very much vulnerable to browning disorders. Rhizome with browning has low market value. Rhizome grown in substrate low in Fe showed less browning from those grown in one with a high Fe content. To avoid enzymatic browning of external cut surface of pre-cut lotus root treatment with a solution of 2% erythorbic acid + 1% citric acid is most effective.

Commercial viability

Indian lotus is a well-known flower to everybody especially in our country where it is considered as a

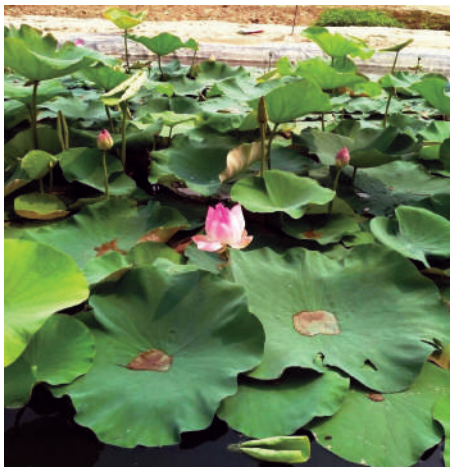
Cutting-preparation

Planting of cutting

Plants developed through leafy-stem cutting

Flowered plant propagated by leafy-stem cutting

Lotus propagation technique of leafy stem cutting



Lotus grown in pond at ICAR-IIVR, Varanasi

National flower. Lotus has many practical uses, beneficial uses (as medicine) as well as cultural uses (to worship Laxmi). Generally we collect lotuses from spontaneous growth of the plant, but to cultivate the plant commercially is out of conception. Growing demand of lotus especially flower has motivated farmers and lotus lovers to think about it. For people who are busy but want to maintain the water plant is the right choice. Maintenance of the lotus plant does not require much time and not technically complex. Durga puja is an important festival all over India and during this festival there is huge demand of lotus flowers according to rituals. Each Puja pandel requires about 108 lotus flowers. Therefore, how much number of lotus flowers is needed? Then the price of flower is not a matter, but availability of flower is really a matter. Hence, there is a good business opportunity. To catch that potentiality, farmers must be motivated by the public or private extension system. In general lotus rhizomes are sold at the rate of ₹150-200 per kg.

Tree bean (*Parkia roxburghii*)

Several vernacular names are available for tree bean viz. Khorial (Assamese); Manipuri seem (Bengali); Zongto (Mizo); Yongchak (Manipuri); Aoelgap (Garo); Bire-phang (Kachari); Themuk-arang (Mikir); Unkamn-pinching (Naga) among the tribal population of the NEH region. Tree bean belongs to family Leguminosae and is regarded as a colourful tree species of Manipur and grown mostly in the home garden, slash and burn or jungle throughout the region. The fruit (pod) is consumed in all its developmental stages and is one of the favourite food items among the people of Manipur as well as to the neighboring states for its unique smell, taste or flavour. The pungent smell of tree bean tells the presence of Thiazolidine-4-Carboxylic acid (TCA, Thioproline), a cyclic sulphur containing amino acids. The tree bean serves as the basic needs of protein and fat to meet the even increasing requirements. The seeds as well as tender pods are known to cure stomach disorders and regulate liver function. Pods pounded in water are used in cleaning the face and head. The pods are reported to be good source of ascorbic acid (26.0 mg/100 g), fat (20.28%), proteins (32.82%) and minerals (4.45%). Studies on protein fractionation reveal that globulin and albumin are the major fractions and the globulin to albumin ratio is very less (1.6). The higher amounts of albumins (8.14%) with the globulins (13.05%) indicate more protein digestibility and higher content of sulphur containing amino acids means more nutritive values as these are the limiting amino acids in legumes. Protein content of the pod ranged from 12.1% in tender to 18.8% in mature pods. Like any other grain legumes, protein content of the kernels (28.8%) was much higher than the pods. Though, protein content of tree bean kernel is lower than soybean (43.0%) it is higher than most other grain legumes such as Bengal gram (23%), cowpea (24%), green gram (24.0%) and red gram (22.0%). Also, the fat content of tree bean kernel is lower than oilseeds such as groundnut (42.0%) however; it is higher than other grain legumes such as winged bean (18.0%) or soybean (20.0%). Maturity of the pods leads to an increase in protein and fat content accompanied by a decrease in the ash as well as carbohydrate content. In addition, unsaturated fatty acids in the tree bean kernel as well as the pods range from 63–67%. The high degree of unsaturated and the substantial amount of fat in the kernels warrants their screening for edible oil production. Compared to other grain legumes, tree bean kernel, as well as the pods has also been reported with good mineral content too. Thus, many investigation envisages that different plant parts of tree bean were found to have high amounts of phenols and AOA; low IC_{50}, low EC_{50}, reasonably good values of ARP which explains their effectiveness towards protection of DNA nicking indicating strong free radical scavenging activity. The antioxidant capacity of extracts varied according to the system-generating reactive species. It is well known that the performance of a complex mixture such as plant extracts in different antioxidant systems is related to the type of radical generated and to the polarity of the substrate system. In most of the assays, the pod extracts showed even higher potency in scavenging of free radicals than quercetin which was used as a standard. Further, it holds promise to identify the potential sources of natural polyphenols with promising AOA, FRSA and wide range of other biological activities. The wood can be used as a source of paper pulp. Pods from the plant growing in different agro-climatic conditions exhibit a high degree of morphological variations. The best season for tree beans is the month of November, the festive

Tree bean plant with flower, pod and ripened seed

season of *Ningol Chakouba*. The leaves are shed mainly in May-June, the flowers appear from mid August and the fresh fruit (pod) start plucking from mid October. Natural regeneration is found to be limited in warm and non shady places. It reproduces and grows well under fairly dense sunshine area. The growth rate is normal and tree lives to some great extent. Artificial regeneration is now a day's very common because seeds do not take time to germinate and growth of seedlings is quite fine. Flying foxes represent a major role in the principal pollination pattern and seed dispersal of tree bean. It is a large tree (up to 25 m height) with spreading branches, generally found in lowland rainforests. Tree bean being a fast-growing leguminous species with multiple uses can be easily propagated through seeds. One- or two-year old seedlings can be transplanted in the field. The leaves are bipinnate with numerous small curved leaflets and flowers in dense turbinate or clavate heads hanging on long peduncles. The fruit comprises bunches of green pods which may be up to 50 cm in length. On maturation, the pods turn black and contain yellow dry powdery pulp in which are embedded several black seeds. The inflorescence head or capitulum arises terminally with clusters of yellowish-white tiny flowers, hanging at the top of long stalks from the branches. The fruits in early stages are soft, tender and bright green in colour. They turn blackish when fully mature in March–April. Pods are formed in clusters of 10–15, each measuring 25–50 cm in length and 3–5 cm in breadth. At the age of 6 years the plant starts its production; however, full bearing stage is only after 10 years. The lifespan of this tree may be 80–90 years or more. During favourable season a full-grown plant bears 10,000–15,000 pods fetching a market value of ₹ 100–150/ kg. Tree bean pods are considered a delicacy in the North-eastern region of India which is consumed either fresh or cleaned and sundried for future use during off seasons.

This tree legume could prove to be an inexpensive and rich nutritious source for human consumption and if properly exploited may be a supplementary source of diet protein. Standardization of its cultivation techniques and augmenting the potential of this 'Wonder Tree' can play an important role to uplift the socio-economic status of the tribal communities too. Besides, harnessing its antioxidant potential along with medicinal properties through scientific insights would provide new paradigms of this multipurpose tree species.

Cluster bean (*Cyamposis tetragonoloba*)

Cluster bean is a drought and high temperature tolerant, deep rooted, annual legume of high social and economic significance. The crop holds great potential like high adaptation towards erratic rainfall, multiple industrial uses, importance in cropping system for factors such as soil enrichment properties, low input requirement, etc. India produces the maximum level of production in the world and contributes to around 80% share in the world's total production. In India it is mainly grown in the dry habitats of Rajasthan, Haryana, Gujarat and Punjab and to a limited extent in Uttar Pradesh and Madhya Pradesh. Rajasthan occupies first position in India both in area and product. The nutrient composition of cluster bean is given in table 2.

In Rajasthan, guar is mainly grown in Barmer, Churu, Sriganganagar, Nagaur, Jalore, Sikar, Jaisalmer, Bikaner, Jaipur, Jhunjhunu and Alwar districts. In Gujarat (Kutch, Banaskantha, Mehsana, Sabarkantha, Vadodara and Ahmedabad), Harayana (Bhiwani, Gurgaon, Mahendragrh and Rewari) and Punjab (Bhatinda, Ferozpur, Muktsar and Mansa). The crop is now being cultivated in dry

Flowering plant of Cluster bean

Table 2. Nutritional composition of green cluster bean pods

Constituent (Per 100 g edible portion)	Content
Energy (Kcal)	16.00
Moisture (g)	81.00
Protein (g)	3.20
Fat (g)	1.4
Carbohydrate(g)	10.8
Vitamin A (IU)	65.3
Thiamine (mg)	0.09
Riboflavin (mg)	0.03
Niacin (mg)	0.60
Ascorbic acid (mg)	49.0
Calcium (mg)	57.0
Phosphorous (mg)	57.0
Iron (mg)	4.5

tracts of Madhya Pradesh, Chhattisgarh, Andhra Pradesh, Karnataka, Tamil Nadu and other parts during *kharif* as well as in summer season. Cluster bean is three-four months crop.

From sowing to harvesting it takes about 90 to 110 days. Crop cycle starts with sowing by first to second week of July. In general flowering stage starts after 40 to 60 days after sowing. The pod formation takes place after 50 to 70 days from the date of sowing. Pod matures in 80 to 90 days of sowing. The harvesting of the crop begins when 90% pods are matured, that is roughly between 90 to 110 days of sowing (depending on the variety, soil and climatic conditions). Cluster bean is a photosensitive crop and requires specific climatic condition to grow. In arid condition cluster bean grows as rainfed crop which requires 300 to 400 mm rainfall in 3 to 4 spells. Cluster bean has the ability to fix nitrogen to the tune of 30-40 kg/ hectare. Several improved varieties of cluster bean have been evolved by Universities and ICAR Institutes in the country. The major research on Cluster bean is being done at ICAR-Indian Institute of Vegetable Research, Varanasi, UP; SKRAU, Bikaner; CAZRI, Jodhpur, Rajasthan and CCSHAU, Hisar, Haryana. Many of the varieties are suitable for cultivation in arid and semi-arid regions. The varieties differ in maturity period, branching habit, quality and quantity of seed yield.

ICAR-IIVR, Varanasi standardized package of practices for early cultivation of cluster bean

To get early crop harvest; four varieties/germplasm namely Pusa Navbahar, Avani-117, Dilojan-3 and RSG 052 of cluster bean were sown on four different dates i.e. on 28th March, 28th April, 28th May and 28th June, 2019 with standard package of practices at ICAR-IIVR, Varanasi. First fruit harvesting was done 55 days after seed sowing. Pod length varies from 9.5-15.5 cm, number of pod per plant varies from 30-65. March 28th, 2019 date of sowing was found best date of sowing to get maximum number of pod per plant and yield per plant followed by 28th June,

Field view of Cluster bean

2019 date of sowing. Hence, early sowing (second fortnight of March) is found to be most suitable date of sowing to get early crop of cluster bean which may fetch high price returns after sell of produce in the market.

Cluster bean varieties for vegetables purposes are - Goma Manjari, Pusa Domausami, Durga Bahar, Pusa Navbahar, Pusa Sadabahar. For fodder- HFG-119, HFG-156, Durgajay, Durgapura Safed, Agaita Guara-111, Agaita Guara-112, FS-277, HG-75, Guara-80, HG-182, Maru guar, HFG-156, Bundel Guar 1, Bundel Guar 2, Bundel Guar 3. The cluster bean seed consists of three parts: the seed coat (14-17%), the endosperm (35-42%), and the germ (43-47%). It is from the endosperm that guar gum is derived, which is the prime marketable product of the plant. This spherical-shaped endosperm contains significant amount of galactomannan gum (19 to 43% of the whole seed), which forms a viscous gel in cold water. The USA is the largest importer of cluster bean and its derivatives from India. The demand of processed cluster bean in world market is expected to increase with the expansion of shale oil gas tracking to new countries like China and Russia and scaling up in prominent existing countries like USA along with other uses in food and textile industries owing to increased food safety and health concerns. This makes it relevant to study the supply response of cluster bean crop particularly when the cultivation of crop is confined to a limited geographical area. The supply response of a crop may be estimated in terms of area, yield and output response. The expansion of uses of cluster bean to new areas like extraction of natural and shale gas has transformed cluster bean in recent years into an important export crop. Increasing demand of cluster bean on account of growth in shale gas

Variability in pods of different genotypes at ICAR-IIVR, Varanasi

Variability in shape and size of cluster bean pods

industry along with other factors has made cluster bean a golden crop. There are number of cluster bean processing units in Jodhpur, Bikaner, Ganganagar, Alwar and Jaipur districts of Rajasthan, Bhiwani and Sirsa districts of Haryana and Ahmadabad district of Gujarat. These units can be grouped into cluster bean split manufacturers and guar gum processors. Though the involvement of processing and high demand in international market have made the marketing and distribution of cluster bean crop very complex, Agriculture Produce Marketing Committee (APMC) markets have an important role to play in the supply chain. The APMC market provides a platform for aggregation and operation for various players operating at the wholesale level like traders, stockist, etc. The trade in these markets is facilitated by commission agents and the traders have to pay prescribed market fee on the value of transaction. At processors level, the splits are packed in plastic bags of 50 kg size while cluster bean powder is packed in paper bags of size 25 kg of powder. There are a few large manufacturers like HICHEM, Dabur, Vikas WSP etc. who produce value added derivative for export as well as domestic market. If crop is grown by adopting all improved package of practices, it is possible to get nearly 7- 8 quintal per hectare seed yield of cluster bean under rainfed condition and 12-15 q/ha in irrigated condition during *kharif* season and 10-12 q/ha during summer season. Average cost of cultivation per hectare occurs about ₹ 28,000-30,000 per for rainfed crop and about ₹ 35,000-40,000 per hectare for irrigated crop. Input: output ratio for cluster bean cultivation is about 1: 1.98.

Harnessing potential and commercial viability of aquatic and minor vegetables: Although aquatic and minor vegetables, both in terms of production and consumption find a place only in local/tribal communities of our country but holds immense potential to contribute towards food security and economic viability. The various parts of the country with swamp lands and shallow ponds have been adjudged to be entirely unsuitable for fish culture or agriculture and the present policy for such areas is to 'drain and develop' them for uses not in accord with their nature. This requires searching innovative techniques that would allow using wetlands sustainably and cultivation of aquatic and minor vegetables is one of the possible ways. However, popularization and proper augmentation of aquatic and minor vegetables on a large scale could make a significant contribution towards nutritional security and economic upliftment of the society. In addition, this is also likely to generate on-farm and off-farm (transportation, storage, processing, marketing etc.) employment. In view of the importance of aquatic and minor vegetables, crop improvement programme has been initiated at ICAR-IIVR, Varanasi, in order to popularize and augment aquatic and minor vegetable production among growers.

SUMMARY

Research is needed to better understand the potential, opportunities and perceived critical bottlenecks faced in their decisions to produce and consume indigenous vegetables to devise effective dissemination and adoption strategies. In order to facilitate effective utilization, it is important to focus on priority indigenous vegetable crops in traditional agricultural areas and development of procedures for assessing the sustainability of their use, tied to focus research to evaluate the potential and ecological requirements. This would facilitate to pave a long way in advancing knowledge and promoting their benefits to reach a larger population. The present compilation is expected to provide sufficient baseline information for further exploration of indigenous vegetables for nutraceuticals purposes as well as for developing new, cheaper, and safe food products. Such scientific insights in these lesser known indigenous food plants would be a significant step towards disease prevention and management through diets.

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Joseph John K, M Latha,
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Indigenous and minor vegetables of Western Ghats

Western ghats are one among the four mega-biodiversity hotspots of India, out of 36 designated hotspots across the globe. UNESCO has declared Western ghats region as a heritage site with high significance to human civilization. Western Ghats are a chain of low to high hills lying parallel to the Arabian Sea with unique agro-ecological habitats, predominantly high rainfall and high humid conditions followed by a mild winter and an extended summer. Prevalence of endemic species is also very high in Western Ghats. The leeward side receives less rainfall and certain pockets are rain shadow areas. The high ranges, midlands and the West coast offer several unique micro climates and specific niches for the evolution, and cultivation of speciality vegetables. Irrigation availability, extended monsoon, no or mild winter and cool climate in the hills, altitudinal and topographic variations, all permit year round cultivation and availability of one or more vegetables. While tuber crops and tree vegetables are seasonal, cultivation of annuals can be taken up more than one crop in a year. Ratoon crops like ivy-gourd, drumstick and vegetable banana are a component of all homestead farms along West Coast. Commercial vegetable plots are few and high density multi-species tree based cropping system is more prevalent in Western Ghats and West Coast. The less known, less cultivated, ethnically important and wild gathered indigenous vegetables of Western ghats are highlighted in this paper.

SPECIES diversity of plants used for vegetable is enormous in this part of the country as immature or unripe fruits of many fruit trees, wild gathered vegetables, less cultivated vegetables, naturalised exotics from iso climatic regions and tropical tuber crops all offer an array of diverse vegetables. Immature fruits of pineapple, sweetsop, mango, jackfruit, banana, papaya etc. are consumed as vegetables. Many wild relatives especially that of crops belonging to genera *Momordica, Solanum, Abelmoschus* (*A. moschatus*), *Colocasia* etc. are also consumed as health foods. There are several ritualised traditions and ITKs associated with indigenous vegetables in Western ghats.

The diversity of recipes and diets depend on the availability of raw materials and ingenuity of chef, both are abundantly present in the region. Drumstick leaves are not consumed in peak monsoon months (*Karkidagam* (July-August) month in Malayalam calendar) as with heavy rain it is believed to accumulate anti-nutrition principles. Also health traditions of using certain curative vegetables for the treatment of piles (*Momordica dioica*), anaemia and those under convalescence (Drumstick leaves) are prevalent in the region. The famous '*pathilakkari*' (ten leaf vegetables) comprising wild *Colacasia*, *Cassia tora*, *Trianthema*, pumpkin, cowpea, Amaranthus, elephant foot yam, taro, ivy-gourd and *Tragia involucrata* is consumed during peak rainy season as health food. '*Thampuli*', a spicy rasam made of leaves of *Coleus aromaticus* is consumed in coastal Karnataka as a prophylactic health food during monsoon season to protect the body from fever. The ritualistic '*Thiruvathira puzhuku*' offering with tropical tuber crops like yams, taro, Chinese potato etc. with horse gram is also a must-to-eat vegetable combination for women devotees during fasting period. The '*Vallasadya*' of Aranmula Sri Parthasarathy temple offers over 101 vegetable dishes using traditional vegetables. Oriental pickling melon is an unavoidable item in the '*Vishukani*' ritual of Kerala homes and temples. The vegetables of Western ghats region are unique for its species diversity, parts used, genetic diversity with specific landraces for specific uses, shelf life, adaptability to organic cultivation, suitability for low input homestead farming and medicinal properties. Vegetables like drumstick, *Boerhaavia,* species of *Solanum* and *Momordica*, *Alternanthera, Centella, Aerva* etc. are well known Ayurvedic medicinal plants.

Only some crops like bitter gourd, brinjal, ash gourd, snake gourd, oriental pickling melon, leafy amaranth and tropical tubers like taro, elephant foot yam, greater yam, lesser yam and Chinese potato are cultivated for commercial market. The indigenous vegetables of Western ghats fall under different categories such as commonly cultivated, less cultivated, wild gathered,

Aerva lanata

Alternanthera sessilis

Amaranthus tricolor

Amaranthus tricolor

Bird's eye chilli

Bittergourd-Rudrakshali

Bread fruit

Centella asiatica

Colocasia gigantea

Curcuma amada

Oriental pickling melon - Mikkikai

Momordica charantia var. *muricta*

Momordica dioca

Momordica tuberosa

Moringa concanensis

Mucuna utilis

Murraya koenigii

Oriental pickling melon

Sauropus androgynus

Sesbania grandiflora

Solanum nigrum

Solanum torvum

Solena amplexicaulis

Talinum triangulare

Canavalia gladiata

multipurpose (cultivated as fruit/pulse but also used as vegetable at early stage of maturity or some other parts like banana pseudostem, banana male inflorescence and *Colocasia* petiole, elephant foot yam leaves, drumstick leaves and flowers, ivy gourd clipping etc.), condiment-taste builders and pickling vegetables. A brief description of native vegetables including naturalised exotics of Western ghats under the category of tree vegetables, commercial vegetables, wild gathered vegetables and those cultivated only for own use are given below.

Tree vegetables

Drumstick (Moringa oleifera)

It is one of the most important tree vegetables in South Indian home gardens. Though tender pods are commercially important vegetable, leaves and flowers are also esteemed as vegetable. Even though propagated through woody stem cuttings, genetic diversity is high due to chance superior seedlings and farmer selections. Medicinal purpose '*Marunnu muringa*', exclusively leafy vegetable purpose '*Elamuringa*', extra long fruited 'Jaffna' are some of the rare landraces prevalent in Kerala. A few released varieties like PKM 1, Anupama, and AD 2 are also available for large-scale cultivation. Drumstick is esteemed for its high nutritional value, appealing flavour and is an unavoidable component in traditional recipes like '*Sambar'* and '*Aviyal.* It is a native of North West India and lower Himalayas but domesticated in South of Vindhyas. It is a good source of medicinal honey. In Deccan Plateau and drier tracts of Western Ghats improved varieties are cultivated in a commercial scale. Value-added products like leaf powder and food supplements from leaf are available.

Agathi/Vegetable Humming Bird (*Sesbania grandiflora*)

It is a small legume tree vegetable grown occasionally for its leaves and flowers used as vegetable.White flowered types are preferred for vegetable and red flowered

ones are more of medicinal value. Even though highly nutritious, it is bitter, the taste can be improved by pre cooking and draining the water and mixing with dal or other vegetables. Agathi is of South East Asian origin adapted to medium to high rainfall and sub humid to humid climates. Propagation is through seeds and leaf harvesting can be taken once in a month from 6th month onwards.

Hog Plum (Spondias pinnata)

Hog plum also called as *Ampatt* and *Ambazhanga* in Malayalam, it is a native tree of India. Used as black pepper support, its tender fruits are used for pickle. Ripe fruit is sweet and sour and is also edible. Fruiting is seasonal with tender fruits available in June-August. Propagation is through mature stem cuttings.

Cultivated commercial/home garden vegetables

Yard long bean (Vigna unguiculata subsp. *sesquipedalis)*

Yard long bean is one of the most popular and preferred vegetables of Kerala. It is grown throughout the tropics, but very common in South eastern Asia and Southern China. It is an annual climbing plant, used as a green vegetable. The pods can be eaten fresh or cooked in a variety of dishes. Young, immature pods are one of the very low-calorie vegetables; 100 g beans contain just 47 calories but rich in protein (4.0 g/100 g). Several improved varieties like Arka Mangala, Githika, Manjari, Jyothika, Lola, Kairali, Vaijayanthi are available for large scale cultivation. Dwarf bush types are also available.

Oriental pickling melon (Cucumis melo var. *conomon)*

It is an annual prostrate to low trailing herb cultivated along West coast for its unripe fruits, used in several ethnic recipes and also in common vegetable preparations like *sambar* and *aviyal*. Its golden coloured fruits with green stripes are an integral part of ritualistic *Kani* offering associated with Vishu festival in Kerala. Good diversity is available in West coast. *Ponavellari, Kallanvellari, Kanivellari*, *Mikkikai* are some of the unique landraces all with high shelf life. Propagation is through seeds and best season is summer as an irrigated crop.

Leafy Amaranth (Amaranthus spp.*)*

'Rajgheera' (*A. blitum* var. *oleraceus*) and *arakeerai* (*A. tricolor* var. *tristis*) are ethnic landraces of leafy amaranth. Very high morphological diversity in Chinese spinach (*A. tricolor*) is available across Western ghats. Multi-cut types, late bolting types, ornamental stem and leaf types have been collected and conserved. Spleen amaranth (*A. dubius*) is also commonly cultivated in West coast and *A. graecizans* is restricted to Nilgiris. The wild and weedy species, Viz. *A. viridis* and *A. spinosus* are also consumed as leafy vegetables.

Chekkurmanis (Sauropus androgynus)

Chekkurmanis is a perennial small shrubby leafy vegetable ideal as hedge. Regular pruning gives plenty of new clippings. The plant is a native of Indo-Burma region with maximum cultivation in South-East Asian countries and Kerala, Coastal Karnataka and North Eastern states of India. Propagation is through semi-hard wood cuttings. Leaves are rich in proteins, minerals and vitamins and aptly called multivitamin *madhura keera*. Tender leaves are of acceptable taste, non bitter, available year round and do not need any pre-cooking.

Malabar Spinach (Basella alba)

Basella (*Pasalakeerai* in Tamil) is of South East Asian origin and cultivated across the country, often in coastal Karnataka home gardens for its tender leaves and clippings used as leafy vegetable. The red form (*Basella rubra*) is also used to a small extent even though the green form is more preferred. Propagation is through fresh ripe seeds and vine cuttings. The crop needs pandal to support for optimum herbage yield. Root knot nematode infestation is a major problem affecting large scale cultivation. It prefers well drained fertile soils and sunny sites for good yield.

Roselle (Hibiscus sabdariffa)

Called as *Mathipuli* in Malayalam and *Pulichakeerai* in Tamil, it is used in preparing fish curries and making chutney, pickle etc. It is an annual herb cultivated occasionally throughout India for its tender leaves and fleshy calyx, both used as an ingredient of dal preparations.Young seedlings and clippings are used extensively in Andhra Pradesh and Telangana as main ingredient in *Gongura* pickle. Propagation is through seeds.

Wild gathered vegetables

Spine gourd (Momordica dioica)

Known as *Erumapaval* (Malayalam), *Aakakara* (Telugu), *Palupakkai, Palapalakkai* (Tamil), it is a dioecious, ratooning tender fruit vegetable related to bitter gourd, but without any bitterness. Leaves are also cooked as greens. Occurring wild in West coast and lower Western ghats, it is a wild-gathered high-value vegetable with high nutritional and medicinal value. Propagation is through tubers, seeds or rooted vine cuttings. It needs staking or '*pandal*' for good crop and prefers partially shaded forest-like habitats.

Mountain spinegourd (Momordica sahyadrica)

Known as *Madagalikka* (Kannada), *Pothupaval* (Malayalam), it is closely related to spine gourd. It is also a wild-gathered, high-value vegetable of Western ghats (hills). Leaves are also used as vegetable. Propagation is through tubers, seeds or rooted vine cuttings. Cultural practices are similar to that of spine gourd. It can be profitably cultivated as a ratoon crop in home garden.

Athalakkai (Luffa tuberosa)

It is a weak-stemmed low herb with perennating tubers, found wild in Deccan Plateau and rain shadow areas and leeward side of Western ghats. Tender fruits are esteemed as a vegetable with medicinal properties especially as health food for diabetics. Propagation is through seeds and tubers.

Kattupaval/Methipaval (Momordica charantia var. *muricata)*

It is a wild gathered or semi-domesticated small bitter gourd. Fruits are small (20-30 g) and esteemed as medicinal health vegetable. Propagation is through seeds

and cultivation is similar to that of bitter gourd.

Karuvachakka (Solena amplexicaulis)

It is a wild-gathered vegetable of drier tracts of Western ghats. Tender fruits are eaten as salad and are crisp and tasty. Propagation is through seeds and it perennates through underground tubers enabling ratooning.

Foetid Cassia or *Thakara (Senna tora* syn: *Cassia tora)*

It is an annual weedy legume, the tender leaves and clippings from seedlings are cooked as vegetable which taste somewhat similar to methi. Consumed across West coast, it is often a wild-gathered vegetable of monsoon season and rarely cultivated.

Ponnankanni (Alternanthera sessilis)

Alternanthera is a genus of perennial low herbs used as leafy greens. *Alternanthera sessilis* is a wild gathered vegetable of moist places esteemed for its delicious taste. *Alternanthera denticulata* and *Alternanthera nodiflora* are also cultivated. The latter two need trimming to encourage new sprouts. Propagation is through stem cuttings.

Common purslane or *Parippukeerai (Portulaca oleracea)*

It is a succulent prostrate annual, often a weed of cultivated fields; it is consumed as leafy vegetable in peninsular India. The cooked vegetable is mucilaginous and slightly sour in taste, but said to be rich in omega 3 fatty acids.

Indian pennywort (Centella asiatica)

Called *Kudangal* in Malayalam and *Vallarai* in Tamil, it is a prostrate aromatic herb with semicircular leaves on erect leaf stalks. It prefers moist wet places and propagation is through offsets. Young leaves are used in the preparation of chutneys and is brain tonic and therapeutic food for mouth ulcer.

Purarnava or *Thazhuthama (Boerhavia diffusa)*

It is a procumbent herb occurring as a weed of open places. Esteemed for its medicinal properties, the whole plant and roots are extensively used in Ayurveda. Tender leaves are cooked as spinach and have an agreeable taste. Propagation is through seeds, stem cuttings or rootstock.

Burmese coriander (Eryngium foetidum)

It is a low herb propagated by seeds and suckers. The aromatic leaves are used as a condiment in chutneys, rasam and also to flavour curries as a substitute to coriander leaves.

Orcah/Hullisoppu (Rumex vesicarius)

It is a kitchen garden vegetable cultivated occasionally in coastal Karnataka districts. It is an annual herb propagated through seeds. Tender leaves are harvested periodically and cooked along with dal or used in chutneys. Taste is sour.

Clove bean (Ipomoea muricata)

It is an annual weak stemmed herb, native to *Terai* belt and Himalayan foothills of Nepal, but domesticated in Kerala and Karnataka as a vegetable. Tender fruits along with fleshy fruit stalk are cooked as vegetable. Propagation is through seeds. It needs staking or *pandal* and open areas for a good crop.

Other less cultivated or wild gathered vegetables and alternate use of other crops of Western ghats are given in Table 2 and 3.

Table 1. Landrace diversity and improved varieties of Indigenous and minor vegetables in the Western ghats

Cultivar name	Botanical name	Landraces	Improved varieties
Brinjal	*Solanum melongena*	*Vengeri vazhuthina, Manjarikkode Baigan, Uduppigulla, Agazim,* Rampur *badane*	Surya, Haritha, Arka Neelkant
Amaranth	*Amaranthus* spp.	*Keerarashi, Thuvanamkeera, Kuppai cheera, Chuvanna cheera, Thandukeera, Rajgheera, Arakkerai*	Arun, Arka Suguna, Arka Arunima, Arka Samraksha, Krishna
Elephant foot yam	*Amorphophallus paeoniifolius* var. *campanulatus*	*Neychena*	Gajendra, Sree Padma
Ash gourd	*Benincasa hispida*	*Neykumbalam, Vallikumbalam, Vaidya kumbalam, Thadiyankai, Elavan*	Indu, KAU local
Taro	*Colocasia esculenta*	*Korikala, Kuttanchembu, Thondi, Kuzhinirayan, Thamarakkannan, Kottachembu, Podichembu, Kulachembu, Vettuchembu, Kodavazha chembu, Kannan, Chemban, Karuthakannan, Velutha kannan, Velumthal, Pindalan, Madi, Karimchembu, Kudamalaran*	Sree Rashmi, Sree Pallavi
Oriental picking Melon	*Cucumis melo* var. *conomon*	*Wyanadan Vellari, Thimbalakkai , Mikkikai Ponavellari, Kallan vellari, Kani vellari*	Aruna, Soubhaghya, Mudicode local
Cucumber	*Cucumis sativus*	*Thonthakkai, Doppasouthe, Mulsouthe, Belisouthe*	Himangi, Heera, Subra, KPCH-1
Snake gourd	*Trichosanthes anguina*	*Kaduthuruthy* local	Manushree, Kaumudi, Baby
Bitter gourd	*Momordica charantia*	*Rudrakshagali, Karandakapaval, Kuttathipaval, Vellapaval*	VK 1, Priya, Preethi, Priyanka

Cultivar name	Botanical name	Landraces	Improved varieties
Greater yam	*Dioscorea alata*	*Elanthoor vella, Pathala kachil, Kizhakka, Pulinthodan, Vellakachil, Unda kachil, Maveran, Elivalan, Kandikizhangu, Kaduvakkayan, Erachilkkachil, Poozhu kachil, Bharanikachil, Parassikkodan*	Indu, Sree Swathy, Sree Keerthy, Sree Karthika, Sree Roopa, Sree, Shilpa
Lesser yam	*Dioscorea esculenta*	*Mukkizhangu, Nanakizhangu, Mullankizhangu*	Sree Latha, Sree Kala
Lablab bean	*Lablab purpureus*	*Mochai, Vellamocha, Kolikkalvara, Pacchavara, Karavari, Palavara, Puttuavara, Nattavara, Chigattiavara, Vellamochai*	Arka Adarsh, A. Krishna, A. Pradhan, A. Visthar, A. Bhavani, A. Prasidhi, A. Swagath, A. Amogh, A. Sambhram, A. Soumya. A. Jaya
Ridge gourd	*Luffa acutangula*	*Pottikka, Erakkai, Thupputhuheerakkai*	Arka Vikram, Arka Prasan
Yard long bean	*Vigna unguiculata* subsp. *sesquipedalis*	*Kuruthola payar, Neelappayar, Kuttipayar, Vellapayar, Chuvappukuruthola, Vithapayar, Padapayar, Valli payar, Pathinettu maniyan, Thattappayar, Chuvannachatta, Kokkiri thenagani, Kanjikuzhipayar, Pullipayar, Karimanippayar*	Arka Mangala, A. Samrudhi, A. Suman, A. Garima, Kanakamani, Githika, Lola, Bhagyalakshmi, Kairali, Anaswara, Vellayani-Jyothika, Kashi Komal, Manjari

Table 2. Less cultivated/wild gathered and alternate use of other Indigenous and minor vegetables of Western Ghats

Species	Remarks
Ceropegia bulbosa	Edible leaves and tubers
Decalepis hamiltonii	More popular in Karnataka; leaves used in pickle and to make sherbat
Remusatia vivipara	Leaf and tuber used as vegetable in parts of Karnataka
Chlorophytum tuberosum	Leaves used as vegetable, medicinal plant
Asparagus racemosus	Swollen roots used for pickling, medicinal health food, wild gathered
Aerva lanata	Leafy vegetable, weed, medicinal use
Bambusa arundinacea	Tender shoots cooked as vegetable or pickled
Kedrostis rostrata	*'Appakovaithalai'* – wild gatherd leafy vegetable in rain shadow areas
Moringa concanensis	Leafy vegetable, rain shadow region of Western Ghats
Amaranthus viridis	*Kuppaikeerai*, a weed used as leafy vegetable
A. spinosus	*Mullankerrai*. A weedy medicinal leafy vegetable for urinary complaints
Tragia involucrata	*'Vallichoruthanam'*, leaves and clippings cooked as health vegetable in Malabar, Kerala
Acalupha indica	*Chinni*-tender leaves cooked in rain shadow areas like Chinnar, Kerala
Celosia argentea var. *cristata*	Cultivated or escape; stem clippings used as vegetable
Cnidoscolus chayamansi	*'Chayamansa'*, exotic; but localized in ths region as leafy vegetable; tasty and also used for diabetic cure
Cassia occidentalis	*'Ponnariveeran'*, flowers cooked and eaten
Passiflora quadrangularis	Exotic, tender fruits cooked as melon or cucumber substitute in curries
Cucumis metuliferus	Exotic. Tender fruits eaten as salad; high shelf life
Curcuma amada	Mango ginger. Rhizome used for pickling and also in chutney preparation
Leucas aspera	Leafy vegetable; weed
Solanum nigrum	*Manathakkali* in Tamil leafy vegetable, wild gathered. Fruits also edible.
S. torvum	Tender fruits cooked similar to brinjal, wild/weed
S. macrocarpon	Occasionally cultivated vegetable of Western Ghats

Table 3. Alternate use of other cultivated crops as vegetable

Species	Remarks
Xanthosoma sagittifolius	Cultivated for its tubers (New Cocoyam) but petiole and tender leaves are also cooked as vegetable
Colocasia gigantea	Leafy vegetable, petiole also cooked
Amorphophallus paeoniifolius var. *campanulatus*	Elephant foot yam; Mainly cultivated as a tuber crop. Tender petiole, young leaves and flowers are cooked as vegetable
Musa × *paradisica*	Male flowers of almost all cultivars except Robusta are used as vegetable. *Monthan* is an exclusively vegetable banana. Pseudostem and sucker rhizome also cooked.
Cajanus cajan	The fully filled in pods after depodding used as vegetable in Southern Western Ghats region
Artocarpus heterophyllus	Jack fruit. Tender fruits, seeds, core, unripe flakes all cooked as vegetable
Emblica officinalis	Fruits used in pickle and chutney and also curried.

Lablab bean is cultivated in almost all home gardens in the drier tract. Vegetable type red gram is cultivated occasionally in home gardens and also on the bunds of paddy fields. *Solanum macrocarpon* is an exotic vegetable occasionally cultivated in homestead in a similar way to brinjal. *Capsicum frutescens* (Bird eye chilli) is an essential component of all kitchen gardens esteemed for its hot green fruits used in ethnic cuisine. Its leaves are also cooked as vegetable by Wayanad tribals. Genetic erosion is very high in tropical vegetables of Western ghats due to replacement by more favoured crops and abandoning of niche vegetables.

SUMMARY

Western ghats are one among the four mega-biodiversity hotspots of India, out of the 36 such designated hotspots across the globe. Irrigation availability, extended monsoon, no or mild winter and cool climate in the hills, altitudinal and topographic variations, all permit year round cultivation and availability of one or more vegetables throughout the year. Diversification, popularisation of potential vegetables, value addition and processing are required for promotion of these less popular Indigenous and minor vegetables of Western ghats.

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Brinjal as National Vegetable

T. Janakiram, Assistant Director General, (HSI)
Horticulture Science Division, ICAR

"We have national fruit mango, national flower Indian lotus, national tree banyan, national bird peacock and national animal Bengal tiger but not national vegetable. We can propose Brinjal as National Vegetable, since brinjal and their progenitor species are believed to be originated in India and also looking into wide range of variability and its usage as important vegetable consumed in India."

First Vegetable Science Congress on Emerging Challenges in Vegetable Research and Education (VEGCON-2019) organized by the Indian Society of Vegetable Science during 1-3rd February, 2019 at AU, Jodhpur, Rajasthan.

P L Saroj and B R Choudhary

Arid zone is a treasure trove of indigenous and minor vegetables

The hot arid zone of the country is spread over nearly 31.7 million hectare area of which 41.5% is arable and 19% is cultural wasteland. The major part of hot arid region is found in Western Rajasthan (19.62 Mha) and North-western Gujarat (6.2 Mha). This region is endowed with several vegetable crops which are not only rich source of nutrients but also possess several medicinal properties. The promising material has been exploited in the form of improved varieties having tolerance against biotic and abiotic stresses which are making strident in arid region of the country. The neglected crops like spine gourd and *jhaar karela* are gaining popularity due to their anti-diabetic properties which also possess resistance against biotic and abiotic stresses.

THE DESERT has diverse agro-climatic conditions (arid, semi-arid and sub-humid tropics) and the nature has imposed some restrictions which limits the scope for diversification through vegetable crops. However, these conditions favour successful cultivation of several vegetable crops like kachri (*Cucumis callosus*), snapmelon/phoot (*Cucumis melo* var. *momordica*), mateera (*Citrullus lanatus*), long melon/kakri (*Cucumis melo* var. *utilissimus*), round melon/tinda (*Praecitrullus fistulosus*), ridge gourd (*Luffa acutangula*), cluster bean (*Cyamopsis tetragonoloba*), etc. leafy (palak, *Chenopodium*, fenugreek, *Amaranthus*), legumes (Indian bean) also have good potential under limited irrigation water facility by adopting suitable production and protection technologies. The vegetable crops like *arya* (*Cucumis melo* var. *chate*), *mathkachar*, spine gourd (*Momordica dioica*), *jhaar karela* (*Momordica balsamina*), ivy gourd (*Coccinia grandis*), *etc.* are naturally grown in different parts of arid zone particularly on neglected places and possess wide genetic diversity. The arid zone is endowed with wide genetic diversity of several vegetable crops given in Table 1.

Table 1. Vegetable crops having wide genetic diversity in arid zone

Common name	Botanical name	Chromosome no. (2n)
Kachri	*Cucumis callosus*	24
Snapmelon	*Cucumis melo var. momordica*	24
Long melon	*Cucumis melo var. utilissimus*	24
Arya	*Cucumis melo var. chate*	24
Round melon	*Pracitrullus fistulosus*	24
Spine gourd	*Momordica dioica*	28
Jhaar karela	*Momordica balsamina*	22
Mateera	*Citrullus lanatus*	22
Bitter apple	*Citrullus colocynthis*	22
Cluster bean	*Cyamopsis tetragonoloba*	14
Moth bean	*Vigna aconitifolia*	22
Khejri	*Prosopis sineraria*	24

ICAR-Indian Institute of Arid Horticulture, Bikaner, Rajasthan is maintaining large number of germplasm of different arid vegetable crops. The collected germplasm has been evaluated, characterized, purified and utilized in improvement programmes. Several promising varieties suitable to arid ecosystem has been developed by utilizing the available germplasm. The promising improved varieties are mentioned in Table 2.

Kachri *(Cucumis callosus)*

Kachri is a drought hardy and high temperature tolerant crop (up to 46°C), found in the arid zones during rainy season. Unripe fruits are bitter in taste but at ripening they become edible. The mature fruits (Table 3) are usually cooked with various vegetable preparations, *chutney*, pickles and are also used for garnishing the vegetables or as salad. Kachri is one of the components of the delicious vegetable popularly known as *Panchkuta* in the desert districts of north-western India. Kachri can be cultivated successfully both during rainy and spring-summer season. It requires warm and dry weather with plenty of sunshine for growth and production. The optimum temperature for seed germination is 20-22°C whereas, 32-38°C is optimum for vegetative growth and fruit setting. Its growth is severely retarded below 12°C and plants are killed instantly by frost or at temperature below 4°C during severe winter.

Table 2. Improved varieties of different cucurbits developed by the institute

Crop	Varieties
Kachri	AHK-119, AHK-200
Snapmelon	AHS-10, AHS-82
Mateera	AHW-19, AHW-65, Thar Manak
Long melon	Thar Sheetal
Ridge gourd	Thar Karni
Sponge gourd	Thar Tapish
Ivy gourd	Thar Sundari
Khejri	Thar Shobha
Brinjal	Thar Rachit
Cluster bean	Thar Bhadavi
Palak	Thar Hariparna
Indian bean	Thar Kartiki, Thar Maghi

Table 3. Nutritive value of kachri (per 100 g of fresh edible fruit)

Moisture	88.2%	Fibre	1.21%	Copper	0.0046 mg
Carbohydrate	7.45%	Calcium	0.09 mg	Zinc	0.052 mg
Protein	0.28%	Phosphorus	0.0029 mg	Manganese	0.058 mg
Fat	1.28%	Iron	0.182 mg	Vitamin C	29.81 mg

AHK-119: Fruits are small, egg shaped and unique in shape, size, taste, colour and very suitable for preparing *chutney*, dry powder, pickle, sauce and mixing with other vegetables for acidic taste. Average fruit weight is 50-60 g. The crop becomes ready for picking in 68-70 days after sowing. It bears about 22 fruits per vine and yield is 95-100 q/ha.

AHK-200: Fruits are 100-120 g in weight. Harvesting starts 65-76 days after sowing and continues up to 90-100 days. It produces 115-120 q/ha. Fruits are suitable for garnishing the vegetables and salad.

Kachri AHK-119 is drought hardy and high temperature tolerant

Snapmelon *(Cucumis melo* var. *momordica)*

Snapmelon is commonly grown as inter crop in maize. Its immature fruits are used as salad, vegetables and for other culinary preparations. Fruits at ripening stage develop suture. Its fruits are generally less sweet as compared to muskmelon; hence it is much liked by the people who are suffering sugar related disorders. Snapmelon pulp is suitable for preparation of jam by adding equal quantity of sugar to pulp. Good quality wine with excellent aroma and taste can be prepared with its pulp. It is a very popular vegetable of arid zone. It is commonly grown as a rainfed crop in Rajasthan and Gujarat. A great extent of genetic variability exists in India with respect to vegetative growth, quality attributes (Table 4) and resistance to biotic and abiotic stresses.

AHS-82, high temperature tolerant variety

Table 4. Nutritive value (per 100 g of edible part)

Moisture	95.7%	Fat	0.1%
Carbohydrate	3.0%	Vitamin A	265IU
Protein	0.3%	Minerals	0.4%

AHS-10: It is an early high yielding variety of snapmelon, selected from the local land race. The fruits are oblong and medium in size, 850-950 g in weight, 17-20 cm in length and 9.7-10.5 cm in diameter having 4.5-5%

Seed production of AHS-82

TSS. Edible flesh thickness is 2.1-2.6 cm and fruit cavity 5.5-6.1 cm wide. Its average yield is 225-230 q/ha.

AHS-82: This is also snapmelon variety, selected from the local genetic material. Plants are vigorous with average vine length of 2.25 m. Fruit harvest starts 67-70 days after sowing. Each vine bears 4.0-5.0 fruit giving yield of about 250 q/ha. The flesh is sweet (4.3-4.9% TSS), tasty and light pink in colour.

Mateera

Mateera is generally known as the poor man's vegetable and the common man's fruit in the desert. It is an indigenous type of drought hardy watermelon (*Citrullus lanatus*) and extensively grown on barren sand dunes of western Rajasthan. The immature green fruits at the tender stage are rich in protein, carbohydrate, crude fibre, calcium and phosphorus. The mateera fruits are sweet with refreshing edible flesh (pulp) and consumed fresh as dessert and have juicy properties. Besides, the tender fruits (*Loiya*) weighing 80-50 g are used extensively as fresh vegetable for making *rayta* and curries. The seeds are protein rich (25-32%) and are roasted, and eaten as snacks.

Seed production of Thar Manak–Drought hardy mateera

Thar Manak: It is a variety of mateera, developed through selection from the local land races found in arid zone. It is drought hardy and suitable for cultivation in arid zone during rainy season. Early and first fruit harvesting can be done in 75-80 days after sowing. Flesh is red, solid (firm) and granular, and has good taste and sweetness (9.5-11.2% TSS). The yield potential is about 400 q/ha.

Mateera diversity in arid zone

Bitter apple *(Citrullus colocynthis)*

Bitter apple is the probable ancestor of watermelon which is bitter in taste and known as *Tumba* or 'bitter apple'. It resembles a common watermelon vine, but bears small, hard fruits with a bitter pulp. Fruit contains 15% pulp, 62% seed and 23% rind. The mesocarp contains glucose (1.3% on flesh basis). The processed mesocarp may be good sources of pectin. The juice of the fruit contains citrullin, citrullene and citrullnic acid. The fruits of bitter apple also contain cucurbitacin B and its glycoside, cucurbitacin I. The peel free flesh of ripe fruits contains yellow bitter oil. The seeds are used for edible purposes as well as to extract oil. Seeds contain 16.7% yellow coloured semi-dry oil rich in linoleic acid. It is one of the most drought cucurbit showing maximum diversity in Thar Desert. It has been widely used in traditional medicines for centuries. Bitter apple can also be used in the preparation of biopesticide formulations.

Tumba–Resistant to biotic and abiotic stresses

Khejri *(Prosopis cineraria)*

Khejri is a perennial plant belonging to family Leguminosae. It is called as *Kalpvriksh* of Thar Desert and drought hardy. It grows luxuriantly under the extremely adverse agro-climate in hot arid regions and that too without much cultural care. Khejri have multiple uses viz., nutritious rich pods, fodder and fuel, besides its favourable effects on ecology and soil fertility. It not only tolerates the extreme edapho-climatic conditions of Thar Desert but also has plentiful foliage, bears flowers and fruits during the driest period. Being leguminous species, it is compatible to almost all companion crops grown under the traditional cropping systems. The immature pods called as *sangri* are used as vegetable. It is a major source

Thornless variety – Thar Shobha

Red podded khejri

of leaf fodder (*loong*) in the arid zone. The pods and fodder is nutritious and high valued. About 10-15 kg tender pods and 25-30 kg *loong* can be harvested annually from a 20 years old tree. From wide genetic variability, some genotypes that produce high quality pods were collected for *ex situ* evaluation and conservation. Among them, Thar Shobha has been selected and recommended to develop systematic plantation for uniform *sangri* production. The fresh and dehydrated pods are sold at high prices in arid zone. It is propagated by patch budding.

Arya *(Cucumis melo* var. *chate)*

Arya is an annual plant and monoecious in nature. Tender fruits are generally used as salad and harvested before maturity. The fruit is climacteric. It is propagated by seeds. Fruit shape is long, skin colour light to dark green and smooth at tender stage. Fruit flesh is light orange at ripening without sugar and aroma. It is cultivated in several parts of arid zone.

Ripe fruit of Arya

Round melon *(Praecitrullus fistulolus pang. syn. Citrullus vulgaris* var. *fistulolus)*

Round melon is also known as round gourd, Indian squash, squash melon and *Tinda*. It is grown for small, tender fruits that are roughly spherical and about 5-8 cm in diameter. The fruits at cooking stage contain 1.4% protein, 1.4% fat, 3.4% carbohydrates, 1% fibre, 0.5% minerals, 13 mg carotene and 18 mg vitamin C/100 g of fresh weight. *Tinda* is extensively cultivated in North India, especially in Punjab, Uttar Pradesh and Rajasthan. It is believed to have originated in India and several landraces are prevalent in arid zone.

Spine gourd *(Kartoli)*

It is a perennial climbing plant. The spiny fruits are used as vegetable in all regions of India. They are quite palatable, rather sweet and entirely free from bitterness and good source of protein and iron (Table 5). Fruits, leaves and tuberous roots are used as a folk remedy for diabetes in India. It has small leaves and small yellow flowers. They are small, dark green, round or oval with spines. Fruits are available from July to October in North India which is rich source of protein and iron. Spine gourd is dioecious and propagated by underground tubers

Arya blooming in desert

Tender fruits of a local landrace of Tinda

and stem cuttings. Wide genetic variability exists in arid zone of Rajasthan particularly in natural habitats.

Jhaar Karela *(Momordica balsamina)*

Jhaar karela is a wild climber containing wide spectrum of medicinal and nutritional value. The fruits are harvested from neglected places from July to October in arid zone. It is monoecious and propagated through seeds. Fruits are small and used as vegetable. The leaves, fruits, seeds and bark of the plant contain resins, alkaloids, flavonoids, glycosides, steroids, terpenes, cardiac glycoside, saponins having various medicinal importances. The therapeutic agent is '*Momordin*' which possess very good anti-diabetic activity. The commercial exploitation for biopharmaceuticals and nutraceuticals are some of the prospective future potential of Jhaar karela. It is found in natural habitats of arid zone particularly neglected places. It possesses resistance against biotic and abiotic stresses which may prove worth in utilizing in the breeding programmes.

Spine gourd

Root of spine gourd–Propagating material

Table 5. Nutritive value (per 100 g of edible part)

Moisture	84.1 g	Phosphorus	42.0 mg
Protein	3.1 g	Carotene	2700 IU
Carbohydrate	7.7 g	Thiamine	45.2 µg
Fibre	2.97 g	Riboflavin	176.1 µg
Iron	4.6 g	Niacin	0.59 mg
Calcium	33.0 mg	Ascorbic acid	275.1 mg

Moth bean *(Vigna aconitifolia)*

Moth bean is an important crop of arid and semi-arid regions. It is a hot weather, drought resistant legume and can easily withstand the lack of water, dying hot winds and other climatic disasters. Being multi-purpose and higher adaptability to uncongenial ecological environments makes it a perfect choice for areas receiving lesser rainfall. Moth bean seeds are a good potential reservoir of proteins and other essential minerals and vitamins. Mature, raw seeds contain water 9.7 g, energy 1435 kJ (343 kcal), protein 22.9 g, fat 1.6 g, carbohydrate 61.5 g, Ca 150 mg, Mg 381 mg, P 489 mg, Fe 10.9 mg, Zn 1.9 mg, vitamin A 32 IU, thiamin 0.56 mg, riboflavin 0.09 mg, niacin 2.8 mg, vitamin B_6 0.37 mg, folate 649 µg, and ascorbic acid 4.0 mg per 100 g edible portion. Being pulse, it is a rich and cheap source of vegetable protein, but part of this protein is unavailable because of the presence of a trypsin inhibitor. The green pods are eaten as a vegetable and the ripe seeds, whole or split, are eaten cooked. Dry seeds of moth bean offers a variety of edible products; vegetable, fodder for animals, whole seed, *Papad, Bhujia, Dal, Mangori, Vada*, etc. It is also assimilated as a flour to prepare south Indian food delights like *Idli* and *Dosa*. India being the origin place has numerous landraces and cultivars of moth bean are available in arid zone.

Phog *(Calligonum polygonoides)*

It is locally known as phog, an endemic and threatened species reported from Thar Desert. It belongs to the family Polygonaceae and commonly grows on dry sandy soils and sand dunes. Its native habitat is hot arid region of Thar Desert of India however, it can flourish under such conditions without any impeded effected on growth and development. Phog is a perennial shrub, usually 4-6 feet in height but occasionally may reach even 15 feet height. It is drought hardy and capable of growing under adverse conditions of soil and moisture. It is not affected by frost. Phog has high economic values as its all plant parts are useful in one or other way. Its abortive flowers and succulent fruits are the most important

Fruits of Jhaar Karela

Seed of Jhaar Karela


Phog – A threatened species of Thar Desert

Khimpoli – Tender pods of khimp used as vegetable

source of food for sustenance during frequently occurring famines and also valued for medicinal properties. Flowers are known as phogla in Rajasthan and used to prepare *rayta*. The wood is used as raw materials in building huts/shelter and scaffolding of wells and other structures. The aqueous paste of plant acts as an antidote against snake bite. It is used for curing typhoid, asthma, cough and cold.

Khimp *(Leptadenia pyrotechnica)*

Khimp is a wonderful desert plant belongs to the family Apocynaceae. It is leafless, erect, evergreen perennial shrub and widespread in arid zone of India. Being highly drought resistant, it play an important role in afforestation of desert. Roots have a strong soil binding capacity and used in sand dune fixation. Khimp possesses antifungal, antibacterial, anticancer, antioxidant, wound healing, anthelmintic, antiatherosclerotic, hypolipidemic, antdiabetic and hepato protective activities coupled with other multifarious uses. Almost all plant parts are used in the traditional medicinal system to treat various disorders. It's flowering and fruiting time is August to January. The pods are known as *khimpoli* which ripe in the month of March. Pods are cooked as vegetable and possess medicinal value. The plant is used in thatching of huts and plant fiber for making ropes.

Long melon *(Cucumis melo var. utilissimus)*

Long melon is popularly known as *Kakri* or *Tar Kakri*. Tender fruits are delicious and used as salad, pickle and cooked as vegetable. Due to its cooling effect, it is very popular in most parts of the Thar Deserts during summers. It is a warm season crop and cultivated in tropical, subtropical and milder zones of India. It is very popular predominantly in Rajasthan, Punjab and Uttar Pradesh. India possesses considerable variability in long melon.

Thar Sheetal: Early variety of long melon and first harvesting took place after 45-50 days from sowing. The fruit length, number of marketable fruits per plant and marketable fruit yield varied from 25-30 cm, 18-22 and 132-142 q/ha, respectively. Bear light green coloured and tender fruits at edible stage which are free from bitterness. It set fruits at high temperature (up to 42°C) during summer under hot arid conditions of Rajasthan.

Ridge gourd *(Luffa acutangula)*

Ridge gourd is an important warm season vegetable crop widely cultivated in tropical and sub-tropical parts of India. The immature tender green fruits are cooked as vegetable. It is a good source of carbohydrates, vitamin C and minerals. Warm and humid climate is favourable for its growth and development. The optimum temperature for its growth and development is 25-30°C. Wide variation

Khipi – highly drought resistant plant

Thar Sheetal – Tolerant to high temperature

Seed production of Thar Sheetal

exists in ridge gourd in arid zone with respect to shape and length of fruits.

Thar Karni: It is important variety of ridge gourds. Fruits are 20-25 cm long weighing 90-110 g and cylindrical with 10 longitudinal shallow ridges. It is tolerant to high temperature (up to 42°C) and disease under field conditions. First picking of fruits can be done in 51-55 days after sowing. It can give 130-140 q/ha fruit yield under hot arid agro-climate.

Sponge gourd *(Luffa cylindrica)*

The tender fruits are used as vegetable which are easily digestible. Besides being a vegetable, the mature dry fruits are used in industries for filter and cleaning the motor car, glass wares, kitchen utensil, bath and body bathing accessories. Several landraces are found in North India and arid zone having wide variability in leaf shape, size of fruit (ranging from a few centimeters to one meter), fruit shape, fruit colour and seed colour (white and black).

Thar Tapish: It is a short duration (110-115 days) variety of sponge gourd. It took 49.2-52.4 days to first harvesting of tender fruits. It is suitable both for rainy and summer season cultivation. Average fruit weight is 116.0 g and produced 11 fruits/plant. It is multiple-stress tolerant/ heat tolerant variety and fruit yield is about 145.80 q/ha.

Ivy gourd (*Coccinia grandis* syn. *C. indica*)

Ivy gourd or *kundru* is perennial climber and dioecious plant. Being perennial in nature it continues up to 2-3 years in same field. It is native of India. Fruits are smooth, small (5-6 cm long) and cooked as vegetable (Table 6). Propagated through stem cuttings. Parthenocarpic germplasm is also found in nature which does not require pollination for fruit set.

Table 6. Nutritive value (per 100 g of edible part)

Moisture	93.5 g	Energy	18 kcal	Thiamine	0.07 mg
Protein	1.2 g	Calcium	40 mg	Riboflavin	0.08 mg
Fat	0.1 g	Phosphorus	30 mg	Niacin	0.7 mg
Mineral	0.5 g	Iron	0.38 mg	Folic acid	18 µg
Carbohy-drate	3.1 g	Carotene	156 µmg	Vitamin C	15 mg

Seed production of Thar Karni

Field view of sponge gourd

Thar Karni – Tolerant to high temperature and mosaic disease

Thar Tapish – High temperature tolerant

Thar Sundari

Thar Rachit – High temperature tolerant variety

Thar Sundari – a parthenocarpic variety

ICAR dignitaries testing the ICAR-CIAH developed varieties

Thar Sundari: It is a stable variety of sponge for sequential female flowering and fruiting. It is short-perennial (4-5 years), gynoecious and produced good quality parthenocarpic fruits. Tender fruits for vegetable culinary are ready within 6.28-8.42 days from opening of female flowers. The elongated-long shape tender fruits are light green-green-dark green in colour with non-clear white strips and soft. It is suitable for harvesting both as rainy and spring-summer crop with yield of 2.85-3.48 kg/plant/season.

Brinjal *(Solanum melongena)*

The intensive germplasm evaluation and systematic utilization in brinjal breeding programme has been done with the core objective of developing varieties having better marketable quality fruit yield. Crop has potential to tolerate high temperature and abiotic stresses of hot arid agro-climate. ICAR-Central Institute of Arid Horticulture has developed Thar Rachit variety which is suitable for high temperature and abiotic stress conditions of hot arid environment.

Thar Rachit: It is an early variety (45 days after transplanting) of brinjal suitable for both rainy-winter and spring-summer cultivation. Plants are short stature (50-65 cm height at 90 days) and semi-erect. Fruits are oblong-round, dark purple colour and small sized. Fruit weight is 40-45 g and number of fruit per plant varies from 80-90. Yields about 3-4 kg/plant under high temperature and abiotic stress conditions of hot arid environment.

SUMMARY

The hot arid zone possesses wide range of genetic diversity among several annual and perennial vegetables. The crops indigenous to arid region are capable to withstand biotic stresses and possess several medicinal properties. The ICAR-Central Institute of Arid Horticulture, Bikaner, Rajasthan is continuously making the efforts for collection, evaluation, maintenance, conservation and utilization of germplasm available in arid zone. Being drought and high temperature tolerant, the varieties developed by the institute are popular among the farmers of arid zone and making strident.

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Indigenous and minor leafy vegetables

India is home to a large number of leafy vegetables which are blessed with enormous potential but practically very few information is available on their production and quality attributes. Consumption of these vegetables is mostly confined to the people living in the areas where they grow with little or no production on commercial scale. Though in the recent years few of them got attention by the growers and consumers worldwide, still most of them are in neglected state and need focused attention for achieving nutritional and health security.

DESPITE our great success towards vegetable production, India still faces challenges of nutritional security at household levels due to nutrient deficiencies such as vitamin A, iron, zinc, and calcium. As per the report of the State of the World's Children 2019, UNICEF, every second child in the age group of below 5 is affected by some form of malnutrition and every second women in our country is anemic. Leafy vegetables are those vegetables whose leaves or twigs are edible and are endowed with the best forms of phytochemicals needed to stay healthy. In India, where a large population is still living in remote areas and cannot afford to purchase high quality vegetables, indigenous wealth of leafy vegetables may serve as a stepping stone in our journey towards nutritional security. This would be particularly beneficial for poor/rural communities who live in marginal areas where major vegetable crops struggle to survive. Generally, leafy vegetables, normally found as wild or weedy can be grown easily with low production cost and high yield. They are highly climate resilient and one of the cheapest vegetables available in market, thus could be rightly described as climate smart as well as nutrition smart crop to be popularized and utilized globally. India is the home to a large number of leafy vegetables including Indian spinach (*Basella alba*), drumstick (*Moringa oleifera*), curry leaf (*Bergera koenigii / Murraya koenigii*), etc. and a number of lesser known leafy vegetables, which are available seasonally.

Leafy vegetables are closely associated with our culture and heritage

Leafy vegetables are commonly called as 'Saag' in most parts of the country and this appears to be derived from the Sanskrit nomenclature for all edible green leaves "*SHAK*". In our country, many leafy vegetables are related to social and cultural heritage. The best example is purslane (*Portulaca oleracea*), locally known as *noni saag* which is being used in Bihar during a festival called *Jivitputrica*. Another example is the '*Chauddo Shaak'*, where there is tradition to prepare 14 leafy vegetables in Bengal on '*Bhoot Chaturdashi'*, the night before Kali Puja. Likewise, Beary Muslims of coastal Karnataka prepare Basalede kunhi pindi (small rice dumplings smeared in gravy prepared from Indian spinach and dried tuna; (a salt water fish). In Bengali cuisine, poi is widely used both in a vegetable dish; cooked with red pumpkin, and in non-vegetarian dishes; cooked with the heads of the Ilish fish and may also be cooked with shrimps. In Andhra Pradesh, a curry of *Basella* and Yam is popularly known as Kanda Bachali Koora (yam and *Basella* curry). In Maharashtra, the demand for greens is driven by festivals like Rishi Panchami, just before Ganesh Chaturthi, which venerates the sages who in Hindu mythology lived in the forests. Because many greens are foraged from the wild, they carry an aura of ancient sanctity, and are cooked as a special dish for the festival. We must respect and follow these traditions and cultures because these are one of the ways to conserve our bio-diversity.

Nutritional and nutraceuticals potential

Green leafy vegetables are blessed with tremendous nutritional and medicinal properties. They are well known sources of minerals (iron, zinc, calcium, potassium and magnesium), vitamins (vitamins A, K, C, E and B complex), essential amino acids, antioxidants, phytopigment (carotene, lutein and zeaxanthin) and dietary fibre which are beneficial for the maintenance of good health. The potassium content of leafy vegetables is good for control of diuretic and hypertensive complications. They play a key role in human health management particularly lowering the risk of chronic human ailments such a cancer, cardiovascular disease and other age related disorders. Leafy vegetables are also low in calories and thus now a day very commonly used as salad, steamed and soup due to increasing concern about calories. Leafy vegetables are the best source of iron as the presence of vitamin C and other minerals make iron easily available to our body, and thus may serve as a boon for eradication of anemia from our population. Moreover, leafy vegetables are the main source of folic acid in the rural and tribal communities where pregnant women are not able to fulfill their requirement of folic acid during pregnancy. The high level of vitamin K in greens makes them important for the production of osteocalcin, a protein essential for

Drumstick leaves are the best source of nutrition

bone health. Some leafy vegetables like amaranth and *Basella* are rich in protein and contains several essential amino acids such as arginine, isoleucine, leucine, lysine, threonine and tryptophan. Purslane (*Portulaca oleracea*) has recently been identified as the richest vegetable source of linolenic acid, an essential omega-3 fatty acid. The lack of dietary sources of omega-3 fatty acids has resulted in a growing level of interest to introduce purslane as a new cultivated vegetable in several parts of the world. Drumstick leaves are perhaps the most nutritious vegetable and that is why it is commonly called as Miracle tree. The nutritional value of the leaves is equivalent to 7 times the vitamin C in oranges, 4 times the Ca in milk, 3 times K in bananas, 2 times the protein in milk, and 4 times the vitamin A in carrot. The leaves and pods are also helpful in increasing milk in the breast feeding mothers. *Basella* is used for its androgenic, antidiabetic, anti-inflammatory, antimicrobial, antioxidant, antiulcer, antiviral, CNS depressant, hepatoprotective and wound healing properties. Brahmi saag is used in the treatment of a number of disorders, particularly those involving anxiety, intellect and poor memory while Indian pennywort (*Centella asiatica)* is used as herbal remedy for skin conditions, wound healing and memory improvement. Water Pennywort is a Chinese herbal drug for hepatoma. The juice of the plant is used in the treatment of fever, and paste made from the plant is applied externally to wounds and boils. A decoction of the plant is used in the treatment of abscesses, boils, bruises, cirrhosis, colds, coughs, hepatitis, hepatoma, influenza, itch, jaundice, sinusitis and sore throat. The leaves of *Oxalis corniculata* are used as an antidote to poisoning by the seeds of *Datura* spp, arsenic and mercury.

Potential to adapt under changing climate

Many leafy vegetables are endowed with a number of surprising morpho-physiological virtues which make them resilient to the adverse effect of changing climate. *Basella* exhibits C_4 photosynthesis under heat and drought stress, and they tolerate a variety of unfavorable abiotic conditions, including high tempered, making them resilient to the changing climate. In fact, C_4 photosynthesis is an adaptation of the C_3 pathway that overcomes the limitation of the photorespiration, improving photosynthetic efficiency and minimizing the water loss in hot, dry environments. *Portulaca oleracea* is one of the very few plants which are able to utilize both CAM and C_4 photosynthesis pathways. *P. oleracea* can switch from C_4 to CAM pathways during times of drought and there is transcription regulation and physiological evidence for C_4-CAM hybrid photosynthesis during mild drought.

Status and diversity of leafy vegetables in India

Though majority of the indigenous leafy vegetables are grown in wild, semi-wild or stray conditions, concentration of genetic diversity comprising native species and landraces occurs more in Werstern ghats, Eastern ghats and North-eastern Himalayas. Eastern India is a territory of diverse ethnic groups, tribes and culture among the ecological and geographical variations starting from coast of Odisha to hilly Terai of West Bengal through the lateritic plateau of Jharkhand and Bihar. The ecological diversity superimposed with tribal and ethnic diversification, plant usages and religious rituals has resulted into the richness of biodiversity. The biodiversity present in leafy vegetables are being used by tribals/rural communities for their day to day requirements of nutrition and herbal therapy. In most of the cases they just collect leaves and twigs from the forest areas or natural vegetation for their use or sometimes for selling. Though a large number of leafy vegetables are commonly consumed in our country, only amaranth, palak, spinach beet and fenugreek has attained

Table 1. Area of diversity and nutritional importance of indigenous leaf Vegetables

Scientific name	Common name/vernacular name	Area of diversity	Nutritional/medicinal importance
Basella alba	Indian Spinach/Poi Saag	Uttar Pradesh, West Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Kerala	Good source of vitamins and minerals particularly calcium, iron, vitamin A and folic acid.
Moringa oleifera	Drumstick/Tree of Miracle	Foothills of the Himalayas in North-western India; tropics of Southern India; tropical forests of Barak valley in Assam	Rich in vitamin A, vit B such as folic acid, pyridoxine and nicotinic acid, vit C, Ca, Fe, K and Zn; vitamin D and E also present, prevent digestive and urinary disorders, cardiac diseases, bronchitis and tuberculosis.
Bergera koenigii L./ *Murraya koenigii* Spreng	Curry leaf/Meetha Neem	Tarai region of Uttar Pradesh, Shivalik hills of North-western Himalaya, Southern parts of the country; foothills and plains of the Himalayas from Kumaon to Sikkim	Rich in vitamin A, vitamin B2, vitamin C, Ca and Fe; known for anti-diabetic and cholesterol reducing property, antimicrobial, antiulcer, antioxidative, cytotoxic, anti-diarrhoea and phagocytic activity.
Hydrocotyle sibthorpioides	Water Pennywort/ Lawn Pennywort/ Laghu Brahmi	Wet valleys, grassy places and stream banks in the Himalayas, Western Ghats	Good source of minerals and vitamins, stigmasterol, daucosterol, hibalactone, genistein, daidzein,methyl-3, 4-dihydroxybenzoate, caffeic acid, isorhamnetin, quercetin.
Oxalis corniculata	Creeping Wood Sorrel/ Amrul	Western Himalayas, hilltops of the Northern Western Ghats.	Good source of vitamin C, used in the treatment of scurvy; leaf juice is applied to insect bites, burns and skin eruptions.
Polygonum plebeium	Knot Weed (Chemti saag)	It is native to the Himalayas, Kashmir to Bhutan.	Good source of protein, fibre and minerals like Ca, Mg, K, Fe etc.
Lasia spinosa	Kohila/Kantakochu	Moist places in tropical and subtropical forests including Assam	Rich in Mg, Fe, Zn, Mn, Cu, Mo; recommended for treating colic, tuberculosis of lymph nodes, swollen lymph nodes, rheumatism/rheumatoid arthritis, injuries, snake bites and insect bites.
Portulaca oleracea	Summer Purslane/ Noni Saag	Northern and eastern parts of India	Rich in omega-3-fatty acid, beta carotene, ascorbic acids.
Diplazium esculentum	Edible fern	Western Ghats	Rich in micronutrients, beta-carotene, folic acid and minerals such as Ca, Fe and P.
Solena amplexicaulis	Creeding Cucumber/Ban Kundari	Tamil Nadu, Karnataka, Kerala. (Endemic)	Known for antioxidant, antidiabetic and antibacterial agent. Used for inflammation, skin lesions, skin diseases and to cure jaundice.
Centella asiatica	Indian Pennywort /Gotu Kola	Assam, Bihar, Kerala, Madhya Pradesh, Manipur, Odisha, Rajasthan, Tamil Nadu	Used as herbal remedy for skin conditions, wound healing and memory improvement.
Bacopa monniera	Brahmi saag	Assam, Andhra Pradesh, Bihar, Madhya Pradesh, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh	Contains many active constituents, including a number of alkaloids and saponins, however, the major constituents are the steroidal saponins, Bacosides A and B.

commercial status. Moreover, out of the indigenous leafy vegetables, very few species like *Basella*, drumstick, curry leaf has gained attention by the researchers and a large number of species are still, rema neglected. Some of the important plants which are commonly used as leafy vegetables are presented in Table 1. These vegetables are generally used as day to day vegetables with small area of cultivation. Apart from this a number of species like *Bacopa monnieri, Boerhavia diffusa, Centella asiatica,* etc. are also used as leafy vegetables basically for therapeutic value. Rural people from North-eastern parts of India prefer non-traditional vegetables like runner and petioles of *Colocasia spp* and *Xanthosoma spp*, bamboo shoots, elephant foot yam petiole, and leaf vegetables like fern shoot (*Ceratopteris*).

Some of the most potential and popular indigenous leafy vegetables are discussed here under:

Indian Spinach

Basella alba, commonly known as Indian spinach/ Malabar spinach is cultivated throughout the country in one or other season. However, it is more popular in eastern and southern parts of India including Tamil Nadu, Pondicherry, Maharashtra, Odisha, West Bengal, Bihar, Madhya Pradesh, Uttar Pradesh, Rajasthan and Gujarat. There are two types of *Basella* under cultivation: green type (*Basella alba* var *alba*) and red type (*Basella alba* var *rubra*). Indian spinach is mostly seen in the home gardens and on a small scale the landraces are under cultivation in tribal, rural and peri-urban vegetable farming systems

Kashi Poi-3, a new variety of *Basella* with delayed flowering habit

by small and marginal farmers of southern and eastern India. Indian spinach is commonly grown for its leaves and young shoots, which make an excellent vegetable after cooking. The soft succulent leaves may be eaten raw as salad. In Thailand, flower spikes are sold as vegetable. Colours obtained from the leaves and stems are used for dying fabrics and in paintings in north eastern parts of India, particularly Manipur. Indian Spinach is quite a good source of vitamins and minerals and 100 g of fresh leaves contain calcium (109 mg), iron (10 mg), vitamin A (8000 IU), vitamin C (102 mg) and folic acid (140 µg). Since, it is a rich source of folic acid, it recommended to pregnant women to avoid neural tube defects in the foetus. *Basella* has long been neglected by the researchers, but in the recent years some attention has been given for improvement and utilization of this potential crop. At ICAR-IIVR, Varanasi, a total of 70 accessions are being maintained, and recently three varieties, Kashi Poi-1, Kashi Poi-2 and Kashi Poi-3 have been released and notified.

Drumstick

Moringa oleifera Lam., commonly known as Drumstick/ Horseradish tree/Saijhan/Sajna/Ben oil tree/Tree of Miracle, possess one of the most nutritious leaves but not yet properly exploited due to lack of awareness. Moringa can withstand both severe drought and mild frost conditions and hence, widely cultivated across the world. In India, its cultivation is mainly concentrated in Tamil Nadu, Kerala, Karnataka and Andhra Pradesh. However, it is also becoming popular in Rajasthan, UP, Bihar, West Bengal, etc. It is cultivated in home gardens and fields for its leaves, flower buds and tender fruits. Every part of the tree is enriched with high nutritive and medicinal values, particularly the leaves are rich in minerals, vitamins and other essential phytochemicals that can be easily absorbed and no allergy has ever been reported so far. As most of the nutrients are retained in dry leaves, leaf powder is commonly used to add nutrients in kids' food. Leaf powder contains 27% protein that can serve as a substitute for meat. Moringa powder can be used as a substitute for iron tablets, hence used as a treatment for anemia. Drumstick leaves are given to pregnant women as well as lactating mother as they provide all the nutrients required for them. Most of the research and development activities in Moringa has been taken place at various SAUs and ICAR institutes like TNAU, Tamil Nadu; ICAR-IIHR, Bengaluru; ICAR-IIVR, Varanasi. However, TNAU is

Drumstick plant in kitchen garden

Kashi Poi-1, a nutrition rich *Basella* variety

Kashi Poi-2, a new bush type *Basella* variety

pioneer in varietal development of moringa. Moolanur Moringa, Chemmurungai, Jaffina type, Kattumurungai, Palmurungai, Punamurungai and Palamedu moringa are locally known ecotypes of perennial moringa cultivated in Tamil Nadu. PKM-1, PKM-2 and KM-1 are high yielding annual moringa varieties released from Tamil Nadu Agricultural University. Looking into the potential of this crop various govt initiatives have also taken place**.** The Madhya Pradesh and Chhattisgarh governments have already accorded the tree enough importance in their annual plantation exercises. Uttar Pradesh government embarks on a mission to plant 22 crore saplings during 2019, a huge demand has been witnessed for the ''sahjan'' saplings. Uttar Pradesh might be the first state in North India to have picked up the tree for promotion and to curb malnourishment.

SUMMARY

Indigenous leafy vegetables have great potential to eradicate malnutrition prevalent in poor/rural section of our population. Many of these leafy vegetables are resilient to the changing climatic and can be raised at lower management costs even on poor marginal lands. Despite all these, this group of vegetables was largely ignored by the scientific world. However, their potential has now been realized and the growers and consumers are showing keen interest in its proper utilization. With the increasing awareness among the consumers, it is essential to increase their production to meet the growing demand. Though, domestication and cultivation of these species are very less but recent awareness about the immense nutritional cum medicinal benefit of these vegetables among the conscious people creating new market niches and are projecting the farmers to cultivate on larger extent.

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Status, diversity and potential of indigenous and minor *Alliums* spp.

Allium **which includes various historical vegetable crops besides onion and garlic like leek, scallion, shallot, wild garlic etc., is one of the largest genera with more than 700 species distributed throughout the world. Records of these plants have been found in the oldest known Indian Ayurvedic medical treatise, 'Charaka Samhita' as medicinal plant. Tracing its footprint, the first published monograph of** ***Allium*** **listed 24 species of the genus by Haller in the year 1745 that has eventually being increased to 750 species. Presently,** ***Allium*** **genus comprises more than 900 species including 15 subgenera and 57 sections; making it one of the largest monocotyledon genera distributed around the globe. Its region of diversity stretches from the Mediterranean basin to Central Asia and beyond. Important species of** ***Allium*** **includes onion and shallot (*Allium cepa*), garlic (*Allium sativum*), leek and elephant garlic (*Allium ampeloprasum*), Japanese bunching onion (*Allium fistulosum*), chives (*Allium schoenoprasum*), and garlic chives (*Allium tuberosum*). Further, many of its species are also grown as ornamentals, *viz. Allium giganteum, Allium christophii, Allium karataviense, Allium aflatunense, Allium caeruleum*, the nodding onion (*Allium cernuum*), the yellow flowered *Allium moly*, and the interspecific cultivar Globe master. A few *Allium* species are also noxious weeds in some parts of the world (e.g. *Allium vineale* and *Allium triquetrum*).**

INDIA exhibits about 35 to 40 species in the temperate and alpine regions of Himalayas. Known for its young bio-diversity, North Eastern Hilly (NEH) region of India, viz. Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura is home to wide varieties of *Allium* species due to its warm tropical climate. In the contending era of changing climate and nutritional importance, indigenously growing vegetable crops are being given tremendous attentions and importance. Viewing to the above entities an attempt has been made to give an insight to the major species of *Allium* that are thriving in the NEH region of India.

Allium ascalonicum

This is the most commonly used local variety in India; known with number of vernacular names such as; Arabic-*Kirath*; Hindi-*Ek kanda*, *Lahshun*, *Ek poti Lahshun*; Bengali-*Paru* or *Gandham*; Punjab-*Gandana*, *Gandhan*; Kashmiri-*Praan*; Nepal-*Chyapi*; Malayalam-*Cheriya ulli* or *Chuvanna ulli*; Tamil-*Chinna vengayam* or (*sambhar vengayam* or the onion of Sambhar) as it is an important ingredient of Sambhar. It is a 30–60 cm heigh perennial plant, generally characterized with two cloves; it occasionally reaches up to 8-10 cloves at a time. It grows in clusters and has a tapered shape which is very distinctive in nature. Cloves are of copper brown or reddish in colour exhibiting a blend of sweet onion and garlic taste. Its morphology resembles both with the onion and garlic. The bulblets resemble garlic and its texture and colour with onion. Insight of its historical values of medicinal importance that it is called as *Ek-dana-lasun* or *Ekla-kali' lasan*, meaning 'one-clove garlic, is used for curing ear-ache. It can also be fried with butter and preserved in honey and can act as aphrodisiac. Further, it was also adopted in Ayurveda as a medicinal herb. In Southern part of India, it is used as an especial ingredient of Sambhar. Shallots pickled in red vinegar are common in many restaurants, served along with sauces and papad on the condiments tray. In the NEH region it's the key ingredient for making '*momo*'. In Kashmir shallots are widely used in preparation of Wazwan Kashmiri cuisine, as they add distinct flavour and prevent curry from becoming black, which is common with onions. In the region; locally preferred over regular onion due to its strong flavour and aroma. It is one of the most important ingredient used daily just after *Allium*

Allium ascalonicum showing its cloves that are native to NEH region

Allium ascalonicum field at Durtlang, Aizawl District, Mizoram

tuberosum and *Allium hookeri* especially in Manipur and Mizoram. Locally known as '*Tilhou*' in Manipur and '*Purub kuwa aei chi*' in Mizoram can be abundantly seen in local markets and small side vegetable shops.

Generally in Mizoram, farmers properly wash the harvest and then carefully bundles 5-10 plants using banana stem or water soaked bamboo threads so as not to damage the leaf otherwise its monetary value resides. The bundles are sold in range of ₹ 20 per bundles to ₹ 50 per three bundles in the region.

Allium ascalonicum in local market (Durtlang Leitan), Aizawl District, Mizoram

Allium chinense

Commonly known as Rakkyo, Chinese onion, Chinese scallion, Japanese scallion, Kiangsi scallion and oriental onion, is a perennial herb. Being served as side dish or as a nutritional supplement, it is traditionally used for treating stenocardia, heart asthma, and antiplatelet aggregation. Its footprint can be observed in local markets of Meghalaya, Manipur, Mizoram, Nagaland and other

Allium chinense at Selesih, Aizawl District, Mizoram

NEH region of India. The plant height ranges from 25 cm to 50 cm. It produces evergreen bulbs with hollow bright green leaves and grows in clumps forming many well developed bulbs. Leaves are slender in nature and thin-walled, 3 to 5 angled (not round) and less stiffly erect having solid seed stalk. Its flowers are lavender in colour with long pedicels, thick perianth segments and long-exerted styles and stamens. Inflorescence bears umbel reddish purple flowers on a stalk 40-60 cm long. Unlike other *Allium* crops, it is on the side of the main growing shoot, not emerging from its centre. Generally, the umbel consists of about 5 to 25 flowers, which are hermaphrodite. The plant root can reach 45 to 50 cm depth and possesses a spherical bulb derived from a valve stem. Bulb is formed in autumn after summer dormancy with oval shape about 4 to 5 cm in diameter after the second or third year of growth. Grey-white or purple with a thin transparent skin, it has an excellent crispy texture that covers its white meat, which has a strong onion flavour at maturity. In Manipur and Mizoram and other part of NEH region, it is locally known as '*Cholam*' and '*Purun var zung lei chi*' respectively and are being used as one the key ingredient in major Manipuri and Mizo dishes. The growing *Allium Chinense* lavender colour flower blooms during November in Mizoram.

Allium chinense with tuber and roots

In Mizoram, their occurrences in local markets have also subsided inflicting the importance of uplifting such local herbs that are generally consumed as key ingredient in festival and ceremonial dishes. Both the leaf and roots are generally consumed as fresh and cooked. In locals it is known mostly for its medicinal values in mitigating and controlling various diseases and stresses like heart problems, headache and worms.

Allium hookeri

It is commonly known as Hooker chives or garlic chives; an evergreen, herbaceous and grassy perennial. In contrast to other *Allium* species, it is devoid of bulb and characterised by white fibrous roots developed from a significantly reduced underground rhizome. The leaves are linear, fleshy and green in colour with prominent midribs and membranous basal leaves length of about 20-60 cm long and flowering scapes 20–60 cm tall. Umbels are crowded with many white or greenish-yellow flowers. Flowering time starts from July to October and

Broader leaf variety of *Allium hookeri*

the seeds ripen from August to November. The species is hermaphrodite and is pollinated by bees and insects. It grows in a wide range of soil types; suitable for light (sandy) and medium (loamy) soils and preferably moist and well-drained soil. It is suitable in all type of soil *p*H ranges. The fibrous roots and the leaves also represent the edible parts of the plant which is mostly consumed as condiments or spices. Apart from consuming as food, it is been used in ethnotherapy of certain diseases and considered of great ethno botanic relevance to certain parts of the country. The therapeutic values of *A. hookeri* are attributed to the higher concentration of total phenols (2 g/100 g dry wt.) and phytosterols (0.5 g/100 g) are known to lower the intestinal absorption of cholesterol in the body. Especially in NEH region, the major variety of the species that is found has broader leaf and locally known as '*Maroi napakpi*' in Manipur and '*Purun ahna aei chi alian*' in Mizoram.

Uses: It is commonly known as *Ja-ut* in Khasi. The leaves and roots are freshly consumed. Their root goes

Allium hookeri grown at farmer's field

Harvested *A. hookeri* at farmer's field

A. Hookeri roots bunch in local market (Bara Bazar), Aizawl District, Mizoram

A. hookeri lead bunch in local market (Pishumthong bazar), Imphal West, Manipur

well with potatoes and other vegetables thereby enhancing their taste and flavour of the dishes. This *Ja-ut* replaces the onion in curries like fish curry, fish chutney (tungtap) or phan-khleh (mashed potatoes).The raw leaves add punch to the salad. *Ja-ut* is not only used as food but is also used in treating ailments like cough, colds, digestive and circulatory system. The leaves and roots are consumed in fresh, dried and powdered form which can be stored in air tight container for preservation. It will not only add flavour to food/dishes but also maintain good health. In Manipur, it is commonly known as *Maroi napakpi,* the broader leaf. It is an indigenous condiment which is used in every dishes/curry. Local healers of Manipur have been using it for ages for medicinal purpose since it has 'nutraceuticals' property. This herb has combined property of nutritive as well as curative benefits. In General, *Allium hookeri* is an excellent food supplement and has nutraceuticals properties, it also contains as natural carbohydrates, proteins, fatty acids, and anti-oxidant properties. Its leave's juices with salt helps in curing ulcers and stomach ailments. When applied with the leave's paste of *Allium hookeri* on forehead reduces high body temperature and blood pressure. Its roots act as natural preservative because of its anti-oxidant characteristics

Being an important key ingredient in daily dishes, its demand is ever-increasing regularly. In Manipur and Mizoram, pockets of NEH Region, it is generally grown in discrete patches of land or in larger scale as per choice of the farmers. Their fibrous roots are also being consumed at large. Generally after harvesting, the roots are properly washed and then sold separately in small bundles. In local markets, the leafy section are sold in small or large bundles ranging from 10-30 and the fibrous roots are also sold in 2 to 3 root bundles at a rate of around 20-30.

Allium tuberosum

It is known for its high medicinal value and herbal nature with potent capacity of treating broad range of diseases and disorders covering hypolipidemic and hypoglycemic attributes. *Allium tuberosum* is used for the treatment of asthma, abdominal pain, diarrhoea, nocturnal emission and diabetes in folklore medicine. It is a perennial herbaceous plant and a late bloomer. Due to its mild garlic flavoured leaves, it's also known as 'garlic chive'. It produces 2 to 5 leaves which are 20-50 cm long and flowering scape of 25-60 cm height from underneath bulb along the rhizome. It exhibits inert contents of about 2.6% protein, 0.6% fat, 2.4% carbohydrate, 0.95% ash

Table 1. Diversity of Allium species in North Eastern Hilly (NEH) region

Species	Distribution	Occurrence Status	Uses
Allium ascalonicum	Assam, Arunachal Pradesh, Nagaland, Manipur, Meghalaya, Mizoram, Sikkim and Tripura	Common	Vegetables, condiment, flavour and medicine
Allium chinense	Assam, Arunachal Pradesh, Nagaland, Manipur, Meghalaya, Mizoram, Sikkim and Tripura	Common	Vegetables, condiment, flavour and medicine
Allium hookeri	Manipur, Arunachal Pradesh, Nagaland, Meghalaya, Mizoram, Sikkim, Assam and Tripura	Common	Vegetables, condiment, flavour and medicine
Allium tuberosum	Arunachal Pradesh, Nagaland, Manipur, Meghalaya, Mizoram, Sikkim, Assam and Tripura	Rare	Vegetable, condiment and medicine

with small amounts of vitamins A, B_1 and C. Having a mild fragrance the flowers are white star shaped. It can grow by both seed or from clumps. Generally, its flowers are cut off after blooming as to avoid unwanted spread. Its seeds are black colour and triangular shaped with a hard capsule. In parts of Manipur, Mizoram, Meghalaya and Nagaland it is found in larger scale. In Manipur and Mizoram it is locally known as '*Maroi nakuppi*' and '*Purun ahna aei chi atae*', respectively.

Allium tuberosum in local market of Manipur

Allium tuberosum at farmer's field, Selesih, Aizawl District, Mizoram

Especially in Manipur it is more preferred ingredient over onion. Its leaves are sliced and fried instead of onion while preparing almost all dish of Manipur. Its importance can be felt in a way that though every household is having kitchen gardening of it, it is still sold in large scale in every local market with ample number of demand. Generally they are sold in medium to large bundles ranging from 25-50.

Uses: Traditionally known as *Maroi nakuppi* in Manipur, apart from being key ingredient of dish, decoction of garlic chives or whole plant is taken as vegetable for curing various liver disorders as well as gastrointestinal disorders. It helps in lessening blood glucose and serum cholesterol level. The plant has been used as an antidote for poisonous bites, and excessive bleeding can be controlled by the plant juice and bulbs contain vulnerary properties. Seeds are used for treating kidney, liver and digestive system problems. In the course of the present article on the major indigenously growing *Allium* species that are thriving in NEH region, a deep ethical grassroots in the region can be seen with profound visibility (Table 1). Further, it is seen that these species are usually used in wide varieties of major regional dishes and as potent medicines. Viewing to the unbound challenges faced by the Indian farmers and the entire population in terms of demands, price hikes nutritional declination and its security which are resultant projections of changing climates and ever increasing population these *Allium* species may outset an open door to mitigate such problems as it can readily replace some of the deficit from the common onion and garlic available in the country.

SUMMARY

Indigenously grown *Allium ascalonicum*, *Allium chinense*, *Allium hookeri* and *Allium tuberosum* are grown/found in almost all the 8 North Eastern States. Moreover these are widely preferred for its existing taste and aroma. These species are also being more accepted over the commonly available onion and garlic in the region. It may be due to its cultural heritage and understanding in its medicinal and health benefits. Further, some of these species are being used as a key ingredient in preparation of festive and ceremonial dishes. Indian agricultural platform, being impounded by a number of affects of climatic, nutritive and socio-economic constrains, these indigenously grown *Allium* species can greatly arrest its effects. It is felt vital and important to highlight its characteristics and benefits so as to fill the voids in securing and mitigating the country's deficits in terms of food, spices and nutritional security in the contending era of changing climate and nutritional security.

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Lalu Prasad Yadav, K Gangadhara,
D S Mishra, Sanjay Singh and P L Saroj

Status, diversity and potential of semi arid indigenous and minor vegetables of western India

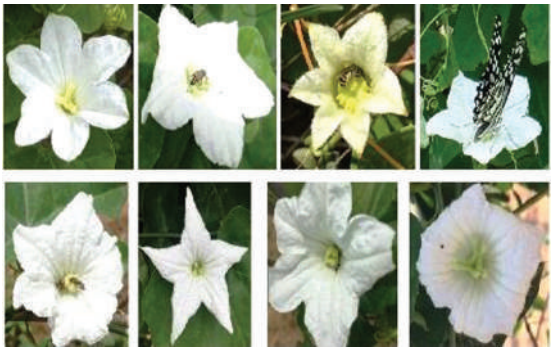
Global diversity in vegetable crops is estimated about 400 species, with about 80 species of major and minor vegetables reported to have originated in India. About 37% of cultivated vegetable species were determined to have an Asian–Pacific origin, 22% originated in the Americas, 17% are from the region spanning Europe, the Mediterranean, Near East and Central Asia, 15% originated from Saharan and sub-saharan Africa, and 10% are wide ranging species that cross several world regions. However, with the advent of cut-and-burn agriculture and green revolution/commercialized agriculture, the development project areas and related activities of these diverse resources are declining at a fast pace. Overgrazing, deforestation, and overexploitation of native resources under range situations have eroded the biodiversity of vegetable crops from this unique ecosystem. Moreover, traditional knowledge about important indigenous plant species has also decreased in the younger generation influenced by urbanization.

Status of semi-arid region of western India

Global expansion of semi-arid region is 22.6 million square kilometer (MSK) followed by arid region (15.7 MSK). Two zones of semi-arid climate are recognized in India, one in the north, is contiguous with the desert of Thar, extending into Rajasthan, Punjab, parts of Uttar Pradesh, Kutch, Saurashtra (the Mountainous region of Gir excluded). The other semi-arid zone is situated in the south. It includes the Deccan plateau, the Coimbatore plateau located in the shadow of the Nilgiri and Palni hills and the extreme south-east corner of Madras comprising Ramanathapuram and Tirunelveli districts. The semi-arid zones of north and south are separated by a narrow humid strip composed of the Satpura range and the plain of the Tapti River. Some regions are characterized by hot and dry summer and cool winter whereas some regions are characterized by hot and wet summer and dry winter.

Potential of semi-arid indigenous vegetable

The indigenous and minor vegetables includes cucurbitaceous vegetables, viz. kachri (*Cucumis melo* var. *callosus / agrestis*), kakadia/snap melon (*Cucumis melo* var. *momordica*), mateera (*Citrullus lanatus*), tinda (*Praecitrullus fistulosus*), spine gourd, ivy gourd; leguminous vegetables, viz. Indian bean, cluster bean (*Cymopsis tetragonoloba*); leafy vegetables like palak, amaranths, fenugreek, coriander, fennel, drumstick leaves, brinjal, drumstick etc. have potential to fight the problems of protein, vitamins, minerals, antioxidants and micronutrients in malnutrition affected areas in western India (Table 1). Various indigenous leafy vegetables of western India are having an optimal source of nutrients such as carotene, folate, iron, calcium, zinc, proteins and dietary fibre. Therefore, documentation of traditional crop knowledge and dissemination of information relating to the indigenous



Variability in ivy gourd flower and different pollinating agents

Fruit variability in Ivy gourd

Promising line of spine gourd CHESSG-11 under semi-arid conditions

vegetable food utilization is very essential for conservation of diversity and solving nutritional problems. Cucurbits are major crops grown in different areas of the state, more specifically in western Rajasthan, and the river belt cultivation of muskmelon and watermelon has been very prominent in the past. Similarly, Shahpura Tinda (round melon) is very famous in our country. Similarly, snapmelon and kachri are also grown in a sizeable area. Similarly, watermelon (mateera) is grown in several parts of western Rajasthan and seeds of watermelon after removal of seed-coat are being exported to several Middle-East countries.

Variability in spine gourd fruits under semi-arid conditions

Diverse collection and improvement on semi-arid vegetable crops at ICAR-Central Horticultural Experiment Station (CIAH RS), Godhra, Gujarat

There is a potential of growing the semi-arid indigenous and minor vegetables like cucurbits (cucumber, spine gourd, kachri, snapmelon, ivy gourd), leguminous vegetables (Dolichos bean and cluster bean), leafy vegetables, brinjal, drumstick etc. with modern agricultural inputs as a sole crop, intercrop or kitchen gardening. Keeping in view, Central Horticultural Experiment Station (ICAR-CIAH), Godhra Gujarat is working to develop different technologies and varieties under semi-arid conditions which will suit to iso-climatic regions for enhancing productivity in semi-arid areas and ultimately enable to improve livelihood security of resource poor farmers. A wide range of variability was found in the part of semi arid region of western India during survey and collection, and evaluation of different genotypes of drumstick (44), ivy gourd (35), spine gourd (20), pole type Indian bean (70), bush types of Indian bean (42) at Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur, Gujarat under semi arid conditions. Drumstick is an important vegetable crop cultivated in semi-arid region for its green pods. Every part of this plant is valuable for food and enriched with nutrients, minerals and vitamins. In addition to its edible and nutritional value, it has tremendous potential on industrial features such as use of roots (alternate to horseradish), wood (making mats, paper and cordage manufacturing), the seeds (water clarification), oil extracted from seed kernels (lubricants in watch making and precision equipments, and in the preparation of cosmetics). In addition to this, moringa is found to have a group of unique compounds containing sugar and rhamnose, which are uncommon sugar modified glucosinolates. In Gujarat, there are two prevalent edible types, Saragvi and Saragva based on their colour and preference, the saragvi is slender, parrot green pods and preferred by consumers, whereas saragva is stout and dark green pod. Thar Harsha is a new high yielding drought tolerant cultivar of drumstick, developed at the institute. It is a late flowering and late maturing type which comes to harvest during March-May. Its hardy

Variability in fruits of Indian bean

Table 1. Recommended varieties of vegetables for semi-arid region of western India

Crop	Varieties
Cluster bean	Goma Manjari, Thar Bhadvi, Pusa Sadabahar, Pusa Mausami, Pusa Navbahar, Durga Bahar, AHG-13
Indian bean	Thar Katki, Thar Mahi, Arka Jay, Arka Bhavani, Arka Swagath
Brinjal	Pusa Purple Long, Pusa Purple Round, Pusa Kranti, Pusa Anmol, Arka Sheet, Arka Shirish, Arka Kusumakar, Arka Navneet, Arka Harshita
Ivy gourd	Thar Sundari
Bitter gourd	Pusa Do Mausmi, Arka Harit, Pride of Gujarat
Drumstick	Thar Harsha
Palak	Jobner Green, Pusa Palak, Pusa Harit, Pusa Bharti, Arka Anupama
Amaranths	Pusa Kirti, Chhoti Chauali, Badi Chaulai, CO-1, CO-2, CO-3

nature facilitate the pod setting which reach marketable size despite of prevailing drought situations and recorded with 20-30% greater marketable yield and 85.90% more total yield as compared to check under drought conditions. Each tree can bear on an average 45-48 kg pods. The pod contains higher protein (9.30 g), vitamin C (246 mg) and vitamin A content (9783 IU) per 100 g.

SUMMARY

Semi-arid indigenous and minor vegetables afford excellent opportunities for improvement of human health, and farmer's household economic and social advancement. These vegetables are ideally suited to accomplish these objectives owing to their high economic and nutritive values and they can often serve as an engine for agricultural and economic diversification. Supplements and fortified foods can effectively address micronutrient deficiencies in the short-term, but food-based solutions, such as increasing the consumption of vegetables represent the most sustainable method of reducing and controlling micronutrient deficiencies in resource-poor communities. Supportive policies are needed to advance research, conservation, and documentation of neglected indigenous semi-arid vegetable species to protect and realize their role in nutrition-sensitive horticulture.

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Winged bean

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Winged bean is an underexploited, multipurpose leguminous vegetable crop which finds an important place in traditional diets. Almost all parts of the plant can be eaten and are consumed by incorporating in a variety of cuisines. The green pods, tubers, seeds, leaves, flowers and shoots, are rich in protein, vitamins and minerals and also possess remarkable soil nitrification properties. The protein content varies in leaves (5-15%) and green pods (1.9-2.9 %), carbohydrates (3.1-3.8 %), rich in calcium, iron and vitamins and tuber contains 10-12% crude protein. It is found that winged bean green pods have higher antioxidant activity than raw tubers. Winged bean can be grown effectively with little care and management and will not compete for available land with other crops. Promotion, augmentation and popularization of such traditional food plants through systematic scientific evidences would support their adoption in the country. An initiative has been taken at ICAR-Indian Institute of Vegetable Research, Varanasi, India by adopting winged bean as a new underexploited vegetable crop.

A K Sharma and Sudheer Kumar Annepu

Status, diversity and potential of indigenous and minor perennial vegetables

Indigenous and minor plants are those whose diversity is known to be in the country of their origin. So far 80 species of major and minor vegetable crops are reported to have originated in Indian sub continent. Among them, *Bambusa* spp., *Moringa oleifera, Murraya koenigi, Sauropus androgynus* and *Sesbania gradiflora* are some of the perennial plants whose plant parts are partly used for vegetable purpose. Many sections of rural population and ethnic communities meet their nutritional requirement through these indigenous vegetable crops and derive substantial income from their collection and trade. Several research studies also demonstrated that many of these indigenous and minor vegetable crops are vital sources of trace minerals and possessing therapeutic properties due to the presence of bioactive compounds. Considering their health benefits these less familiar vegetable crops are also gaining equal acceptability among the urban conglomeration.

INDIGENOUS and minor vegetables are best defined as the traditional crop species that are native to that particular region. They are important in view of nutrition, health and sustainability of the social systems in the region where they have been evolved over a period of time. Traditional vegetables play a major role in the diversification of diet leading to more balanced source of micronutrients. Unlike annual and biennial vegetable crops, which has major share in Indian vegetable production, perennials such as drumstick, ivy gourd, pointed gourd, spine gourd, sweet gourd, bread fruit, chow-chow, chekurmanis, etc. are grown and consumed in relatively small scale. These perennial vegetables have a handful of vital nutrients, trace minerals, antioxidants and medicinally important bioactive compounds. Lack of knowledge in consumers and farmers tendency to grow annual vegetables renders these vegetables of minor important in the human diet. Further, exotic perennial vegetables such as asparagus, rhubarb, artichokes, etc. are not part of the average Indian human diet even today. Indigenous vegetables shows substantiate biodiversity and are adapted to specific marginal growing conditions with minimal inputs. Diversifying the existing production systems with traditional vegetables will increase the heterogeneity and subsequently lead to better resilience to abiotic and biotic stresses.

Potential role of indigenous perennial vegetable crops

Ecosystem stability

Climate extremities and the increased degradation of land and water resources have led to a growing interest in crops that are adapted to difficult environments. Being a native to the habitats, indigenous perennial vegetables can be grown under adverse soil and climatic conditions. Drumstick is well adaptable to dry and hot climates of the north-western plains, central India and dry regions of peninsular India and is considered as drought resistant. Farming with perennials provides an important way of mitigating climate change by means of aerial carbon sequestration.

Bamboo spp.

Basella rubra

Carissa

Crambe cordifolia

Gmelina arborea

Parkia roxburghii

Income diversification for rural poor

With increased awareness about healthy diet, the demand for novel food products is gaining momentum especially from the markets in developing countries. These market opportunities can generate additional income for poor farmers in less-favoured environments where these crops have comparative advantages over the commercial crops. Perennial vegetable cultivation demands less expenditure and gives high returns. Consumption of perennial vegetables makes the availability of nutrients and vitamins at cheaper cost, thereby helps in solving malnutrition in rural areas. Growing of perennials with multiple uses food, fodder and fuel will diversify the income source.

Combating malnutrition

Many indigenous and minor vegetables are nutritionally rich. Utilization of these species, either wild or cultivated, can have significant impact on the nutritional security and well-being of the poor. Their enhanced use can bring about better nutrition. For instance, Chekurmanis is known as multivitamin green as

Table 1. List of indigenous and minor perennial vegetables in which leaves are used as vegetable

Scientific name	Local name/s	Family	Growth habit	Ethno botanical use
Bacopa monnieri	Indian brahmi	Plantaginaceae	Creeping herb	It is bitter, pungent, heating, emetic, laxative and useful in bad ulcers, tumours, enlargement of spleen, indigestion, inflammations, leprosy, anaemia, biliousness, etc. It is a promising blood purifier and useful in diarrhoea, fever, epilepsy.
Bambusa spp.	Bamboo	Poaceae	Perennial herb	Edible shoots are low in fat and calories, good source of fibre, and have several medicinal properties including anticancer, antibacterial, antifungal and antiviral activity.
Basella spp.	Indian spinach	Basellaceae	Perennial vine	The tender shoots, leaves, leaf stalk and stem are used as vegetable, soups or stew. *B. alba* is used as cooling medicine in digestive disorders and contains antiviral substances.
Clerodendrum colebrookianum	East Indian glory	Lamiaceae	Perennial shrub	Boiled decoction is taken to get relief from high blood pressure and for rheumatic pains. Roots with bark are used in treating bronchitis and asthma.
Diplazium esculentum	Vegetable fern	Athyriaceae	Perennial fern	It is rich in micronutrients, especially iron, manganese and zinc, and is used in curry in various forms, or prepared as vegetable and pickle.
Gmelina arborea	Malay bush beech	Lamiaceae	Deciduous tree	The root and bark are stomachic, galactagogue, laxative, and anthelmintic. They improve appetite and are useful in hallucination, piles, abdominal pains, burning sensations, fevers, 'tridosha' and urinary discharge.
Nymphaea spp.	Water lily	Nymphaeacea	Perennial shrub	The rhizomes are cooling, sweet, bitter and tonic, and useful in treating diarrhoea, dysentery, dipsia and general debility.
Paederia foetida	Stinkvine	Rubiaceae	Perennial vine	Useful in treating bowel troubles, rheumatism, urinary retention, urinary bladder stones, fevers and flatulence.
Pandanus amaryllifolius	Indian pandan	Pandanaeae	Perennial shrub	leaves of the Indian pandan are used as a flavouring agent in cooking especially rice dishes cakes and sweet beverages.
Pisonia grandis	Lettuce tree	Nyctaginaceae	Perennial shrub	Leaves are used as diuretic and also for treating diabetics.
Polygonum spp.	Knotweed	Polygonaceae	Perennial shrub	Leaves are crushed with ginger and eaten.
Urtica spp.	Nettles	Urticaceae	Perennial herb	It is used in anti-itch drugs and in cremes containing antihistaminics or hydrocortisone.
Zanthoxylum hamiltonianum	Tejamoo	Rutacea	Prickly shrub	The dried and powdered fruits are consumed to increase appetite. The tender stem is used to brush teeth when there is toothache.

Table 2. List of indigenous and minor perennial vegetables in which fruits and leaves are used as vegetable

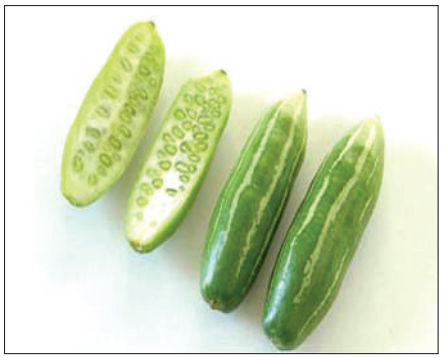
Scientific name	Crop	Family	Growth habit	Ethno botanical use
Coccinia grandis	Ivy gourd	Cucurbitaceae	Perennial vine	Fruits are nutritious - the young and tender green fruits are used raw in salads and curry or cooked as vegetables. The juice of the roots and leaves is used in treating diabetes and gonorrhoea. The leaves are used as a poultice in treating skin eruptions.
Moringa oleifera	Drum stick	Moringaceae	Deciduous tree	Drumstick tree or horse radish tree is rich in vitamins A and C, mineral-packed (calcium, phosphorus and iron), and highly nutritious perennial vegetable.
Parkia roxburghii	Tree bean	Fabaceae	Deciduous tree	Mature flowers and young shoots are used as curry and in salads. Tender pods are rich sources of fibre, protein, vitamin C, phosphorus and iron.
Piper mullesua	Hill pepper	Piperaceae	Perennial vine	The dried plant is consumed to cure malaria and cough diseases. Roots and fruits are used in Ayurvedic medicines.
Sesbania grandiflora	Agathi	Fabaceae	Small tree	It is aperient, diuretic, emetic, emmenagogue, febrifuge, laxative and tonic, and is a folk remedy for bruises, cataract, dysentery, eyes, fevers, headaches, smallpox, sores, sore throat, stomatitis and night blindness.
Solanum indicum	Bush tomato	Solanaceae	Perennial shrub	Fruits are digestive but more quantity is considered toxic due to the presence of solasodine. Fruits are eaten to cure dysentery, gastritis, malaria and indigestion due to high alcohol consumption.
S. spirale	Titakuchi	Solanaceae	Perennial shrub	Green fruits are eaten, especially during malaria outburst. The dried ripe fruits are used (sole or mixed) for stomach pain and gastric problem.
Trichosanthes dioica	Pointed gourd	Cucurbitaceae	Perennial vine	Pointed gourd has been used for overcoming problems like constipation, fever, skin infection and wounds. It also improves appetite and digestion.

Table 3. List of indigenous and minor perennial vegetables in which fruits are used as vegetable

Scientific name	Local name/s	Family	Growth habit	Ethno botanical use
Artocarpus altilis	Bread fruit	Moraceae	Perennial tree	Fruits of the bread fruit are rich in carbohydrates and are used mostly as vegetable for culinary purposes.
Capparis deciduas	Ker	Capparaceae	Bushy shrub	Fruits are used to cure many ailments in traditional medicines. Seeds contain 20% oil, 1.7% sugar and 8.6% protein.
Carissa carandas	Karonda	Apoynaceae	Perennial shrub	Fruits are antiscorbutic and useful in curing anaemia. Ripe fruit is sweet and cooling, and used as appetiser. It is useful in treating anorexia, vitiated conditions of pitta and vata, burning sensation, skin diseases, and scabies.
Cordia myxa	Lasora	Boraginaceae	Deciduous tree	The fruits are useful in vitiated gastric problems, ulcer, leprosy skin diseases, dry cough, bronchitis, burning sensation, chronic fever, arthritis and skin disorders.
Dillenia indica	Elephant apple	Dilleneacea	Perennial shrub	Fruits are juicy and acidic, eaten raw and also used in making jelly, cooling drink and vegetable curry.
Litsea cubeba	Mountain pepper	Lauraceae	Evergreen tree	Seeds are chewed in case of threadworm infection. Oil from unripe fruits (61.8%), flowers and leaves are rich in citral which is used in perfume and medicine. It possesses antimicrobial property apart from its effectiveness in coronary heart diseases.
Prosopis cineraria	Khejri	Fabaceae	Deciduous tree	Pods are astringent and rich in crude protein, carbohydrates and minerals. They are also used as famine food. The bark is cooling, anthelmintic and used as tonic for curing leprosy, dysentery, bronchitis, asthma, leucoderma, piles, tremors of the muscles, rheumatism, cough, cold and asthma.
Sechium edule	Chayote	Cucurbitaceae	Perennial vine	Chayote or *choko* fruits are rich in amino acids and are used as vegetable and snack. Infusions of the leaves are used to dissolve kidney stones and to treat arteriosclerosis and hypertension; infusions of the fruit are used to alleviate urine retention.

Polygonum spp.

Sechium edule



Tricosanthes dioica

it holds a good number of vitamins in appreciably higher quantities in its leaves. Basella (12276 IU/100 g), drumstick leaves (11187 IU/100 g) and chekurmanis (9510 IU/100 g) contain high levels of vitamin A than other annual vegetables such as amaranthus (9108 IU/100 g), spinach (8100 IU/100 g), and carrot (1000 IU /100 g). Many indigenous vegetables contain more vitamin C and pro-vitamin A than widely available commercial crops. Focusing attention on indigenous vegetables is an effective way to combat micronutrient deficiencies, the so-called 'hidden hunger', particularly among the rural poor.

Diversity in indigenous perennial vegetables

Indigenous and minor vegetables are regionally important. Due to their limited use and limited areas of cultivation not much selection pressure has operated on them and thus they are likely to carry some useful traits like adaptability to adverse environmental conditions and tolerance/resistance to diseases. Some of these less-known vegetables occur as semi-wild/protected/ gathered from wild and show trends of domestication. Protein rich pods of *Parkia roxburghii* consumed as staple legume vegetable in the north eastern region of India. Despite being recognized for their nutritional value, the possible reasons of low utilization of this crop species is lack of supply and non-viable indigenous market when compared to major vegetables. In drumstick (*Moringa oleifera*) considerable research work is going on in India and cultivars have been developed. Over 257 accessions mainly of cultivated *M. oleifera* were collected from different phyto-geographical regions of the country. Wild/ semi-domesticated leafy vegetables are extensively used by the tribals of north eastern region and have been short-listed (336) for collection by ICAR-NBPGR. Information on tribal vegetables such as *bohar bhaji* (*Hymenodictyon excelsum*) consumed for succulent leaves (a trees usually grown around tribal homes in Chhattisgarh used for preparing delicious vegetable) was gathered during plant exploration. Semi-protected populations of *Cassia tora* (often collected from the wild) was reported under cultivation by tribals of Khammam district of Telangana and Bastar and Dantewada districts of Chhattisgarh. Meetha patta (*Plukenetia corniculata*) was noted under cultivation at field as well as homestead level for use as a leafy vegetable by the Naga tribes in Dimapur and Mokokchung districts of Nagaland. A total number of 307 accessions in *Coccinia grandis*, 40 accessions in *Sechium edule*, 158 accessions in *Tricosanthes dioica*, 24 accessions in *Murraya koenigi*, 94 accessions in *Basella alba* have been collected and conserved at ICAR-NBPR, New Delhi.

Indigenous and minor perennial vegetables

The list of promising indigenous and minor perennial vegetables are categorized based on the plant parts used as vegetable such as plants in which only leaves are used as vegetable; plants in which both leaves and fruits are used and plants in which only fruits are used as traditional vegetable (Tables 1,2,3). Details are also mentioned regarding their traditional and ethno botanical usage in the native regions.

SUMMARY

Despite possessing an immense value as a nutritious food source, many indigenous and minor perennial vegetable crops remain widely unknown. Still cultivation and their consumption are restricted to few sections of the society. Given the rapid decline on traditional knowledge on these crops, it is pertinent to document the existing diversity, assorted usage and information on cultivation practices. It is also true that many more indigenous and minor vegetable crops believed to be edible are yet to be documented and bring them into the scientific domain. These vegetables grow well in low input farming systems which is gaining popularity in the recent time. They have a definite role in alleviating hunger and micronutrient deficiencies. The rich diversity can also be explored to identify the genes conferring abiotic and biotic resistance for future breeding programmes. Modern scientific studies validated the therapeutic applications of the biologically active compounds identified in these crops. These applications created a greater scope for exploring the pharmaceuticals. Developing an inventory of indigenous and minor perennial vegetable crops, information on ethno botanical properties, evaluation of nutritional benefits can establish these vegetable crops as an alternative to achieve nutritional security and livelihood sustenance.

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A C Mishra, Lalit Bhatt and R K Dubey

Uttarakhand Himalayas harbour rich diversity of indigenous and minor vegetables

The Himalaya of Uttarakhand is adorned with a vast plant biodiversity including shrubs and herbs of immense nutraceuticals, medicinal and aesthetic importance. Most of the species are of ancient and indigenous origin but many of them have been introduced by foreign invaders, rulers and visitors with the span of time.

THERE are many cultivated and forest species which are supposed to be originated in some other geographical regions with similar agro-climatic conditions but they have been most acclimatized species of this region. Similarly, in vegetable crops also there are many crops which in spite of their exotic origin have been fairly acclimatization in this hilly areas. However, there are many crops of indigenous origin or long back introduced traditional crops of exotic origin seeking place for research attention even after having a great nutraceuticals potential. An account of some of these indiginous and minor vegetables crops has been given hereunder.

Mustard greens *(Brassica juncea* var. *rugosa)*

Mustard greens or vegetable raie cultivation in Uttarakhand Himalaya has been under cultivation since long back in high hill tracts of Kumaon and Garhwal by the name 'Chinese Sarson', characterized by flat, broadened, dark green leaves with white and thick midribs with or without waxy coating on leaves. Another landrace 'Hathikan' with flat, broadened leaves with thin midribs was extensively grown in Jaunsar region of Uttarakhand (Uttarkashi and Tehri districts) and adjoining districts of Himanchal Pradesh. Different phenotypic forms are available in the multiple leaf nipping type of *B. Juncea* var. rugosa. A wide range of variability occurs in this crop with respect to leaf shape, size and colour. Colour of leaves ranges from light green in *Hathikan* to purple in *Badshahi*. Many local races of mustard greens are under cultivation extending from J&K to North Eastern Himalayan regions. Owing to its palatability and nutritional values, this crop is extensively grown for domestic consumption in Punjab, West Bengal, Assam and almost all the Himalayan states of India. The mustard greens are grown after the rainy season, harvesting of leaves starts from November and continues to late January - February when there is scarcity of vegetables in local markets due to heavy frost. During this extremely low temperature and severe frost, mustard greens because of its frost tolerance nature is only vegetable crop which can be grown. It is rich in iron, sulphur, potassium, phosphorus and many other minerals. The leaves contain 71.7-110.9 mg/100 g ascorbic acid, and profuse quantity of carotenoids and anthocyanins (purple leaved types).

Crop improvement

Pusa Sag-1 has been developed by IARI regional Station, Katrain to promote this crop. In recent years, Department of Vegetable Science, Ranichauri, Uttarakhand

UHFVR12-1 (IC-0598459)

UHF VR12-2 (IC-0612094)

University of Horticulture and Forestry has undertaken intensive work on crop improvement and production technologies. Consequently, two lines have been isolated and purified with following peculiarities:

UHFVR12-1 (IC-0598459): This is selection from local race *Badshahi*. The leaves are purple, broad, flattened, succulent, crispy, non-bitter, non-pungent and rich in anthocyanin. First leaf picking starts 35-40 days after sowing or 20 days after transplanting. The purple colour due to anthocyanin development gives more attraction to consumers. It can withstand frost and gives green leaf yield is about 334.3 q/ha at national level and 500-600 q/ha in hilly areas. This line has been identified to release for Zone-III (Humid Eastern Himalaya and Bay Island: Sikkim, Meghalaya, Manipur, Nagaland, Mizorum, Tripura, Arunachal Pradesh and Andman & Nicobar Island) during **XXXVI** Annual Group Meeting of All India Coordinated Research Project (Vegetable Crops).

UHFVR12-2 (IC-0612094): This is selection from local race *Hathikan*. The leaves are green, broad, flattened, succulent, crispy, non-bitter and non-pungent. It can also withstand frost. Leaf yield varies from 519.2-629.5 q/ha.

Round-rooted radish *(Raphanus sativus* L.*)*

Round rooted radish is an extensively grown crop used as cooked vegetable as well as *salad* purpose in Kumaon region of Uttarakhand. *Doonagiri* is a popular landrace of this crop named after a Himalayan peak in Kumaon hills. This landrace can be characterized by white to pinkish white, crispy, oval to oblong roots with sweet and light pungent taste and aroma. The leaves of *Doonagiri* are also variable type ranging from deeply serrated lamina and light green midribs to deeply serrated lamina and pinkish midribs. Uttarakhand University of Horticulture and Forestry, Bharsar have selected populations of round-rooted radish with variation in colour and shape were purified and one advanced line with the name of UHF R12-1 (IC-0598463) has been identified for released for **Zone-I** i.e. Humid Western Himalaya J&K, HP & Uttarakhand) during **XXXVII** Annual Group Meeting of All India Coordinated Research Project (Vegetable Crops). The UHF R12-1 is characterized by leaves with deeply dentate with serrated margin, 20-30 cm in length and dark-green in colour produced in rosette of 7-8 leaves, round to slightly tapering roots of 10-12 cm in length and width, white in colour, weighing 110-130 g at edible maturity, root core colour white resembling to peel, sweet-pungent taste of roots with peculiar aroma, suitable for *Salad* as well as cooked vegetable. Roots attain harvestable maturity in 55-60 days after sowing, 380-400 q/ha root yield has been realized in hilly areas.

Variations in round rooted radish

Pahari palak/Spinach *(Spinacea oleracea)*

This vegetable has significant morphological variability extending from light green leaves and green stem to dark green leave and deep red stems. Pahari palak is free from oxalate content in comparison to beet leaf with considerable quantity.

Variable form of Pahari Palak-genotype UHFES-12-2 (IC-0598460)

Stuffing cucumber *(Cyclanthera pedata)*

Locally known as Pahari Karela/Meetha Karela because of its bitterless taste. Young fruits are eaten raw or pickled. Young shoots and leaves are eaten as greens. This crop has a wide variability in fruit morphology, fruit size, yield and vine proliferation. The fruits may be smooth to spiny and small (12-15 g) to big (12022 g). Plants are monoecious and may have male and female flowers on the same leaf axil. Male flowers are borne on long stalk in the small racemes whereas female flowers are borne on small stalk as solitary axillary or in pairs. New crop is grown during rainy season which comes to flowering and fruiting during October-December. The plants are sufficiently tolerant to frost and are usually free from foliar diseases and insect-pests. This vegetable is much liked by local peasantry. Immature fruits are used as cooked vegetable whereas mature and ripe fruits are dried after removal of seeds and kept for off-season consumption. Fruits are also used as anti-inflammatory, hypocholesterolaemic and hypoglycemic. The fruit are rich in calcium (14.0 mg) and phosphorus (14.0 mg). A genotype UHF Meetha Karela-1 (IC-0619212) bearing paired female flowers in leaf axils, spineless and small fruits was identified by the Department

Flowering and fruiting in Meetha Karela

of Vegetable Science, Ranichauri Campus of Uttarakhand University of Horticulture and Forestry, Bharsar.

Marrows *(Cucurbita pepo)*

Himalayan region has profound genetic variability in all three species of genus *Cucurbita* (*C. pepo*, *C. maxima* and *C. moschata*). The vining marrow shows much variability in fruit shape and size. This is an important crop of hilly areas. The green as well as yellow ripe fruits are used as cooked vegetable in the season and off seasons also. The marrow fruits are rich in proteins, fats, beta-carotene, minerals and vitamins. The indigenous genotypes have vining plants and oval to oblong fruits but introduced recent varieties are bushy in nature with slender long fruits. The fruits of Pahari marrow (locally called *Khirboj*) have higher carotene content as compared to bushy marrows. The plants are more tolerant to excessively moist rhizospheric and phyllospheric environments and thus exhibiting more tolerance to disease and insect-pests.

Variability in fruit colour, size and shape in marrows

Pahari Kheera: Locally known as kakri, is a wonderful landrace of cucumber in Uttarakhand hills bearing fruits of 25.30 cm length, 10-12 cm diameter and 500-800 g in weight at edible maturity. Even in bulky fruits, seeds remain tender for a longer time. The plants are profusely vining in growth. They tolerant to excess soil moisture, foliar diseases and insects as it is grown during monsoon. Owing to huge genetic and morphological diversity in cucumber ranging from small and spiny fruited pickling type (*C. hardwickii* or gherkin) to giant and smooth fruited *Kakri*, the Himalayan region is considered as origin place of this crop. A genotype UHF Cu 12-1 (IC-0612095) with fruits weighing 800-900 g at edible maturity, and brownish rind colour at maturity was identified by the Department of Vegetable Science, Ranichauri Campus, Uttarakhand University of Horticulture and Forestry, Bharsar.

Fruit variability in Pahari Kheera

Sem or Dolichos bean *(Dolichos lablab)*

In Dolichos bean, many morphological forms ranging from green and flat poded to purplish green and long poded in Himalayas. Immature tender pods are used for cooked vegetables and pickles whereas dried seeds for pulses. It shows tolerance to light frost however; heavy frost can kill the vines. It is grown as rainfed crop during rainy season. Photo insensitive dwarf varieties have great potential in hilly areas. Nutritionally, it is rich in proteins, vitamins and anti-oxidants.

Variable forms of fruits in Sem

Yardlong bean (*Vigna unguiculata* ssp. *sesquipedalis*)

The yardlong bean or vining type cowpea is a widely grown crop in Himalayan regions during rainy season for its long tender pods as vegetable and seeds as pulse. This crop is an efficient nitrogen fixing crop profoundly rich in proteins, vitamin A, C and minerals as compared to other legumes of the same family such as lima beans, faba bean, green beans etc. There is enormous diversity in yardlong bean Himalayan region for day length responsiveness and pod length and colour.

Fruiting in yard long bean

Yam *(Dioscorea alata)*

Yam belongs to the family Dioscoreaceae. Tubers are rich source of starch, fiber and mineral nutrients (K, Na, P, Ca, Mg, Cu, Fe, Mn, Z and S). It has been used as a laxative and vermifuge, and in treatment for fever, gonorrhea, leprosy and tumors.


Plant and tuber of yam

Taro *(Colocasia esculenta)*

Many forms of taro occur in hills of Uttarakhand. It is a tropical plant grown primarily for its edible corms. It has been utilized for treatment of various ailments such as asthma, arthritis, diarrhea, neurological disorders, and skin disorders. This crop is grown during the monson and both nutritive leaves with petioles and corms are consumed as cooked vegetable. The corms are rich source of starch whereas leaves and petioles are rich in minerals, proteins, fats and vitamins.

Variable forms of Taro

Bitter cress *(Cardamine oligosperma)*

The bitter cress popularly known as Chamsur in Kumaon hills and Nepal and has been under cultivation and consumption since centuries in hilly areas of Nepal and Uttarakhand and now it has gained commercial importance. Botanically it belongs to the family Brassicaceae with almost 26 species widely distributed in cooler parts of the world. The plants have serrated leaves with dentate margin tender shoots. The shoots remain tender up to flowering stalks start to emerge. The flowers are white borne in cluster of racemes. The crop is quite tolerant to frost but quick and faster growth is assumed at 10-15^{0}C. The shoots and leaves are rich in viatamin C and A, and most of the minerals. A wide range of variability in plant morphology has been noticed in Kumaon and Garhwal hills. A mass selected population, UUHF/Chamsoor12-3 (IC-0598461) has been developed by Department of Vegetable Science, Ranichauri, Uttarakhand University of Horticulture and Forestry, Bharsar with certain desirable characters like green, tender and foliaceous shoots with delayed bolting.

Plants of bitter cress

Chow chow *(Sechium edule)*

Chayote is a single seeded cucurbit profusely occurs in Himalayan region extending from West to North-East. Fruits, root, stem, seeds and leaves are edible. The tubers are eaten like potatoes or other root vegetables. It is a good source of amino acids and vitamin C and is also very rich in Ca in stem (58 mg/100g). It is resistant to diseases and pests.

Fruit of Chow chow

Stinging Nettle *(Urtica dioica)*

Stinging Nettle or Kandali Sag/Bichhu Ghas belongs to the family Urticaceae. The plants occur gregariously in abandoned or waste lands. These grow to a height of 150-180 cm during spring-summer season in hills. Leaves and shoots have trichomes containing formic acid as irritant on skin. It is propagates through seeds. However, deep growing perennial rhizomes are the main source of next

Plants of Stinging Nettle

year flushes of shoots. The plants remain free from biotic and abiotic stresses. Leaves and stems are used to treat the arthritis and roots are beneficial in frequent urination disorder. The tender shoots and leaves are used as cooked vegetable by local people of hilly areas.

Fiddlehead ferns *(Matteuccia struthiopteris)*

It is a terrestrial fern species belonging to the family Onocleaceae. These are found in shady and swamp places in forest areas. The tightly coiled tender fern fronds which resemble the head of fiddle are edible and are harvested from clumps almost round the year with plenty in spring to rainy seasons. It is highly nutritious and 100 g fresh weight of it contains 4.6 g protein, 0.32 mg copper, 4.98 mg niacin, 26.6 mg ascorbic acid, 0.51 mg manganese and 1.31 mg iron.

Harvested produce of Fiddlehead ferns

SUMMARY

All indigenous and minor vegetable crops are grown for domestic consumption and even many of them have not been brought under systematic cultivation. The farmers use to save their own seed of the crops which are in cultivation and grow in subsequent years and thus, crops always remain under thrust and underutilized. For exploitation of the potential of these traditional and indigenous vegetable crops of Himalayan regions, an intensive research work is needed for identification of nutraceuticals rich promising types, development of high yielding and stress tolerant varieties, agronomical packages of practices and seed chain system.

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Akhilesh Sharma and
Shweta Sharma

Diversity and potential of indigenous and minor vegetables of Himachal Pradesh

Indigenous crops are used at small scale within local communities but is having the potential to contribute to food security and to be cultivated at commercial level. There is need to gather the knowledge about indigenous and minor vegetables from the local community in order to facilitate research. The present article focuses on the indigenous vegetables adapted to North-Western Himalayan region of India, their diversity, nutritional importance and potential. Indigenous or traditional vegetables are defined as the species that are of local importance for the sustainability of economy, nutrition and social systems but lacking global recognition to the level of cultivated species/crops. Indigenous vegetables can play an important role in alleviating food security, malnutrition, hunger and have therapeutic potential, but they are mostly neglected in research. These are also tolerant to climate change than the exotic vegetables. Therefore, there is a need to initiate an awareness campaign on large scale to educate the people about their nutritional importance.

IN North-Western Himalayan region of India, indigenous/ traditional vegetables are consumed traditionally in the form of special dishes in different areas. With the risk of a shrinking cultivated area due to climate change, addition of indigenous and minor vegetable crops into local food systems will help to mitigate malnutrition since they are well adapted to extreme weather conditions. Crops such as faba bean, colocasia etc. are adapted to extreme weather (drought and heat stress). Indigenous crops generally require less water and have high water use efficiencies. They can also be grown in those areas which are no longer suitable for commercially cultivated crops such as marginal lands, dry lands and swamps. Therefore, the cultivation and expansion of indigenous crops must be supported at a large scale.

Diversity of indigenous and minor vegetable crops

Indigenous and minor vegetable crops form a part of species rich agro-biodiversity. Cultivation of indigenous vegetable crops could provide nutritional diversity for people, other benefits like crop rotation to disrupt pest and disease cycles, creates niche markets in local economies, utilize and protect knowledge, agro-biodiversity and ecosystem. Therefore, harnessing local knowledge about indigenous crop species has huge potential to improve food security. The important indigenous crop species and their distribution in north-western Himalayas have been described in Table 1.

***Amaranthus* species**

These are leafy vegetables having various local types that possess varying degree of pungency. Species are consumed as soups after boiling or as leafy vegetables. These also provide as a substitute for spinach. Under domestication, high variability occurs in *A. viridis*. Tender shoots of *A. lividus* and *A. viridis* are rich in minerals and are often used as substitute for *Asparagus*. Young plants of *A. retroflexus* are rich source of nitrogen, while those of *A. spinosus* are rich in calcium. Leaves are good source of vitamin A, B_6, C, riboflavin, folate and dietary minerals such as calcium, iron, magnesium, phosphorus, potassium, zinc, copper, and manganese. *A. gangeticus* Linn. syn. *A. tricolour* Linn, a leafy herb is largely cultivated but also found wild. The leaves and young shoots of *A. viridis* are eaten and found as a weed in rainy season.

Buckwheat (*Fagopyrum* spp.)

There are two species of buckwheat, viz. *F. esculentum* (common buckwheat, *Kotu*) and *F. tataricum* (Bitter buckwheat, Duck wheat, Indian Buckwheat). Flowers produce nectar, which is used in the preparation of honey. It is also used as a medicinal plant due to the presence of a glucoside named 'rutin' which reduces haemophilia and heart attack chances. In India, it is grown entirely in the temperate part of Himalayan range and in South Indian hills. The species can withstand poor unferti1e and acidic soils. The leaves and young shoots are boiled and eaten like spinach and in summer, it is used as potherb.

Mountain spinach, garden orach and sea purslane (*Atriplex hortensis*)

It is an annual herb and locally known as Phaltora

Buck Wheat

Allium zummi

Lasoda

and Ustak in Ladakh region. The leaves are rich source of calcium, fat, carbohydrate, fiber, carotene and saponin. Besides, they are diuretic and effective to treat gout. It is used as health tonic and helps in nutrition absorption, digestion and enhances the metabolism. It is also high in flavonoids and amino acids.

***Allium* species**

Allium stracheyi and *A. victoralis* are important species as edible types and plants are perennials. Dried leaves of *A. stracheyi* are stored semi-powered used for flavouring and garnishing soups and curries. The shoots of *A. tuberosum* and *A. victoralis* are boiled as soup, consumed as salad and also cooked as vegetable. Zimmu leaves are more pungent and consumed both as raw, cooked and in *chutney*. Sun dried and crushed leaves of it are used as condiments for garnishing cooked dishes. Its leaves are heart stimulant and have bactericidal properties. It also lowers the cholesterol in the blood, while dried foliage is used for culinary purposes as a spice. *Allium govanianum* is a herb found in the Himalayas. The young aromatic leaves are used as green vegetable and for garnishing after drying. *A. stracheyi* Baker, *A. wallichii* hunth, herbs are found in Himalayas. *A. sphaerocephalum* is an herb from north western Himalayas. Its leaves are eaten in Lahaul (Himachal Pradesh). Other species consumed likewise are *A. carolinianum* DC. *A. consanguineum* Kunth, *A. rubellum* M. Bieb, *A. semenovii* Regel and *A. victorialis* Linn.

Chayote (*Sechium edule* (Jacq.) Sw)

In India, the fruit and roots of chayote are not only used as food but also as fodder. The fruit and seeds are rich source of amino acids. Infusions of the leaves are used to dissolve kidney stones and to assist in the treatment of arteriosclerosis; infusions of the fruit are used to alleviate urine retention. It also possesses hypoglycemic properties.

Lasoda, Indian cherry (*Cordia myxa*)

Unripe fruits are eaten as vegetable, pickles whereas, ripe fruits are used in making country liquor. Fruits are useful in gastric problems, ulcer, leprosy, skin diseases, dry cough, bronchitis, chronic fever and arthritis. This tree is found in lower hill region of Himachal Pradesh. The mucilage and the kernel are reported to have useful medicinal properties.

Kachnar, Orchid tree, Mountain Ebony (*Bauhinia variegata*)

The buds and flowers are traditionally eaten as vegetable in different areas of Himachal Pradesh. Flowering in Kachnar occurs in March and fruiting in rainy season. Buds are boiled, mixed with curd and spices and local preparation are well-liked. The boiled stuff is also fried and eaten as vegetable. Dried buds are used in dysentery, piles and worms. The buds have high phenol contents and have antioxidant properties. The protein in Kachnar is 46.5 g and oil is 17.3 g per 100 g of fruit. Fruit oil is rich in unsaturated fatty acid. Flavonol glycoside possesses anti-inflammatory activity.

Broad bean (*Vicia faba*)

Pods and seeds are used as vegetable. It has certain unique qualities such as fruiting on main stem from base of the plant, responsiveness to irrigation and rich source of protein (25%). It contains L-Dopa which helps to check Parkinson disease.

Diplazium (Lungru) (*Diplazium esculentum*)

Lungru is used as cooked vegetable and in pickle. It is most commonly consumed fern, quite tasty, giving it the name 'vegetable'. Young fronds, rich in iron, manganese and zinc, are eaten as salad, vegetable or pickle.

Khatta Palak, Sorrel (*Rumex* species)

More than 10 species are reported from different regions of India, mainly from the Himalayas and consumed as potherbs. In the Western Himalayas, *Rumex acetosella, R. hastatus, R. patientia* and *R. scutatus* are mostly confined to temperate habitats up to 3,600 m. Some are also distributed in the Western ghats or peninsular hilly tracts such as *R. acetosella, R. dentatus* and *R. maritimus*. *R. acetose* and *R. hastatus* are more diverse exhibiting more variability in plant type, flavour and colour. They are strongly acidic to less acidic. Mostly consumed raw, as salad and considered as a famine food. The leaves of *R. dentatus* are rich in calcium, carotene, and vitamin C and form a nutritious vegetable. *R. hastatus* leaves are mildly acidic and more preferred over other wild types. *R. patientia* has leaves that taste like sorrel. Its roots are also consumed raw.

Table 1. Diversity of Indigenous vegetable in North-Western Himalayan region of India

Crop	Family	Edible part	Diversity and distribution
Amaranth greens	Amaranthaceae	Leaves and young shoots	About 15 species exist wild in India, with more diversity in the Himalayas
Buck Wheat	Polygonaceae	Seeds	In India, it is grown in the temperate part of Himalayan range
Allium species	Alliaceae	Leaves and young shoots	In temperate zone, mainly in alpine meadows in the Himalayas about 30 species occur wild in India. As edible types *Allium stracheyi* and *A. victoralis* are more important. More diversity occurs in small-plot cultivation near hutments in high altitudes at 3,000- 4,000 m in the Western Himalayas. Chinese chive*, Allium tuberosum, Zimmu,* (a natural cross between onion and garlic) is reported wild in Himachal Pradesh and in adjoining Western Himalayas
Chayote	Cucurbitaceae	Fruits	It is widely distributed in sub-tropical, sub-temperate Western and Eastern Himalayas
Lasoda	Boraginaceae	Unripe fruits	Tree is most commonly found in lower hills of Himachal Pradesh
Kachnar	Fabaceae	Buds and flowers	Kachnar occurs in sub Himalayan tract, dry forests of Central, Eastern and Southern India as well as in the lower dry regions of Himachal Pradesh
Broad bean	Fabaceae	Young pods and seeds	In India, it is grown as a source of vegetable and fodder mostly as in Himalayan hills
Lungru	Athyriaceae	Fruits	It is commonly found in the hilly areas of North India
Sheep sorrel or Khatta palak	Polygonaceae	Leaves and roots	It is consumed as potherbs. Over 10 species are reported from different regions of India, mainly from the Himalayas. *Rumex acetosella, R. hastatus, R. patientia* and *R. scutatus* are mostly confined to temperate habitats upto 3,600 m in the Western Himalayas. Some are also distributed in the Western Ghats or peninsular hilly tracts such as *R. acetosella, R. dentatus* and *R. maritimus*. *R. acetose* and *R. hastatus* are more diverse exhibiting variability in plant type, colour and flavour. They are strongly acidic to less acidic.
Curry leaf	Rutaceae	Leaves and shoots	It is an evergreen shrub found naturally in Shivalik hills especially at an altitude of 300-900 m amsl
Endive	Compositae	Leaves and flowers	This herb is commonly found as weed in Punjab and also in the colder parts of Western Himalayas
Brahmi sag	Cruciferae	Tender shoots and leaves	It is found at many places especially in mid hills of Himachal Pradesh
Mountain spinach	Chenopodiaceae	Leaves	It is an annual herb which is locally known as *Phaltora* and *Ustak* in Ladakh region
Blackjack	Asteraceae	Tender shoots	It is found in India in Ladakh Himalaya, Jammu and Kashmir
Spine gourd	Cucurbitaceae	Green fruits	It is commonly found in Asia with extensive distribution in India and Bangladesh.
Arenaria holosteoides	Caryophyllacease	Entire plant	A slender herb occurring in Western Himalayas is used as vegetable in Ladakh and Chamba
Crambe cordifolia	Cruciferae	Young leaves	It is an herb found in north western Himalayas
Himalayan Desert Candle	Liliaceae	Leaves	It is a tall herb occurring in Western Himalayas. The leaves are used as vegetable in Lahaul valley. It is used as emergency food in Majauri-Kirchi tract of J&K and other parts of north western hills
Rocket Salad	Cruciferae	Young plants	An herb mainly cultivated in Western Himalayas up to 3000 meters
Polygonum alpinum	Polygonaceae	Leaves and stems	An herb found in Western Himalayas is eaten raw or cooked and is believed to be taste like rhubarb
Ravandchini, Chuchi	Polygonaceae	Tender leaves	It is an herb found in the Himalayas. People of Lahaul (Himachal Pradesh) use the leaves as vegetable
Kindut	Crassulaceae	Leaves	An herb found in rocky habitats of the Western Himalayas and the leaves are eaten in Lahaul (Himachal Pradesh)
Taro	Araceae	Tuber	It is mainly distributed in humid tropical regions. It is common in foothills of Himalayas. More diversity occurs in north eastern and peninsular region where cultivated and feral forms exist

Kachnar

Artiplex

Endive (***Cichorium endivia***)

This herb is commonly found as weed in Punjab, and extending to colder parts of Western Himalayas. Leaves and flowers are edible parts. The young shoots are used as salad, and the leaves are eaten as vegetable. It is rich in vitamins and minerals, especially in folate and vitamins A and K, and is high in fibre. It acts as a stomachic tonic, has hepato-protective properties, favors blood circulation and acts as a laxative.

Watercress (***Nasturtium officinale***)

The tender shoots or leaves are cooked as vegetable, used in soups and also to garnish for various dishes. Leaves are exceptionally rich source of vitamin C, folic acid, ascorbic acid and minerals especially iron. It is used as a detoxifier, antiscorbutic, diuretic and stimulant.

Blackjack or Spanish needle (***Bidens pilosa***)

It is a medicinal herb in Chinese medicine. Its edible parts are tender shoots. It is high in beta-carotene, vitamin E, ascorbic acid, iron, calcium and protein. It contains anti-inflammatory, antioxidant and anti-gastrointestinal properties.

SUMMARY

There is a need to develop a clear plan for research and development of indigenous and minor vegetable crops through concerted efforts involving all the stakeholders from farmers and consumers to researchers and policy makers. There is a need to exploit these indigenous resources through coordinated efforts for the improvement of existing diversity for more methodized cultivation. Globally these crops would significantly contribute to food and nutritional security. They represent a rich heritage of genetic material which is of global importance. For the promotion of indigenous and minor vegetable crops, it will be important to enhance research and development programme to collect genetic variability, conserve it and utilize for development of improved cultivars or for harnessing fruitful results in future.

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V B S Chauhan, Kalidas Pati,
V V Bansode and M Nedunchezhiyan

Status, diversity and potential of indigenous tropical tuber vegetables

Tropical tuber crops are important group of crop species which produce tubers that are used for human food and animal feed. The popular tropical tuber crops include cassava, sweet potato, greater yam, white yam, lesser yam, taro, tannia, elephant foot yam, yam bean, coleus etc. The root and tuber crops play an important roles in feeding large number of population in developing countries. They contribute substantial amount of cheap energy coupled with high quality nutrition for more than 2 million people living in developing countries. Tropical tuber crops are rich source of energy and carbohydrates although each of them also provides other important nutrients as well. They contribute 3.9% (cassava 1.9%, sweet potato1.5% and yams and other root and tuber crops 0.3%) energy requirement of world population. Tropical tuber crops supply 28.5 kg/head/year food and 75 kcal energy/head/day. They produce large quantities of energy (carbohydrate) in relatively less time than other crops. They are most efficient in converting solar energy, for example cassava produces 250×103 kcal/ha and sweet potato 240×103 kcal/ha as compared to 76×103 kcal/ha for rice, 110×103 kcal/ha for wheat and 200×103 kcal/ha for maize.

TARO (*Colocasia esculenta*) was originated in India, most probably in North Eastern region. It spread by cultivation eastward into Southeast Asia, East Asia and the Pacific Islands; westward to Egypt and the eastern Mediterranean Basin; and then southward and westward from there into East Africa and West Africa, where it spread to the Caribbean and Americas. Today the plant is widely used throughout the world, in Africa, Asia, the West Indies, and South America. Taro is of great importance in many places such as the Carribbean, Hawaii, the Solomons, American Samoa, Western Samoa, the Philippines, Fiji, Sri Lanka, India, Nigeria, Indonesia, New Hebrides, Tonga, Niue, Papua New Guinea, Egypt, and these areas many people depend heavily upon taro as a staple food.

Field view of Taro crops

Status of taro cultivation

Taro is one of the oldest cultivated crops grown for its edible corms and leaves. It is an important tropical tuber crop, used as a staple food or subsistence food by millions of people in the developing countries in Asia, Africa and Central America. World-wide it is the fifth most consumed root vegetable with over 25% produced in Oceania and South-East Asia. It is widely used as a tuber vegetable in India, whereas it is the staple food and also very closely associated with culture in many of the South Pacific islands. Taro is ordinarily grown in the homestead garden and its cormels, petiole and leaves serve the important purpose as an instant vegetable. In India, it is grown in Uttar Pradesh, Madhya Pradesh, Odisha, Andhra Pradesh, West Bengal, Kerala and North Easter region. It is called Arvi in Hindi in Central and North India, which is often pronounced as Arbi. It is also called kachu in Sanskrit. In Mizoram, it is called bal; the leaves, stalks and tubers are eaten as dawl bai. The leaves and stalks are often traditionally preserved to be eaten in dry season as "dawl rep bai". In Assam, taro is known as "kosu". The leaf buds called "Kosu loti" are cooked with sour dried fruits called Thekera or sometimes with tamarind or elephant apple alone or with a small amount of pulses and sometimes fish. A fried dish with sour objects is also made from its flower (Kosu kala). In Manipur, taro is known as *pan*. The kuki tribes called it bal. Boiled bal is a snack at lunch along with *chutney* or hot chili-flakes

besides being cooked as a main dish along with smoked or dried meat, beans, and mustard leaves. They also sun-dry the leaves and keep them for future use as broth and hodge-podge. In Himachal Pradesh, taro root is known as ghandyali, and the plant is known as Kachalu in Kangra and Mandi district. The dish called patrodu is made using taro leaves rolled with corn or gram flour and boiled in water. Another dish, pujji is made with mashed leaves and the trunk of the plant and ghandyali or taro roots are prepared as a separate dish. A tall-growing variety of taro is extensively used on the western coast of India to make patrode, patrade, or patrada, literally a "leaf-pancake". In the Dakshin Kannada district in the state of Karnataka, it is used as a morning breakfast dish, either made like fritters or steamed. In Maharashtra, the leaves, called alu che paana, are de-veined, rolled with a paste of gram flour, tamarind paste, red chili powder, turmeric, coriander, asafoetida, and salt, and then steamed. These can be eaten whole or cut into pieces, or shallow fried and eaten as a snack known as alu chi wadi. In Goa cuisine as well as the Konkani cuisine taro leaves are very popular. In Gujarat and Maharashtra, the leaves are used to make patra a dish with gram flour, tamarind and other spices. Sindhis call it kachaloo; they fry it, compress it, and re-fry it to make a dish called tuk which complements Sindhi curry. In Kerala, taro corms are known as chembu-kizhangu. Taro is used as a staple food, as a side dish, or as an ingredient in various side dishes like sambar. As a staple food, it is steamed and eaten with spicy chutney of green chilies, tamarind, and shallots. In Tamil Nadu and Andhra Pradesh, taro corms are known as sivapan-kizhangu (seppankilangu or cheppankilangu), chamagadda, or in coastal Andhra districts as chaama dumpa in Telugu. It can be cooked in many ways, such as deep-fried in oil for a side item with rice, or cooked in a tangy tamarind sauce with spices, onion, and tomato. In West Bengal, taro roots are thinly sliced and fried to make chips called kochu bhaja. The stem is used to cook a very tasty Kochur saag with fried hilsha fish head or boiled chhola (chickpea), often eaten as a starter with hot rice. The roots are also made into a paste with spices and eaten with rice. In the Mithilanchal region of Bihar, taro root is known as Adua and its leaves are called Adua ke patte. A curry of taro leaves is made with mustard paste and Aaml (sun-dried mango pulp used for a sour taste in daal, curry and sour gravy). In Odisha, taro root is known as saru. Dishes made of taro include saru besara (taro in mustard and garlic paste). It is also an indispensable ingredient in preparing the heart of Odia cuisine, the dalma, where vegetables are cooked with dal. In Uttarakhand and neighboring Nepal, taro is considered a healthy food cooked in a variety of ways. The delicate Gaderi taro of Kumaun, especially from the Lobanj region is much sought after. Most commonly it is boiled in tamarind water until tender, then it is diced into cubes which are stir-fried in mustard oil with methi (fenugreek) leaves. Boiling it in salty water in iron cooking pots until it becomes like porridge, is another technique. The young leaves called gaaba, are steamed, then sun-dried and stored for later use.

Taro corms

Potential of Taro

Taro is a widely cultivated species of family Araceae used as vegetables for its corms, leaves, and petioles. It has good potential for food security, nutritional security and as industrial crops for employment generation and development of value added products. The corms are generally used as the main starch in meals, however, snacks are prepared from taro in numerous countries and are either sweet or salty, moist or crisp. Hawaiians traditionally use taro to make poi. Like the roots of other crops, taro corms are high in carbohydrates and low in fat and protein. Human digestibility of the raw taro starch is about to be 97% and is the same as raw potato starch. The excellent digestibility suggests efficient release of nutrients during digestion and absorption of this food. Taro corms contain 0.78% of oxalic acid, however, which can bind calcium in the plant as well as in the intestinal tract and render it unavailable for nutritional utilization. Some corms contain raphides, which are needles of calcium oxalate, suggesting a high concentration of oxalate. Boiling, baking, washing, and mashing of corms would reduce the oxalate content to some extent when the corms are served as prepared food. The leaves of certain cultivars of taro that are low in oxalic acid are used for green leafy vegetables. Cultivars chosen for leafy greens vary among different countries and population groups. The old favorite in Hawaii is the cultivar Apuwai, which is still being cultivated in home gardens by older residents. Ninety-nine percent of the market variety is the cultivar Bun-Long, and since it is low in acridity, both younger and older leaves may be consumed without irritation to the mucous membrane of the mouth. The vegetable variety in India appears to be similar to Bun-Long. Taro petioles are eaten raw only in the Khasi and Jaintia Hills of North Eastern region of India. After the outer thin covering is peeled off, the young stems are cut into 1 cm pieces and mixed with pieces of lemons or limes, salt, and chili pepper. Usually the mixture is used as a snack.

Nutritional quality

The nutritional composition of taro corm like other root crops is low in protein and fat, but high in the carbohydrate. It is a good source of potassium and provides moderate level of phosphorus. It is low in vitamin C and deficient in the vitamin A. Taro corm is a good source of minerals and the small granule size of its starch helps increase the bioavailability of its nutrients

due to efficiency of digestion and absorption.

Starch: Taro corm has been reported to have 70–80% (dry weight basis) starch with small granules. Because of the small sizes (1–4 µm in diameter) of its starch granules, taro is easily digestible and as such has been reported to be used for preparing of infant foods. Taro starch, in view of its small granule size, has also been used for industrial applications. Taro starch is easily digestible, the starch grains are fine and very small, it has hypoallergenic nature (low tendency to cause allergic reactions) and also the starch is gluten free. The size of the starch granules varies with the variety and ranges from 1.5–6.6 µm. They are polygonal. Taro starch contains about 50% less amylose and an amylopectin content which is higher compared to other cereals. The amylose/amylopectin ratio is 1:7. The most important sugar in taro is sucrose, but fructose, maltose, glucose and raffinose are also present. Malic acid is the most important organic acid (60%) followed by citric acid (25%) and oxalic acid (15%).

Moisture: Since taro is a root crop, its moisture content is very high and accounts two third of the total weight of the fresh crops. Moisture content of taro varies with variety, growth condition and harvest time. In general the moisture content of taro ranges from 60-83%.

Protein: Taro contains about 11% protein on a dry weight basis. This is more than yam, cassava or sweet potato. The protein fraction is rich in essential amino acids of trionine, leucine, arganine, valine and phenylalanine. Among the essential amino acids, methionine, lycine, cystine, phenylalanine and leucine are relatively abundant in the leaf than the corm. The protein content of the corm is higher towards the corm's periphery than towards its centre. This implies that care should be taken when peeling the corm; otherwise significant amount of the protein could be lost in the peeling. Concerning the leaf, like higher plant, taro leaf is rich in protein. It contains about 23% protein on a dry weight basis.

Fat: Like many other root and tuber crops, the fat content of taro is very low and its fat content is mainly composed of the lipids of the cell membrane and it is also variable among cultivars. In general the fat content of taro root ranges from 0.3-0.6%.

Crude fibre: Taro contains both dietary and non-dietary fibre. Crude fibre content of taro ranges from 0.3-3.8%. Crude fibre has many desirable functional properties. These include facilitating alimentary functions, helping in micro-component delivery and glucose metabolism and also slowing down the process of re-absorption of undesirable dietary components such as cholesterol, decrease intestinal transit time, reduce total and LDL cholesterol in the blood.

Total ash: Taro contains fairly high amount of ash. From which it can be inferred that it has good mineral content. The ash content of taro ranges from 3.54-7.78%.

Mineral: Taro is a good source of minerals including iron (8.66-10.8 mg/100g), calcium (31-132 mg/100g), sodium (82-1521.34 mg/100g), magnesium (118-415.07 mg/100g), phosphorus (72.21-340 mg/100g), zinc (2.63 mg/100g), copper (1.04 mg/100g) and an excellent source of potassium (2271-4276.06 mg/100g).

Vitamins: Vitamin C and vitamin B complex (niacin, riboflavin and thiamin) which are important constituents of human diet, are present in appreciable quantity in corms and leafs of taro. Cooked leaf of taro contains beta carotene, iron and folic acid which protects against anemia.

Health benefits of Taro

Phytochemicals: Taro has high amount of β-carotene in the corm and will impart vitamin A and antioxidant property in the body. β-carotene differs only very slightly in terms of structure. They have potential health benefits.

Phenolic acids: Phenolic acids are widely distributed in the plant cell walls and consequently are significant components of the human diet. Yellow-fleshed cultivar of taro is associated with a high level of total phenolic compounds.

Processed food

Taro has been processed into many products which include poi (fresh or fermented paste, canned, and canned-acidified), flour, cereal base, beverage powders, chips, sun-dried slices, grits, and drum-dried flakes. Corms may be roasted, boiled, baked, steamed, or fried. Pulverized cooked corms are mixed with corn meal to make bread in Brazil. In the Philippines, the corms are boiled as vegetables or sliced thin and fried to produce chips. Taro is popular in Hawaii as poi and as a dessert, kulolo. In Samoa, taro is made into a sweet dessert.

Industrial uses

Special features of taro starch: The most conspicuous feature of taro starch that sets it apart from the more familiar commercial starches is its particle size. The rice starch has 5 um mean diameter is the finest of the commonly available starches, while all the taro varieties so far examined have particles between 1 and 6.5 µm.

High fructose enriched syrup (HFES): Taro and related root crops can be processed into high fructose enriched syrup. High fructose enriched syrup (HFES) is a sweetener (a liquid sugar) made from starch. HFES is a very desirable sweetener, inexpensive and easy to use. The nutritional value of HFES is similar to that of sucrose. The syrup can be used for canning, jams, jellies and in soft drinks.

Alcohols for fuel: Many developing countries could reduce their dependence on imported oil considerably by replacing part of their petroleum requirement with alcohol produced from sugar or starch-containing crops. Taro would serve perfectly well as a feed material provided only that local economics were favorable. Roughly, the starch-to-alcohol conversion ratio has been accepted to be 1.76 kg of starch to 1.0 litre of alcohol.

Fillers/modifiers for plastics: It is now well established that up to 40% of plastic compounds based upon such polymers as polystyrene, polyethylene, polyvinyl chloride, and so on, can consist of starch. The incorporation of moderate amounts of starch does not materially affect the original physical properties of the plastics. When taro starch is used in the production of plastics in an appropriate formulation, the result can be a useful acceleration of the biodegradability of the parent

Muktakeshi

Pani Saru-1

Sonajuli

NEH-12

Pani Saru-2

Bastar-2

Jhankri

Megh-18

Megh-19

polymer. Such plastics will become very important as waste material becomes an increasingly difficult problem for a society moving toward affluence. Taro starch granules are likely to be superior to other starches for the production of biodegradable plastics because of their extremely small size, which is approximately one-tenth of the size of a maize starch granule.

Taro gums: A gum like substance is present in taro. It swells in water and becomes highly hydrated. The potential usefulness of this gum lies in its value as an emulsifying, thickening, and smoothing agent for creams, suspensions, and other colloidal food preparations. It is also possible that the removal of the gum would improve the properties of taro products and render them less sticky and viscous.

Diversity of Taro

Taro belongs to genus *Colocasia* and family Araceae which is made up of at least 100 genera and more than 1500 species. The two most widely cultivated taxonomic varieties include *Colocasia esculenta som esculenta* and *Colocasia esculenta som antiquorum* which is commonly known as the dasheen type (*Colocasia esculenta som esculenta*), which has a large central corm with suckers and stolons and the second is the eddoe type (*Colocasia esculenta som antiquorum*), which has a small central corm and a large number of smaller cormels. The available growing genotypes of taro categorized in to wild and cultivated type. The wild type is not used as food. The corms of wild taro cannot be used as food due to an extremely high concentration of calcium oxalate crystals. It is naturally

a perennial monocotyledonous herb, but for practical purposes is harvested after 5-12 months of growth. Taro grows to a height of 1-2 m consisting of a central corm, lying just below the soil surface, from which leaves grow upwards, roots grow downwards, while cormels, daughter corms and runners grow laterally. It has heart-shaped green or purple leaves together with long petioles, fibrous roots and cylindrical or often irregular nutrient storage organ (corm). Taro seldom flowers and when flowers occurs the inflorescence consists of a cylindrical spadix of flowers enclosed in a 12-15 cm spathe with the female flowers located at the base of a spadix and the male flowers at the top. Morphological taro characterization can be done based on its corm, stolon, leaf, petiole and floral characters and other quantitative traits. Maximum morphological variability in taro accessions is found in Southeast Asia and Oceania. The variability with regard to morphological traits includes colour, shape and size of tuber, petiole length and colour, and stolon formation. Moreover, presence of greatest morphological variability in root colour, cormel flesh colour, corm dry matter percentage, corm shape and cormel shape was reported in taro collected from Asia, Africa and America. Concentration on morphological variability study in Asia might be due to large cultivation area and growing in the region. Variability in taro has been reported from every states of India. North Eastern region of India is a rich reservoir for taro diversity. The genus *Colocasia* includes several species, of which few species are reported in Northeast India like *C. affinis, C. esculenta, C. fallax, C. gigantea, C. lihengiae* etc., among them *Colocasia esculenta* is edible. *Colocasia esculenta* is usually diploid (2n = 28) or triploid (2n = 42). More than 200 landraces have been reported from this region. Rich genetic diversity exists in jhum fields, homestead gardens, near water bodies, river banks, forests and road sides for both cultivated and wild species. Over the centuries, landraces continue to exist based on ability to survive in extreme natural calamities. Natural hybridization and introgression occur between and within species that results into new species and varieties. The resulted species or varieties vary in their ecological adaptation. In nature, evolution of new species or varieties by introgression or horizontal gene transfer is a natural phenomenon. This natural phenomenon leads to the occurrence of huge genetic diversity of *Colocasia* in this ecological niche.

ICAR-Central Tuber Crops Research Institute, Trivandrum is the sole research Institute in India engaged in the genetic upgradation of all tropical tuber crops including taro. This Institute possesses the richest germplasm wealth of 429 edible genetic stocks of taro in its HQ at Trivandrum in the south and 507 in its Regional Centre at Bhubaneswar in East India. Genetic resources of taro are also collected and maintained by the National Bureau of Plant Genetic Resources, New Delhi in its regional station at Trichur, Kerala and the research centers/agricultural universities located in different agro climatic zones in India under the All India Coordinated Research Project on Tuber Crops. At the ICAR-CTCRI, the genetic stocks are maintained in the field gene bank for enabling the studies of plant characters, pre-breeding studies and directed crosses in addition to *in vitro* conservation of the same. Cytological and morphological screening of the genetic stocks has been done and yield attributes identified. The frequency and distribution of the different ploidy types in India were also ascertained. The frequency of the ploidy types showed clear difference in ploidy-wise distribution in the different zones of the country. Although both the types occur in all the regions, the diploids predominate in South India over the triploids while the triploids convincingly out-numbered the diploids in the North. Several factors are known to influence the frequency of polyploidy in different ecogeographical regions. It is found that polyploidy in general have larger dimensions and greater adaptability which apparently enable them to thrive better in a wide range of higher latitudinal and altitudinal zones. Characterization is based on morphological features of individual genotype as per modified IPGRI descriptor for taro. The data revealed prevalence of a wide spectrum of variability among the Indian collections with regard to several characters.

SUMMARY

Several economically desirable important genetic stocks identified from the germplasm are under advanced stages of evaluation. Taro germplasm collection, characterization and evaluation under different agro-ecology plays great role for variability identification, conservation of desirable genotypes and utilization in crop improvement through breeding.

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Movable screens in rose production

- Use movable screen, an important tool for rose cultivation.
- It can help growers manipulate environment conditions — lowers temperature, changes humidity and influences production numbers.
- The movable screens can be used year-round and in a variety of climates — from the Netherlands to India.

Sudhir Singh and Swati Sharma

Advances in processing and post-harvest management of indigenous vegetables

Presently the value addition in vegetable sector is 2.2% and large quantities of vegetables (4.58-12.44%) amounting to ₹ 14,842 crore in 2014 (CIPHET Report, 2015) perish due to poor post harvest management and lack of suitable processing facilities. There is an urgent need of effective postharvest management practices and low cost processing technologies for handling large quantities of vegetables to produce cost effective value added processed products.

Challenges and prospects of Indigenous vegetable processing in India

Urban population in cities is demanding newer processed ready-to-eat and easy-to-cook form of vegetables due to rapid change in the eating habits of the urban population. There are 350 million strong urban middle class population which demand large quantities of processed vegetable products depending upon the taste. Ministry of Food Processing Industries, Govt. of India has introduced number of schemes for providing financial assistance for setting up modern vegetable processing units, building infrastructure, supporting R & D and skill development to encourage growth of vegetable processing sector. Our national policy also aims to increase the present level of processing from 2.2% to 25% by 2025. Vegetable processing level is alarmingly very low as compared to 35% level of processing in milk, 20% of buffalo meat, 26% of fish and 6% of poultry meat. There is an urgent need to address the problem related to low processing in vegetables as compared to large production and subsequently low return to producers due to low price of vegetables in peak production. Our infrastructural facilities in terms of post harvest management in vegetables are very poor which needs greater attention both from public and private sectors.

Vegetable processing challenges

- **Cold chain management:** Presently there are 7,645 cold storages in India with the capacity of 34.5 million tonnes against the required capacity of 61.13 million tonnes. Majority of cold storages are meant for storage of potato having optimum storage temperature of 2-4°C and 90-95% RH. Moreover, vegetable production is confined in villages and cold storages are constructed in cities. However, storage conditions would lead to chilling injuries in majority of vegetables during storage.
- **Lack of mechanized sorting/grading facility:** There have been no mechanized grading/sorting facilities for vegetables in many vegetable markets in India. Only handgrading/sorting facilities exist in vegetable markets which is cumbersome and time consuming. Furthermore, it is inefficient for the grading of large volumes of vegetables.
- **Non availability of varieties suitable for processing:** Vegetable breeding programme in public and private sector is confined mainly to develop varieties for higher yield. There is no serious thinking towards breeding programme for improvement in quality and more precisely for varieties suitable for processing. There have been no linkages among farmers, public institutions and processing industries. Many leading processing industries such as ITC, Heinz and Kisan are still importing tomato paste and tomato puree from China and European countries. Many public institutions can play big role in promoting their varieties suitable for processing.
- **Optimum harvesting stage of vegetables:** Vegetables attain maximum sensory perception during certain stage of their growth in terms of sensory qualities such as flavour, colour and appearance and overall acceptability. Harvesting of vegetables should be done at optimum maturity stage.
- **Complete value chain of vegetables:** There should be complete package of practices for product and by product utilization for sustainability as well as for better return to processing industries.

Post-harvest management practices of important indigenous vegetables in India

Pre-harvest practices also play an important role in the quality of harvested vegetables. The increased application of nitrogen fertilizer adversely affects the quality in terms of sensory perception as well as shelf life of vegetables. Apart from fertilizer, the quantity of irrigation as well as its duration also plays an important role in quality of vegetables. Harvesting time of vegetables is also very important. Vegetables should be normally harvested before maturity for obtaining the maximum sensory perception of the vegetables. It is also important that harvesting should be carried from the day of anthesis so that batch to batch quality variation gets be minimized. Some important post harvest management practices are as follows:

i) **Harvesting time:** The vegetables should preferably be harvested before sunrise or after sunset. Respiratory activity of vegetables is increased after harvest of vegetables. This leads to increase in temperature and adversely affects the quality of harvested vegetables. The harvesting time of few vegetables is documented with respect to attaining maximum quality. Eggplant is harvested 13-14 days after anthesis.

ii) **Sorting/grading:** The vegetables after harvest should be sorted/graded on the basis of size, shape and colour. The diseased vegetables should be discarded as it would spoil the whole lot of vegetables. Proper sorting and grading would fetch good return to producers.

iii) **Washing:** The vegetables should be washed thoroughly in potable water after harvest. This will reduce the temperature of the harvested vegetables as well as reduce the bacterial load of the vegetables as many vegetables are in direct contact of soil.

iv) **Maintenance of low temperature:** Vegetables after harvest should be maintained at desired low temperature to reduce the respiratory activity so that biochemical changes after harvest can be minimized. It is generally advisable that vegetables should be stored at a temperature above the chilling injury. All the vegetables have definite storage temperature at which there has been maintenance of maximum sensory perception as well as maximum shelf life. Many cucurbit vegetables such as sponge gourd, ridge gourd are preferably stored at 12-14°C to attain maximum shelf life and quality attributes.

v) **Edible coating:** Edible coating provides partial barrier to moisture and gas, especially carbon dioxide and oxygen exchange. Coating on the surface of vegetables improves mechanical handling properties, thus, retaining volatile flavour compounds and carrying food additives containing anti-microbial agents and anti-oxidants properties. The basic purpose of edible coatings for indigenous vegetables is enhancing the natural barrier properties or replacing with a new barrier in which handling and washing is partially removed or altered. Proteins, lipids and polysaccharides are commonly the main constituents of edible films and coatings. Among the commonly used protein-based edible coating, wheat gluten, corn zein, soy proteins, rice proteins, egg albumin and milk proteins are generally used as coating in vegetables. Polysaccharide-based edible coatings, such as alginate, pectin, cellulose and derivatives, starch and sucrose polyesters, have been used for extending the shelf life of indigenous vegetables. To extend the shelf life of perishables, lipids as well as resins are also used for extending the shelf life of harvested vegetables. Shellac resin, mostly produced in central India, is a secretion by the insect *Lacifer lacca*. This resin is composed of a complex mixture of aliphatic alicyclic hydroxy acid polymers, such as aleuritic and shelloic acids. This resin is soluble in alcohols and alkaline solutions. It is also compatible with most waxes, resulting in improved moisture barrier properties and increased gloss on the coated surface. It is permitted as an indirect food additive in food coatings and adhesives. The shellac coating emulsion is prepared by dissolving dewaxed and bleached shellac in alkaline aqueous medium with the addition of polyvinyl alcohol as binding and coating agent. Binder and defoaming agent is added to make stable emulsion after adding hot water, triethanol amine as surfactant and oleic acid as lubricant. Sodium alginate or carboxy methyl cellulose as thickener is added for effective and stable coating on the surface of fruits and vegetables.

Application

The shelf life of shellac coated pointed gourd is increased to 15 days at refrigerated storage as against 6–8 days of control pointed gourd during refrigerated storage. There has also been significant increase in shellac coated eggplant during ambient storage. As compared to 2–3 days of control eggplant during ambient storage, the shelf life of shellac-coated eggplant is increased to 7 days. There has been increase in physiological loss in weight from 6.0 to 25.7% and increase in total solids from 8.5 to 11.9% after 7 days of ambient storage. There had been 35–40% decrease in texture and 50–55% in antioxidant activity.

Potential vegetable processing technologies for commercial usage

The use of appropriate post-harvest technology reduces the post-harvest and storage losses, adds value to the product, generate employment in village and promote establishment of agro-industries in rural sector. Presently,

Shellac coated pointed gourd and brinjal

the farmers sell their products without processing. If they do primary processing and value addition in the villages, it will generate more income and employment in rural sector.

i) **Dehydration:** The drying operation in convection type of heating involves moisture transfer from wet material to heated air, which may be reflected as a transport of moisture from the material core to its surface, followed by evaporation from the surface of the material and dissipation of water vapour into the bulk of the drying air. Drying as such without suitable additive treatments causes irreversible structural damage to the cellular structure of vegetables. The damage to the cellular structure further prevents proper drying, and rehydration of dried products as well as quality of dried vegetables is adversely affected. The terms dried and dehydrated are used interchangeably, USDA lists dehydrated foods as those which contain no more than 2.5% water (dry basis), whereas dried foods apply to any food product with more than 2.5% water (dry basis). Vegetables and their products are dried to enhance the storage stability to minimize the packaging costs due to bulk reduction and to reduce the transportation cost. Nonetheless, in India, vegetables are dried on mechanized dryers at a very small scale. Still majority of drying is preferred as sun drying in rural areas of India. Drying process has not gained much popularity in India as consumers have biggest concern on the perception of nutritional and sensory qualities of dried vegetables and majority of Indian consumers are satisfied with homemade vegetable dishes. Furthermore, availability of many important vegetables throughout the year has also led to less demand of consumers for preferring dried vegetables. Drying processes can be channelized to improve the sensory perception of vegetables in terms of flavour, colour and body and texture of rehydrated vegetables along with handling of large quantities of vegetables during peak season of production. This would prevent the enormous post-harvest losses of perishable vegetables and would help in maintaining nutritional security as well as prevent the high prices of off season vegetables. Consumers today are highly pertinent to quality and safety of processed food products. Therefore, alternate technologies which offer convenience of traditional drying without compromising on quality are of much demand. The technologies include low-temperature drying, freeze drying and vacuum drying. The most applicable method of drying includes freeze, vacuum, osmotic, cabinet or tray, fluidized bed, spouted bed, microwave and combination thereof. These are the basic techniques to force water to vaporize, whereas forced air is applied to encourage the removal off the vapour. A large number of food and biomaterials are dehydrated in a variety of units with diverse processing conditions. The choice of drying method depends on various factors such as the type of product, availability of dryer, cost of dehydration and final quality of desiccated product. Energy consumption and quality of the dried produces are other critical areas in the selection of a drying process. To reduce the cost of fossil fuel, electrical energy is an alternate source of energy for drying applications, especially in which electricity is generated by a renewable energy source such as hydropower or wind power. Osmo air-drying has greater potential for drying of large quantities of vegetables with good sensory properties. This drying can be adopted as a rural based simple technology by small entrepreneurs, home-scale industry and also by self-help groups in close association with NGOs. Small entrepreneurs can adopt this process on large scale. There is ample scope for cost reduction through the use of solar energy for brine concentration and dehydration process. Osmo-air drying of bitter gourd slices, cauliflower, carrot, okra, broccoli, cabbage, cow pea and ivy gourd slices during osmotic diffusion treatment in 5-10% salt solution at 40–60°C osmotic diffusion treatment for 2-3 hours followed by drying at 65-70° C for 6-8 hours. The effectiveness of drying technology requires the treatment of vegetables with permissible additives to ensure good rheological, sensory and rehydration properties.

ii) **Steeping preservation:** Vegetable production in India is seasonal and production of indigenous vegetables exceeds the demand during peak season of production, hence the producer is bound to dispose the perishable horticultural crops in no time of storage. Large quantities of vegetables during peak season of production can be preserved in steeping solution consisting of permissible chemical preservatives and other food additives which is non-thermal and alternate to processing technology with considerable scope for adoption at rural sector by women. Consumers are more conscious of health benefits and are demanding additive free processed food products. Food Safety Standards Authority of India (FSSAI) is regularly monitoring the level of the permitted food additives and some of the permitted additives are either deleted or the level is reduced depending upon nature of health hazards associated with additives. However, the steeping treatment involves the use of permitted additives at a low level of maximum permissible limit and at the same time it should not affect the sensory and nutritional properties of the product and should also be convenient and economical to use.

iii) **Ready-to-eat convenience vegetables:** Convenience foods refer to the category in which foods have undergone major processing by the manufacturers such that these type of products require no secondary processing and cooking before consumption. The choice of the day can be designed to suit all segments of population including armies, airways, railways and even patients with suitable supplement. The demand for convenience food is growing at a faster pace due to changes in social and economic patterns, as well as increase in urbanization, buying power and awareness about health foods, changes in meal pattern and existing food habit, desire to taste new products, etc. The consumer preference is focused towards convenient form of food products which are

Easy-to-cook spinach leaves

Easy-to-cook *Bassela* leaves

easy to procure and consume instantly. Hence, the vegetables can be suitably processed in ready-to-eat convenience form such as processing the vegetables for chips production.

iv) **Easy-to-cook leafy vegetables:** Large quantities of indigenous leafy vegetables spoil due to rapid loss of moisture. Leafy vegetables such as spinach and *Bassela* can be developed in the form of easy-cook-leafy vegetables. Leafy vegetables after sorting, cleaning and washing are blanched with permitted additives followed by osmotic diffusion treatment and subsequent drying at 50-55°C for 7-8 hours to reduce the final moisture to less than 1.0%. These dried leafy vegetables can be effectively preserved in polyethylene pouches for 6-8 months at ambient storage.

v) **Bio-preservation of vegetables:** The bio-preservation of vegetables in common salt or in vinegar is known as pickling. It is one of the most ancient method of preserving vegetables. Pickles are either manufactured at cottage or home scale as well as commercially manufactured and exported. Pickling is the result of fermentation by lactic acid bacteria which are generally present in large numbers on the surface of fresh vegetables and fruits. These bacteria can grow in acidic medium and in the presence of 8-10% salt solution, whereas the growth of majority of undesirable organisms is inhibited. Lactic acid bacteria are most active at 30°C, so this temperature must be maintained as far as possible in the early stage of pickle manufacturing process. When vegetables are placed in brine, it penetrates into the tissues of vegetables and soluble material present in vegetable tissues diffuses into brine solution by osmosis. The soluble material basically includes fermentable sugars and minerals. The fermentable sugar is broken down by lactic acid bacteria which convert them into lactic and other acids. The acid brine, thus, formed acts upon vegetable tissues to produce characteristic taste and aroma of pickle.

Prospects of vegetable processing

India has strong supply base of indigenous vegetables. Considerable international demand of fresh and processed vegetables has placed big opportunities and challenges to the processors to produce nutraceuticals rich processed vegetables to consumers. The vegetable processing prospects can be focused due to following reasons:

- Fast growth in organized retail over the last two decades which acted as catalyst for increasing the growth similar to west.
- Consumer fast demanding trend convenience types of vegetables such as easy-to-cook and ready-to-eat vegetables.
- Global shift to outsourcing from India across products/ services to many countries in world.
- Deregulation and liberalization of the Indian economy helped to promote many new processed vegetable products in the market.

Projection of Indian Food Industry

The Indian food industry is projected to grow from US $100 billion to US $ 500 billion by the end of 2025. During this period, the share of processed food in terms of value is expected to increase from 43% to 50% of total food production. The food processing industry is of enormous significance for India's development as it has efficiently and effectively linked the nation's economy, industry and agriculture. The indigenous vegetable processing industry is highly decentralized and a large number of units are in cottage, household and small scale sectors, having small capacities of up to 250 tonnes per annum. In contrast to small scale processing, multinational companies are processing 30 tonnes per hour. Since 2000, the food processing industry has seen a large growth in ready-to-serve beverages, fruit juices and pulps, dehydrated and frozen fruits and vegetable products, pickles and ready mix vegetables.

Challenges and opportunities in indigenous vegetable sector

In view of huge post-harvest losses in indigenous vegetables and losses of valuable life protecting bioactive compounds, huge potential exists in safer environmental friendly post-harvest treatment in vegetables. Due to change in lifestyle and rapid growth in urban sector, the demand for processing in indigenous vegetable sector is increasing. Many low cost processing technologies have been focused to make the processed products affordable to a large section of population. In this regard, edible

coating in the form of carnauba wax and shellac based coating can make indigenous vegetables more attractive in the form of glossy appearance with much reduced respiration and transpiration thereby increasing the shelf life of vegetables to the greater extent. The demand of cut, core and sliced form of vegetables is quite high due the less time for processing and change in socio economic status of urban consumers. Minimal processing can be very effective for handling of vegetables with good safety measures for controlling of food borne diseases of Salmonella, Shigella, *Escherichia coli*, etc. Apart from traditional vegetable processing such as drying, canning, freezing, juice extraction and concentration etc., vegetable sector have huge potential to fuel the growth of food processing in India. Some potential future areas which require utmost importance are as follows:

- Nutraceuticals industry
- Ready-to-eat industry
- Cut fruit and vegetable industry
- Post harvest treatment in indigenous vegetables
- Development of low cost indigenous vegetable processing machines

Marketing problems and opportunities

A very large amount of indigenous vegetables get perished because of poor marketing infrastructure. The perishable nature of the produce and the careful handling needs are the major challenges to be attended with utmost care. Unlike milk, indigenous vegetables need a far different technological approach with regard to storage and marketing. There have been acute shortages of cold chain facility in rural and peri-urban areas where the availability of indigenous vegetables is surplus. Lack of preservation facilities leads farmers to sell their produce at unconsciously low prices during peak season. The States and Central Government should take concreted steps to resolve the situations of the farmers. The establishment of agro parks in many states has tried to solve the problem to a greater extent. However, these agro parks are used for other purposes because of the lack of enthusiasm from entrepreneurs. In recent years, the Ministry of Food Processing Industries is taking big strides to solve these ironical problems related to processing and marketing of perishable vegetables. In the west, the bulk of vegetables are processed and the scale of the processed food industry is so large that it can sell processed foods much cheaper than fresh vegetables. In the western markets the fresh vegetables are relatively expensive due to large demand and preference towards fresh vegetables. In dairy sector, farmers get 66% of the price which consumer pay for milk whereas in vegetable sector, farmers get less than 20% of what the consumers pay. This is quite clear that the price elasticity in dairy sector is more as compared to fruits and vegetable sector. Many big private players are joining regularly and posing challenges to public sector in dairy sector. However, the time has come for replicating the business of dairy sector into vegetable processing sector.

Major challenges for the processed vegetable industry

- Consumer education that processed vegetables can be more nutritious
- Low price-elasticity for processed vegetable products
- Need for distribution network and cold chain
- Backward-forward integration from farm to consumers
- Development of marketing channels of processed products
- Development of linkages between industry, government and institutions
- Streamlining of food laws

Innovative ideas in indigenous vegetable sector

- Focus on market build quality brands at low cost product development
- Focus on traditional food processing and technology such as low cost chapatti making technology, long shelf life idli/dosa batter, low cost large scale drying technology, efficient low cost cool chain management, focus on low cost food equipment design and R&D
- Focus on self-help group infrastructure development to meet the local demand
- Close association of food industries with public sector institution for solving the need based problem
- Focus on nutraceuticals industry to reduce the burden on healthcare industry
- Focus on refinement in zero energy cool chamber structure for long term usage
- Focus on concentrating Brand India concept to popularize the product.

SUMMARY

The processed indigenous vegetable industry has great potential to realize the agricultural resources. There has been a huge challenge to our industry to increase the processing of the perishables to provide sufficient growth to the global trade by adding increased value to the end products. The Ministry of Food Processing, Govt. of India, also intends to increase the processing of horticultural crops from 2% to 20%, value addition from 7% to 35% and share of global trade from 1% to 3%. Farmers particularly women in rural sector can play a crucial role to give a boost in the processing of perishable products at small sector. There is an urgent need to support farmer-managed rural production and marketing ventures in horticulture, and post-harvest processing and to provide technology training and input support to farmers to take advantage of emerging high-value agribusiness sector. Agro-processing particularly indigenous vegetable processing can generate employment for whole family of farmer so that farmer's income can be increased. Harvesting of indigenous vegetables at proper stage of maturity, storage under cold chain management and suitable processing with assured marketing of processed products can increase the income of the farmers and it would be a step towards fulfilling the mission of our Honourable Prime Minister by doubling the farmer's income by 2022.

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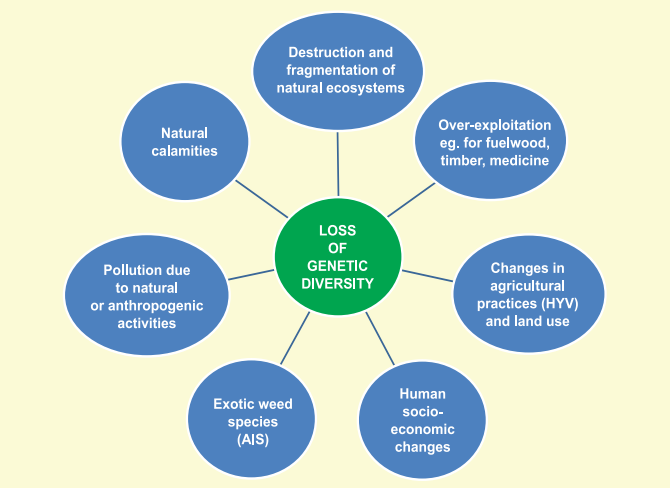
Diversity and conservation of indigenous and minor vegetables

More than 100 indigenous and minor vegetables are widely grown all over the country throughout the year for their edible leaves, stems, flowers buds & open flowers, fruits, seeds, roots etc. Indigenous vegetables, *viz.* brinjal, bitter gourd, ridge gourd, sponge gourd, satputia, ashgourd, snakegourd, longmelon, snapmelon, round melon, cucumber, pointed gourd, ivy gourd, spine gourd, sweet gourd, basella, lotus, colocasia, cluster bean, Indian bean, water spinach, palak etc. are primary members for greater use of crop biodiversity as they are enjoyed locally and can be produced profitably with the minimal external inputs in both rural and urban environments. Today these indigenous and minor vegetables need greater attention of researchers, policymakers, and funding agencies to safeguard the extinction of biodiversity which is not only a source of well-being but also the foundation of their cultural and spiritual identities.

Extinction of Indigenous genetic diversity

There are several species which are becoming extinct day by day in changing scenario in cultivation especially monoculture, development of hybrids, urbanization, fragmentation of habitats, deforestation, overexploitation, rapid changes in the hydrological regime and land use patterns, soil degradation, air and water pollution, adverse impact of development and increase in the population (Table 1). Incidence of biotic and abiotic stress and many natural and biological factors, there is threat to the existing indigenous vegetable genetic wealth.



Loss of genetic diversity through different major factors

In situ conservation

In situ conservation is very 'Dynamic conservation' where mostly wild, landraces and locally adapted materials are maintain in the naturally adopted field condition where continuous evolution takes place. For majority of the situation, *in situ* conservation is ideal method of conserving wild plant genetic resources and perennial vegetables, which either do not set or set recalcitrant seed, or do not produce plants true to type or produce seeds having unequal male and female progenies. of greatest conservation concern is the fate of long-lived species like-pointed gourd, ivy gourd, spine gourd, curry leaf as their replacement may take longer time. Some perennial vegetable crops are being maintained in different agro-ecological niches as National Active Germplasm Sites (NAGS) designated by ICAR-NBPGR, New Delhi or for promotion of research on locally adopted/dominating crops.

Diversity in long melon and bitter gourd

Table 1. Rare and endangered cucurbitaceous species in India

Cucurbitaceous species	Biogeographic zones
Corallocarpus gracillipes	Western ghat
Gomphogyne macrocarpa	East Himalayas
Indogevillea khasiana	North Eastern region
Luffa umbellata	Western ghat
Melothria amplexicaulis	Deccan Peninsula
Momordica subangulata	Deccan Peninsula , Western ghat
Trichosanthes lepiniana	Deccan Peninsula, Western ghat
Trichosanthes perrotteliana	Western ghat
Trichosanthes villosula	Deccan Peninsula, Western ghat

Ex situ Conservation

Ex situ conservation or "Static conservation" involves removal of plant propagules (seed, stem, root, meristem part, pollen, protoplast etc.) from its natural environment and storing them in gene bank under suitable conditions that maintain propagules viability and vitality for longer period. Basic strategy is to conserve accessions for longer period under controlled conditions without changing their original genetic integrity.

Seed banks

Seed conservation is quite easy, relatively safe and needs minimum space. Seeds are classified, on the basis of their storability into two major groups:

Orthodox: Seeds which can be dried to low moisture content and stored at low temperature without losing their viability for long periods of time is known as orthodox seeds. eg. *Canavalia*.

Recalcitrant: Seeds which show very drastic loss in viability with a decrease in moisture content below 12 to 13% are known as recalcitrant seeds.

Low energy gene bank at ICAR-IIVR, Varanasi

Table 2. Variability, distribution status and conservation priorities of Indigenous and minor vegetable crops

Crop	Genera	CS	DS	GVS	GES	GCP
Brinjal	*Solanum* species	C	W	W	M	H
Cluster bean	*Cyamopsis* species	C	R	M	M	M
Lablab bean	*Lablab* species	C	W	H	M	M
Climbing spinach	*Basella* species	C	W	M	M	M
Palak	*Beta* species	C	R	M	M	H
Bitter gourd	*Momordica* species	C	W	H	M	H
Snapmelon	*Cucumis* species	C	W	H	M	H
Pointed gourd	*Trichosanthes dioica*	C	L	H	H	M
Ridge gourd	*Luffa* species	C	W	H	H	H
Sponge gourd	*Luffa* species	C	W	H	M	H
Satputia	*Luffa* species	C	W	H	M	H
Tinda	*Praecitrullus fistulosus*	C	L	M	M	M
Ash gourd	*Benincasa hispida*	C	W	H	M	M
Snake gourd	*Trichosanthes anguina*	C	W	H	M	H

CS-Crop status (C-cultivated, W-Wild), **DS-**Distribution status (**W**-wide spread distribution, **R**-regional distribution, **L**- localized distribution), **GVS-**Germplasm variability status (H-high, M-medium, L-low), **GES-**Genetic erosion status (H-high, M-medium, L-low) and **GCP-**General crop priorities (H-high, M-medium).

Seed stored with Zeolite beads

Ultra-dry seed storage by Zeolite beads

Ultra-dry storage, also called low moisture content storage, is a technique for decreasing seed moisture content to less than 5-6% using desiccants. Desiccant technology works by adsorbing moisture in the surrounding air; adsorption occurs when moisture is tightly held at a molecular level versus absorption where moisture is dissolved. The desiccant then adsorbs the moisture in the air, causing the seeds to continue losing moisture until the seed, relative humidity in the air and the desiccant have reached a moisture balance. Zeolite is a naturally occurring clay that has been effectively used as an absorbent for drying seeds endash a requirement for long term storage. Zeolite drying beads are desiccants that adsorb water and can be used indefinitely through "recharging" or heating to release moisture. The beads can absorb up to 25% of their weight in water.

Field or plant bank

Field or plant bank is an orchard or a field in which

Table 3. Designated centers for maintenance, multiplication and conservation of indigenous and minor vegetable crops

Vegetable crop	Designated sites of conservation
Brinjal	ICAR-IIVR, Varanasi (UP); ICAR-NBPGR, New Delhi & its centres; ICAR-IARI, New Delhi; ICAR-IIHR, Bengaluru (Karnataka); Indira Gandhi Krishi Vishwavidyalay, Raipur (Chhattisgarh); Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur (Bihar)
Cucumber	ICAR-IIVR, Varanasi (UP); ICAR-NBPGR, New Delhi & its centres; ICAR-IARI, New Delhi; ICAR-IIHR, Bengaluru (Karnataka); Mahatma Phule Krishi Vidyapeeth Rahuri (Maharashtra); Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri (Maharashtra); G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand)
Bitter gourd	ICAR-IIVR, Varanasi (UP); ICAR-NBPGR, New Delhi & its centres; ICAR-IARI, New Delhi; ICAR-IIHR, Bengaluru (Karnataka); Indira Gandhi Krishi Vishwavidyalay, Raipur (hattishgarh); Kerala Agricultural University, Thrissur. Vellanikara (Kerala); Mahatma Phule Krishi Vidyapeeth Rahuri (Maharashtra); Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu)
Ash gourd	ICAR-IIVR, Varanasi (UP); ICAR-IARI, New Delhi; Kerala Agricultural University, Thrissur Vellanikara (Kerala)
Ridge gourd	ICAR-IIVR, Varanasi (UP); Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra); ICAR-IIHR, Bengaluru (Karnataka)
Sponge gourd	ICAR-IIVR, Varanasi (UP); Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra); ICAR-IIHR, Bengaluru (Karnataka)
Satputia	ICAR-IIVR, Varanasi (UP); Mahatma Phule Krishi VidyapeethRahuri (Maharashtra); ICAR-IIHR, Bengaluru (Karnataka)
Snake gourd	Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu)
Long melon	ICAR-IIVR, Varanasi (UP); ICAR-Central Institute for Arid Horticulture, Bikaner (Rajasthan)
Snapmelon	ICAR-IIVR, Varanasi (UP); ICAR-Central Institute for Arid Horticulture, Bikaner (Rajasthan)
Round melon	ICAR-IIVR, Varanasi (UP); ICAR-Central Institute for Arid Horticulture, Bikaner (Rajasthan)
Basella	ICAR-IIVR, Varanasi (UP)
Indian bean	ICAR-IIVR, Varanasi (UP); ICAR-IIHR, Bengaluru (Karnataka); ICAR-IARI, New Delhi; Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh); ICAR-ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra
Cluster bean	ICAR-IIVR, Varanasi (UP); ICAR-Central Institute for Arid Horticulture, Bikaner (Rajasthan)
Palak	ICAR-IIVR, Varanasi (UP); ICAR-IARI, New Delhi
Lotus	ICAR-IIVR, Varanasi (UP)
Water spinach	ICAR-IIVR, Varanasi (UP)

Table 4. Germplasm conservation status of indigenous and minor vegetable crops at various research organizations

Vegetables	No. of collections	Source
Cucumber	2638	ICAR-IIVR, Varanasi (UP); ICAR-NBPGR, New Delhi & its centres; G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand); Kerala Agricultural University, Thrissur, Vellanikara (Kerala); NDUA&T, Ayodhya (UP); ICAR-IARI, New Delhi; ICAR-IIHR, Bengaluru (Karnataka) ICAR-RCER Research Centre, Ranchi (Jharkhand); ICAR-CIAH, Bikaner (Rajasthan); PAU, Ludhiana (Punjab); Acharya N.G. Ranga Agricultural University, Rajendra Nagar (Telangana); Rajasthan Agricultural Research Institute (Sri Karan Narendra Agriculture University, Jobner) Durgapura, Jaipur (Rajasthan); Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh)
Bitter gourd	973	
Snap melon	697	
Kachri	648	
Snake gourd	289	
Pointed gourd	324	
Ivy gourd	154	
Spine gourd	80	
Sweet gourd	65	
Sponge gourd	1852	
Ridge gourd	1628	
Satputia	19	
Ash gourd	1139	
Round gourd	164	

Table 5. Conservation facility, condition and storage in field bank

Conservation facility	Condition of storage	Category of PGR	Form in which stored
Field gene bank (including clonal repository)	Ambient temperature and conditions of an open field or in screen house/ net house/green house	Species which do not produce seeds, or if they do, produce few seeds (threatened, wild and/or endemic species); species which are propagated vegetatively or as clones; species that produce non-orthodox seeds (desiccation-sensitive); species that require a long life cycle to generate breeding and/or planting material	Whole plants

Table 6. Centre for maintenance, multiplication and conservation of indigenous perennial vegetable crops

Vegetable crop	Sites of conservation
Pointed gourd	ICAR-IIVR, Varanasi (UP); ICAR-RCER Research Centre, Ranchi (Jharkhand); Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur (Bihar); Acharya Narendra Deva University of Agriculture & Technology, Ayodhya (U.P.), Bihar Agricultural University, Sabour, (Bihar); Bidhan Chandra Krishi Viswavidyalya, Mohanpur (West Bengal); Odisha University of Agriculture & Technology, Bhubaneswar (Odisha)
Ivy gourd	Regional Research Station, Kushinagar of ICAR-IIVR, Varanasi (U.P.); Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh); Kerala Agricultural University, Thrissur, Vellanikkara (Kerala)
Sweet gourd and spine gourd	Regional Research Station, Kushinagar of ICAR-IIVR, Varanasi (U.P.); ICAR-Research Complex-Barapani, (Meghalaya); Regional Research Station of ICAR-Research Complex-Tripura, Bidhan Chandra Krishi Viswavidyalya, Mohanpur (West Bengal); Odisha University of Agriculture & Technology, Bhubaneswar (Odisha); ICAR-CITH Regional Station, Mukteshwar-Kumaon, Nainital (Uttarakhand)
Curry leaf	University of Agricultural Sciences, Dharwad (Karnataka)
Dioscorea sp.	ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram (Kerala); ICAR-CTCRI, Regional Centres; NBPGR Trissur and ICAR-NBPGR, New Delhi

Ash gourd maintained at ICAR-IIVR, Varanasi

accessions of vegetatively propagated crops are grown and maintained. As per the guidelines of ICAR-NBPGR, New Delhi, several vegetable crop base research institute maintaining field gene bank of mandated perennial and vegetatively propagated species in the field condition.

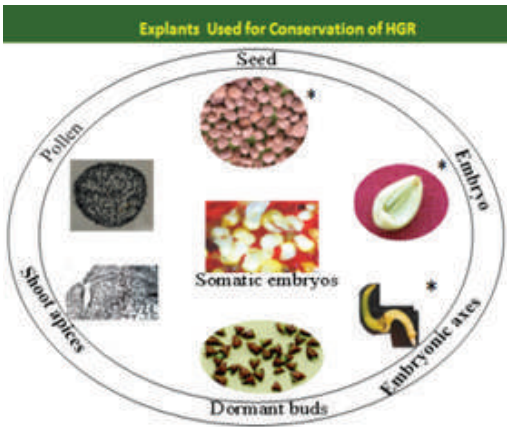
Shoot tip banks: Genetic stocks (basically vegetatively propagated crops like *Colocasia* (due to poor seed set) is conserved as slow growth cultures of shoot-tips/meristem and node segments. *In vitro* slow/normal growth techniques offer short to medium term storage option avoiding risk of losses of indigenous genetic diversity in field gene bank due to insects, nematodes, disease attacks and natural disasters. In such gene banks, germplasm is conserved as slow growth cultures of shoot-tips and nodal segments. It is commonly used for vegetatively propagated species, non-orthodox seeded species and wild species which produce little or no seeds. Their regeneration consists of sub-culturing the cultures, which may be done every 6 months to 3 years. Regeneration of meristem is extremely easy. Each genotype can be conserved indefinitely free from virus or other harmful pathogens.

Cell and organ banks: A germplasm collection based on cryopreserved (at –196°C in liquid nitrogen) embryogenic cell cultures, somatic/ zygotic embryos can be called as cell and organ bank. Cell and organs are becoming very popular in conservation programme. Pollen grains are a rich source for diverse alleles in any gene pool, holding large genetic diversity in small sample, size offering an effective propagule for germplasm conservation. Its inherent ability of hardiness and stability in harsh conditions enables its long-term cryogeneic storage. The pollen of *Cucumis sativus* can be stored for longer period. In these banks, DNA segments from the genomes of germplasm accessions are maintained and conserved for longer period. For this slow freezing

(conventional method using programmable freezer) and fast freezing (desiccation, pre-growth, pre-growth-desiccation, encapsulation-dehydration, vitrification, encapsulation-vitrification and droplet freezing) can be used. Another approach is slow growth culture where a large number of samples can be stored. Under *in vitro* condition *Colocasia esculenta* can be stored successfully up to 7 months.

Regeneration protocols of indigenous perennial vegetable crops

Regeneration protocols in indigenous perennial vegetable crops have been standardized to maintain the genetic purity for longer period.



Explants used for conservation

Table 7. *In vitro* cryo gene bank storage

Types of conservation facility	Condition of storage	Category of PGR	Form in which stored
In vitro gene bank	Ambient temperatures, 25 ± 2 °C (short-term storage) or low temperatures of 4-15°C (medium-term storage)	Species which do not produce seeds, or if they do, produce few seeds (threatened, wild and/or endemic species); species which are propagated vegetatively or as clones; species that produce non-orthodox seeds (desiccation-sensitive); species that require a long life cycle to generate breeding and/or planting material	Tissue cultures (plantlets, shoot cultures, somatic embryos, root cultures, meristem cultures, embryogenic callus cultures, cell suspensions) which may be actively or slow growing.
Cryo-gene bank	Ultra-low temperatures, ranging from - 130 to -196°C (using liquid nitrogen)	Species which do not produce seeds, or if they do, produce few seeds (threatened, wild and/or endemic species); species which are propagated vegetatively or as clones; species that produce non-orthodox seeds (desiccation-sensitive); species that require a long life cycle to generate breeding and/or planting material	Seeds, embryos, embryonic axes, buds, shoot tips, meristems, pollen, cell suspensions, DNA
DNA Bank	Low temperatures of 4°C (short-term storage for 1-2 years) and -20°C (medium-term storage for 3-5 years); Ultra-low temperatures, ranging from -70 to -196°C (long-term storage for > 5 years)	Any species, especially wherever genomic resources are being generated	Genomic, mitochondrial or chloroplast DNA; cloned genes, promoters fused with reporter genes; sub-genomic, cDNA, EST, repeat enriched libraries; cloning vectors, expression vectors, binary vectors, RFLP probes; BAC, YAC, PAC clones.

Table 8. Regeneration protocols in indigenous perennial vegetables

Vegetable Crop	Protocol	
Pointed gourd	Stem cutting comprising 1, 2, 3 and 4 nodes were treated with 0, 50, 100 and 150 ppm IBA and NAA, IBA at 100 ppm proved to be beneficial and it expressed the maximum percentage of sprouting, shoot growth and root performance. Increase in concentration beyond 100 ppm did not prove effective. IBA maintained its superiority over NAA with respect of all the vegetative and root attributes. The establishment per cent of 4 node cuttings in field condition was highest (73.56%) while among all the doses of Auxins, IBA at 100 ppm resulted in the maximum percentage of survival (61.13) of rooted cuttings.	

Pointed gourd-stem cutting

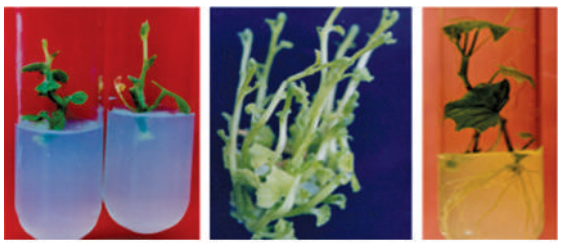
Vegetable Crop	Protocol
Spine gourd	Generally propagated through underground tubers (male and female separately) and getting sufficient quantity of tubers is difficult and also only one tuber can develop one plant. Therefore an experiment was conducted to multiply the crop through clonal propagation. An efficient protocol for rapid *in vitro* clonal propagation of genotype RSR/DR-15 (female) and DR/NKB-28 (male) was developed through enhanced axillar shoot proliferation from nodal segments. Maximum shoot proliferation of 6.2 shoots per explants with 100% shoot regeneration frequency was obtained from the female genotype on MS medium supplemented with 0.9 microMN6-BA and 200 mg/l casein CH. No polymorphism was detected revealing the genetic integrity of *in vitro* propagated plants. This micro propagation procedure could be useful for raising genetically uniform planting material.
Spine gourd	In spine gourd application of IBA 200 ppm concentration can be used in sprouting of shoot under moist soil condition. This technique helps in reducing the use of tuber for multiplication and storage.
Ivy gourd	Cuttings with 4 nodes sprouted earliest (8.8 days after planting) and enhanced the sprouting percent, length and diameter of vine, number of branches per shoot, number of leaves per cutting, length and diameter of root and regeneration percent than 1, 2 and 3 nodes/cutting. Cuttings treated with 75 ppm IBA took minimum days to sprout and improved sprouting percent, increased length and diameter of vine, number of branches per shoot, number of leaves per cuttings, length and diameter of root and regeneration percent than 75 ppm NAA and 25, 50, 100, 125 and 150 ppm IBA and NAA each.

Regeneration protocol in spine gourd

Sprouting of spine gourd with application of IBA 200 ppm

Table 9. Minimum seed viability standards of Indigenous and minor vegetables for long term conservation

Botanical name	Minimum germination (%)	Minimum seed quantity (No.)
Luffa echinata	50	500
L. pentandra	50	500
Momordica dioica	60	500
M. sahyadrica	30	500
M. subangulata ssp. *renigera*	30	500
M. tuberosa	30	500
Solanum spp.	30	500
Trichosanthes bracteata	30	500
T. cucumerina	30	500
T. cuspidata	30	500
T. lobata	30	500
T. nervifolia	30	500
T. palmata	30	500
T. tricuspidata	50	500



Shoot Initiation Shoot multiplication Root initiation

Conservation and propagation techniques through tissue culture

SUMMARY

The Indian gene centre has vast diversity of indigenous and minor vegetables in edible and wild/weedy form. Indiscriminate extraction of biological material from the wild threatens their survival, even to the extent of pushing some species into extinction. It is true that once they disappear; there is no alternative source for acquiring the unique qualities they provide. It is hence, important to develop sustainable harvesting and conservation regimes that do not undermine the capability of a plant species to survive in the wild. The scientists have shown great concern over the conservation and preservation of environment, biodiversity and ecosystem in a sustainable manner.

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Indigenous and minor vegetables of Manipur

Indigenous and minor vegetables are used or consumed in many forms as raw or cooked by the local people. Various delicacies and products are prepared comprising of the various indigenous and minor vegetables along with meat and fish. The local delicacies prepared from indigenous and minor vegetables are a must in the everyday lives of the people, and sometimes it is even more prominent and important than the standard staple crops and vegetables. Here, an effort has been made to list out various indigenous and minor vegetable crop species and the delicacies prepared from them by the local people. Research attentions and interests should be taken in these crops for exploring new food crops and food ensure and nutritional security of the country.

INDIGENOUS (Traditional) and minor vegetables are best defined as species that are locally important for the sustainability of economies, human nutrition and health, and social systems but which have yet to attain global recognition to the same extent as major vegetable commodities. Some indigenous and minor vegetables grow in the wild and are readily available in the field as they do not require any formal cultivation. Indigenous and minor vegetables represent inexpensive but high quality nutritional sources for the poor segment of the population especially where malnutrition is wide spread as in some part of the underdeveloped countries in particular. People living in hills and valleys have rich traditional knowledge of plants and herbs which are edible, with their direct impact on health benefits; they have a tradition of eating raw leaves, young inflorescences, and tender stalks as nutrient supplement in their diets. Traditional knowledge of eating raw plants by inhabitants as medicinal or health supplement in their diet is an age old practice. Different indigenous and minor vegetables are used for preparation of delicious dietary items. Some of them are winged bean, sword bean, rhizome of lotus, arrowhead, fermented and non-fermented bamboo shoot and Foxnut etc.

Different uses of Indigenous and minor vegetables in local cuisine

Altogether 31 indigenous and minor vegetable plants belonging to 29 genera and 20 families are found in different parts of Manipur inhabited by the *Meitei* community. The different traditional *Manipuri* cuisines prepared from different indigenous and minor vegetables by the local people from time immemorial are documented below.

Singu: It is a typical Manipuri salad prepared by mixing finely chopped raw vegetables with salt, red chilli, roasted sesame powder, roasted pea powder (Besan). It is originated from *Meitei* community of Manipur but well eaten by the sibling communities of the state. Singju is of two types–without fermented fish and with fermented fish. The former type is mainly served at ritual occasions, ceremonial, traditional and customary festive feast while the later type is for home consumption. Singju has been the all time favourite side dish for meals and as afternoon or evening snacks too. Though this is a popular food item, it remains as an underutilized food due to its little or lack of commercial market. Variety of green vegetables are used to prepare different/recipe of singju. Some of the vegetables which are commonly used for preparing singju

Bamboo shoot eromba

Banana flower Paknaam

Chinese chive fritters

Table 1. Common indigenous and minor vegetables of Manipur, their dietary uses and health benefits

Scientific Name	Local name	Family	Parts uses	Dietary uses and preparation	Medicinal values
Alocasia macrorrhiza	*Singju-paan*	Araceae	Corm	Corm cooked with fermented soybean. One of the important ingredients of *singju*.	Purify blood
Allium hookeri	*Maroinapakpi*	Liliaceae	Whole plant	Leaves are used in *paknam*, other Manipuri dishes and root are also used in fish curry.	Aphrodisiac
Allium tuberosum	*Maroinakuppi*	Liliaceae	Whole plant	Leaves are used in preparing fritter and can be used in different Manipuri dishes.	Aphrodisiac and diuretic.
Alpinia nigra	*Pullei*	Zingiberaceae	Rhizome	Rhizome used in *eromba* (used in religious ceremonies, symbolic of Manipuri New Year)	Carminative, aphrodisiac, tonic, diuretic, expectorant, appetizer and analgesic. Skin infections
Alocasia indica	*Yendem*	Araceae	Stem, rhizome	Whole plant can be used in *eromba* and *kangsoi* preparation.	Purify blood
Amomum aromaticum	*Namra*	Zingiberaceae	Stem, rhizome	Rhizome as a constituent in the preparation of *eromba*.	Powder is taken to control high blood pressure.
Canavalia cathartica	*Tebi*	Papilionaceae	Fruit	Young pods are used in *singju, eromba, chagempomba* preparation.	Anthelmintic or vermifuge.
Cardamine hirsuta	*Chantrukmana*	Brassicaceae	Stem, leaves	Whole plant except root is used in *singju*.	Diuretic, paste is applied on cut and injuries
Centella asiatica	*Peruk*	Apiaceae	Whole plant	Whole plants except root is used in preparation of *kangshu,* simple boil or eat as raw.	Expectorant and against cold & gastric.
Colocasia esculenta	*Lam paan*	Araceae	Stem, leaves	Corm and leaf cooked eaten as *ooti*.	Extract is tonic, given in cough and diabetes.
Cycas pectinata	*Yendang*	Cycadaceae	Leaves	Young shoot is used in preparation of *kangshu*	Against dysentery.
Elsholtiza blanda	*Lomba*	Lamiaceae	Inflorescence	Leaves and dried inflorescences are used in *singju* and *eromba* as raw.	Antipyretic, expectorant, against high blood pressure and menstrual disorder
Euryale ferox	*Thangjing*	Nymphaeacea	Fruit	Fruit cooked eaten or raw in *eromba*.	Raw fruit eaten against diabetes; leaf petiole paste applied on burns and boils.
Hedychium coronarium	*Lok-lei*	Zingiberaceae	Rhizome	Rhizome is used in preparation of *eromba*.	Paste of rhizome is eaten against cough, fever; leaf extract is given against throat complaint.
Houttuynia cordata	*Toningkhok*	Saururaceae	Whole plant	Leaves are used in *singju* and *eromba* as raw	Anti-diuretic, against cholera and dysentery
Ipomoea aquatica	*kolamni*	Convolvulaceae	Stem, leaves	Shoot cooked eaten and used in preparation of *singju*.	Boiled leaf extract is used as ear-drop to treat ear-ache; leaf paste is applied on insect bite.
Musa paradisiaca	*Laphu*	Musaceae	Stem, flower	Young pseudo-stem is used in preparation of *eromba*. Banana flower is used in preparation of *paaknam*and *singju*.	Easy movement of bowel and against dysentery, diarrhoea, cholera
Nelumbo nucifera	*Thambal*	Nelumbonaceae	Root, fruit	Young leaves are eaten as raw and lotus rhizome is one of the important ingredients in preparation of *singju*.	Paste of petiole is applied on boils and burns.
Neptunia oleracea	*Esing-ekaithabi*	Fabaceae	Whole plant	Shoot cooked as *erombaor* eaten raw as *singju*.	Eaten raw in dysentery and intestinal infections.
Oenanthe javanica	*Komprek*	Apiaceae	Whole plant	Shoot and leaf is one of the best and preferred species used in the preparation of *singju*.	Boiled in little water and the filtrate is used as ear-drop to cure ear-ache.

Scientific Name	Local name	Family	Parts uses	Dietary uses and preparation	Medicinal values
Parkia roxburghii	*Yongchak*	Fabaceae	Fruit and flower	Young inflorescences and tender pods are used in *singju*. Mature pods are used in *eromba*.	Carminative & against piles
Persicaria posumba	*Kengoi*	Polygonaceae	Whole plant	Used in preparation of *Kangsoi*	Eaten to cure diabetes, piles and intestinal disorder.
Polygonum barbatum	*Yelang*	Polygonaceae	Tender shoot	Used in preparation of *Kangsoi* and *eromba*.	Paste is taken to treat stomach disorder and dysentery.
Psophocarpustetra gonolobus	*Teng-noumanbi*	Papilionaceae	Fruit and roots	Young pods are used in preparation of *singju, eromba, chagempomba.*	Expectorant
Sagittaria sagittifolia	*Koukha*	Alismataceae	Corms	Used in preparation of *bora, eromba*	Paste along with honey is given in cough.
Bambusa spp.	*Usoi*	Poaceae	Tender shoot	Used in preparation of *kangshu* and *ooti*	Anthelmintic or vermifuge
Sesbannia grandiflora	*Chuchu-rangmei*	Papilionaceae	Tender shoot	Young pods and tender twigs are used in preparation of *singju* and *eromba*.	Expectorant, antipyretic & against diabetes
Trapa natans	*Heikak*	Lythraceae	Fruits	Fruit cooked eaten or as raw, petiole eaten as *eromba* and *singju*	Nutrition & tonic
Meyna laxiflora	*Heibi*	Rubiaceae	Fruits and leaves	Young leaves used preparation of *singju*.	Anthelmintic or vermifuge
Viola pilosa	*Huikhong*	Violaceae	Shoot	Shoots is used in preparation of *Kangshu*	Cooked and eaten to cure cough, running nose and stomach ulcer.
Wendlandia glabrata	*Pheija*	Rubiaceae	Inflorescence	Young shoots are used in preparation of *singju* as raw and cooked in preparation of *eromba*	Expectorant and against dysentery.

are Lotus rhizome (*Thambou*), unripe papaya, winged bean, cabbage, sword bean, banana flower (*Laphutharo*), water parsley, tender shoots of pea, water mimosa, stink bean etc. The chopped vegetables are mashed along with chilli, besan, salt etc.

Eromba: It is one of the most popular dishes of Manipur. It is a type of chutney made with boiled vegetables mashed with chilli, potato and fermented fish. It can be made with any vegetables depending on our culinary imagination like stink bean eromba, colocasia eromba, bamboo shoot eromba, broad bean eromba, etc. To make it tastier, it is garnished with herbs like chinese chive, coriander leaves, lemon basil, chamomile leaves and roots and many more. It can also be prepared without fermented fish by using fried chilli, fried chives, onions etc.

Paknam: It is a type of pancake prepared by using besan along with a mixture of hooker chives *(Maroinapakpi),* young banana inflorescence, pea flour, wild coriander and fermented fish, salt, chilli and spices. All the content are mashed properly and the pea flour (besan) is added into it, which should be mixed thoroughly and placed in one or two layers of turmeric leaves, final wrapping can be done by using banana leaves. The whole content is baked on a hot pan and light weight is placed upon it. After 30 to 45 min, it imparts a typical flavour which indicates the product is cooked. Instead of this, it

Indian Pennyworth Kangsu

Kangsai

Ooti asangba

Stink bean eromba

Stink bean

can be cooked in steam, the preparation can be sealed in a small tiffin box and put inside pressure cooker for up to 3 whistles and then pan roast until it turn to somewhat brown. Paknam can also be prepared by using tree mushroom (*Kanglayen*) instead of the vegetables.

Khoukha bora/ Koukha kanghou (Arrowhead fritters /fried): Arrowhead is the edible tuber of the arrowhead plant which grows in rice field and swamps. In Manipuri cuisine, it is eaten stir fried (koukha kanghou) or as fritters (koukha bora). It is prepared by frying the arrowhead dipped in besan paste. It is famous for its taste and delicacy in every local markets and small hotels.

Kangshu: It is another typical traditional food which is popular in *Meitei* community. Indian Penny worth (Peruk) is cooked in pressure cooker up to 2 whistles and squeezed dry to remove water and mashed with boiled roasted dried yellow peas and mix with fermented fish, red chilli and salt. Kangshu can be prepared with non-fermented bamboo shoot (Ushoi kangshu), wendlandia paniculata (U-thummana khangsu) etc.

Kangsoi: It is a mixture of various boiled vegetable along with fermented fish, dried fish, chillies and salt, Chinese chive and hooker chives. Various indigenous and minor vegetables are used in preparation of kangsoi such as *P. olygonium orientale* (*yellang*), *Persicaria posumba* (*kengoi*), *Stellaria media* (*Yerum keirum*), etc. Kangsoi is generally an important and daily consumed cuisine in Manipuri house hold.

Ooti: Ooti is a very well known cuisine of Manipur, cooked and consumed in every house. It is cooked using non fermented bamboo shoot (Ushoi) along with dried yellow peas after soaking it overnight. Chinese chives, salt, chilli. Sodium bicarbonate is one of the compulsory ingredients in the preparation of ooti for its flavour. Another kind of ooti is ooti asaangba (green ooti) which is prepared with rice and colocasia leaves. One should keep in mind that stirring with spoon during the whole process of preparation should not be done as it will render the ooti lack of taste

Chagem pomba: Chagem pomba is also one of the important dishes of manipuri's which is prepared by mixing varieties of vegetables, dried fish, fermented fish, salt, chilli, turmeric powder, bay leaf, mustard oil ,Chinese chive, cut rice and fermented soybean. Some vegetables which are used in preparation of Chagempomba are water mimosa, mustard leaf, pea tips, stink bean, broad bean, and pea. Cut rice and fermented soybean is compulsory to put in preparation of chagempomba. Cut rice is called chagem in Manipuri, from which it derives its name, chagempomba. The list of indigenous and minor vegetables consumed by Manipuri people as raw or cooked along with their scientific names, uses as delicacy and health benefits are given in table 1 and, the family dominance and the percent of plant parts as usage are presented in for a better knowledge of the preference of indigenous and minor vegetable crops in this region.

SUMMARY

The indigenous minor vegetables are available freely or consumed in many forms as raw or cooked by the *Meitei* community in Manipur from time immemorial. They are used for various local delicacies preparation due to its medicinal value and good taste. However, little attention has been paid on these crops and hence no proper scientific methods of nutritional and chemical profiling and agro techniques of these plants have not been worked out till now. Therefore, without further delay documentation should be done and conserved as a nutritional vegetable for the future generation.

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Status, diversity and potential of indigenous and minor vegetables of North-Western Himalayan region

Indigenous (Traditional) vegetables are the species that are important for the economic, nutrition, health and social sustainability of local communities of that particular area but are yet to attain global recognition. About 20% of population in developing countries suffers from iodine deficiency. Subclinical vitamin A deficiency affects about 25% of children and more than 40% of women are anaemic. More over due to climate change, the indigenous vegetables may play an important role in future. The strategy to combat this problem is to diversify the diet and increase the intake of vegetables and fruits. Indigenous or traditional vegetables of a particular area show very substantive biodiversity, are adapted to specific marginal soil and climatic conditions, and often can be grown with minimal external inputs. Including the production systems of a particular area with traditional vegetables will not only increase the heterogeneity but will also subsequently lead to better resilience to abiotic and biotic stresses. This will help in increasing the socio-economic status of rural, poor smallholders with limited land resources and agronomic inputs. However, they have remained underutilized due to lack of awareness and popularization techniques for utilization.

Common Buckwheat (*Fagopyrum* spp.)

The name buckwheat comes from Anglo-Saxon word 'boc' seed resembles a small beech nut and '*whoet*' (wheat). It is an ancient dicotyledonous crop, belonging to family Polygonaceae. Altough it is an underutilized crop in India, it still plays an important role in food and nutritional security of rural people. There are about 20 species under genus *Fagopyrum*. Only two species, viz. *Fagopyrum tataricum* (tatary buckwheat) and *Fagopyrum esculentum* are cultivated in India. It is an erect, much-branched annual plant with hollow stems. It can grow from 60–120 cm tall. The seed of buckwheat is an important subsistence food in parts of Asia, where the plant has a history of cultivation going back at least 1,000 years. It is the most widely consumed buckwheat species with its advantages of sweet taste and large, easily de-hulled seed. It is often raised as a leafy vegetable crop in many areas of the Indian subcontinent.

Diversity

There are about 23 species of *Fagopyrum* that occur in the highlands of the Euro-Asia region. A wide range of ecogeographican conditions in the Indian Himalaya has generated tremendous genetic diversity in buckwheat species namely, tartary buckwheat (*Fagopyrum tataricum),* common buckwheat (*Fagopyrum esculentum*) and several wild and weedy forms. In India around 1,050 accessions of buckwheat have been collected from Indian Himalayas and introduced from other regions. These are maintained as active collection at the National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Shimla (Himachal Pradesh) and also represented as base collection in the Indian National Gene Bank at NBPGR, New Delhi. Himalayas offer a wealth of diversity in terms of landrace populations of buckwheat since the crop is cultivated in large stretch of land of higher hills of Himachal Pradesh, Uttaranchal, Jammu and Kashmir, Sikkim and North-Eastern hills for centuries, and this extent of diversity would suggest need for their continuous collection and devising strategies for *ex situ* and *in situ* conservation.

Distribution

Buckwheat exhibits rich biodiversity including those of wild species. It is distributed throughout the Indian Himalayan region with more diversity in Western Himalayan region than North Eastern region. This may be attributed to the common border of Western Himalayas and Tibet and the probable migration that could have taken place through several trade routes such as silk route. The most important areas where cultivation of buckwheat is most predominant are Kargil and Drass sectors, Gurez valley of Jammu and Kashmir; Bharmaur, Pangi, outer Saraj, Chopal, Dodra Kuar, Neshang, Pooh, Lahaul Spiti, Pin valley of Himachal Pradesh; Pindari valley, Dharma Valley, Jolwan, Jonpur, Kapkote in Uttaranchal; Cooch Behar, Darjeeling in West Bengal; Lanchan Lachoong

in Sikkim; Tawang, Bomdilla and Dirang in Arunchal Pradesh, and also sporadically in Nilgiris and Pilani hills in Southern parts of India.

Prospects and potential

The leaves and young shoots are boiled and eaten as spinach. Its perisperms can be used as fuel in producer gas plants. A dye prepared from its hulls is used in textile fabrics. It is useful as a green manure crop for renovation of low productivity land because it grows well on such land and produces a green manure crop in a short time and its cultivation promotes improved soil texture and increases production of fallow crop. It is consumed in many different preparations in different countries. The leaf flour is used in Japan as an additive to some food products, for example ice cream and to declare the functionality of the product. In Russia and Poland, the groats and flour are used to make porridge and soup. In Sweden, it is used to stuff fish. In China, buckwheat is used for the production of vinegar. In Southeast Asia, buckwheat is a staple food in many hilly areas. In Europe and North America, buckwheat flour is generally mixed with wheat flour to prepare pancakes, biscuits, noodles and is used as a meat extender. In Eastern Europe, roasted groats called roasted kasha are cooked and served like rice. The groats are used in the United States as a breakfast cereal. In North-Western Himalyas, its leaves are mostly consumed to make local delicacy known as '*Phafru'*. Buckwheat, although is an underutilized vegetable crop, has many advantages for both the grower and the consumer. It has very short growing season and is thus often grown in area with short growing period, or as a second crop. It has the potential of diversifying cropping systems, enhancing human nutrition and contributing to regional economies. The buckwheat fields in flowering can serve valuable source of nectar for bees. Honey produced from buckwheat is typically dark and has a stronger flavor than honey produced from clover and is preferred by consumers. Buckwheat has the ability to establish itself quickly and compete with weeds with minimum fertilizer requirements and can be left from planting to harvest. The cold arid region of Indian Himalaya is highly suitable for buckwheat cultivation. This crop has also been recognized as one of the most important nutraceuticals food.

A lot of information on the origin and distribution of various species of buckwheat has appeared, a great effort is required to search for more variability including the traits of economic importance. The buckwheat of the Himalayan region are geographically unique and the preservation and conservation of the crop in this region should be given emphasis and more knowledge should be gathered about diversity of buckwheat landraces and farming systems in the traditional mountain farming systems. On farm conservation of buckwheat landraces is an important component of crop improvement, human health and conservation.

Pako fern/lingru/vegetable fern (*Diplazium* spp.)

Ferns are mostly considered as ornamental plants but many of these species are edible and eaten either raw or cooked in different parts of the world due to their

Buckwheat

nutritive values. In India, *Diplazium esculentum* (Retz.) Sw. (Family: Athyriaceae) is one of the very popular edible ferns found throughout Asia and Oceania. It is probably the most commonly consumed fern. It is known as *pucuk paku* and *paku tanjung* in Malaysia, *pakô* in the Philippines, *dhekia* in Assam "Dhenkir Shaak Bengali", paloi saag, *ningro* in Nepali and *linguda* in Northern India, referring to the curled fronds. The plant is sold in bundles of fresh aerial parts in the local markets and believed to be the tastiest among other ferns locally used. *Diplazium esculentum* is a vascular plant and belongs to the class of Pteridophyta. It does not produce seeds or bear fruits but is propagated through spores. The plant is mainly terrestrial, growing in open marshy areas, stream banks and canals from sea level to 2,300 m above mean sea level and occasionally on limestone rock. Rhizome erect, rhizome scales dark brown with black margins, up to 10 mm long, margins finely toothed; vegetatively spreading and forming colonies from root buds. Fronds large, tufted, erect. Stipe up to 6 cm long, grooved, pale brown above, darker and more scaly at the base. Lamina 2- to 3-pinnate, up to 0.85 m × 0.6 m, triangular in outline. Pinnules triangular-linear, variable in size, up to 8 × 2.5 cm, dark green, subsessile, very shallowly cut into lobes with rounded apices, margins toothed, glabrous above, but costules and veins below with scattered, pale brown scales; veins free or forked, basal 3-5 pairs of adjacent veins anastomosing below the sinus. Rhachis grooved, subglabrous with small light brown scales especially along the groove. Sori linear, set along most veins; indusium dark brown, thin, margins becoming uneven with age.

Diversity

The genus *Diplazium* comprise 400 species distributed in different regions. The rare fern *Diplazium molokaiense* was reported in East Maui, Hawaii. *Diplazium fimbriatum* has been reported as a new species from Brazil. Several *Diplazium* spp. are known from Thailand (*Diplazium bantamense*, *Diplazium cordifolium*, *Diplazium crenatoseratum*, *Diplazium esculentum*, *Diplazium polypodioides*, *Diplazium riparium*, *Diplazium silvaticum*, *Diplazium simplicivenium*, *Diplazium sorzogonense* and *Diplazium tomentosum*). Indonesia also possesses many *Diplazium* spp. (*Diplazium asperum*, *Diplazium cordifolium*, *Diplazium esculentum*, *Diplazium lomariaceum*, *Diplazium pallidum*, *Diplazium simplicivenium*,

Diplazium sorzogonense and *Diplazium tomentosum*). Nearly 40 species of *Diplazium* are reported in India and upto 17 species have been reported in Sikkim alone. The common *Diplazium* in India include *Diplazium bellum*, *Diplazium dilatatum*, *Diplazium doederleinii*, *Diplazium esculentum*, *Diplazium forrestii*, *Diplazium kawakamii*, *Diplazium latifolium*, *Diplazium laxifrons*, *Diplazium longifloium*, *Diplazium maximum*, *Diplazium medogense*, *Diplazium polypodioides*, *Diplazium sikkimense*, *Diplazium spectabile*, *Diplazium squamigerum* and *Diplazium stoliczkae*. *Diplazium spp*. has also been reported from Western Ghat regions of Maharashtra, Karnataka, Kerala and Tamil Nadu.

Distribution

Diplazium esculentum is an edible fern, pan tropical in distribution and occurs widely and commonly throughout India, China, Cambodia, Laos, Thailand, Vietnam and Malaysia. It grows in gregarious colonies in open marshy areas, stream banks and canals from sea level to 2,300 m. In India it is distributed in West Godavari and Srikakulam districts of Andhra Pradesh; Chakmanglur, Hassan, Kodagu, Shimoga and Uttara Kannada district of Karnataka; Similipal hills, Kalahandi district, Mahendragiri hills, and Berbera forest of Odisha; Kullu, Kangra, Shimla, Kinnaur, Solan and Lahaul Spiti districts of Himachal Pradesh and Poonch, Bhadarwah and Reasi districts of Jammu and Kashmir.

Prospects and potential

Diplazium ferns are considered the most important ferns for human consumption. They show potential as 'functional food' in view of the significant therapeutic and nutritive benefits. The tender uncurling leaves of *Diplazium* are eaten boiled or steamed as a leafy vegetable or raw as a salad with various dressings. It is an appreciated vegetable, being slimy and sweetish after cooking. Occasionally it is used as an ingredient in more complicated dishes. *Diplazium esculentum* is the most palatable and most popular vegetable fern used as human food in the world. It is reported that the edible fronds of this fern are rich in iron, phosphorus, potassium and protein. It is believed by the native tribes in India that *Diplazium esculentum* serves as an appetizer and useful to treat constipation. The decoction of dried rhizomes of this fern serves as laxative, anti-inflammatory, antioxidant, anthelmintic, antimicrobial, cytotoxic and has the capacity to cure haemoptysis as well as cough. The *Diplazium esculentum* is also known for β carotene, folic acid, phytic acid and tannins. An extract of mature leaves is applied externally against fever and the leaves are rubbed on the body to get rid of the unpleasant smell of sweat. The pulverized rhizome, soaked in water, is taken against diarrhoea and dysentery. Besides this, *Diplazium esculentum* and *Diplazium proliferum* are also attractive ornamentals in gardens and are widely cultivated for this purpose.

Diplazium esculentum

Bathua *(Chenopodium* spp.*)*

The genus *Chenopodium* belongs to the Amaranthaceae, syn. Chenopodiaceae family. With a few exceptions, the majority of them are annual weeds. The genus includes herbaceous and perennials, and is distributed throughout Asia, America and Europe. Chenopodiaceae has been included as one of the six families that lack clear delimitation or valid synapomorphies. It is erect annual herb up to 1.5 m tall. The young vegetative parts are densely clothed with mealy-white or red-purple vesicles. Stem is angular, ribbed, with longitudinal dark green or red streaks. Leaves are alternate, simple and lower leaves have long petioles, irregularly and coarsely toothed or incised, while higher ones gradually have shorter petioles, elliptical-oblong-lanceolate, less deeply incised or entire. The inflorescence is axillary and terminal leafy panicle consisting of clusters of flowers. Flowers are bisexual, regular with superior ovary. Seed is nearly smooth, lenticular and 1–2 mm in diameter.

Diversity

Genus *Chenopodium* comprises 250 species, which are herbaceous perennials belonging to the family Amaranthaceae (syn. Chenopodiaceae). The genus is economically important because many species e.g. *Chenopodium quinoa*, *Chenopodium berlandieri* subsp. *nuttalliae*, *Chenopodium pallidicaule*, *Chenopodium album* and *Chenopodium giganteum* have a long history of domestication as grain, vegetable or forage crops. Among these, *Chenopodium quinoa* is a high protein pseudo cereal and used as staple grain grown in South America, though recently its cultivation is spreading to many other parts of the world. Both *Chenopodium quinoa* and *Chenopodium berlandieri* subsp. *nuttalliae* are allotetraploids, though studies with regard to their exact genomic constitution, mode of origin and phylogenetic relationships with other related wild species are at a preliminary stage.

Distribution

Amaranthaceae is a widespread cosmopolitan family and is spread from the tropics to cool temperate regions, whereas Chenopodiaceae had its centers of diversity in dry temperate and warm temperate areas. Genus *Chenopodium* has a worldwide distribution and contains about 250 species; 21 species have been reported in India. The most widespread species in the Indian subcontinent is *Chenopodium album* L., a common weed in wheat fields in northern India. It is popularly known as bathua in Hindi. Other reported *Chenopodium* weed species in India include *Chenopodium ambrosioidas*, *Chenopodium murale*, *Chenopodium opulifolium* and *Chenopodium botrys*. *Chenopodium album* grows as a weed all over India and some names in other Indian languages include Chakvit

Bathua

(Konkani), Vastuccira (Malyalam), Paruppukkirai (Tamil) and Pappukura (Telugu). The common English names are goosefoot and lambs quarters.

Prospects and potential

Bathua has been used in India as green vegetable and for stuffing parathas (layered bread) in north India since ages. The leaves of *C. album* are rich in protein (2.6–6.4%), carotenoids (78–190 mg/kg) and vitamin C (0.5– 2.5 mg/kg). Its flour mixed with wheat flour can be used for making chapatis and when mixed with gram (*Cicer arietinum*) flour, it can be used for making sweets, such as laddoos. In Himachal Pradesh, its grain is used for making a gruel-type dish called phambra or laafi and for making mildly alcoholic beverages such as soora or ghanti. It has also been used in Ayurvedic and local medicines in India as a blood purifier, hepato-protective, laxative, and diuretic, sedative and anthelmintic against round and hook worms. However, it could not emerge as a foodgrain crop, due to large biodiversity provided by Himalayas and it had to compete with other crops like buckwheat (*Fagopyrum esculentum*) and a number of small millets such as barnyard millet (*Echinochloa crusgalli*), proso millet (*Panicum miliaceum*), little millet (*Panicum sumatrense*), kodo millet (*Paspalum scorbiculatum*) and fox tail millet (*Setaria italica*), which have larger grain size, which was one of the criteria used by ancient humans in domesticating plant species. However, people of Andes, South America (Peru, Bolivia, Ecuador, Venezuela, Colombia, Chile and Argentina) domesticated quinoa (*Chenopodium quinoa* Wild) around 3000–4000 years ago and made it a successful grain crop. Quinoa has been an important staple in the Andean culture.

Jangli Palak (*Rumex* spp.)

Rumex nepalensis belongs to Polygonaceae family. It is an herbaceous, perennial plant producing erect, branched stems 50–180 cm tall from a large rootstock. The basal leaves of *Rumex nepalensis* may be different from those near the inflorescence. The inconspicuous flowers are formed like whorls quite above the leaves. The flowers are hermaphrodite and can act as male or female flowers. The plants have high amount of oxalic acid which gives an acid flavor to its leaves.

Distribution

Members of this genus are very common perennial herbs with a native almost worldwide distribution, and introduced species growing in the few places where the genus is not native. The plant is grown in many parts of India. In India, it is found grown in Assam, Himachal Pradesh, Kashmir, Meghalaya, Western Peninsula and temperate Himayalas.

Jangli palak

Prospects and potential

The leaves of *Rumex* spp. (Polygonaceae) plants are used in traditional medicine for the treatment of several health disorders such as infections, diarrhoea, diabetes, jaundice, oedema, hypertension, diuretic, analgesic and inflammation. It has various pharmacological activities such as antitumor, antibacterial, antiviral, antifungal, antioxidant, antiplasmodial, antinematodal and antiinflammatory activities. Antraquinones, flavonoids, stilbenoids, naphtalanes, tannins, tritepenoids, carotenoids, polysaccharides have been reported in the *Rumex* spp. It is used as a substitute for rhubarb. A decoction of the root is drunk for the treatment of rheumatism, colic, stomach-ache and abdominal pains caused by intestinal parasites. The leaves are used in the treatment of colic. The plant is also considered to be antidote, depurative and laxative, as well as a medicine for treating coughs and headaches. The root contains 5-13% tannin. It is used for dyeing. Dark green to brown and dark grey dyes can be obtained from the roots of many species in this genus.

Indian Spinach (*Basella* spp.)

Basella alba L. (2n=48) and *Basella rubra* L. (2n=44) are one of the rapidly growing leafy vegetables, also noted by regional names in different regions in Asia viz. Ceylon spinach, Malabar spinach, Saan Choy (Chinese), mong toi (Vietnamese), Alugbati (Philippines), Pui Saag (Bengali), Remayong (Malay) belongs to the family Basellaceae and order Caryophyllales. Although the plant is a perennial climber, it is cultivated as an annual leafy vegetable. It is an important and reliable source of income for marginal and small farmers and tribal folks of India. It is widely adapted to a variety of soils and climates. It thrives well in tropical and subtropical climate. Being a warm season crop, it is extremely heat tolerant and frost tender. It

Basella spp.

can thrive under conditions of moderate soil fertility and can grow in highly acid soils, but is quite responsive to nitrogen fertilizer. It is a minor leafy vegetable and since it is generally grouped together with other greens.

Distribution

It is native to tropical Asia, probably originating from India or Indonesia. The distribution of Basella extends from the tropical and subtropical regions mostly America, Africa, Madagascar and south India to New Guinea. It is grown in almost all parts of India, tropical Asia and Africa. It is gaining popularity in some of the tropical and temperate climates of Asia, America, Australia and Europe.

Prospects and potential

The plant is found to be versatile in properties. It can be used as leafy vegetable, ornamental, dye and medicine. Tender shoots with succulent stem along with thick, semi-succulent and mucilaginous leaves are used as leafy vegetable. It is appreciated for its organoleptic characteristics and makes a tasty addition to salads, dips and meals. The leaves are also used for making soups. It has high economic, nutritional and medicinal values. This crop is a valuable income source for marginal and small farmers near the principal urban centers. It plays a vital role in food and nutritional security particularly during the dry periods. It is rich in food value, supplying minerals, vitamins, proteins, carbohydrates and dietary fibre. It is a good source of calcium, iron, vitamin A, vitamin B9 and vitamin C. *Basella alba* has been used from a long time back for the treatment of many diseases like dysentery, diarrhea, anaemia and cancer. The Ayurvedic treatment in India used *B. alba* leaves and stems for anticancer such as melanoma, leukemia and oral cancer. In India, it has been used for antipruritis and burn, and has been used in Bangladesh for acne and freckle treatment. Stems and leaves are used as mild laxative, diuretic and antipyretic. Roots and leaves have been used for the removal of after birth and stomach pains and for increasing milk production. A decoction of the leaves is a good laxative for pregnant women and children. The boiled leaves along with sorghum flour are an effective antiulcer agent. The roots are used in the treatment of diarrhea, the cooked leaves and stems are used as laxatives. The flowers are used as an antidote to poisons and also as diuretic and febrifuge.

Sonchal *(Malva* spp.*)*

Common mallow can be found growing erect or prostrate, which may initially cause confusion because it is easy to assume they might be two different species. Mallow's kidney-shaped or palmately-lobed leaves are notably creased, typically with dentate margins. The leaves often show a purple spot in the centre of the base of the leaf and this can also be seen to run down the petiole on some specimens. On other specimens, the purple spotting and coloring is completely absent. Mallow leaves have long petioles. Their deep green foliage hints at a renowned drought tolerance. During flowering, the leaves appear alternately on the stems. Holding a leaf relays the surface coarseness. But tear and crush one, and you discover a family pattern-the mucilage. You will soon experience a slimy and tacky feel between your fingers. All parts of the plant contain mucilage. In bloom, the Malvaceae family plants produce five large notched petals in each open flower. Common mallow has showy pink petals laced with darker-colored strokes. In the centre of the flower lies a pollen-loaded column of fused stamens. This surrounds the stigma, which rises above the column. Mallow is known to freely seed. The round seed pods, known as 'cheeses', soon follow flowering. These were once munched by children on their way to and from school. The pods are held on stalks, close to the flowering stem.

Distribution

This species is globally distributed in temperate and subtropical Eurasia, introduced and naturalised in North America. Within India, it is found from Kashmir to Kumaon up to an altitude of 2400 m. Bihar and parts of the Deccan Peninsula, mostly as a weed. It is also cultivated in gardens.

Prospects and potential

As with many wild food plants, the common mallow also has a long history of medicinal use. Due to its high mucilage content, mallows make excellent soothing demulcent herbs, especially for cases of inflammation, either for the urinary, digestive or respiratory systems. Pregnant women or new mothers may like to know that mallow leaves can provide useful amounts of iron,

Sonchal

as well as being quite high in zinc and most vitamins. Creative cooks can substitute mallow for spinach in many dishes, including soups, salads, gnocchi and quiche. Mallow also makes a great addition to soups, whereby the mucilage helps to thicken them. During the war of 1948, when Jerusalem was under siege, mallow was an important famine crop, and one that is still celebrated on Independence Day every year with a traditional dish made from mallow leaves. In China, mallow roots are a popular and a common ingredient in making hearty, yet medicinally potent soups and broths. The seed pods can be substituted for most of the egg white if desiveting to make mallow meringues.

Tarad *(Dioscorea* spp.*)*

It is a non woody vine, twining, glabrous and attains 10–15 m height. It has shallow, fibrous root system which is mostly confined to the top 1 m of the soil. Tubers are usually single which vary in size and shape, often very large cylindrical or clavate in shape or globose, stout and short, pyriform, lobed or fingered and fascinated or curved. The colour of the skin vary from brown to black, with white, cream or purplish flesh. Leaves are mostly opposite, sometimes alternate on branches of rapid growth. Inflorescences are axillary, unisexual, pendulous. Staminate inflorescences are paniculate that contain numerous male flowers. Pistillate inflorescences are racemose, with few flowers. Fruits 3 locular capsule, 2-3 cm wide, each locule flattened like a wing, with 2 seeds inside.

Diversity

The family Dioscoreaceae includes about 4-6 genera and 870 species. The members of this family are often herbaceous climbing vines. The circumscription of this family remains controversial. While some authors define this family in a strict context including only the genera *Dioscorea, Tamus* and *Rajania*, others define this family in a broader context, also including the genera *Avetra, Trichopus, Stenomeris* and *Tacca*. The genus *Dioscorea* includes about 350 – 800 species distributed largely in the tropics, but also in the warm and temperate regions. Species in this genus are dioecious, twining and herbaceous to woody vines with single or clustered large tubers, some of which are edible and are known as yams.

Distribution

Yams (*Dioscorea spp*.) are important food security crops for millions of small-scale farmers in the tropical and subtropical regions of Africa, Asia, the Pacific, the Caribbean and Latin America. It is locally called as 'Tarad' in Northern India. *Dioscorea alata* (known as the 'greater yam' or the 'winged yam') is one of the major cultivated species with wide geographical distribution. Several traits of *Dioscorea alata* make it particularly valuable for commercial cultivation. These include high yield potential, ease of propagation, early growth vigour for weed suppression, and long storability of tubers. Tubers possess a high nutritional content with an average crude protein content of 7.4 %, starch content of 75–84 %, and vitamin C content ranging from 13.0 to 24.7 mg/100g.

Prospects and potential

Dioscorea species with nutritive and antioxidant content not only enrich the diet of the local rural and local people but also make them ethnomedicinally important. Tubers of different species of *Dioscorea* are used for curing various diseases and ailments in different formulations. Most of the tubers of *Dioscorea* are used for birth control and skin infections. Tubers and vegetative parts of these species are used either in single or in multiple formulations. This chemical can be made in the laboratory into various steroids, such as estrogen and dehydroepiandrosterone (DHEA). The root and the bulb of the plant are used as a source of diosgenin, which is prepared as an 'extract,' a liquid that contains concentrated diosgenin.

Ethno medicinal uses of 16 species of *Dioscorea* have been documented for their therapeutic properties for curing various ailments such as cough, cold, stomach ache, leprosy, burns, fungal diseases, skin diseases, contraceptive, dysentery, arthritis, rheumatism, etc and among these species *Dioscorea alata*, *Dioscorea pentaphylla*, *Dioscorea bulbifera* and *Dioscorea villosa* show maximum medicinal properties. *D. deltoidea* is quite exceptional because extract of its tubers is mostly used as a detergent to wash clothes and as an insecticide. It is not used for culinary purpose because of the presence of hard and fibrous tubers and its poisonous nature. Again consumption of *Dioscorea*

Dioscorea pentaphylla *Dioscorea alata*

Tarad *(Dioscorea spp.)*

bellophylla lowers blood cholesterol and thereby reducing the chances of heart attacks. *Trinervia* can cure chronic diarrhoea, asthma and diabetes. *Dioscorea hamiltonii* is used in religious rites. It is seen that tubers or rhizomes of almost all the species are edible. They are eaten boiled or roasted or as vegetables or cooked with mushrooms and other vegetables in curries. The most preferred and valuable edible species recorded are *Dioscorea alata*, *Dioscorea esculenta*, *Dioscorea pentaphylla*, *Dioscorea pubera*, *Dioscorea bulbifera*, *Dioscorea aculeata*, *Dioscorea sativa* and *Dioscorea arachnida*.

Chulai

Chulai *(Amaranthus spp.)*

It is commonly called as Chulai belonging to family Amaranthaceae. It is primarily used as pot herb. It is most common leafy herb grown in India during summer and rainy season. Most of the *Amaranthus* spp. are originated from India or Indi China region. Among leafy types *Amaranthus tricolour* L. is the main cultivated species of India. It is an annual herbaceous plant, 30–60 cm in height. It has stout stems, much branched, with angular, glabrous leaves arranged spirally, simple elliptic to lanceolate. Leaf colour dark green, light green or red. Terminal leaves may be red, purple, yellow or variegated. Inflorescences borne terminal and axillary, globose cluster up to 2.5 cm in diameter, upper clusters form a terminal spike, male and female flowers intermixed. Flowers unisexual, subsessile. Male flowers have three stamens, female flowers have superior single celled ovary with three stigmas. Fruit ovoid-urceolate capsule.

Distribution

Tropical Asia, mainly South Asia, more variability in the Himalayas and northern plains of India; also Bangladesh, Sri Lanka; partially domesticated and grown in home gardens. Leaves boiled as soup, or chopped and cooked as a vegetable; also *A. viridis*, the green amaranth. *Amaranthus* spp. (Amaranthaceae). South/Southeast/East Asia; also sporadic distribution in the Pacific Islands. The amaranth-vegetable genepool has several species grown as pot herbs, in backyards, kitchen gardens/home gardens - *Amaranthus blitum*, *Amaranthus dubius*, *Amaranthus tricolor/ gangeticus*, *Amaranthus graecizans*, *Amaranthus polygonoides*, *Amaranthus spinosus*, *Amaranthus viridis*. Most of these have sporadic distribution with native or introduced diversity being grown for local use; some like *Amaranthus paniculatus/Amaranthus tricolor* are more popular with wider distribution and diversity of local and improved types.

Diversity

Diversity of *Amaranthus* (Family Amaranthaceae) can be observed from sea level to high altitudes even in the worse climatic conditions, and they are rich in micro nutrients and bioactive compounds. In the rural areas of India, amaranths occupy an unparalleled position and are been used in a large number of culinary preparations.

Prospects and potential

The cultivated amaranths are utilized as food grains, leafy vegetables, and forage crops in diverse geographic areas, such as America, China, Greece, Italy, Russia, Nepal, and India. The superior nutrition, drought tolerance, disease and pest resistance, high yield in production, and increasing rate of consumption have made this crop more attractive for cultivation in developing countries such as India. Compared with traditional crops, this pseudo cereal is rich in protein (17–19% of dry weight) with double the amount of essential amino acids than wheat grain protein. It is considered to have medicinal properties and is used against external inflammation and bladder distress. It is also reported to improve the kidney function and aid digestion. The roots of red spinach are used as a remedy for dysentery. It is highly recommended for consumption by patients with colon cancer, diabetes mellitus, high blood cholesterol.

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Sudhakar Pandey, Tribhuvan Chaubey, R K Dubey, P Karmakar, Keshav K Gautam, Vikas Singh, D R Bhardwaj and P M Singh

Status, diversity and potential of indigenous and minor cucurbitaceous vegetables

The main goal of research on cucurbits in India is to double the productivity on sustainable basis. The breeding programmes have been shifted towards development of biotic stress and abiotic resistant varieties/hybrids coupled with quality attributes. Cucurbit breeding strategy and targets are dependent on consumer demand. Indigenous cucurbitaceous vegetables like cucumber, bitter gourd, pointed gourd, ash gourd, teasel gourd etc. have significant nutritional, medicinal and economic importance due to presence of several bioactive compounds responsible for therapeutic activities, usefulness for processing purpose and comparatively higher market price. Pointed gourd and teasel gourd are highly suitable for small and marginal farmers due to their high market value and minimal price fluctuation. In present time, there is a large Indian population residing in foreign countries especially in middle east Asia, south east Asia, Australia, USA, Canada etc. and there is huge demand of indigenous cucurbit vegetables i.e. pointed gourd, bitter gourd, ridge gourd, ivy gourd. Farmers may benefit from export of these vegetables.

CUCURBITS are vegetable crops belonging to family Cucubitaceae, which primarily comprises 118 genera and 825 species. In India, 37 genera and about 100 species of cucurbits, including wild and cultivated, have been reported. About 60 cucurbit crops are grown in India and half of these are indigenous to India or Indian subcontinent. These indigenous crops are grown in summer and rainy season in northern and eastern part, while throughout the year in southern part of India. In India, cultivation of these crops is fitted in several commercial cropping systems and also as popular kitchen garden crops. Cucurbits are variously used as food, medicine, as well as utilitarian and ornamental items. Some cucurbits possess industrial importance too. These cucurbits are consumed in various forms i.e. salad (cucumber, gherkins, longmelon), sweet (ash gourd, pointed gourd), pickles (gherkins and cucumber) and others in culinary purpose. Cucurbits share ~5% of the total vegetable production in India which includes indigenous cucurbits. Being the largest group of vegetables, cucurbits provide better scope to enhance overall productivity and production of vegetable to meet the challenges. The important indigenous cucurbit crops grown in India are cucumber, bitter gourd, ridge gourd, sponge gourd, pointed gourd, ash gourd, snake gourd, ivy gourd, longmelon, roundmelon, snapmelon and spine gourd.

Role in diet diversification and medicinal importance

With the changing lifestyle and dietary pattern, the consumers in India are becoming more health conscious and also want more vegetable diversification and a continuous supply. In cucurbits, generally fruits are eaten but in case of longmelon, pointed gourd tender leaves are also equally preferred. Cucurbit vegetables are purchased partly based on their nutritive values, appealing appearance and price. Product differentiation, including introduction of new types is still a key strategy for expanding sales in vegetable markets. For example, the introduction of new vegetables such as ivy gourd, longmelon, sweet gourd and hermaphrodite ridge gourd (satputia) in market has opened new opportunities for domestic producers. To exploit important virtues of cucurbits, it is important to continue research, disseminate information regarding the nutritional benefits of these vegetables, develop new improved cucurbit cultivars, processed products, evaluate the economic opportunities and the market scope of these new products, and identify marketing trends and alternatives. Providing customers with innovative combinations of products (pickles from cucumber, sweets and candy from ash gourd and pointed gourd, juice from ash gourd, chips and powder from bitter gourd) and services is the key to the processed vegetables.

The Cucurbitaceae family still retains a lot of medicinal properties, but in the medicine field they are not gaining popularity because the healing ability of these vegetables is not known to people. The research work was done over a few decades to find out the phytochemical significance of cucurbits. Cucumbers are known for their cooling and astringent properties. It is very useful in curing skin problems, hence, commonly used in formulation of cosmetics. The seed of cucumber has medicinal properties which are tonic and diuretic. The fruit of bitter gourd is having an anthelmintic, stomachic, antibilious and laxative properties and used as febrifuge, rheumatism, gout and disease of liver and spleen. Fruit juice of Bitter gourd has been used as traditional medicine for diabetes because it

is having insulin like polypeptides which is responsible for hypoglycemic properties. Leaves of ridge gourd are used as poultice in haemorrhoids, leprosy and splenitis; juice in conjunctivitis and jaundice; decoction for uraemia and amenorrhoea. Fruit are demulcent, diuretic and nutritive. Juice of sponge gourd leaves are used to cure conjunctivitis and jaundice. Roots have laxative effects and seeds are used for treatment of asthma, sinusitis and fever. Snake gourd's leaves and stems are used for the treatment of skin disease, whereas fruits are used as appetiser. The seeds of snake gourd have deworming properties. The leaves and stems of pointed gourd are hypocholesterolemic, hypoglyceridimic, hypoglycemic, hypophospholipemic and commonly prescribed for digestive complaints as tonic and febrifuge. Fruit extract helps in lowering cholesterol activity and blood sugar. The roots are diuretic and good medicine for ascites.

Fruits of ivy gourd are also used for the treatment of leprosy, fever, asthma, bronchitis and jaundice. Its leaves are used to control skin disease. The fruit of ash gourd is nutritive, diuretic, styptic and purgative and also has low calorific value. Its regular use relieves piles, dyspepsia, diabetes and inflammation in digestive system. The fruit juice is beneficial in treatment of peptic ulcer, haemoptysis, respiratory trouble and other internal haemorrhage discharges from stomach, lungs, kidneys, etc. It acts as a blood coagulant. The shelled seeds are also useful to expel out intestinal worms.

Origin and distribution

Cucumber

Cucumber (*Cucumis sativus* L.) is an indigenous vegetable to India. It is under cultivation over 3000 years. Burma could be regarded as a secondary centre of origin of this crop. The possible progenitor of cucumber is *Cucumis hardwickii* R. The cucumber seed was carried westward to Asia Minor, North America and Africa. It is grown throughout the world in sub-tropical and tropical climates. The sub genus cucumber X=7 consists of 3 Sino Himalayan species including *Cucumis sativus* (cucumber), *Cucumis hystrix* (Syn. *muriculatus*) and *Cucumis hardwickii* R. *Cucumis hardwickii* R., a small bitter cucumber with sparse and stiff spines, has been found in wild in the foothills of Himalayas. Free hybridization with cultivated *Cucumis sativus* with no reduction of fertility in F_2 generation might be a feral form or more likely progenitor of the cultivated cucumber.

Bitter gourd

The origin of bitter gourd is India (Indo-Burma centre of origin). The region of eastern India and southern china are suggested as possible center of domestication. It is widely cultivated in India, Indonesia, Malaysia, Singapore, China, Japan, South-East Asia, tropical Africa and South America. Wild *Momordica charantia* var. *abbreviata,* a native of Asia, may be the progenitor of bitter gourd. The somatic chromosome number of bitter gourd is 2n=2x=22. The related species of bitter gourd are *Momordica dioica* Roxb. ex Wild., *Momordica cochinchinensis* (Lour.) Spreng., *Momordica tuberose* (Roxb.) Cogn. (syn. *Momordica cymbalaria*), *Momordica balsamina* L. and

Bitter gourd variety – Kashi Mayuri

Momordica cabriei. Among the above, first 2 species bear edible and cultivated. Wild species of genus *Momordica* are *M. subangulata* Bl., *M. denudata* and *M. macrophylla*.

Ridge gourd and sponge gourd

Both crops originated in India. They are found wild in the North-West of India. It is only genus of the subtribe *Luffinae* C. Jeffr., tribe *Benincaceae* Ser., sub family cucurbitoideae. The genus includes 7 species, 4 paleotropic and 3 neotropic in distribution. Two species are cultivated i.e. *Luffa acutangula* (L.) Roxb. (2n=26 ridge gourd, ribbed gourd, angled *Luffa*) and *Luffa cylindrica* M.J. Roem. (2n= 26 sponge gourd, towel gourd, smooth loofah, vegetable sponge dish cloth gourd, syn. *L. aegyptiaca* Mill.). Other related species are *Luffa operculate* (L.) Cogn. (grown in tropical America), *Luffa graveolens*, *Luffa umbellate*, *Luffa peritadra*, *Luffa gigante*, *Luffa scabra* and *Luffa narylandica*.

Satputia variety – Kashi Khusi

Ash gourd

Ash gourd is believed to have originated in Indo-Malayan area of Southeast Asia and Japan. However. Indo-China area is the center of greatest diversity. It is widely cultivated in India, China, Malaysia, Indonesia, Philippines, Taiwan, Bangladesh and the Caribbean Islands. It is grown up to an altitude of 1500 m. *Benincasa* is monospecific genus, *B. hispida* (Thunb.) Cogn. (syn. *B. cerifera* Savi.) belonging to the tribe Beniscaseae Ser., subfamily Cucurbitoideae. In ash gourd four major cultivar groups are recognized i.e. (i) a late maturing winter melon group that have unridged seeds and cylindrical (50-100 cm long), dark green fruit, sparse wax, (ii) a ridged winter melon group that is similar except the seeds are ridged, (iii) a fuzzy gourd group with ridged seeds and narrow

Variety Kashi Surabhi

Waxless Ashgourd

cylindrical (20-25 cm long), green, hairy, sparsely waxed fruit, and (iv) the wax gourd group that also has ridged seeds, and oblong (10-60 cm in diameter), light green waxy and sometimes hairy fruit.

Pointed gourd

Trichosanthesis is a large genus of Indo-Malayan distribution, with about 44 species, of which 22 are found in India. The species of *Trichosanthes*, especially *T. dioica*, originated in the Old World, most probably in India. The name petola or patala, which signifies snake gourd (*Trichosanthes cucumerina*) in Malay Peninsula and Philippine islands, is of Sanskrit origin (patola), indicating that the genus *Trichosanthes* may be indigenous to India. Assam-Bengal region of India was the primary center of origin because this region, including Bangladesh, exhibits a rich species diversity of this crop. However, wild forms of *T. dioicadioca* are found throughout northern India.

Pointed gourd

Snake gourd

Snake gourd (*Trichosanthes cucumerina* L., syn. *Trichosanthes anguina* L.) occurs in the wild form in India, South-East Asia and tropical Australia. The Indian Archipelago is thought to be its place of origin. The genus includes about 40 species occurring in East, South Asia, tropical Australia, and Fiji. The species are distributed in South-East Asia, extending through Malaya to North Australia in one direction and China to Japan in another. Generally the genus is divided into 2 sections namely Eutrichosanthes and Pseudotrichosanthes, former containing 23 species and the latter 3 only. Two cultivated species under the genus are *Trichosanthes anguina* and *Trichosanthes dioica.*

Ivy gourd

Ivy gourd is believed to have its origin in India. It is distributed in Burma, Pakistan and whole South East Asia. It is grown in most part of India, tropical Africa, Central America, China, Malaysia and other tropical countries. It has 30 species in the old world, most are in Africa. Only one species *Coccinia indica* (syn. *Coccinia cordifolia*, *Ciphlandra indica*) is cultivated and occurring naturally throughout India and Tropical Africa.

Ivy gourd

Longmelon

Longmelon (*C. melo* var. *flexuous*) popularly known as *kakri* is valued for tender fruits which are eaten as salad. It is warm season crop grown mainly in tropical and sub-tropical regions, popular during summer months in most part of the country due to its cooling effect. In Middle Eastern countries where longmelon fruit is known as Armenian cucumber whose immature fruit used in salad as well as cooked. Longmelon grow well at day temperature between 25-35^{0}C and also tolerates cool

Snake gourd

Long melon

climate better than other melons. It cannot tolerate frost and strong winds. Low temperature and high relative humidity stimulate the development of female flowers. The pale green fruit are long and slender with a smooth longitudinally slightly ridged surface. Fruit length varies from 20 cm to 1 m and diameter from 4 to more than 10 cm.

Snapmelon

Snapmelon (*C. melo* var. *momordica* Duthie & Fullar), is commonly grown in North India during rainy season in mixed cropping, with its vines trained on maize or sorghum. Its production and popularity is largely limited to India, where it is locally called 'Phoot' which means 'to split.' The name Phoot/Snap is related with the cracking of fruit surface and its disintegration with advancing maturity. The fruits are oval or elliptic, with smooth skin, orange or light yellow in colour with weight about 900 g. The striped fruit has a light orange or white mealy flesh and sourish without sugar or aroma. The plants are monoecious. Immature fruits are cooked or pickled. After removing the coat, seeds are used in bakery products and the traditional drink 'thandai' and rich source of vitamin C, iron and calcium.

Roundmelon

Praecitrullus fistulosus is commonly known as Tinda and Indian round gourd in English with basic chromosome n=12. It is an annual, creeping or climbing herb with round fruits of the size of a small beet, pale or dark green in colour with black to brown seeds. Two type of fruits usually grown as a vegetable one with green fruits and the other with pale green fruits. *Praecitrullus fistulosus* is cultivated as a vegetable in India, Pakistan and Afghanistan. The origin is probably north-western India, where wild types may still be found and cultivated in Pakistan and Afghanistan. In India, Punjab, Western Uttar Pradesh, Mumbai and Rajasthan are major growing areas as well as important markets. It likes warm, sunny conditions of 25-30°C at daytime and 18°C or more during the night and performs less well in cooler and humid areas. In India, it is either grown in the dry season (February to end of April) or in the rainy season (mid-June to end of July).

Teasle gourd

The teasle gourd (*Momordica subangulata* Blume ssp. renigera) is probably native to India. It is dioecious in nature and a perennial climber with tuberous roots mainly cultivated in Assam, West Bengal, Bihar, Odisha, North-eastern states, Maharashtra, Gujarat and Andaman Islands. This high quality minor crop could play an important role in food and nutritional security than many currently commercially produced crops, which are low in vitamins and minerals. Unavailability of improved varieties, difficulties in propagation by seed due to dormancy, low multiplication rate, and unpredictable sex ratio in seed-based populations are problems in increasing the yield potential of the teasle gourd. This crop has many problems, including poor natural pollination of female flowers and susceptibility to biotic stress.

Teasle gourd

Spine gourd

Spine gourd (*Mamordica dioica* Roxb) is an underutilized vegetable of high nutritional, medicinal and economic value. It is a native of tropical regions in Asia, Polynesia besides tropical Africa and south America. As many of the species of this genus have been found to grow wide in India, Bangladesh, Sri Lanka, Myanmar and Malaysia etc. which indicates that this region might be the origin

Round melon

Spine gourd

of spine gourd. Spine gourd is mainly grown in Odisha, Bihar and West Bengal but occurs as wild in Punjab, Uttar Pradesh, Rajasthan, Madhya Pradesh, Kerala and Maharashtra. Spine gourd has a number of problems including low yield. Fruits become inedible at maturity owing to the presence of large number of hard seeds. Low rate of tuber production (10-20 tuberous pieces per year); germination of seeds is very low or impossible due to hard seed coat, non-availability of improved varieties, difficulties in propagation by seed due to dormancy, dormancy of tubers and unpredictable sex ratio in seedling progeny.

Plant genetic resources and registered unique germplasm

In India, ICAR institutes and State Agriculture Universities are involved in collection, conservation and utilization of indigenous cucurbits (Table 1). Rich genetic diversity in wild and cultivated species of *Luffa*, *Momordica*, *Cucumis*, *Coccinia* and *Trichosanthes* has been augmented. There are several cucurbits, which have adaptability to a particular region of India i.e. *Momordica cochinchinensis* to Tripura, Assam and West Bengal, and *Trichosanthes dioica* to Eastern Uttar Pradesh, Bihar and West Bengal.

The Indian Institute of Vegetable Research is a National Active Germplasm Site for the systematic management and utilization of germplasm wealth of vegetable crops including indigenous cucurbits. The major activity includes collection, evaluation, maintenance and distribution of germplasm (Table 2).

Table 1. Institutes/SAUs involved in the research activity of indigenous cucurbits

Crop	ICAR institute/SAU/CAU
Cucumber	IIVR, Varanasi; IIHR, Bengaluru; IARI, New Delhi; HPKV, Palampur; MPKV, Rahuri; GBPUAT, Pantnagar
Bitter gourd	IIVR, Varanasi; IIHR, Bangalore; IARI, New Delhi; PAU, Ludhiana; KAU, Vellanikkara; TNAU, Coimbatore; CSUAT, Kanpur
Pointed gourd	IIVR, Varanasi; BAU, Sabour; HARP, Ranchi; Kalyani; NDUAT, Faizabad; IGKV, Raipur
Snake gourd	KAU, Vellanikkkara; TNAU, Coimbatore
Ivy or scarlet gourd	IIVR, Varanasi; IGKV, Raipur; CHES, Bhubaneswar; TNAU, Coimbatore; BAU, Sabour
Longmelon	PAU, Ludhiana; IIVR, Varanasi; CIAH, Bikaner
Snapmelon	IIVR, Varanasi; IARI, New Delhi; CIAH, Bikaner
Roundmelon	HAU, Hisar; IIVR, Varanasi; IIHR, Bengaluru
Ash gourd	IIVR, Varanasi; IARI, New Delhi; KAU, Vellanikkara; TNAU, Coimbatore; ICAR Research Complex, Barapani
Ribbed or ridge gourd	IARI, New Delhi; IIHR, Bengaluru; IIVR, Varanasi; AAU, Anand
Sponge gourd	AAU, Anand; IIHR, Bengaluru; IIVR, Varanasi; HARP, Ranchi; RAU, Samastipur
Hermaphrodite ridge gourd	IIVR, Varanasi
Sweet gourd	IIVR, Varanasi; CHES, Bhubaneswar; ICAR Research Complex, Barapani

Table 2. Indigenous cucurbits germplasm maintained

Crop	Germplasm maintained	
	ICAR-IIVR, Varanasi	ICAR-NBPGR, New Delhi
Cucumber	115	625
Bitter gourd	120	487
Ridge gourd	53	46
Sponge gourd	173	411
Hermaphrodite ridge gourd (Satputia)	33	-
Ash gourd	94	281
Pointed gourd	145	01
Snake gourd	15	62
Ivy gourd	20	-
Longmelon	40	46
Round melon	20	49
Snapmelon	100	206
Spine gourd	20	05
Teasle gourd	55	66

ICAR-NBPGR, New Delhi has provided a mechanism for registering germplasm having unique trait under 'Registration of Plant Germplasm'. A total of 15 germplasm of 8 indigenous cucurbits have been registered, which could be utilized by breeder of different organization (Table 3).

Table 3. Indigenous cucurbits germplasm registered for unique traits

Crop	Name of line	Natl. identity no.	Registered unique traits
Bitter gourd	GY-63	INGR-03037	Gynoecious line
	PreGy-1	INGR-12014	Predominately gynoecious habit
Cucumber	AHC-2	INGR-98017	High yield and long fruit
	AHC-13	INGR-98018	High yield, small fruit, drought and high temperature tolerance
	IC420405	INGR-18029	High carotenoid content and orange flesh colour
	IC257296	INGR-18030	Two female flowers per node, earliness, small fruit
Sponge gourd	VRSG-52-1	INGR-10159	Cluster bearing fruiting habit
	DSG-6	INGR-12013	Highly resistant to Tomato Leaf Curl New Delhi Virus
Roundmelon	HT-10	INGR-99038	Intermediate, semi-spreading vine, tolerant to downy mildew and root rot wilt
Snapmelon	AHS-10	INGR-98015	High yield and drought tolerance
	AHS-82	INGR-98016	High yield and drought tolerance
	B-159	INGR-7044	Downy mildew resistance
Pointed gourd	IIVR PG-105	INGR-03035	Seedless fruit, obligate parthenocarpic with long duration fruiting
Ivy Gourd	CHIG-15	INGR-9126	Fruit length (8.5-9 cm), uniform cylindrical shape
Kachari (*Cucumis melo* subsp. *agrestis*)	AHK-119	INGR-98013	High yield and drought tolerance

Crop	Name of the accession	Unique traits
Bitter gourd	IC-44428 and IC-44438	Nematode resistance
Longmelon	VRLM-172	Dwarf plant with erect fruit
Sponge gourd	VRSG-7-17	This genotype possess aroma like 'Basmati rice' in leaves, flowers, fruits, blossom end of fruits, plant vine and peel due to the presence of Hexenal, 1-octene3-ol and limonene
Pointed gourd	VRPG-103	Cluster bearing habit. The number of fruits per cluster varied from two to four. The double fruited cluster contributed maximum toward the number of fruit per plant
Ash gourd	VRAG-12-2	Wax less fruits

Erect fruited long melon

Cluster bearing pointed gourd

Unique traits identified in different indigenous cucurbits

During evaluation of germplasm and segregating population, some unique traits i.e. aromatic sponge gourds, dwarf plant with erect fruit habit in longmelon, nematode resistant in bitter gourd, waxless in ash gourd and cluster bearing in pointed gourd were identified. These germplasm/lines are in the process of registration and are being utilized in breeding program.

Breeding trends in indigenous cucurbits

Breeding of cucurbits has to address and satisfy the needs of both the consumer and the grower. The general objectives for growers are high yield, disease and pest resistance, uniformity, and tolerance to abiotic stresses. Objectives for consumers are quality, appearance, shelf life, taste, and nutritional value. Quality in vegetable crops, in contrast to field crops, is often more important than yield. Thus, colour, appearance, taste, and shape are usually more important than productivity. For example, in India, cucumber breeding programme is concentrated only on slicing cucumber with objective of high yield, quality and resistance. Breeding work on parthenocarpic cucumber (controlled by single dominant gene with many modifiers) with gynoecious sex expression is initiated at

GBPAUT, Pantnagar and IIVR, Varanasi for protected cultivation. The major colour segment in cucumber is light green, green, dark green and creamy skin. Several varieties and hybrids have been developed in slicing cucumber for commercial cultivation. In bitter gourd, fruit shape is main segment of variation. Four type of fruit shapes are found in bitter gourd i.e. a) large fusiform fruits pointed at both end dominated with triangular tubercles, b) small spindle shape; c) cone shaped, length 9-12 cm with dark green rind having prominent tubercles and d) Chinese long fruited (30-60 cm) with smooth ridge, light green skin colour. Gynoeciuous line (INGR 03037) has been developed and efforts are being made to utilize this line for development of better F_1 hybrids. Fruit fly and poty viruses are becoming limiting factors for bitter gourd production. This invites initiation of a breeding programme to develop few resistant varieties/hybrids.

Considering the importance of ash gourd in diet as good source of nutrition, medicinal properties and importance in petha industry, it is need of the hour to develop new varieties with better traits. For petha preparation, big size (10-15 kg) oval to cylindrical fruits are required, while for household consumption small cylindrical fruits (1-2 kg) without ash are in demand. Breeding for seedless, or fruits with less seeds may be the focus of present research as seedless fruits are easy for processing in petha industry. In ridge gourd and sponge gourd, major emphasis should be given to develop small cylindrical fruits having sequential fruiting habit (bearing on each node). The hermaphrodite ridge gourd may be utilized for developing ridge gourd and sponge gourd with sequential fruiting genotypes. These cultivars should be resistance to downey mildew, powdery mildew and viruses.

Genetic improvement to increase levels of specific micronutrients has been pursued in longmelon. The yield and nutritional content of longmelon has been increased significantly by exploiting intraspecific genetic variation of genetically diverse melons. Inbred long melon 'Punjab Long melon 1' (PLM1) was hybridized with 5 genetically diverse inbred melons namely KP 7 (var. *momordica*), AM 72 (var. *acidulus*), Arya 1 (var. *chate*), 04-02 (var. *tibish*) and Punjab Wanga. The parents and hybrids were evaluated at three locations for 9 traits. Hybrids PLM1 × 04-02 and PLM1 × Punjab Wanga exhibited significant heterosis for the number of marketable fruits per plant, ascorbic acid and carotenoid content. Snapmelon is available in the Indian markets for about five months in the rainy season and are utilized by poor and middle-class consumers. Mineral and vitamin rich varieties would be important supplement to the nutritional needs of these consumers. Carotenoids in mature fruits of snapmelon accessions ranged from 34.7 to 308.2 mg/100 g. Ascorbic acid was more in the snapmelon landraces from northern India (up to 34.1 mg/100g) as compared to the accessions from eastern India (up to 19.4 mg/100g). The germplasm of ivy gourd, sweet gourd, snake gourd, roundmelon and pointed gourd should be characterized properly and promising accessions should be recommended for cultivation. The availability of quality planting material is very important for popularization of ivy gourd, pointed gourd and sweet gourd as they are vegetatively propagated.

Varietal development

The evaluation of indigenous and exotic germplasm introductions, and their hybridization resulted in the selection of superior varieties of different cucurbits. As a result of multi-location testing under All India Coordinated Vegetable Improvement Project, improved varieties in many indigenous cucurbits have been identified and recommended for cultivation and release for various agro-climatic regions of the country (Table 4). Many indigenous cucurbits are not included in multilocation testing of AICRP-VC. Hence, varieties of these crops have been recommended by states of the respective Institute/ University.

Among the released and notified varieties, following are very popular among the farmers due to their high yield potential and specific traits. The adopted areas and salient features of important varieties are given in Table 5.

Table 4. List of the open pollinated varieties/hybrids released in India

Crop	National level	State /Institute level
Bitter gourd	Priya, RHRBG-4-1, KBG-16, PBIG-1	Coimbatore Long, Pusa Do Mausmi, Pusa Vishesh, Punjab-14, Kalyanpur Baramasi, CO-1, CO-2, Kashi Mayuri
Cucumber	Swarna Ageti (CHC-2), S. Sheetal (CH-20), Pant Khira-1 (PCUC-28)	Japanese Long Green, Straight-8, Pusa Uday, Himangi, Phule Subhangi, Swarna Poorna, Sheetal, CO-1, Pant Parthenocarpic Khira-1, Pant Parthenocarpic Khira-2
Ridge gourd	S. Manjari (CHRG-1), PRG-7, Arka sumeet (IIHR-7), Kashi Shivani	Swarna Uphar, Co-1, Co-2, PKM-1, Arka Sujat, Pusa Nasdar, Pusa Nutan, Punjab Sadabahar, Haritham, Hisar Kalitori, GJRGH-1, Gujrat Anand Ridge Gourd-1, Pant Torai-1, Arka Vikram (H)
Sponge gourd	Pusa Chikni, CHSG-1, JSGL, Kashi Divya, Kashi Shreya	Pusa Sneha, Pusa Supriya, PSG-9, Rajendra Nenua-1, Azad Torai-1, Azad Torai-2, Kashi Jyoti
Ash gourd	Kashi Ujwal, Kashi Surbhi, KAG-1, Pusa Ujjwal, PAG-72	Kashi Dhawal
Pointed gourd		'Swarna Alaukik', 'Swarna Rekha', 'Rajendra Parwal-I', 'Rajendra Parwal-II', 'Narendra Parwal-260', 'Narendra Parwal-307', 'Narendra Parwal-604, Kashi Divya, Kashi Suphal, Kashi Alankar, Kashi Amulya
Ivy gourd		Indira Kundru-05, Indira Kundru-35, Co-1, Kashi Bharpoor

Crop	National level	State /Institute level
Longmelon		Arka Sheetal, Karnal Selection, Punjab Longmelon-1, Pant Kakri-1
Roundmelon		Arka Tinda, Hisar Tinda (HT-10), Pusa Raunak
Snapmelon		Pusa Shandar
Hermaphrodite ridge gourd (Satputia)		Kashi Khushi
Snake gourd		CO-1, CO-2, PKM-1, Konkan Sweta, Baby, Manushree, Harithasree
Spine gourd		Arka Neelanchal Shanti
Teasel		Arka Neelanchal Gaurav
Hybrids		
Cucumber	Pant Sankar Khira-1, PCUCH-3, Hybrid No.1	Pusa Sanyog, AAUC-1, AAUC-2, Kashi Nutan
Bitter gourd	Pusa Hybrid-2, NBGH-167, Vivek	
Ridge gourd	Pallavi, HYRGH-5HB	
Sponge gourd	Kashi Rakshita	Kashi Saumya
Ash gourd	DAGH-14, DAGH-16	

Table 5. Salient features and adoption of important varieties/hybrids of indigenous cucurbits

Crop/Variety/hybrid	Adaptability	Salient features
Bitter gourd		
Kashi Mayuri	Uttar Pradesh	Green medium fruit with discontinuous ridges and medium tubercles, bears 14-16 fruits/plant, length 18-20 cm, weight 100-115 g, yield 190-200 q/ha.
Cucumber		
Kashi Nutan*	Uttar Pradesh	Fruit light green with mottle ting at peduncle side, length 21-24 cm, each plants bears 8-9 fruit having 200-225 g fruit weight, yield 150-175 q/ha.
Sponge gourd		
Kashi Divya	Uttar Pradesh, Delhi, Bihar, Madhya Pradesh, Chhattisgarh, Uttarakhand and West Bengal	Fruiting starts 48-50 days after sowing, single plant bears 10-12 light green fruits of 15-16 cm length, each of 80-85 g, suitable for rainy and summer season cultivation, yield 250-300 q/ha.
Kashi Shreya	Punjab, Uttar Pradesh, Bihar and Jharkhand	Fruit dark green, long straight (20-25 cm on flat bed, up to 32 cm on bower) and with 3-3.75 cm diameter. Fruits harvest at 50-55 days from sowing date, yield 150-200 q/ha.
Kashi Rakshita*	Punjab, Uttar Pradesh, Bihar and Jharkhand	Fruits dark green, long straight (20-25 cm on flat bed and up to 30 cm on bower) with 3-4 cm diameter. Fruits harvest starts from 48-52 days from sowing date, yield 200-250 q/ha.
Kashi Jyoti	Uttar Pradesh	Fruits light green, long straight (20-25 cm on flat bed and up to 30 cm on bower), width 2.5-3.0 cm. Fruit weight ranges from 100 to 140 g. Fruit harvest starts at 50-55 days of sowing, yield 140-160 q/ha.
Kashi Saumya*	Uttar Pradesh	Fruits green, long straight 20-25 cm and may increase on bower up to 32 cm with a diameter of 2.5-3.25 cm. Fruit weight ranges from 155 to 165 g. Fruit harvest starts at 45-50 days after sowing. The average yield 189.31 q/ha and potential yield 250 q/ha.
Ridge gourd		
Kashi Shivani	Punjab, Uttar Pradesh, Bihar and Jharkhand	Fruit green, long straight 20-30 cm and may increase on bower up to 40 cm with a diameter of 3-4 cm. Fruit weight ranges from 100 to 150 g. Fruit harvest starts at 50-60 days after sowing, yield 180-200 q/ha.
Hermaphrodite ridge gourd (Satputia)		
Kashi Khushi	Uttar Pradesh	Bearing hermaphrodite flowers on every node after 45-47 days of sowing. Fruit length 13-15 cm, weight 28-31 g, straight, with attractive light green, surface smooth with 10 dark green superficial and continuous longitudinal sutures, yield 128-144 q/ha in 8-10 pickings. Rainy season is most suitable period of cultivation.

Crop/Variety/hybrid	Adaptability	Salient features
Ash gourd		
Kashi Dhawal	Uttar Pradesh, Punjab, Bihar and Jharkhand	Fruits oblong, average weight 11-12 kg, fruit flesh thickness 8.5-8.7 cm, linear seed arrangements, crop duration 120 days, yield 550-600 q/ha, suitable for preparation of Petha sweets due to high flesh recovery.
Kashi Ujwal	Punjab, Bihar, Uttar Pradesh, Jharkhand, Karnataka, Tamil Nadu and Kerala	Less seeded fruits with average weight of 10-12 kg with globular in shape, yield 400-500 q/ha, suitable for preparation of Petha sweets due to high flesh recovery.
Kashi Surbhi	Punjab, Uttar Pradesh, Bihar and Jharkhand	Oblong shape fruit, medium in size (9.5-10 kg), flesh thickness 8.5-8.7 cm, 2.5-3.0, high flesh recovery, suitable for preparation of *Petha* sweets, yield 700-750 q/ha.
Pointed gourd		
Kashi Alankar	Uttar Pradesh and Jharkhand	Fruit colour green, spindle in shape and striped at distal end of the fruit, single plant bears 120-130 fruits of 6.7 cm length and each weighing 25-27 g, yield 180-200 q/ha.
Kashi Suphal	Uttar Pradesh	Fruit colour light green, fruit with mild stripe and slightly tapper at the stem end and blossom end. Fruits are fleshier and contain soft seeds. Fruit length and diameter range from 6-7 cm and 2.5-3.0 cm respectively and yield 190-200 q/ha.
Kashi Amulya	Uttar Pradesh	Fruit colour light green, fruit with sparsely distributed white stripe. It is less seeded and contains only 5-8 seeds/fruit as compared to 20-28 seeds in seeded variety. Fruit length and diameter is 7-7.5 cm and 3.0 cm, respectively and yield 200-210 q/ha.
Snake gourd		
Harithasree	Kerala	This variety produces dark green fruits with white stripe and having high yield potential. Identified in 2013 for areas where green fruits are preferred.
Ivy gourd		
Arka Neelachal Sabuja	Odisha	Fruits are dark green in appearance with fractured stripe and conical in shape. It gives 70-80 harvest per season (10-11 months) and having a yield potential of 200-250 q/ha.
Round melon		
Pusa Raunak	Delhi NCR	First harvesting can be done 55-60 days after sowing. Young fruits at marketable stage are attractive green, shiny, uniform, flattish round in shape, 5 cm in diameter and single fruit weight is 60 g at marketable stage and yield is 75 q/ha.
Snap melon		
Pusa Shandar	Delhi NCR	Early maturing (46-48 days after sowing) tolerant to many diseases. Average fruit weight 700 g, having creamy white to light pink thick flesh and yield potential is 385 q/ha.
Spine gourd		
Arka Neelanchal Shanti	Odisha	It is developed through hybridization between spine gourd and teasel gourd. Fruit size medium (20 g) and yield potential is 15-16 kg/vine.
Teasel gourd		
Arka Neelanchal Gaurav	Odisha	Fruits are attractive, uniform lush green round-oval fruit with soft seed and high-quality edible portion for culinary purposes. Tolerant to downy mildew and anthracnose. Yield potential of this variety is 180-200 q/ha.

*Hybrid

Sponge gourd

Insect pest and diseases are the major problem for realizing maximum yield in indigenous cucurbits. Resistant variety for downy mildew and mosaic virus has been developed and recommended for cultivation (Table 6).

Varieties developed for processing purpose

The institute has initiated the research on identification of suitable variety for preparing the different product i.e. petha sweet, parwal sweet and, bitter gourd chips/powder,

Table 6. Response of varieties/hybrids to different biotic stresses

Crop	Disease	Variety/hybrid
Ash gourd	Tolerant to anthracnose	Kashi Dhawal
Sponge gourd	Resistant to sponge gourd mosaic virus	Kashi Shreya, Kasha Rakshita*, Kashi Jyoti and Kashi Saumya*
Ridge gourd	Tolerant to downy mildew	Kashi Shivani
Hermaphrodite ridge gourd (Satputia)	Tolerant to downy mildew	Kashi Khushi

* Hybrid

Table 7. Suitable varieties/hybrids for processing

Value added and processed product	Name of varieties
Petha sweet and preserved	Kashi Dhawal, Kashi Ujwal
Bari & Tilauri (Local product prepare using petha fruits)	Kashi Dhawal, Kashi Ujwal, Kashi Surbhi
Parwal sweet	Kashi Alankar
Bitter gourd chips/powder	Kashi Mayuri

through value addition and processing. The following varieties have been identified and notified for value addition and processing (Table 7).

Future challenges

- Most of the indigenous cucurbits except bitter gourd and cucumber are grown in specific location/pockets hence needs wide popularity.
- Lack of diversity in clonally propagated crops i.e. pointed gourd, ivy gourd, spine gourd and teasle gourd is a problem for further genetic improvement.
- Problem of fruit set, yellowing and dropping of immature fruits reported in pointed gourd due improper pollination. The proper ratio of male and female plants (1:10) needs to be maintained in the field.
- Due to fluctuation in temperature and high vector population the dynamics of virus infestation are changing very fast and maximum percent of incidence recorded for begmovirus (93.33%) followed by poty virus (39.44) and tobamovirus (38.33%) in cucurbits and these viruses are causing considerable losses in total productivity.
- Occurrence of melon weevil damaging fruits and vines, becoming a serious pest of sponge and ridge gourds.

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– Editor

Shailesh K Tiwari, Pallavi Mishra and Krishna Kumar Rai

Ethnobotanical importance of brinjal in India

Brinjal is an important vegetable crop which has been known for its culinary and therapeutic uses since ancient times. The cultivar differences concern mainly the peel colour, shape, size and weight of comestible fruits, but the chemical composition, earliness of fruiting, and environmental-posed challenges also play a significant role in genesis of variability and acquisition of different morphological forms. Variation in morphology and biochemical content in brinjal fruits is an important factor that governs the choice of fruit for human consumption or liking for a specific type. The genetic differences among the genotypes are potentially relevant to breeding programs in that the variability created through hybridization of the contrasting forms could be exploited. Although it is a popular vegetable in India, the various plant parts are also used as medicines for treatment of inflammations, cardiac disabilities, bronchitis, asthma and several forms of neuralgias.

Brief history of brinjal

Brinjal (*Solanum melongena* L.) is grown worldwide for its edible fruit. Most commonly seen form is purple one which is the spongy absorbent fruit used in several cuisines. Brinjal and their progenitor species are believed to be originated in India but its cultivation in China began in 5th century B.C, which is now reported to be the secondary center of origin and domestication of brinjal. Therefore, brinjal is referred to be a vegetable of 'Indo-Chinese' center of origin. Brinjal is usually used as vegetable but the ancient history also describes the therapeutic uses of brinjal, which is usually a warm-weather crop but the related species are dispersed in different climatic zones from arid and semi-arid zone to desserts with extremely high temperature.

Taxonomical hierarchy

Solanum represents one of the most hypergenus group among the angiosperms comprising nearly 1,500 species. Many Solanum species are widely used as vegetables and also as popular medicines due to presence of steroidal alkaloids and phytochemicals of human benefit. Species level taxonomy of Solanum is always challenging due to presence of large number of species distributed around almost all the parts of the world in an array of habitats. The genus *Solanum* is sub-divided into 13 major clades, the largest of which is the Leptostemonum clade comprising nearly 450 species. Brinjal exists in three common cultivated forms, *S. melongena* (brinjal brinjal), *S. aethiopicum* (scarlet brinjal), and *S. macrocarpon* (gboma brinjal) which are native to Asian, African and Europe countries, respectively. They are well-suited for phenotyping and agronomical studies as they exist in several morphological forms. The European Brinjal Genetic Resources Network and the International Board for Plant Genetic Resources have developed various morphological descriptors to characterize brinjal for use in breeding programs.

Distribution of brinjal and species diversity

Brinjal is an important crop of subtropics and tropics and grown extensively in India, Bangladesh, Pakistan, China and Philippines. It is believed to be originally domesticated from the wild nightshade species *S. incanum* also known as bitter apple, with two independent domestications centers, one in South Asia and another one in East Asia. Crop Wild relatives (CWR) of brinjal are good choice for interests in breeding as they render an extremely valuable gene pool to draw useful alleles required in breeding programs. Some wild forms used in breeding and related to common brinjal includes *S. insanum*, *S. incanum*, *S. macrocarpon*, *S. aethiopicum*, *S. torvum*, *S. khasianum*, *S. sisymbrifolium*, *S. indicum*, *S. nigrum*, *S. xanthocarpum* and *S. gilo*.

Cultivated brinjal exists in three most common forms, *S. melongana var. esculentum* which is the common aubergine including many cultivars; *S. melongena var. depressum* which is dwarf aubergine; and *S. melongena* var. serpentium which are the snake aubergines. Many other forms/types of brinjal like *agreste, album, divaricatum, esculentum, giganteum, globosi, inerme, insanum, leucoum, luteum, multifidum, oblongo-cylindricum, ovigera, racemiflorum, racemosum, ruber, rumphii, sinuatorepandum, stenoleucum, subrepandum, tongdongense, variegatum, violaceum, and viride* are also known which are considered as different cultivar groups of brinjal. Even with availability of such large germplasm of cultivated type and related wild species of brinjal, the research in brinjal has not gone mostly beyond the yield

Wild species of *Solanum* maintained at ICAR-IIVR, Varanasi

attributes and developing varieties for biotic and abiotic stress.

A major break-through in brinjal improvement has been mediated through genetic engineering; the *Bt*-brinjal developed by inserting the *cry1Ac*-gene from *Bacillus thuringiensis*. *Bt*-brinjal was developed with a view to have complete control over brinjal fruit and shoot borer (BFSB) without affecting non-target arthropod biodiversity, reduced insecticide sprays and up to six fold increase in the farmer's profit. In view of nutritional security and toxicity-assessment upon human health and strict monitoring of the regulatory mechanism for such GM crops in the country, the technology is under moratorium from the Parliamentary Committee on Agriculture since 2012.

Nutritional value and phyto-chemistry of brinjal

Every hundred grams of a raw brinjal fruit comprises 92% water, 6% carbohydrates, 1% protein, and has negligible fat. Minor changes in nutrient composition may occur with changes in climate or environment of cultivation and genotype. Although it provides low amounts of essential nutrients with only manganese having a moderate percentage (11%) of the daily value, fruits are rich source of dietary fibres, vitamin B1, B3, B6, C, K, pantothenic acid, beta-carotene equivalents and folate. Fruits also contain arginine, aspartic acid, histidine, delphinidine–3 bioside (nasunin), oxalic acid, solasodine, ascorbic acid, tryptophan, *etc.* Leaves contain rich amounts of chlorogenic, hydrocaffeic and protocatechuric acids. Some of the alkaloids present are tropane, pyrrolidine, quinazolizidine, steroid alkaloids and glycoalkaloids. Two namely steroidal saponins melongoside-L and melongoside-M, and three new saponins melongoside-N, -O and P, have been isolated from Brinjal seeds. Catechol oxidase has been isolated and characterized from *S. melongena*. Another bioflavonoid glycoside, s*olanoflavone* present in the leaves and fruits of *S. melongena* has also been isolated.

Medicinal and culinary uses of brinjal

The medicinal properties of the plant are derived from its chemical constituents. The plant's antioxidant property is due to the presence of flavonoids. The presence of terpenes makes it useful for bronchitis and as an analgesic because of the alkaloids. Besides these, brinjal is also known to possess anti-pyretic, antioxidant, anti-asthamatic and spasmogenic activities, and hypotensive, anaphylactic and hypo-lipidemic actions. Besides these, the biological activities of alkaloids such as *calystegines* and *nortropane* isolated from brinjal have also been described in regulating normal heart functioning. Fruits of brinjal contains high amount of dietary fibre which benefits to manage blood cholesterol levels. Chlorogenic acid which is a primary antioxidant in brinjal is known to decrease the levels of low density lipoprotein (LDL) or bad cholesterol and reduces the risk of fatty liver diseases. The polyphenols present in brinjal helps protect the body from severe forms of cancer. Anthocyanins and chlorogenic acid are also known to protect tissues from damage caused by free radicals. In the long term, this may help prevent tumor growth and the spread of cancer cells. Anthocyanins also helps achieve this by preventing new blood vessels from forming tumor, reducing inflammation, and blocking the enzymes that help cancer cells spread. Other research on animal studies has suggested that nasunin, an anthocyanin in brinjal skin helps protect the brain cell membranes from damage caused by free radicals. Nasunin also helps transport nutrients into cells and move waste out.

In India, generally the choice of people for the type of brinjal changes in every 250-300 km providing a wide range of market segment for the vegetable crop. This high variation in choice for brinjal could not be attributed just to the existing morphological variation, but also provides scope for nutrient profiling of diverse germplasm of the crop collected and being conserved at various government institutes/organizations.

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Nagendra Rai, R K Dubey,
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Status, potential and improvement of Indian bean

The genus *Lablab* refers to the hyacinth bean, bonavist bean, sem, egyptian bean, field bean, Australian pea, Indian butter bean and belongs to the family leguminosae (Fabaceae). In Flora Indica, Roxburgh (1832) exemplify 'Dolichos' in *Dolichos lablab* as Greek word that symbolize long pod and 'lablab' as Arabic or Egyptian word implying shallow vessel enclosing seed. Backer (1984) on the basis of shape, texture and angle of attachment of seeds to the suture of the pods categorized all the five cultivated varieties in two cross compatible botanical groups i.e., *Lablab purpureus* var. typicus and *Lablab purpureus* var. *lignosus*. *Lablab purpureus* L. var. *typicus* (Syn. *Lablab niger* var. typicus) is widely cultivated as garden type bean with soft pods that has long axis in which seeds are arranged parallelly to the suture and *Lablab purpureus* var. lignosus (Syn. *Lablab niger* var. lignosus) where the seeds are arranged at right angle to the suture, is mainly cultivated as field bean and most commonly used as pulse containing more protein (20.9-29.2%) than *Lablab purpureus* var. typicus.

PODS of *Lablab purpureus* var. *lignosus* is highly preferred by farmers and consumers as they radiate certain oily substances that gives pods their characteristic fragrance. This distinctive aroma of *Lablab purpureus* var. lignosus pods is due the presence of two dominant fatty acids i.e., trans-2-dodecenoic acid and trans-2- tetradecenoic acid.

Botany and floral biology

Hyacinth bean plant is a tropical, dicotyledonous, herbaceous and temperature sensitive flowering plant with annual growth habit. Plants are robust twiner with woody stem, having large trifoliate heart shaped leaves along with broad ovate-rhomboid shape leaflets measuring 7 to 15 cm long and 4.5 -15 cm wide. The dorsal side of the leaf is smooth with the ventral side being hairy. Plant consists of tap root system and main root has several lateral roots distributed uniformly along the main axis. Flower is usually bisexual, hypogenous and pentamerous varies from white, pink to purple in colour with axillary, erect and raceme inflorescence. Stamens are usually arranged

Variability in pods

Character	Range
Pod length	4.45-16.0 cm
Pod diameter	1.24-3.73 cm
Pod weight	3.0-13.4 g
Pod colour	Green, light yellow, brown, dark brown, whitish green, whitish brown, greenish brown, purplish white, greenish yellow and yellowish green
Seed colour	Greenish brown, yellowish brown, blackish brown, white, yellowish white
Seed length	0.75-1.35 cm
Seed diameter	0.64-1.32 cm
Seed weight	18.5-38.3 g

in 9+1 configuration, with uniform anther, having sessile ovary with incurved style and terminal glabrous stigma. Seeds are variable in colour such as white, ochreous with black dots or black with white dots, uniformly brown or black. The flowers generally open two days after anther dehiscence. The presence of superfluous floral nectarines at the bottom of the corolla attract bees, flies and ant, however, heavy insect pressure may suppress the development of wing petals that could lead to stamen and stigma exertion. In hyacinth bean, flowers bloom between 6.30 h to 7.00 h and are predominantly a self-pollinated crop. However, insect mediated cross pollination occurs up to an extent of 6-13%. The optimum time for emasculation of hyacinth bean flower ranges between 16.30-17.30 hours and for hand pollination 7.00-9.00 hours, the next day in the morning. Pollens are fertile on the day of anthesis which remains viable for 42 hours at room temperature of 28.5°C with 85-90% relative humidity. The pollens can remain viable for much longer duration i.e., up to 50-60 hours if they are stored under cold environment in refrigerator.

Varieties developed

Pole type

Kashi Haritima (VRSEM-8): This variety was developed at ICAR-IIVR, Varanasi through selection of local material collected from Tripura of NEH and released by Central Variety Release Committee in 2012 for commercial cultivation in Sikkim, Meghalaya, Manipur, Nagaland, Mizoram, Tripura, Arunchal Pradesh, Punjab, Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu and Kerala. Average yield is 380.0 q/ha (green pods) in fruiting period from last week of November to first week of March and give 28.23% more yield compare with national check variety Swarn Utkrisht.

Kashi Khushhal (VRSEM-3): This variety is cluster bearing and very early in fruiting. Pods become ready for harvesting in 95-100 days after seed sowing. Fruiting starts from last week of September and continues till second week of February in agro climatic condition of Varanasi. An average green pod yield is 357.0 q/ha. This variety was released and notified by SVRC in 2018 for commercial cultivation in Uttar Pradesh.

Kashi Sheetal (VRSEM-11): This variety was released and notified by SVRC in 2018 for commercial cultivation in Uttar Pradesh. Average pod yield is 359 q/ha green pods which is 30.6% more yield compared with national check variety Swarn Utkrisht. This variety has been found as tolerant to DYMV in field condition.

VRSEM-6: This variety was developed at ICAR-IIVR, Varanasi through selection and tested in AICRP (VC) from 2008-2011. High yield was reported by reporting centers like Coimbatore (Tamil Nadu), Raipur (Chattisgarh), Kalyani (West Bengal), Parbhani (Maharashtra), Bengaluru (Karnataka), Portblair (Andaman and Nicobar) and Barapani (NEH). Average pod yield is 369.0 q/ha.

VRSEM-186: This variety was developed at ICAR-IIVR, Varanasi through selection and tested in AICRP (VC) from 2007-2010. Average yield is 341.0 q/ha green pods which is 22% more yield compared with national check variety Swarn Utkrisht. This is cold tolerant variety (less than 6°C) and also tolerant to DYMV under field condition.

VRSEM-501: This variety was developed at ICAR-IIVR, Varanasi through individual plant selection and tested in AICRP (VC) from 2008-2011. Average yield is 343 q/ha green pod.

Bush Type

VRBSEM-3: This advance line has been developed through hybridization using parentage VRSEM-11 (Pole Type) and Arka Vijay (Bush type) followed by single plant selection at ICAR-IIVR, Varanasi and is being under AICRP (VC) trial from 2016. Pods are light green measuring 12.5-14.2 cm in length and 1.8-2.0 cm in width. This variety yielded an average yield of 360 q/ha with high protein (93.5 mg/g) and carotenoid (0.212 mg/g). This variety is tolerant to DYMV under field condition during cropping season.

VRBSEM-9: This advance line has been developed through hybridization using parentage VRSEM-11(Pole Type) and Gomachi Green (Bush Type) followed by single plant selection at ICAR-IIVR, Varanasi and is being under AICRP (VC) trial from 2016. Pods are light green measuring 10-12 cm in length and 1.3-1.5cm in width. This variety yielded an average yield 350 q/ha with high phenol (1.81 mg/g) and chlorophyll (1.29 mg/g). This variety is tolerant to DYMV under field condition during cropping season.

Production tips

Sowing time	**Pole type**:15 July to 10th August **Bush type:** Last week of September to Last week of October
Seed rate and spacing	**Seed rate:** Pole type – 30-35 kg/ha Bush type – 50-60 kg/ha **Spacing** Pole type : Row to Row – 2.5 m, Plant to Plant – 1.0 m Bush type : Row to Row – 60 cm, Plant to Plant – 45 cm
FYM and fertilizers	Well rotten FYM @ 200 q/ha is mixed in the field 15 days before seed sowing. Nitrogen, phosphorous and potash are applied in the ratio of 40:30:30 kg/ha.
Weed control measures	Three to four manual weedings are required. One hoeing and earthing up is done at 40 days after seed sowing. Subsequently two to three manual weeding are required at 25-30 days interval.
Plant protection	Control of leaf spot and anthracnose diseases with 2-3 sprays of Dithane Z-78 or Dithane M-45 @ 1.5 g/liter of water at 20 days interval starting from second week of December till last week of January. Control aphids with 2-3 sprays of cypermethrin @ 2 ml/liter at 15 days interval starting from second week of January till last week of January depending upon climatic condition. Control pod borer with 3 sprays of Rogor @ 1.5 ml/liter of water or Indoxacarb @ 0.5 ml/ litre water at 15 days interval starting last week of January till last week of February.
Irrigation doses and timing	Irrigation is must at the time of flowering, fruiting in the month of November to December depending upon the moisture level in the field. Subsequent irrigations are done as per need.
Harvesting	Harvest edible pods 25 days after fruit setting

Type of variety	Sowing time	Harvesting started	Peak harvesting period	Economical total harvesting
Pole type				
Kashi Haritma	Second week of July	Second week of December	December to last week of January week	5-6
Kashi Khushaal	Second week of June	Last week of September	Last week of October to first week of December	6-7
Kashi Sheetal	Second week of July	Second week of November	Last week of November to last week of December	5-6
Bush type				
VRBSEM-3	Last week of September	Last week November	Last week of December to first week of March	4-5
VRBSEM-18	Last week of September	Second week of November	Last week of December to third week of March	6-7
VRBSEM-14	Last week of September	Last week November	Last week of December to second week of February	4-5

Market price variation of Indian bean in market at Varanasi

Month	Farmer field price (Average of three years)	Market price (Average of three years)
September	50-60	75-80
October	45-55	65-70
November	25-30	45-60
December	15-20	30-40
January	15-20	25-30
Feburary	25-30	45-50
March	35-40	55-60
April	20-25	35-40

VRBUSHSEM-14: This advance line has been developed through interspecific hybridization of Kashi Sheetal (Pole) and Konkan Bhushan (bush) followed by single plant selection. Plants are bushy in growth and attained height upto 45 cm and took 51 days for 50% flowering if seeds are sown in third week of September. Flowers are white and borne light green flat pods measured 12.6 cm in length and 1.8 cm in width. Peak fruiting period is first week of January and continues upto last week of March. Edible fresh pod holds protein 77.6 mg/g FW, phenol 1.36 mg/g FW and prolene 1.42 ug/g FW. Yield potential is 215.0 q/ha in 4-5 harvesting. During fruiting period this line is tolerant to DYMV.

VRBSEM-18: This advance line has been developed through interspecific hybridization of Kashi Sheetal (Pole type) and Konkan Bhushan (bush type) followed by single plant selection. Plants are bushy in growth and attained height up to 51 cm and took 45 days for 50% flowering if seeds are sown in third week of September. Flowers are purple and borne light purple twisted pods measured 9.2 cm in length and 1.6 cm in width. Peak fruiting period is second week of January and continues upto last week of March. Yield potential is 245 q/ha in 4-5 harvesting. During fruiting period this line is tolerant to DYMV.

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Indigenous and minor vegetables of North-East India

North Eastern region of India comprising all the 8 states falls under the Indo-Burma hotspot due to its rich biodiversity. A vast range of horticultural diversity is also found in this region under natural habitats as well as under cultivation. More than 92 species belonging to 27 families of diverged local vegetables are found in this region which represents for centre of diversity for many other vegetables. Majority of the population of this region is ethnic tribes whose livelihood is based on farming system such as integrated farming system (IFS), Jhum (Shifting cultivation) and mixed farming. Unique specialty of food habit of this region, apart from meet-fish based foods, is locally grown traditional vegetables and various wild-semi wild plants-based foods. Moreover, all these minor traditional vegetables are rich source of vitamins and minerals and provide nutritional security for the small and marginal households as well as for the below poverty level populations. Many of these minor vegetables are also used for ethno-medicinal purposes by the local traditional healers.

Diversity of indigenous vegetables in North East India

Indo Burma centre of origin under which North eastern region falls is home centre of origin for vegetables namely eggplant, cucumber, radish, taro, yam, cowpea, turmeric and black pepper. This region is rich in diversity for many other vegetables especially cucurbits namely bottle gourd, pumpkin, ash gourd, sweety gourd, spine gourd, chayote, pointed gourd, tuber crops namely taro, swamp taro, greater and lesser yams, elephant foot yams etc; solanaceous namely chilli and brinjal; leguminous namely hyacinth bean, velvet bean; leafy vegetable like amaranthus and bulbous crops onion and garlic. There are many other crops namely bamboo and jute originated

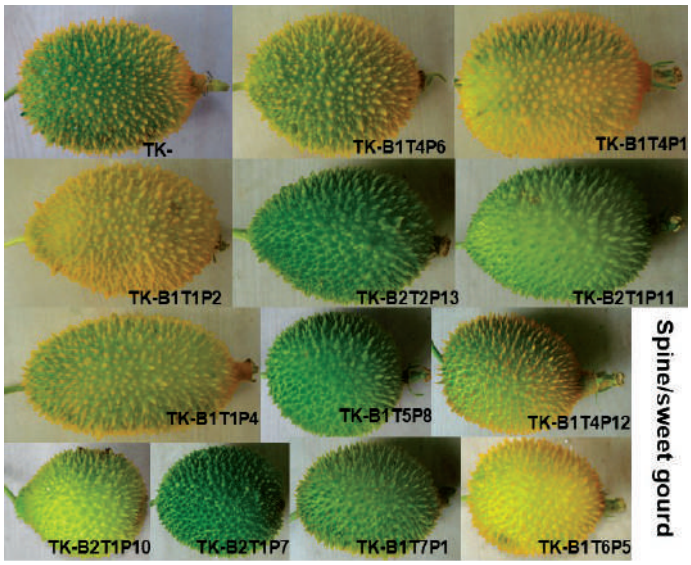
Local variability of brinjal in NEH region

in this region and extensively used as ethnic vegetables. Moreover, not only these crops, north eastern parts of India is also known for many diversified plant species which are consumed by the local communities and these foods share a major part of family nutrition.

Solanaceous: North east region is one of the important centre for a greater range of egg plant and other solanaceous wild as well as cultivated germplasm with variability in plant characters, fruit shape, size and colour. Many of the indigenous genotypes are totally resistant to wilt disease. Some of the common genotypes cultivated are brinjal (*Solanum melongena*), Turkey berry (*Solanum torvum*), poison berry (*Solanum indicum*), bitter brinjal (*Solanum gilo*), African eggplant (*Solanum macrocarpon*), thorny nightshade (*Solanum xanthcarpum*), kotahi begena (*Solanum khasianum*), spiral nightshade (*Solanum spirale*), sticky nightshade (*Solanum sisymbrifolium*), bhekuri (*Solanum kurzii*) and scarlet eggplant (*Solanum aethiopicum*). Some of the local varieties and landraces namely Singhnath, Bholanath, Laffa and RCMBL2 are commercially important. Various species diversities of chilli found in NEH region are, common hot pepper (*C. annum*), bird pepper (*C. annum* L. var. *avicular*), sweet pepper (*C. annum* var. *grossum*), Indonesian red chilli (*C. annum* var.

Table 1. Tuber crops found under natural habitats and cultivation in NEH region

Crop name	Scientific name	Acridity	Edible parts used
Elephant foot yam	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	Low	Tuber and petiole
Wild elephant foot yam	*Amorphophallus bulbifer* (Roxb.) Blume., *A. sylvaticus* (Roxb.) Kunrth. and *A. muelleri* Blume	Petiole low to medium, but tubers are extremely acrid	Immature bud sprouts, petiole and tuber
Greater yam	*Dioscorea alata* L.	Low to medium	Tuber
Lesser yam	*D. esculenta* (Lour.) Burkill	Low to medium	Tuber
Aerial yam	*D. bulbifera* L.	Low	Tuber and aerial bulbils
Mountain yam	*D. hamiltonii* Hook. F.	Low	Tuber
Five leaf yam	*D. pentaphylla* L.	Low	Tuber
Chinese yams	*D. oppositifolia* L.	Low	Tuber
Cassava	*Manihot esculenta* L.	Low	Tuber
Taro: Eddoe type (Taro)	*Colocasia esculenta* var. *antiquorum* Schott	Low to medium	Rhizomes, petiole and leaves
Taro: Dasheen type (Bunda)	*C. esculenta* var. *esculenta* (L.) Schott	Low to medium	Rhizomes, petiole and leaves
Taro (Semi wild green petiole)	*C. esculenta* (L.) Schott	Medium to high	Petiole, leaves, stolon and rhizome
Taro (Semi wild red petiole)	*C. esculenta* (L.) Schott	Medium to high	Petiole, leaves and stolon
Sweet potato	*Ipomoea batatas* (L.) Lam.	Nil	Tubers
Swamp Taro: Green petiole	*Colocasia esculenta* var. *stolonifera* L. Schott	Low	Rhizome, petiole and stolon
Swamp Taro: Red petiole	*C. esculenta var. stolonifera L. Schott*	Low	Rhizome, petiole and stolon
Swamp Taro: Purple petiole	*C. esculenta var. stolonifera* (L.) Schott	Low	Rhizome, petiole and stolon
Swamp Taro: Semi wild type	*C esculenta var. stolonifera* (L.) Schott	Medium to high	Small rhizomes, petiole, leaves and stolon
Elephant Ear taro/Giant rooted taro	*Alocasia macrorrhiza* (L.) G. Don	Medium	Giant rhizome
Giant arum	*Steudnera colocasioides* Hook. f.	Extreme	Giant rhizome
Bengal arum	*Typhonium trilobatum* (L.) Schott	Petioles low to medium, tuber is acrid	Tender leaves and stems
Tannia: Blue/purple petiole	*Xanthosoma violaceum* (L.) Schott	Low to medium	Petioles
Tannia: Green petiole	*X. violaceum* (L.) Schott	Low to medium	Petioles
Tannia: Errow leaf elephant's ear	*X. sagittifolium* (L.) Schott	Low to high	Rhizome and petiole



longum), Habanero type pepper/Bhut Jolokia/king chilli/ Naga chilli (*C. chinense*), purple-flowered capsicums (*C. eximium*), tobacco pepper/bird chilli (*C. frutescens*) and bird eye chilli (*C. minimum*). Apart from species diversity, there is a wide range of intra specific diversity in *C. annum*, *C chinensis*, *C. minimum* and *C. frutescens* found in different states in NEH region.

Cucurbitaceous vegetables: There are many local genotypes of various cucurbitaceous vegetable crops in the region. In 'Jhum' cultivation, wide range of diversity of these crops are found. Bottle gourd and pumpkin tender shoots of 90-150 cm length are very popular as vegetables. Soft young leaves are consumed as leafy vegetables, or mashed after boiling into paste with chilly and onion-garlic, or even used in preparation of dry fish or fish pieces after wrapping with these leaves. Male flowers are deep fried with corn flour/rice floor/besan coating. Local types of bottle gourd, ash gourd and pumpkin especially grown in 'Jhum' areas are very much popular as vegetables. Sweet gourd/spine gourd, pointed gourd and Chow-chow are also very popular vegetables. Various species are, cucumber, ridge/sponge gourds, spine gourd (*Momordica dioica*), sweet gourd (*Momordica chochinsinensis*), pointed gourd (*Trichosanthers dioca*) and tinda (*Praecitrullus fistulous*) etc. are very much indigenous to NEH region. However, many other cucurbitaceous crops namely bottle gourd (*Lagenaria siceraria*), pumpkin (*Cucurbita pepo*), ash gourd (*Benincasa hispida*), snake gourd (*Trichosanthes anguina*), chow-chow/chayote (*Sechium edule*), spong gourd/dhundhul (*Luffa cylindrical*), Rakhalsasha/ Kundari (*Melothria heterophylla*), Jangli karela/wild bitter gourd *(Momordica charantia* var. *municata*), ribbed melon (*Hodgsonia macrocarpa*), ivy gourd (*Coccinia grandis*), Kachri (*Cucumis callosus*).

Leguminous crops: This region may be called centre for secondary diversity for various leguminous crops which are consumed as ethnic foods by the tribal as well as non-tribal communities of NEH region. Hyacinth bean (*Lablab purpureus*), there is a vast diversity in hyacinth bean in the region in terms of stem colour, flower colour, leaf shape, pod colour, shape, seed shape and colour etc. Tree bean (*Parkia roxburghii*) is a medium-large tree which may attain upto 30 m height with spreading branches. Flowers, tender pods and seeds are consumed as vegetable. Sword bean (*Canavalia gladiate*) and Jack bean (*Canavalia ensiformis*) has white seeded varieties (bushy in nature) and red seeded varieties (trailing type). Tender pods and soft seeds are consumed as vegetable, though it has anti-nutritional properties. Winged bean (*Psophocarpus tetragonolobus*) is also consumed by ethnic communities. There is a wide diversity in cow peas (*Vigna Uunguiculata*), yard long bean (*Vigna unguiculata* sub sp *sesquipedalis*), vegetable French bean, kidney bean (*Phaseolus vulgaris*), Yam bean (*Pachyrrhizus erosus*) and Velvet bean (*Mucuna pruriens*).

Tuber crops: There are rich diversity in various type of tuber crops which are very much popular as ethnic food as well as ethno-medicinal purposes. Yams have their center of origin in this region, however, there are varieties of indigenous tuber crops in NEH region.

Other indigenous vegetables and spices: Turmeric (*Curcuma longa*) is indigenous to this region with wide range of diversity among which Lakadong and Megha Turmeric 1 are commercially popular. Even, variability in ginger is also very much common such as aromatic ginger (local name-Sying shmoh), Manipur No. 1, Basar, Tura Local, Thingpui, Meghalaya Local, Thinglaidum, Kachai Ginger and Nagaland Local. Apart from these, variability is also observed in local onion, garlic, long pepper, large cardamom and black pepper.

SUMMARY

North eastern region of India is rich in biodiversity of flora and fauna. Apart from major vegetables which are indigenous to this region, there are diversified traditional plants which are consumed as ethnic foods. Conservation and documentations of all these major and minor vegetables is very much essential.

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R K Yadav, B S Tomar and
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New bathua cultivars: a weed to wealth

AMONG the green leafy vegetables, chenopodium (*Chenopodium album* L.) which is commonly known as bathua grows as a weed during winter season and consumed as leafy vegetable. It is also known as pigweed or lamb's quarters and belongs to family Chenopodiaceae. It is rich in nutrients and cheapest available in winter in North India. It is good source of dietary fibre and store house of vitamin A, vitamin C, folic acid and riboflavin as well as minerals viz. iron, calcium and phosphorous, hence suitable for overcoming problem of anaemia. Its leaves can be used in fresh as well as dry forms like kasuri methi through various preparations viz. *roti/ puri/ parantha* etc. with wheat flour. The green foliage of bathua can be used as fodder for animal. Bathua can be used as a potential vegetable as well as fodder for diversification of agriculture to newer areas, environmental sustainability and for combating the nutritional deficiency in human being in many parts of the world. Its cultivation does not require much inputs and could be easily grown on agriculturally marginal lands. Keeping view its potential as a cheap source of antioxidants and other nutrients, nutritionally rich and high yielding genotypes, Pusa Bathua-1 and Pusa Green with good quality traits have been developed by Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi. Similarly, ICAR-Indian Institute of Vegetable Research, Varanasi has also developed two cultivars, namely Kashi Bathua-2 and Kashi Bathua-4 & notified by CVRC for cultivation. The characteristics of bathua varieties are given below.

Pusa Bathua-1: This is the first improved variety developed by Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi. It is a multi-cut variety with large size and dark green leaves. Plants are 2-2.5 m tall having reddish green leaves and red pigmentation on stems. The tender leaves can be harvested 45 days after transplanting. It is 60% more rich in vitamin C and 10% more rich in beta carotene than locally available bathua marketed. It may attain a height of 1.8-2 m at 150 days after sowing. The average green leaf yield is 30 tonnes per hectare.

Pusa Green: It is a multi-cut variety with large size and dark green leaves which is developed by Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi and notified by Central Variety Release Committee for cultivation in NCT Delhi. It gives leaf yield of 36.8 t/ha. It is suitable for both direct sowing in October and transplanting in November. Plant growth is luxuriant. Leaves are smooth and attractive dark green in colour with medium lobbing and serration. The leaves are big in size having 18 cm length and 9 cm width. It recorded high total carotenoids (91.31 mg/100g), iron content (7.6 mg/100g), dry matter 13% and ascorbid acid (50 mg/100g) on fresh weight basis. It may attain a height of 2-2.5 m at 150 days after sowing. It is late bolting in nature and less attacked to diseases and insects.

Kashi Bathua-2: It is a high yielding (36.7 t/ha) cultivar having green leaf, petiole and stem. Plant growth is luxuriant which is ready for first cutting after 40 days of sowing and it continues up to 120 days at regular interval. Its leaves contained 15.2% dry matter alongwith source of vitamin C (21.2% higher), vitamin A, folic acid and minerals. It is an excellent source of phenolics (30% higher) and antioxidants (43.1% higher) than wild bathua. It may attain a height of 1.8-1.95 m at 160 days after sowing. It is notified for Uttar Pradesh.

Kashi Bathua-4: It is a high yielding (40.7 t/ha) cultivar having purplish green leaf and petiole with pink pigmentation on nodes at early stage of growth, and stem colour turns to complete pink at flowering

Pusa Green

Pusa Bathua-1

Kashi Bathua-4

Kashi Bathua-2

stage. Plant growth is luxuriant which is ready for first cutting after 40 days of sowing and continued up to 120 days at regular interval. Leaves have 16.1% dry matter alongwith excellent source of vitamin C, vitamin A, folic acid and minerals. It is also good source of phenolic and antioxidants. It may attain a height of 2-2.15 m at 160 days after sowing. It is released and notified for Uttar Pradesh.

Crop production

It is a cool season crop and fairly tolerant to frost. At high temperature early flowering takes place. It can be grown on a variety of soils but sandy loam or loam soils are best suited than heavier soils. It is a moderately salt tolerant and can also be grown successfully in saline-sodic soils. It responds well to farm yard manures. 1.5-2.0 kg seed are required for direct sowing, however; 450 g seed is sufficient for raising nursery for transplanting 1 hectare field. Treat the seeds with Thiram @ 3g/kg of seed. For direct sowing, seed is mixed with sand and broadcasted in field as it is very small in size. It can be sown in the month of October-November. The seed being very small should be sown not more than 3 mm deep in the soil. The seed is either sown directly in the main field or transplanted after raising nursery. For direct sowing, it is sown in main field in rows 30 cm apart in proper soil moisture. 35 days old seedlings raised in the nursery bed are transplanted at spacing of 30 cm between rows and 20 cm between plants. Immediately after sowing or before transplanting, pendimethalin @3.5 litre/ha should be applied on ground in 500 litre water solution to control pre-emergence weeds. A basal dose of 25-30 tonnes of farmyard manure per hectare should be incorporated in the soil at the time of preparation of land. Application of nitrogen fertilizer is the foremost requirement for leafy growth. N: P: K @ 80:50:50 kg/ha should be applied. It is advantageous to apply 50-60 kg urea per hectare as top-dressing in three split doses after first, second and third cuttings of the leaves. Apply 1% urea and 0.5% micronutrients solution (multiplex) after each cutting for quick growth of leaves. One light irrigation is given immediately after transplanting the seedlings in case the crop is raised by transplanting method. This crop requires less irrigation. However light irrigation should be given in 10-12 days interval. Two to three weeding or hoeing are required to keep the crop free of weeds i.e. 30, 45 and 60 days after sowing/transplanting. First harvest is available 40-45 days after seed sowing or transplanting. Subsequent cuttings can be done at about 20 days interval and 4-6 cuttings are possible till the crop starts flowering when the leaves become unfit for consumption. Average 35 t/ha green leaves are harvested. No serious insect-pest is observed. However, aphids may sometimes cause damage and can be controlled by spraying of malathion @ 2 ml/litre of water. Spray 5% neem seed kernel extract after cutting to keep insects away from crop.

Leaves of Pusa Green

Pusa Green seeds

Seed production

Bathua is cross pollinated crop where pollination takes place by wind. Isolation distance for foundation and certified seed production of *Chenopodium* is 1600 m and 1000 m respectively. The seed crop of these varieties must be raised through transplanting and 400-500 g seed is required for raising nursery on raised bed for transplanting 1 hectare area in the month of October. Seed should be sown in rows at 2-3 mm depth and 35-40 days old seedlings with 3-4 leaves having 10 cm height are used for transplanting. The transplanting is done at a spacing of 60 cm × 45 cm. About 20-25 tonnes of farm yard manure along with 50 kg nitrogen, 50 kg phosphorus and 50 kg potash are applied to the soil at the time of field preparation. Two leaf cuttings are generally taken after 45 and 60 days of transplanting and after that it is left for seed production. An additional dose of 20 kg nitrogen/ha should be applied after each cutting. Rogueing should be done for off-type plants, plants of other varieties, volunteer plants, weeds and diseased plants. All early bolters should be removed from seed production field. A minimum of three field inspection should be made at pre flowering, flowering and post flowering stages. The seed crop should be harvested at right stage of maturity and becomes ready for harvesting in the month of May after 150-180 days after transplanting. It is threshed by stick beating or by mechanical thrasher and then seeds are cleaned by winnowing. Seeds must be dried 6-8% moisture levels and packaged in different packaging materials. A good crop may give yield upto 6-7 quintal seed per hectare.

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Water chestnut

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Water chestnut is most commonly used as edible nut. Kernel contains a large amount of protein, starch, tannins, fat and sugar. It is also a good source of fibre and vitamin B along with Ca, K, Fe and Zn. Nuts with different husk colour like green, red or purple and a blending of red and green colour are found.

Propagation is commercially done by seeds. The fully mature nuts are placed in container with little water to germinate the seeds. Harvesting of nut is usually done at the month of September and continues up to November. Fresh nut yield ranges between 25.0-30.0 q/ha area of pond.

Harvested kernel can be stored in the bottom of the fridge in sealed plastic bags or containers to prevent them from drying out. Content of zinc, iron and manganese are more in nut husk than shelled nut. Popularization and proper augmentation of water chestnut on a large scale could make a significant contribution towards nutritional security and economic upliftment of the society. In addition to food and nutritional security, this is also likely to generate on-farm and off-farm (transportation, storage, processing, marketing etc.) employment.

Concerted efforts are needed to assess the food value for their exploitation at commercial scale. In view of the importance of water chestnut, crop improvement programme has been initiated at ICAR-Indian Institute of Vegetable Research, Varanasi, India in order to popularize and augment its production among growers.

B R Raghu, T S Aghora and
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Genetic improvement of curry leaf in India: Challenges and future prospects

Curry leaf is a perennial leafy vegetable with numerous uses and benefits. It is an integral part of Indian Cuisine. Several medicinal uses are known for this crop. Essential oils and other bio-active chemicals in curry leaf have several industrial applications. Constant domestic and international demands have encouraged the farmers to cultivate curry leaf as sole crop under high density planting. Low input costs, three harvests per year, low post harvest losses; perennial nature with more than 10 years of plantation viability makes curry leaf a best alternative profitable crop for climate resilient agriculture to small and marginal farmers. Despite several benefits attached to curry leaf, research progress in terms of genetic improvement, PGR management and production technologies appears to be infant stage in India. The present article highlights status of genetic improvement, opportunities and challenges for curry leaf in India.

CURRY leaf (*Murraya Koenigii* (L.) Spreng) is an auromatic, semi-evergreen perennial leafy vegetable distributed widely in tropical and sub-tropical regions of the world. It is used for several culinary, nutraceutical, medicinal, therapeutic and industrial purposes owing to the presence of wide range of bio-active and aromatic compounds. Sabinene, Pinene, Cadinol, Caryophyllene and Cadinene are the major compounds responsible for characteristic intense flavour. Monoterpenoids and their oxygenated derivatives are the chief chemical constituents present in essential oil of curry leaf. Carbazole alkaloids having anti-cancerous, antidiabetic and anti-oxidant properties are the bio-active compounds present abundantly in curry leaf. The crude extract from different parts of curry leaf is an important ingredient in Indian systems of medicine like Ayurveda, Siddha and Unani. The distill extraction of aromatic and volatile oils from curry leaf plant has applications in several cosmetic, perfumeries, soap and food processing industries.

Curry leaf is an indispensable part of India systems of food preparation. It is a cheap and rich source of nutrients like calcium (Ca), vitamin A, amino acids and dietary fiber. Other elements present in trace amounts like iron (Fe) and Magnesium (Mg) are also a valuable sources of nutrients to daily consumers. Curry leaf plant is commonly seen in every kitchen garden in South India. However, in recent years, the constant demand in export and local market has encouraged several small and marginal farmers to take up curry leaf cultivation on commercial scale in many districts of Southern India. Thus, its genetic improvement and development of suitable production technologies is very essential to ensure sustainable and profitable cultivation of curry leaf in India. With this background, the present article briefly discusses on present status of genetic improvement of curry leaf and its opportunities and challenges in India.

Curry leaf usages and benefits

Curry leaf is a perennial leafy vegetable with multiple uses and benefits. It is used as fresh leaves, dried leaves, dried powder and processed powder with other spices. The shelf life of curry leaf can be enhanced by reducing the leaf moisture level under shade or sun drying. The fresh leaves are integral part of curries, chutny, sambar and other food preparations in Southern India. It not only adds flavor to food but also enhance taste and palatability. Nutritional composition of the food with respect to Ca, vitamin A, amino acids, digestible fiber and other micro-elements is improved due to curry leaves. Regular use of curry leaves is known to reduce blood sugar level. Several anti-oxidants, anti-diabetic, anti-cancerous properties present in curry leaves will aid to better functioning of kidney, heart, liver and other vital organs and thus, is regarded as functional food for the man. The nutrient composition of fresh and dehydrated curry leaves is as follows.

Nutrient	Fresh leaves (100 g)	Dehydrated leaves (100 g)
Carbohydrate	8.7 g	64.31 g
Protein	6 g	12 g
Fat	1 g	5.4 g
β-carotene	7560 µg	5292 µg
Calcium	830 mg	2040 mg
Iron	0.93 mg	12 mg

Source: Indian Journal of Natural Products and Resources Vol. 2(4), December 2011, pp. 508-511.

Morphotypes in curry leaf

Curry leaf makes an important part of Ayurveda and other traditional medicinal systems. The ethno-botanical use of curry leaf for medicinal purposes is known since centuries. The crude extracts from different parts of the curry leaf plant is used to treat several diseases and disorders such as piles, influenza, dropsy, itching, bronchial eruptions, fever, asthma, body aches, diarrhoea, kidney pains and vomiting. The green leaves are eaten raw to cure dysentery. The pulped bark and root of curry leaf are externally applied to cure eruptions, fresh cuts and bites of poisonous animals. Besides, essential oil extracted on steam distillation has applications in several industries such as soap, perfumeries, pharmaceutical, nutraceatical and other functional food industries. Owing to its growing demands in both domestic and international markers, the curry leaf cultivation as a commercial leafy vegetable has made its way into several districts of Karnataka, Tamil Nadu, Andhra Pradesh, Telangana and Kerala. India is regularly exporting fresh and dried leaves to Gulf and European countries and earning a considerable amount of foreign returns. The fresh leaves are sold as leafy vegetable in local markets all round the year. This has encouraged many small and marginal farmers to cultivate curry leaf as a sole crop. Besides, low input demand, low post harvest losses and access to local markets has ensured assured income to the growers throughout the year. Curry leaf is perennial crop, a well maintained plantation can last more than 10 years, which provides continuous income to the farmers.

Plant genetic wealth of curry leaf in India

Curry leaf plant is originated from India and its adjoining regions of Sri Lanka, Bangladesh and Nepal. Later, it has spread to other parts of the world by Indian migrants. In India, it is distributed throughout its mainland including Andaman and Nicobar Islands, and found naturally in semi-deciduous to evergreen forests with medium to high rainfall. Foot hills of Himalayas in North, continued through Terai region, Sikkim hills, Darjeeling hills and end up in Khasi-Garo hills in far east, reaching far up to Nilgiri and Annamalai hills in South, covering deciduous and semi-deciduous forests in Middle India and Eastern Ghats, including evergreen forests of Western Ghats are the major diversity regions for curry leaf in India. A huge morphological and chemical diversity is reported in curry leaves. Broadly, curry leaf is classified into three morphological types *viz.,* Brown/ Gamthi (GM), Regular (RE) and Dwarf (DF) based on growth habit, colour and size of leaves and flavor. Slow growing genotypes with dark brown small and thick leaves having serrated edges are Brown/Gamthi (GM). It is most fragrant type of curry leaf. Whereas, genotypes grow very fast, sometimes turn into small-medium-sized trees and produces exstipulate, bipinnately compound dark leaves with long reticulate venation are referred to as regular type (RE) and this type is available throughout India. Dwarf types (DF) are moderately growing genotypes with spreading branches to form bushy habit and its leaves are light green, exstipulate, bipinnately compound with long reticulate venation and having unique aromacity. Besides, these morphotypes vary for anti-oxidant activity in the order of Gamthi>Dwarf>Regular types.

Similarly, a tremendous variability for chemical composition of essential oils in curry leaves was observed with respect to different regions. The variation is highly inherited and is recognized as chemotypes. Two main chemotypes with essential oils predominant in monoterpenoids and sesquiterpenoids were recognised in India. The chemotypes of Western Ghats were dominated by monoterpenes such as sabinene (6.90-40.59%), β-phellandrene (1.39-45.89%) and α-pinene (1.93-63.66%), followed by sesquiterpene like β-caryophyllene (6.68-18.46%). Four chemotypes *viz.,* β-phellandrene, sabinene, α-pinene and β-caryophyllene were reported from Western Ghats. Besides, four other genetically diverse chemotypes of curry leaves such as β-pinene, α-pinene, β- caryophyllene and β-phellandrene were reported from other parts of India.

Genetic improvement of curry leaf in India

Despite multiple use and numerous benefits, the curry leaf is still an under-utilized and unexplored vegetable in terms of efforts towards its genetic improvement and area under cultivation. The genetic improvement of curry leaf still is in nascent stage and unsystematic in India. Earlier, few efforts were made to characterize

Senkaampu, a popular farmers variety of curry leaf commercially being cultivated in different parts of Tamil Nadu

curry leaf germplasm for different morphological and bio-chemical traits. More often, they are isolated programmes, characterized by limited use of plant genetic resources (PGR), and has narrow genetic base. Moreover, in majority of the studies, the sampling was done on natural populations, wherein, such samples lack replications and uniform environments. The inferences made from such studies, especially on traits like bio-chemical composition and essential oils content which vary greatly with locations and seasons, often failed to provide comprehensive information regarding extant of genetic base of plant diversity. Further, some other studies have done nutrient analysis and profiling in curry leaf. However, in those studies, genotype × environment interaction components has not been dissected for nutritional related traits. Thus, it implied that, no comprehensive efforts have been made to collect and conserve curry leaf germplasm covering different geographical regions, and characterize under uniform environmental conditions. Further, an inclusive field gene bank contains broad based germplasm in terms of number, regions and traits, is lacking in curry leaf.

In spite of lack of comprehensive PGR activities in curry leaf, a few and scanty breeding initiates were made in the past. Towards this end, two improved varieties of curry leaf namely, DWD-1 and DWD-2 (Suhasini) were developed and released by University of Agricultural Sciences (UAS), Dharwad. Basically, these two varieties were developed by clonal selections from the germplasm collected from Western Ghats. Both have good aroma and suitable for fresh leaves. The oil content reported to be 5.22% and 4.09% in DWD-1 and Suhasini, respectively. DWD-1 is cold sensitive and shows poor growth in winter season. Whereas, Suhasini is insensitive to low temperature and thus produces higher yield than DWD-1. Besides, several local landraces and farmers' varieties are being popularly grown by the farmers; these were selected based on appearance, fragrance and response to local environments. Senkaampu is such local landraces or farmers' variety are being popularly grown in many parts of Tamil Nadu. It has pigmented petiole, shiny and leathery leaves with good fragrance. It has huge local demand for fresh leaves. Lately, ICAR-Indian Institute of horticultural Research (ICAR-IIHR), Bengaluru, has initiated comprehensive breeding programme in curry leaf. Till now, it has collected more than 150 germplasm from different parts of India covering Himachal Pradesh, Odhisa, Karnataka, Tamil Nadu and Kerala, and successfully established a field gene bank to conserve them. Germplasm characterization with respect to different morphological traits, bio-chemical and nutritional traits including chemical profiling for essential oils are being taken up in different seasons. Further, germplasm augmentation is being done through regular exploration programmes concentrating in different states and regions.

Challenges ahead

Expansion of area under curry leaf cultivation

In India, more than 60% of cultivable area is under rain fed and more than 80% farmers are small and marginal. Curry leaf can be easily introduced to such farmers and provides assured income with low input cost over long period of time. However, commercial cultivation of curry leaf is presently confined to few districts of Southern states. Thus, curry leaf cultivation can be expanded to other parts of the country, wherever local demand for curry leaf is exists.

Collection and conservation of PGR in curry leaf

Curry leaf is native to India. A tremendous variability exists for this crop. In order to understand the extant of genetic diversity for important agronomical and bio-chemical traits, and identification of trait specific genotypes followed by allele mining and traits discovery requires comprehensive exploration of PGR, and its characterization and documentation, and conservation through field gene banks. Regular germplasm exchange between working institutes will further augment the PGR in curry leaf.

Comprehensive research efforts in curry leaf

A breeding programme inclusive of development and utilization of different genomic resources in PGR management, trait discovery and allele mining, identification of trait specific genotypes and its successful introgression into elite lines is need of the hour in curry leaf. Being a perennial tree species, different breeding methods like clonal selection, mutation breeding and polyploidy breeding should be integrated in curry leaf. Further intensive efforts towards ideotype breeding in curry leaf is required for development of bushy, evergreen, winter insensitive genotypes with high fragrance.

Development of Distinctness, Uniformity and Stability test guidelines in curry leaf

Several local landraces and traditional and farmers' varieties of curry leaf are being popularly grown in different parts of India. These varieties posses several unique traits with many pharmaceutical, nutraceutical and functional food properties. Protection and conservation of such unique germplasm requires novelty, distinctness, uniformity and stability tests conducted through nationally or internationally accepted guidelines. However, there is no internationally or nationally accepted DUS test guidelines available in curry leaf, which is a mandatory requirement to protect unique germplasm under PPV&FRA, New Delhi.

Inter-institutional linkages

Collaborative germplasm exploration and exchange programmes, collaborative research between ICAR institutes, SAUs and other research establishments is required to accelerate the curry leaf improvement in India.

SUMMARY

Curry leaf is a multi-utility commercial crop with low investment cost and huge export value. Crop improvement in terms of research progress and area under cultivation is still in nascent stage for curry leaf in India. PGR management needs to be strengthened by more and more exploration programmes and establishment of field gene banks. Multi-environmental systematic evaluation of genetic resources with broad genetic base with increasing use of latest genomic resources for trait specific characterization and trait discovery for pharmaceutical and nutraceutical properties has to be given emphasis. To harness benefits out of present growing demands and new found horizons of applications, area under curry leaf needs to be expanded to small and marginal farmers. To achieve towards this end, farmers' friendly technologies like high yielding varieties with inbuilt resistance to biotic and abiotic stresses are to be developed in addition to suitable protection techniques. By doing this, in near future, curry leaf will be proved to be very good alternative crop to small and marginal farmers for climate resilient agriculture.

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Vegetable soybean

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Vegetable-soybean [*Glycine max* (L.) Merrill] is also known as green beans. Its green-pods can be consumed in various ways such as snacks, salad, etc., while its green-seeds (beans) can be consumed like peas. On an average it contains 13% protein, 5.7% cholesterol-free fatty acids, 6.5% TSS, 158 mg/100g of phosphorus, 78 mg/100 g of calcium, 0.4 mg/100g of vitamin B1 and 0.17 mg/100g of vitamin B2.

In addition, it is also a good source of isoflavones and tocopherols. It is one of the few green-vegetables that have all essential amino acids in their protein compositions thus be considered as 'complete proteins', at par with meats, milk products and eggs.

At present, Jharkhand is the only state where commercial cultivation of this crop has been started, and it is becoming popular especially among children. Since research on vegetable soybean in India is still in blooming phase, there is urgent need to focus research on this crop to harness its nutritional potential especially for the new niches of the country. An initiative has been taken at ICAR-Indian Institute of Vegetable Research, Varanasi by adopting Vegetable soybean as a new underexploited vegetable crop.

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Geographical indications of vegetables in India

Geographical indication (GI) is a region or a locality used to identify products that come from these places and have distinctive characteristics. World Trade Organization says that quality, reputation or other characteristics of a comodity or product is attributed to its place of origin. GI registration is granted to a product if the product has a 'link' with the region or locality, which provides the uniqueness to the product. It is a community right and all the producers within the specific region holds the right to obtain benefits. GI's have to be protected in order to avoid misleading the public and to prevent unfair competition. It plays an important role in promoting the conservation of biodiversity among the rural populations. Among 86 horticultural products, vegetables cover 15% share to the total number of GI's. till 13 vegetable goods have been registered covering crops like chilli, brinjal, tomato, garlic, onion and French bean.

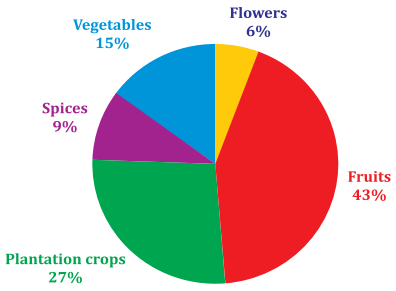
INDIA is a mega-diverse nation, housing around 10% of world's plant species. It has a rich cultural heritage back to thousands of years. Much of Indian biodiversity is intricately related to the socio-cultural practices of the land. Unfortunately, due to population explosion, climate change and lax implementation of environmental policies, several species are facing the threat of extinction. Not only does this affect the food chain, but also the livelihood and the culture of millions of Indians who depends on local biodiversity. It is vital that the common man is made aware of the domino effect of species loss and what we stand to lose. There are various ways to protect and conserve valuable biodiversity *viz.*, government legislation, nature preserves, reducing invasive species, habitat restoration, captive breeding and seed banks, reduce climate change, Geographical Indication and so on.

Geographical Indication (GI)

Article 22.1 of the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement of World Trade Organization defines GI as 'indications which identify a good as originating in the territory of a member, or a region or locality in that territory, where a given quality, reputation or other characteristic of the good is essentially attributable to its geographical origin'. Article 22 of TRIPS Agreement guarantees a standard level of protection for the products covered by it. It has also defined by the Section 2 of G.I. Act 1999. In general, it is a name or sign used on certain products which corresponds to a specific geographical location or origin. Indication includes any name, geographical representation or any combination of them conveying or suggesting the geographical origin of goods to which it applies.

The GI tag for the registered products means that their uniqueness has been verified by the expert committee nominated by Govt. of India. It ensures that only authorized users or community within a geographic region or locality involved in development/production of registered products can use the GI tag to claim benefits out of visual branding and marketing. In India, Darjeeling tea was the first item to obtain a GI tag in 2004. As of now, 361 products have been accorded with GI tags in India, viz. handicrafts (194) agricultural goods (109), manufactured goods (24), foodstuffs (16) and natural goods (1). Agricultural products have received significant attention in this regard to preserve their biodiversity and rights of people or community as a whole in conservation of agricultural crops. Among agricultural crops, horticultural crops have been considered major attention with fruit crops being major share in getting GI tags. Mango, citrus and banana have bagged the highest number of GI tags. Elite clones of fruit crops such as grape, pineapple, litchi, strawberry, guava, kokum, fig and custard apple have also obtained GI tags. Chilli followed by brinjal and onion have got the maximum number of GI tags among the vegetable crops. Jasmine and Kewda flowers have got GI brand among flowers.

Geographical indications of horticulture crops (% share) upto March 2020



Name of GI and Tag number	Scientific name	Area	State	Year of Registration	Unique Characteristics	Representative photograph
Naga Tree Tomato **(GI tag. 374)**	*Solanum betaceum*	Kohima, Wokha, Zunheboto, Kiphiri, Tuensang, Mon and Phek region	Nagaland	2015	The Naga tree tomatoes are locally known as *sei bangenuo*. The fruit looks like tomato with oval or egg shape which is a 'traditional food item of the Naga people'. The fruit is rich in vitamin A and C as well as an excellent source of calcium, iron, potassium, phosphorous and magnesium. Naturally, it helps in controlling high blood pressure and to bring down cholesterol levels	
Byadagi Chilli **(GI tag. 129)**	*Capsicum annum*	Byadagi region of Haveri	Karnataka	2011	Chilli is known for its deep red colour and got the highest colour value of 1,50,000 - 2,50,000 CU. It is not very pungent and is used in many food preparations in India. This chilli is characterized by wrinkles on the pods, low pungency and sweet flavour. The two main types are Bydagi Kaddi and Bydagi Dabbi	
Guntur Sannam Chilli **(GI tag. 143)**	*Capsicum annuum var. Longum*	Guntur, Prakasam, khammam	Andhra Pradesh	2010	It has long fruits (5 to 15 cm in length) and diameter range from 0.5 to 1.5 cms. It has thick skin. The chilli is hot and pungent with average pungency of 35,000 to 40,000 SHU. The content of Capsaicin is about 0.2260/0. This chilli is rich in Vitamin C (185 mg/100g) and Protein (11.98g/100g)	
Mizo chilli/ Mizoram's Bird Eye Chilli **(GI tag. 377)**	*Capsicum frutescence*	Mizoram	Mizoram	2015	Fruit is small sized pods and very high pungency. Color of mature fruit is blood red. Fruit size is not more the 4.5 cm It is one of the hottest chillies in the world. (SHU- 50000 to 100000)	
Bhiwapur Chilli (Doda chilli) **(GI tag. 473)**	*Capsicum annum*	Bhiwapur, Umred and Kuhi taluquas of Nagpur	Maharashtra	2016	Bhiwapur Chilli is known for its pungency. The colour is dark red. Outer covering is thick hence less chances of breakage and long shelf life. It length approximately measures 1.5 inch which describes its short size. The red colour of Bhiwapur chilli is darker than other Chillies like Guntur chillies. It is main ingredient in popular 'Varhadi Thecha' (spicy red chilli chutney)	
Khola Chilli / Kholchi Mirchi **(GI tag. 618)**	*Capsicum annum*	Canacona region	Goa	2019	Chilli is characterized by attractive red in colour with long in length and having medium pungent taste and thus is widely used in making papad. 'Khola/Canacona' chillies have been cultivated in Khola village during *Kharif* entire village community is involved in their conservation.	

Name of GI and Tag number	Scientific name	Area	State	Year of Registration	Unique Characteristics	Representative photograph
Jalgaon Bharit Brinjal **(GI tag. 501)**	*Solanum melongena*	Jalgaon	Maharashtra	2016	The golden-brown colour and tempting taste after roasting the brinjals make this variety popular among people. Jalgaon Brinjal is specifically used for making traditional spicy dish 'Khandeshi bharit'	
Udupi Mattu Gulla Brinjal **(GI tag. 199)**	*Solanum melongena*	Udupi region	Karnataka	2016	It has very thin skin and small spines on the fruit surface. It has unique taste and virtually gets dissolved while cooking and also less astringent and less bitter when compared to other variety of Brinjal	
Lasalgaon Onion **(GI tag. 491)**	*Allium cepa*	Nashik, Lasalgaon region	Maharashtra	2016	Lasalgaon light red onion variety is popular due to its colour, pungent taste, long shelf life and bigger size	
Bangalore Rose Onion/ gulabi eerulli **(GI tag. 212)**	*Allium cepa*	Districts of Bangalore Urban, Bangalore Rural, Chik-kaballapur and Kolar.	Karnataka	2014	Grown mainly for export purpose. It has scarlet red colour, anthocyanin, phenols and high pungency. The pungent property of these onions makes them suitable to be used in pickles	
Waghya Ghevada **(GI tag. 476)**	*Phaseolus vulgaris*	Koregaon, Khatav Tehsils, District Satara	Maharashtra	2016	Faint pink colour having red lines on it which resembles tiger skin. High nutritional content–rich in carbohydrates and protein. Tastes sweeter as compared to other Rajama varieties. Ghevda beans also contain protein, calcium, dietary fiber, iron and several other essential nutrients. These beans have impressive amount of antioxidants and even provide cardiovascular benefits	
Naga Mircha **(GI tag. 109)**	*Capsicum chinense*	Manipur, Arunachal Pradesh, Assam, Mayanmar	Nagaland	2008	Commonly known as the Ghost Chilli (Bhut Jolokia Mirchi). Naga Chilli is the World's hottest chilli ever found on this earth. It is 110 times hotter than the Hottest Guntur Chilli and 400 times hotter than the mildest Chilli's. Finely wrinkled skin with thin flesh. Fruity aroma and distinctive pungency. Exquisite unique taste. It has vitamins which prevents cardiac arrest. Acts as antibiotic. Used as pain killer, insect and pest repellent and anti-venom	
Kodaikanal Malai Poondu Syn. Kodaikanal Hill Garlic **(GI tag. 616)**	*Allium sativum*	Dindigul district	Tamil Nadu	2019	Kodaikanal Malai Poondu is known for its medicinal and preservative properties. It has anti-oxidant and anti-microbial potential. It has a presence of higher amount of organosulfur compounds, phenols and flavonoids compared to other garlic varieties. It's usually white or pale yellow and each bulb weighs 20-30g on an average	

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Significance of Geographical Indication

Legal protection: It confers legal protection to GI products in India. It prevents unauthorized use of a registered GI's by others. It provides exclusive rights to community/authorized users for GI products. It also enables seeking legal protection in other WTO member countries.

High market price and demand: GI's provide an effective platform for getting premium market price and more demand. Consumers are willing to offer better price for GI's as they are branded products. GI's increase better revenues for local producers and small scale entrepreneurs.

Conservation of biodiversity and traditional knowledge: GI's protect the biodiversity in plants and traditional knowledge of local people, community and tribal areas involved in developing handicrafts, natural goods, artifacts and manufactured goods. It offers huge market potential and better income for the people in villages or community. GI's enhance socio-economic conditions and livelihood of rural communities.

Improve tourism industry: GI's are unique products coming from demarcated areas. Cultivation or manufacturing process itself can attract many tourists. Handicrafts and handlooms with special characteristics are always attractive to tourists. Regions can attract tourists to taste the special GI foods or drinks or buy the unique products with discounts leads to strengthen market potential and export earnings.

Registration of GI products

The registration and administration have been envisaged to be discharged by the geographical indications registry under the GI of Goods (Registration and Protection), Act, 1999. The Geographical Indications Registry is located at Chennai. Any person who produces the goods in case agricultural commodities and includes processes or packages such goods, exploits the goods in case of natural goods, manufactures the handicraft or industrial goods or a person who trades or deals in such production, exploitation, making or manufacturing of the goods can be apply for registration.

GI registration provides the registered proprietor and the authorized user the exclusive right to protect the registered GI on the specified goods. Monopolization of the market enables the producers to control prices, i.e., can charge premium prices, thereby enhancing profits. It has been revealed that 80% consumers are ready to pay 20-30% higher prices as they believe that GI products are having better qualities over other goods.

GI protection for vegetables

India is a rich source of diversified vegetables possessing unique quality characteristics which are cultivated and conserved since many years by the local farmers and tribal community in specific geographical regions. Indeginous species/varieties of vegetables acquired distinctive quality characteristics like taste, aroma, high antioxidants, pigments, proteins, dietary components etc. as they are cultivated in specific location and climate. Government of India has recognized the wide diversity in vegetable sources like chilli, tomato, brinjal, onion, gralic and beans and accorded GI tags to popularize and enhance their economic potential. Till today, GI tags have been granted to 13 different vegetable varieties including chilli (6), tomato (1), brinjal (2), Onion (2), garlic (1) and French bean (1).

SUMMARY

Protection of intellectual property rights through GI is an important instrument in promotion of cultivation and conservation of vegetable varieties. Various institutions, state departments, govt. agencies and NGO's are involved in ensuring legal protection for Indian GI products. Granting GI tags to popular vegetable types will help to promote local people, rural communities/enterprises to ensure wider access to markets.

Govt. of India recently proposed 'One Product One District' (OPOD) approach, an action plan for promoting horticulture crops. It involves linking the said initiative with registration of GI products. It was already implemented in Japan and Thailand and has contributed to the rural development in both the countries. This approach would recognize to local products, traditional knowledge, bring down unemployment rate and more income for the rural community. GI products of vegetables have huge economic potential to reach global market and earn higher foreign exchange thereby enhance national income of country. Effective post-GI mechanism may be implemented to avoid unethical marketing practices and intervention of middlemen in domestic markets.

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– *Editor*

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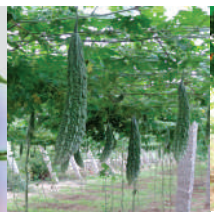
- ☑ Article should not be based on compiled matter or on some survey, report or record of extension education.
- ☑ Article should not be of theoretical nature or only of local relevance. Article text gives complete relevant details of practical utility to the farmer in clear and simple English.

T Janakiram

Bitter gourd at a glance


Baby bitter gourd


Bitter gourd on trellis


Long-light colour fruit


Colour break in bitter gourd


Spineless long fruited bitter gourd


Dark green small fruit

Bitter gourd is one of the most nutritionally rich vegetable with medicinal properties. It is an annual fruit vegetable and is also referred to as bitter melon, Karela or balsam pear. The fruits, seeds, leaves, vines and roots of bitter gourd have been used as food and as remedy from various types of diseases. It is an important source of essential amino acids, vitamins and minerals and has an important role in human diet for maintaining sound health. Different concentration of bitter gourd juice, sugar and citric acid is used to prepare ready to serve bitter gourd beverages. Bitter gourd extract might be applied as natural antioxidant instead of synthetic antioxidant in food sector for extending shelf life of food commodity owing to higher natural plant phenolics and antiradical power.

Botanical name : *Momordica charantia*

Family : Cucurbitaceae

Chromosome No. : 2n = 2x = 22

Place of origin : Indo-Burma region

Variability available : Shape, size and colour

Propagation : Seed

Seed sowing time : Summer crop- January to March

: Rainy crop- June to July

: Hills- March to June

Seed rate : 5-6 kg/hectare

Optimum temperature : 24-27^{0}C

Manure and Fertilizers : 20 tonnes of FYM + N: P: K: @ 120 : 100 : 100 kg/hectare.

Seed treatment : Seed should be treated with Captan at the rate of 2 g/kg seed.

Staking and trellising : The trellis should be 1.8-2.0 m high, constructed from stakes 1.2-1.8 meter apart, which is almost similar to the plant row spacing.

Irrigation : Usually fields are furrow-irrigated every 10 days during the cool dry season, and weekly during hot-dry season.

Harvesting and yield : Harvesting is done when fruits are still young and tender. On ripening the fruit changes its colour from green to yellow and orange. Picking may be done every alternate days. The average fruit yield varies from 90 to 150 quintal/ hectare.

Important diseases: Downy mildew, Powdery mildew, *Alternaria* leaf spot, *Fusarium* wilt and mosaic.

Important insects: Aphid, Fruit fly, *Epilachna* or Hadda beetle.

Varieties

Small fruited : Pusa Do Mausami, Small green, Pusa Purvi

Medium long fruited : Pusa Hybrid-2, Arka Harit, Pusa Vishesh, Pusa Rasdar, Priyanka, Konkan Tara, Meghna, Pusa Hybrid-4

Long fruited : Kashi Mayuri, Pusa Aushadhi, Hirkani, Coimbatore long white, MDU-1, Coimbatore long, Preethi, VK-1, Priya

Green and Dark green : Kashi Mayuri, Pusa Do Mausami, Arka Harit, Pant Karela-1, VK-1, Priya, CO-1, Pusa Vishesh, Coimbatore green, Hirkani, Phule green, Konkan Tara, Punjab-14, Meghna

White fruited : Preethi, Priyanka, Coimbatore Long White


Dark green fruit


Medium ribed fruit


Ripened fruit ready for seed extraction


Light colour bitter gourd


VRBTG-10


Wide ridged fruit Bitter gourd

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