Diversity in Underutilized Plant Species
– An Asia-Pacific Perspective

R.K. Arora
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– An Asia-Pacific Perspective

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The Asia-Pacific region is agriculturally diverse and very rich in plant genetic resources, including those of underutilized species and less known food plants. Several useful plants have been domesticated in this region and are important from economic development and food security point of view.

This publication deals with 778 underutilized cultivated food plants, pseudocereals, millets, grain legumes, root/tuber crops, vegetables, fruits and nuts, and several other species used as condiments, and for agroforestry development and multipurpose uses. Besides, it also lists species of industrial use that need further focus for research and development. In addition to geographical and ecological coverage, the compilation presents information on utilization of these relatively less utilised species, providing an analysis of their nutrition/food values. It also deals with required prioritisation of species for intensive research. Also, emphasis is laid on the native as well as endemic species needing priority attention for both research and conservation. The chapter on ‘Emerging Concerns’, brings out useful synthesis of information concerning the use of genetic diversity through scientific assessment, use of biotechnology, ethnobotany, ecology, etc. and gives an account of policy implications. It also points out to the role of different organizations such as Bioversity International (formerly IPGRI), International Center for Underutilized Crops (ICUC), and regional fora such as Asia-Pacific Association of Agricultural Research Institutions (APAARI) in networking and setting up new institutional arrangement, namely, ‘Crops for the Future’ by merging the Global Facilitation Unit GFU) under Bioversity International and the ICUC.

In the wake of emerging realisation about the importance of underutilised species, the account presented in this book will be useful in filling the gaps in research needs, in sorting out species of relatively more importance in different regions such as : East Asia, South Asia, Southeast Asia and Pacific/Oceania. Enormous diversity of underutilized crops exists in the region but their potential is not fully exploited. Studies on these genetic resources need to be intensified. The publication amply highlights such concerns. Overall, major emphasis has been laid on the effective and efficient utilization of these underutilized and less known cultivated species mainly grown by native communities, often in home
gardens and marginal lands, towards food security, addressing malnutrition, poverty alleviation and income generation – thereby helping towards meeting the Millennium Development Goals (MDGs).

Late Dr. R.K. Arora had earlier written a book on ‘Genetic Resources of Less Known Cultivated Food Plants’, presenting worldwide analysis, which was published by the National Bureau of Plant Genetic Resources (NBPGR) with support from International Board on Plant Genetic Resources (IBPGR). This publication stems from that initiative. The work embraced in this book is confined exclusively to Asia-Pacific region, considering the importance of this region in the global context. I am sure, this well synthesized account will generate further interest on research and development of underutilized crops for widening our food basket in the region.

I highly appreciate the dedicated efforts made by late Dr. Arora, just prior to his demise, in bringing out this very thought-provoking book on a subject which needs much greater attention of all concerned. The National Agricultural Research Systems (NARS) in Asia-Pacific region, regional fora like APAARI, members of national and international organizations, researchers, teachers and students will find this publication immensely useful and rewarding. I greatly appreciate the sincere efforts made by Drs. Roshini Nayar, Anjula Pandey and Umesh Srivastava in finalising the manuscript which Dr. Arora attempted but could not finish, by adding some useful information, where necessary and revising the same to enhance its utility. I also appreciate very much the funding support extended by Bioversity International, mainly through special efforts of Dr. P.N. Mathur, South Asia Coordinator for bringing out this publication. Help of Dr. Bhag Mal, Senior Consultant, APAARI in perusing the manuscript and advising the final layout is also acknowledged.

Raj Paroda  
Executive Secretary  
APAARI
The book commemorates his passion and dedication to the field of underutilized crops and useful wild relatives of crop plants.
Nature has provided different sources of life forms on which human survived on planet Earth. Primitive man ate all types of fruits, leaves, roots and tubers of plants collecting from wild; before he learnt to grow plants. Many wild edible plants are nutritionally rich and supplement nutritional requirements of human and livestock, especially the vitamins and micronutrients. Underutilized plant species have great potential for contribution to food security, health (nutritional and/or medicinal), income generation and environmental services, but these have remained underexploited. One important reason for their underutilization is that they are neglected by mainstream research which did not provide solutions to agronomic and post-harvest constraints, nor did it develop attractive value added products for a broader market. In recent years, however, underutilized plant species have received increased attention by National Agricultural Research Systems (NARS), policy-makers and funding institutions, recognizing their importance for diversification of farming systems, and thus mitigating the impacts of environmental and economic disasters on the rural poor. These increased efforts need direction and focus to yield significant and visible impact. The International Centre for Underutilised Crops (ICUC), the Global Facilitation Unit for Underutilized Species (GFU) and the Bioversity International (earlier IPGRI) had a wide consultation process with the aim of developing a strategic framework to guide future work on underutilized species. The world is presently over-dependent on a few plant species. Diversification of production and consumption habits to include a broader range of plant species, in particular those currently identified as ‘underutilized’, can contribute significantly to improved health and nutrition, livelihoods, household food security and ecological sustainability. In particular, these plant species offer enormous potential for contributing to the achievement of the Millenium Development Goals (MDGs), particularly in combating hidden hunger and offering medicinal and income generation options.

The Asia-Pacific region holds rich biodiversity in underutilized plant species. It is a centre of diversification and domestication of crop plants. Being culturally, ethnically and ecologically very diverse, several underutilized species are grown here and maintained by native farmers under subsistence agriculture.
Four regions of diversity, namely, Chinese-Japanese, Indochinese-Indonesian, Australian/Pacific and Indian region are located in this region. Also, eight out of the 17 mega-biodiversity countries namely Indonesia, Australia, China, India, Malaysia, PNG, the Philippines and Thailand are in this region.

Dr. R.K. Arora, during his long career as plant collector, was instrumental in locating underexploited and underutilized domesticated/semi-domesticated and wild plants particularly those used by ethnic communities in north-eastern and other regions of India. He had earlier written a book on ‘Genetic Resources of Less Known Cultivated Food Plants’ presenting world wide analysis in the year 1985. This publication stems from that account but Dr. Arora, in the present book, extended the scope of his study and documentation within the Asia and Pacific region, an area known to have rich ethnic diversity and historically linked biogeographic regions of plant diversity, both native and introduced. Actually, the account was mostly prepared by him but unfortunately, he could not do the final consolidation and editing during his life time due to prolonged illness.

Dr. Raj Paroda desired that his left over work may be completed, published and dedicated in his remembrance and also to commemorate his passion and dedication to the field of underutilized crops and useful wild relatives of crop plants. At his instance, the unfinished work was reviewed critically, information added where necessary, consolidated and edited by his colleagues Drs. E. Roshini Nayar, Anjula Pandey and Umesh Srivastava to bring it to its present shape while the text as close to the original manuscript as possible.

It deals with the enumeration of 778 species of underutilized and less known minor food plants grown in different regions of Asia-Pacific. It has 6 chapters and information presented has been classified under use-based categories such as cereals/pseudocereals (28 species), grain legumes/pulses (14 species), roots and tubers (55 species), vegetables (213 species), fruits (261 species), nuts (34 species), industrial crops (25 species) and those providing spices, condiments, and of multi-purpose use (148 species) including agro-forestry species and environment-friendly species. The choice for the priority species for R&D needs has also been suggested/discussed and the role of native/endemic diversity dealt with. Also information has been added to provide relative analysis of food/nutritional values of selected underutilized species. A thought-provoking need-based focus is also given for the use of other disciplines in meeting the growing need to promote and assess this diversity: use of biotechnology, ethnobotany and documenting indigenous knowledge, diverse uses and conservation of such species. The greater need for partnership/networking at national, regional and international level for realizing the full potential of underutilized species has also been stressed a great deal.
We express our gratitude to Dr. Raj Paroda, Former Secretary, Department of Agricultural Research & Education (DARE) and Director General, Indian Council of Agricultural Research (ICAR), currently Executive Secretary, APAARI and Chairperson, Trust for Advancement of Agricultural Sciences (TAAS), New Delhi for his constant encouragement in bringing out the book and also for writing the ‘Foreword’ to this book. Our sincere thanks to Dr. Prem Mathur, Regional Director, APO Office and South Asia Coordinator, New Delhi of Bioversity International for taking keen interest in the book and also funding etc, and Dr. Bhag Mal, Senior Consultant, APAARI for constant guiding, pursuing and advising throughout the finalization of manuscript. Furthermore we would like to acknowledge our colleagues in NBPGR (Drs. K.C. Bhatt, K. Pradheep, S.K. Malik, Anuradha Agrawal, K.V. Bhat, Soyimchiten and Mr. O.P. Dhariwal) for providing certain photographs. In addition, Bioversity International has kindly provided permission to use their resources. We acknowledge this gesture. We would also like to appreciate the efforts of Mr. Vinay Malhotra of Malhotra Publishing House, Kirti Nagar, New Delhi who has taken up the task of printing the present publication satisfactorily.

It is felt that APAARI member-NARS and other members including concerned CG centres, researchers, teachers, students and all those engaged and interested in the subject will find this well documented/synthesised information both useful and rewarding. We are sure, the book will generate further interest on this upcoming subject for widening the food basket to feed the growing population.

E. Roshini Nayar
Anjula Pandey
Umesh Srivastava
# Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tr>
<td>ACIAR</td>
<td>Australian Centre for International Agricultural Research</td>
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<td>ADB</td>
<td>Asian Development Bank</td>
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<td>AFCP</td>
<td>AgriFood Charity Partnership</td>
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<tr>
<td>AFLPs</td>
<td>Amplified Fragment Length Polymorphism</td>
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<tr>
<td>APAARI</td>
<td>Asia-Pacific Association of Agricultural Research Institutions</td>
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<td>APO</td>
<td>Asia, Pacific &amp; Ocenia</td>
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<td>AVRDC</td>
<td>Asian Vegetable Research &amp; Development Center</td>
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<td>BI</td>
<td>Bioversity International</td>
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<td>BMZ</td>
<td>German Federation Ministry for Economic Cooperation and Development</td>
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<tr>
<td>BSI</td>
<td>Botanical Survey of India</td>
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<tr>
<td>CBD</td>
<td>Convention on Biological Diversity</td>
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<tr>
<td>CGIAR</td>
<td>Consultative Group on International Agricultural Research</td>
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<tr>
<td>EST-SNP</td>
<td>Expressed Sequence Tag- Single Nucleotide Polymorphism</td>
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<td>EST-SSR</td>
<td>Expressed Sequence Tag- Simple Sequence Repeat</td>
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<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
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<td>FAO-RAP</td>
<td>Food &amp; Agriculture Organization-Regional Office for Asia and the Pacific</td>
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<tr>
<td>GCDT</td>
<td>Global Crop Diversity Trust</td>
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<td>GFAR</td>
<td>Global Forum on Agricultural Research</td>
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<td>GFU</td>
<td>Global Facilitation Unit</td>
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<td>GPA</td>
<td>Global Plan of Action</td>
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<td>Abbreviation</td>
<td>Full Name</td>
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<tr>
<td>IARI</td>
<td>Indian Agricultural Research Institute</td>
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<td>IBPGR</td>
<td>International Board of Plant Genetic Resources</td>
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<td>IBS</td>
<td>Indian Botanical Society</td>
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<td>ICAR</td>
<td>Indian Council of Agricultural Research</td>
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<td>ICARDA</td>
<td>International Center for Agricultural Research in the Dry Areas</td>
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<td>ICRISAT</td>
<td>International Crops Research Institute for Semi Arid Tropics</td>
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<td>ICUC</td>
<td>International Centre for Underutilized Crops</td>
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<td>IFAD</td>
<td>International Fund for Agricultural Development</td>
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<td>IIHR</td>
<td>Indian Institute of Horticultural Research</td>
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<td>IIVR</td>
<td>Indian Institute for Vegetable Research</td>
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<td>IJPGR</td>
<td>Indian Journal of Plant Genetic Resources</td>
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<td>IK</td>
<td>Indigenous knowledge</td>
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<td>INRC</td>
<td>Italian National Research Council</td>
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<td>IPGRI</td>
<td>International Plant Genetic Resources Institute</td>
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<td>ISPGR</td>
<td>Indian Society of Plant Genetic Resources</td>
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<td>ISSR</td>
<td>Inter Simple Sequence Repeat</td>
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<tr>
<td>MDG</td>
<td>Millenium Development Goals</td>
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<td>MSSRF</td>
<td>M.S. Swaminathan Research Foundation</td>
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<tr>
<td>NAAS</td>
<td>National Academy for Agricultural Sciences</td>
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<td>NARS</td>
<td>National Agricultural Research Systems</td>
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<td>NAS</td>
<td>National Academy of Sciences, India</td>
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<td>NAS</td>
<td>National Academy of Sciences, USA</td>
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<td>NBPGR</td>
<td>National Bureau of Plant Genetic Resources</td>
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<td>NHRI</td>
<td>National Horticultural Research Institute</td>
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<td>PGR</td>
<td>Plant Genetic Resources</td>
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<td>PNG</td>
<td>Papua New Guinea</td>
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<td>PROSEA</td>
<td>Plant Resource of South-East Asia</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>QRT</td>
<td>Quinquennial Review Team</td>
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<tr>
<td>RAPD</td>
<td>Random Amplified Polymorphic DNA</td>
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<tr>
<td>RFLP</td>
<td>Restriction Fragment Length Polymorphism</td>
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<tr>
<td>SSR</td>
<td>Simple Sequence Repeats</td>
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<tr>
<td>TAAS</td>
<td>Trust for Advancement of Agricultural Sciences</td>
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<tr>
<td>UNESCO</td>
<td>United Nations Educational, Scientific and Cultural Organization</td>
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<tr>
<td>USDA</td>
<td>United States Department of Agriculture</td>
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<tr>
<td>UTFANET</td>
<td>Underutilized Tropical Fruits in Asia Network</td>
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<td>WHO</td>
<td>World Health Organization</td>
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Dr. Rajeshwar Kumar Arora was an able and eminent plant scientist. He was born in Kamalia, Lyallpur (presently Faisalabad in Pakistan) on 14 December, 1932. He received his graduation (1954), post-graduation (1956) and doctorate (1961) degrees in Botany from Panjab University. He devoted his entire career to the field of plant systematics, ethnobotany, phytogeography and plant genetic resources. He was a visionary and a modest human par excellence.

Dr. Arora started his professional career at the Botanical Survey of India where he served in various capacities till 1968 when he joined the then Division of Plant Introduction, Indian Agricultural Research Institute (IARI), New Delhi as Senior Scientist, where, besides conducting research on collection and evaluation of economically important plants, he taught post-graduate courses in systematic botany and economic botany. After the elevation of Plant Introduction Division to a full-fledged institute, the National Bureau of Plant Genetic Resources (NBPGR), Dr. Arora served as the Head, Division of Plant Exploration and Germplasm Collection and later as the officiating Director. In 1989, Dr. Arora joined International Board of Plant Genetic Resources (later as International Plant Genetic Resources Institute and now Bioversity International), Office for South Asia, New Delhi as Associate Coordinator and later as South Asia Coordinator. After retirement, he continued to work with the Bioversity International as Honorary Research Fellow till middle of 2009 when his ill health forced him to work from home.

With his vast knowledge of Indian flora, Dr. Arora made pioneering contribution to collection and documentation of economically important plants of India, particularly wild crop-related species. He brought to public knowledge several less-known and under-utilized plants including *Digitaria cruciata*, *Moghania vestita* and *Inula racemosa*, and led major collection missions to several distant and unexplored areas of the country. His surveys contributed very significantly to our knowledge of agricultural biodiversity in India. Keenly aware of the richness of the Indian crop gene centre, he made exceptional efforts in coordinating activities on collection, conservation and use of plant genetic resources.
Dr. Arora was a prolific writer which combined with a deep understanding of plant genetic resources led him to produce a number of original and highly informative publications like “Wild Relatives of Crop Plants in India”, “Genetic Resources of less-known cultivated Food Plants”, “Wild Edible Plants of India: Diversity Conservation and Use”, and “Plant Genetic Resources Conservation and Management: Concepts and Approaches”. These have become reference books for researchers, students and policy makers engaged in plant genetic resources collection, conservation and utilization. Besides, he published over 160 articles in national and international journals and presented papers in several national/international conferences and scientific meetings.

During his tenure with Bioversity International, Dr. Arora devoted himself to promoting conservation and use of genetic resources at the international level. In addition, he associated himself with the Asia-Pacific Association of Agricultural Research Institutions (APAARI) and lent a helping hand in the promotion of agricultural research for development in the entire Asia-Pacific region. He contributed very significantly towards publication of success stories, conference reports and the newsletter brought out by Bioversity International and APAARI.

Dr. Arora was the founder Editor-in-Chief (1987-88) of the Indian Journal of Plant Genetic Resources (IJPGR) published by the Indian Society of Plant Genetic Resources (ISPGR). He was honoured with the “Dr. Harbhajan Singh Memorial Award” by the ISPGR and the “Harshberger Medal in Ethnobotany” by Society of Ethnobotany for his life-time contribution to research on economic plants. He was elected as Fellow of National Academy for Agricultural Sciences (NAAS), India; National Academy of Sciences (NAS), India; Indian Ethnobotanical Society; and Indian Botanical Society.

He was very keen to revise his earlier publication on this subject and started the work in this direction but could not complete the task during his lifetime. The publication partially prepared by him was again viewed and revised by his colleagues Drs. Roshini Nayar, Anjula Pandey and Umesh Srivastava to give final shape to it. This is being published and dedicated in his remembrance and also to commerorate his passion and dedication to the field of underutilized crops and useful wild relatives of crop plants.

Dr. R.K. Arora, an eminent scientist in the field of plant genetic resources (PGR) and recipient of the prestigious Dr. J.W. Harshberger Medal for 1996 instituted by the Society of Ethnobotany of India, Lucknow passed away on 3 March 2010. Dr. Arora made significant contributions in the field of germplasm collection, use and management with particular emphasis on diversity of crop plants, their wild relatives and underutilized species native to the Hindustani centre of megadiversity; taxonomy, ecology, phytogeography and ethnobotany of Indian species particularly wild edible species was a focal point for collection, study and analysis. For his extensive and intensive contributions in plant genetic resources of India, Dr. Arora was awarded the Dr. Harbhajan Singh Memorial award for 1998 by the Indian Society of Plant Genetic Resources, New Delhi.

Dr. Arora completed his graduation and post-graduation from Panjabi university, Amritsar and began his career as Assistant Ecologist (1960-1964) and Systematic Botanist (1964-1967) at the Botanical Survey of India, Calcutta (as Kolkatta was known then) after completing his Ph.D. in 1961 on the flora of Kanara district of Western Ghats. He joined as Senior Scientist in the Division of Plant Introduction, Indian Agricultural Research Institute (IARI), New Delhi in 1968; besides survey and collection of Germplasm he was also involved in teaching systematic botany and economy botany (1968-76). In 1976, when Division of Plant Introduction was upgraded to become an independent institute, Dr. Arora headed the Plant Exploration Division (1976-1982) and again in 1986. In his capacity as Head exploration programmes Dr. Arora undertook several exploration trips to areas with high diversity in remote areas such as the Pangi Valley for collection of cold tolerant wheat and barley germplasm and medicinal plants such as Saussurea lappa and Inula racemosa from the temperate and alpine regions of the Western Himalayas; north eastern region in search of locally domesticated and underutilized crops such as Coix lacryma-jobi, Moghania heterophylla, oilseed crop, Hodgsonia heterooclita, highly localized dual-purpose grass Digitaria cruciata var. cruciata from the
higher altitudes of Arunachal Pradesh; and the Chhota Nagpur plateau and Western Ghats for search and collection of progenitor wild species of native legumes such as the varieties \textit{sublobata} and \textit{silvestris} of green and black gram, respectively and the Eastern Ghats for endemic species of Cajanus. Dr. Arora also undertook collection missions in Africa and travelled widely in his capacity as expert in plant genetic resources to USSR, Indonesia, etc. He subsequently became the Officiating Director of NBPGR (1987-88) before leaving NBPGR and taking a lead in coordinating PGR programmes for South Asian region as Associate Coordinator (1989-1991)/ Coordinator (1992-1998) at the Regional Office for South Asia, New Delhi of the International Board for Plant Genetic Resources (IBPGR) later designated as the International Plant Genetic Resources Institute (IPGRI) Office for South Asia/ Bioversity International Sub-regional Office for South Asia. Here, he continued his work on PGR, promoting conservation and use of tropical fruit species in Asia and coordinating diverse PGR activities and projects on tropical fruits. After retirement, he continued to work as Honorary Research Fellow in the Bioversity International Office up to June 2009.

Dr. R.K. Arora was a prolific writer, and in addition to over 160 publications in national and international journals, he has authored/ co-authored nearly ten books on plant genetic resources of the Indian region. He authored/ co-authored the book on ‘Wild Edible Plants of India’ in 1978, later revised with emphasis on conservation and utilization in 1996; his publication entitled ‘Genetic Resources of Less-known Cultivated Food Plants’ was published in 1985. The pioneering contribution however was the book co-authored on ‘Wild Relatives of Crop Plants in India’ in 1984; this work delineating wild related species of crop plants that are a priority for collection and conservation in the Indian region was among the first of its kind for a megadiversity centre. During his tenure at the IBPGR/ IPGRI/ Bioversity International, Dr. Arora co-authored several books and publications on tropical fruit crops, another priority area of research in plant genetic resources. Dr. Arora also headed the team involved with the publication of the Annual report of NBPG, Research Highlights, Newsletter and other institute publications of the NBPG (1978-1986); he was the the founder Editor-in-Chief (1987-88) of the Indian Journal of Plant Genetic Resources (IJPGR), published by the Indian Society of Plant Genetic Resources (ISPGR), and the Bioversity Regional Newsletter for Asia, Pacific and Oceania at the South Asia Office of the Bioversity International.

In view of his wide experience on a wide repertoire of subjects relating to the PGR of the South Asian region and the Indian region in particular, Dr. Arora was closely associated with the national and international policy relating
to collection, conservation and management of PGR diversity. His scientific contributions led to his election as Fellow of several scientific bodies such as National Academy of Sciences, India (NAS), the National Academy of Agricultural Sciences (NAAS), Indian Ethnobotanical Society and the Indian Botanical Society. He is also on the Board of Trustees of TAAS (Trust for Advancement of Agricultural Sciences), New Delhi.

In spite of his vast experience and recognition as a doyen of PGR, Dr. Arora has been an unassuming person. Despite a heavy workload due to his wide expertise, he was able to execute and complete a large number of assignments and academic works. It was a privilege to work with Dr. Arora or be associated with him in work of a collaborative nature. He literally ‘burnt midnight oil’ and when working on projects of a collaborative nature, he contributed a ‘lion’s share’. More importantly he made his collaborators and co-workers aware of their strengths and provided a lesson in sharing benefits of a work to mutual benefit. One felt privileged to work with him. When responding to his requests to provide him with some help, may be by providing information or editing a table, one ended up learning something new. Dr. Arora was generous in sharing his ideas and conclusions and his colleagues were free to question and criticize them. His rewards were also satisfying; he would make an effort to search out and find an elusive but highly valuable reprint or book. Dr. Arora continued to contribute to PGR in spite of continued ill-health in the last few years and actively pursued his writing work almost till the end. His demise is a major loss to plant science in general, and PGR in particular, as he was undoubtly one of the doyens in this field.

Excerpts from obituary published in Ethnobotany (7th March 2010)

Dr. S.K. Jain, Former Director, Botanical Survey of India writes:

In the sad demise of Dr. R.K. Arora, destiny has snatched from India, rather South east Asia one of the ablest and devoted explorer of plant genetic diversity. He botanised from hot dry deserts of Rajasthan to evergreen forests of north east and East India, and from cold and humid regions of Leh-Ladakh to humid evergreen forests far south in peninsular India. Dr. Arora’s hard and scholarly work on collection study analysis of landraces and wild relatives of crop plants contributed very largely to our knowledge of India’s biodiversity, conservation of valuable germplasm and significant improvement in many economic crops of India and other countries. His scientific contributions have remained undisputed.
My association Dr. Arora dates back to middle of last century when he worked as Research Scholar in Botanical Survey of India (BSI) in Pune; he accompanied me in several field trips in north and south Canara in Western Ghats and coastal Maharashtra. Later, he joined BSI and our association became closer when we lived in different floors in the same building in Calcutta. We spent long evening discussions, plan of field work, seminars, conferences and publications. Even after he moved to ICAR, we regularly met. As a member of Quarterly Review Team (QRT), of NBPGR during 1980s, it pleased us greatly to see the outstanding work, organization and guidance which he provided to his colleagues as Senior Scientist and later Head of NBPGR.

Dr. Arora had excellent communication skills, and his lectures and writings received wide acclaim. He shunned publicity and advertisement, but his excellent work attracted attention of international bodies and the FAO and IBPGR invited him for several consulting assignments and later made him the head of the regional South East Asia office of IBPGR at Delhi. He served with IBPGR till his failing eyesight and other medical problems intervened. My tribute to him will not complete without a few words of admiration for his very supportive wife, Smt. Krishna Arora, who happily allowed his frequent long absences for field work or assignments as Consultant; she not only single handedly managed the house but also ably organized the education and development of their two loving children.


**Dr. Bhag Mal writes...**

I first came in contact with Dr. R.K. Arora in 1975 when I joined at the Plant Introduction Division of Indian Agriculture Research Institute (IASI) for pursuing my Ph.D. Subsequently, after my joining as Geneticist (Grasses) at the Indian Grassland and Fodder Research Institute (IGFRI) Jhansi, when I visited National Bureau of Plant genetic Resources (NBPGR) and met Dr. Arora, he advised me to apply for the post of Project Coordinator. All India Coordinated Research Project on Underutilized Crops (AICRP-UUC) and based on his advice, I applied for this position and fortunately got selected and joined as Project Coordinator (AICRP-UUC) at NBPGR, New Delhi. During my assignment at NBPGR, my association with him had been very cordial and I found him a very sincere, dedicated, hard working person and a systematic botanist par excellence with dynamic leadership quality and down-to-earth nature.

Dr. Arora possessed an excellent organizational capacity which I witnessed when an International Workshop on Maintenance and Evaluation of Life Support
Species in Asia and the Pacific Region was jointly organized by Commonwealth Science Council (CSC) and NBPG/ICAR at NBPG in April 1987 under the able guidance and dynamic leadership of Dr. R.S. Paroda, the then Director, NBPG with which I was also associated. The proceedings of the Workshop were later published as a book entitled “Life Support Species: Diversity and Conservation” and I shared the editorial responsibility with him in bringing out the publication which proved to be immensely useful to policy makers, researchers, teachers and students.

After about a decade, I got the opportunity to take over the charge of South Asia Coordinator, International Plant Genetic Resources Institute (IPGRI) from Dr. Arora when he retired from this position after serving for nine years. Owing to his outstanding contributions, he was again appointed as Honorary Research Fellow at IPGRI, South Asia Office and continued working till his last breath. I do remember that as per IPGRI rules in vogue at that time, he accompanied me to Bangladesh, Bhutan, Nepal and Sri Lanka to get me introduced with Heads of National Agricultural Research Systems (NARS) and acquainted with IPGRI programs and activities being implemented in these countries. During these visits, I had an opportunity to closely observe his personal qualities and found him a person of extremely high integrity, good behavior, humble nature, helpful attitude, good temperament, soft spoken and a fine human being par excellence.

During my tenure as South Asia Coordinator, he was kind enough to provide me full support particularly in bringing out half yearly IPGRI Newsletter which was considered to be the best among the Newsletters published from other regions of IPGRI. He was a prolific writer with several books and a large number of high quality research papers to his credit. He possessed exceptionally remarkable editorial skill and hence provided tremendous help to me in reviewing and editing several publications, progress reports, and conference proceedings, etc. I do remember that whenever I faced any problem/difficulty, I always depended on him and his kind advice was instantly available to me.

After my retirement, I also had an opportunity to serve Bioversity International (formerly IPGRI) in the capacity of Honorary Research Fellow like Dr. Arora and fortunately we used to share the same room. This provided us great opportunity to share our views, discuss on issues of importance to Bioversity International, jointly review programs and activities and edit proceedings of conferences/workshops, success stories and status reports and provide support to Dr. P.N. Mathur, who took over from me the position of South Asia Coordinator. But, unfortunately, this association did not last long since Dr. Arora left us for heavenly abode in March, 2010.
Dr. Arora’s love for the cause of science and its dissemination is widely known and is well reflected through his dedicated service to the Indian Society of Plant Genetic Resources (ISPGR) as the Editor-in-Chief of Indian Journal of Plant Genetic Resources (IJPGR) for many years. For his significant achievements and outstanding contributions in the field of plant genetic resources, he was honored with Dr. Harbhajan Singh Memorial Award of ISPGR and the cash prize received was donated by him to ISPGR. Subsequently, he donated some more money to the Society. During my tenure as President, ISPGR, on my initiative, the Executive Council instituted Dr. R.K. Arora’s Best Paper Award to promote scientific writing relating to plant genetic resources.

Dr. R.K. Arora will always be remembered by the scientific community for his significant achievements and outstanding contribution for all time to come. I found in him a great supporter, good friend and a guide and I will always cherish my long association with him in various capacities at NBPGR and Bioversity International).

(Prof. Bhag Mal, Consultant, APAARI, Formerly, South Asia Coordinator, Bioversity International, Director, IGFRI & ADG, ICAR)

Dr. Umesh Srivastava writes...

In his book ‘Plant Genetic Resources in Indian Perspective: Theory and Practices’, Dr. Umesh Srivastava, Former Assistant Director General (Horticulture), ICAR mentions, ‘------------------’. Later M.W. Hardas, K.L. Mehra, R.S. Paroda and R.S. Rana with dedicated team of scientists namely R.K. Arora, B.S. Joshi, S.R. Wadhi and others like S.A. Dadlani, T.A. Thomas, K.C. Sanwal, A.K. Lambat, P.P. Khanna, B.P. Singh and K.P.S. Chandel had played a key role in building up the institute (NBPGR) at initial stages and in strengthening different aspects of plant genetic resources including germplasm introductions and exchange activities. ------------------. (on p 168).’

I was associated with Dr. R.K. Arora soon I joined as Scientist S-1 in NBPGR in initial years of my career from year 1978-1980 and later from 1985-1989. After his joining IBPGR/IPGRI/Bioversity International in 1989, I was taking his advice as and when needed. I learnt a lot from him, skill of plant exploration and germplasm collection, visiting only mostly to far flung places and tribal belts, analysis of collected material, ethnobotanical aspects, and writing skills. When he returns after spending several weeks in tribal belts in north eastern states, and Western Himalayan peaks in search of rare and useful germplasm, I used to spend sometime with him to learn his practical experiences and skill of collecting wild relatives of crop plants. Although, he was reluctant sometimes due to his busy schedule in several
NBPR activities but I used to extract from him. The courage which I gained from him, for instance, crossing high current Ravi river at high altitudes in Himachal Pradesh with rope and basket system (used by locals in the area) in search of valuable germplasm and many other difficulties (and how to overcome those) prompted me to go anywhere without fear and face the difficult problems as well. Inspired by him, I chose to travel mostly in difficult areas like inaccessible Abujhmarh (Narayanpur) and naxal dominated south west of Bastar- Bijapur, Geedam, Jagargunda, Konta, Sukma, Dantewada etc and Sironcha of Chandrapur (now Gadchiroli district) and Nimar area in south west of Madhya Pradesh including Dhar, Jhabua, Alirajpur areas and far flung places like Bharmour, Manimahesh in Himachal Pradesh among so many other difficult areas. I faced problems also several times and used to overcome the same with the skills developed in me. He always used to praise for my efforts in collecting wild relatives and other stable types of germplasm (a kind of repeated select material by farmers in several years) which can make a variety in itself. He guided me always to develop myself a good explorer. I argued with him several times and differed with him a little bit. I appreciate his efforts to collect rare and good germplasm material throughout his life and differed with him that he did not have a track of his material as far as its evaluation and utilization is concerned. I preferred to engage myself in exploration of germplasm material and also its evaluation part. The experience which he gained during field trips could help him in analysing his material too much.

I learnt a great deal from him on writing skills also. He used to give me long reports of several pages to reduce to one page without deletion of facts and figures and I could able to do it perfectly. He depended on me a great deal when he was Head of Plant Exploration Division of NBPR in eighties. For difficult work, he used to catch me thinking that I can perform to his satisfaction and quickly also.

My association with him for a long period in NBPR and otherwise gave me so much strength that I could develop my personality in terms of high level of strategic judgement, adaptability and resourceful person, develop inter-personal relationship, motivation techniques, negotiation skills, communication ability, persuasive power and skills to develop win/win relationship with network of senior contacts as well as peers and junior workers. I remember him on these accounts so much.

(Dr. Umesh Srivastava, Former Assistant Director General (Horticulture), Indian Council of Agricultural Research, New Delhi, India)
Dr. Prem Mathur writes…

My association started with Dr. R.K. Arora when I joined Germplasm Evaluation Division of NBPGR New Delhi after my transfer from IGFRI Jhansi in the year 1985. At that time, he was Head of Plant Exploration Division and next to Director. I used to take guidance from him time to time. Reposing confidence in me, he was instrumental in suggesting Director NBPGR to give me responsibility of coordinating newly agreed ICRISAT-NBPGR collaborative research programme which I performed with full devotion. It continued for about two decades and was adjudged as one of the best project NBPGR has performed those days. In the meantime in year 1989, Dr. R.K. Arora moved to South Asia Office of Bioversity International (then IPGRI) located in New Delhi as Coordinator. Interacting with Dr. M.H. Mengesha, other ICRISAT scientists and senior/peer scientists in NBPGR, I developed keen interest in all kinds PGR activities a great deal. The experience and confidence which I gained paved my way in getting the position as Associate Coordinator in the Bioversity International in the year 1995, and luckily under Dr. R.K. Arora only who was working there as Coordinator. Working with him, my association deepened and I found him a very sincere and hard working person with dynamic leadership quality.

With his full support and association, I picked up tricks of the trade quickly and have become acutely aware as to how important it is to be consistent, fair and inclusive in all decisions one makes and the importance of making decisions within the approved policy framework. I learnt a great deal from him. He guided me in initial stages to work more independently and this has helped me too much in dealing with difficult problems without any hindrance. Under his guidance, I have also developed managerial skills in terms of planning, organizing, actuating and monitoring for successful completion of tasks. In the process I have also been able to help my peers and subordinates to develop their own personalities. Besides, I have acquired high level of confidence in me and the technique of fund raising activities independently.

After his retirement, he served Bioversity International in the capacity of Honorary Research Fellow and helped in activities like editing of proceedings of Conferences / workshops, status reports and in bringing out half yearly IPGRI Newsletter etc. Dr. Arora was generous in sharing his ideas. His association for a very long time at NBPG and Bioversity International has provided me great opportunity to share my views both in personal and official work as also had guidance on various issues related to Bioversity International. I remember him too much on these accounts.

Dr. Prem Mathur, Regional Director, Asia, Pacific and Oceania & South Asia Coordinator, Bioversity International, Sub-Regional Office for South Asia, G-1, B-Block, NASC Complex, DPS Marg, Pusa Campus, New Delhi 110012, India
Dr. E. Roshini Nayar: homage to Dr. Arora

Dr. R.K. Arora’s contributions, in his own words, relate to locating underexploited/underutilised cultivated and wild, domesticated and semi-domesticated plants used by ethnic communities and documentation of native useful genetic resources. This book epitomises the same, documenting important lesser known plants of the region covering Asia and Pacific regions. This is a work he wanted to finish but could not complete because of his ill health. From the time I joined the NBPG in 1977, I have been privileged to work with Dr. Arora and learn from the experience of collaborating in the work of documenting and prioritising wild relatives of crop plants, diversity of Indian region vis-à-vis other megacentres of diversity, and differences between the crop and wild species. Looking back, the significant aspect of working with Dr. Arora has been not only collaborating on some of the pioneer areas of work but also his positive role in helping me to develop my strengths and contributing meaningfully to the projects in hand. Whatever work I have done for him or with him, I have received doubly in return in terms of knowledge imparted and shared by him. He epitomised the role of guide and teacher not only to me but to my contemporaries and juniors too.

Dr. E. Roshini Nayar, Offg Head, Plant Exploration & Collection Division, National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi 110012, India.

Dr. Anjula Pandey writes...

When I joined the NBPG in 1986, the first person I met was Dr. R.K. Arora who was then the nodal person for ARS Scientists’ orientation programme. Throughout my association with him for more than eight years when he was in NBPG, he always remained as a guiding force and source of encouragement that helped me in grooming my skill for work on the plant genetic resources. His constant motivation helped me to write my first paper on “Ethnobotanical Evidences vis-à-vis Domestication Trends in “Cheura” [Aisandra butyracea (Roxb.) Baehni] that was co-authored with him and was published in journal of Ethnobotany. Throughout my association with him, my understanding on the subject improved gradually. Later in 1996, I got a golden opportunity to be co-author in his book on “Wild Edible Plants of India: Diversity Conservation and Use”. His great passion for neglected/underutilised plants, especially the wild potential species was evidently reflected in this compilation. Even today I feel proud to admit that he has nurtured my scientific calibre in a big way.

Dr. Anjula Pandey, Principal Scientist, Plant Exploration & Collection Division, National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi 110012, India.
Asia-Pacific region: Richness in plant diversity

Asia Pacific region has a rich diversity of plants, which have been used by people for generations. The majority of people in Asia Pacific still rely directly on the diversity of plants or plant genetic resources for food and medicine. There is an abundance of local expertise in PGR that has been in use over a considerable period of time and is also constantly evolving. In agriculture, for instance, the knowledge is shown in the development and adaptation of plants and crops to different ecological conditions.

The Asia-Pacific region consists of 39 countries representing West Asia, South Asia, Southeast Asia, East Asia and the Pacific (APAARI, 2006; Fig. 1). Its vast area represents diverse eco-climates and physiography, supporting semi-arid to humid tropical, littoral, subtropical to temperate high altitude, biodiversity-rich habitats. The region also possesses rich ethnic and cultural diversity that reflects its agricultural heritage. It is a seat of domestication and diversification of food crops and other important agrobiodiversity. Besides, a unique and rich wild flora, it also abounds in economic plant wealth of diverse useful/edible species, most of them underutilized.

As pointed out in the recent findings/studies relating to the floristic richness of species in different phyto-geographical regions of the world (Mittermeier et al., 1997), there are 17 mega-biodiversity countries. Table 1 provides the estimates of the richness of total species, and the percentage of endemic/native species within these countries, which fall under the following major geographical regions.

- South America: Brazil, Peru, Colombia, Ecuador, Venezuela
- Central America: Mexico
- North America: USA
- Africa: South Africa, Madagascar, Democratic Republic of Congo
- Asia and the Pacific: Indonesia, China, India, Australia, Papua New Guinea, Malaysia, Philippines

Table 1 lists these countries in the decreasing order of species richness and of these 17 mega-biodiversity countries, seven are from the Asia-Pacific region. The figures in Table 1, for Asia-Pacific region, also point out that:
Fig. 1. Geographical jurisdiction of Asia-Pacific region
• Indonesia has higher number of species, with equally high endemic wealth, followed by China.
• India, Papua New Guinea (PNG) and Australia fall below China, and PNG with Australia possess very rich wealth of endemic species.
• Malaysia falls below PNG in endemic species, followed by the Philippines.

The number of species within these mega-biodiversity countries of the Asia-Pacific region varies between 37,000 species in Indonesia to 8,000 – 12,000 species in the Philippines, with endemic species wealth of about 14,800 – 18,500 and 3,800 – 6,000 species in Indonesia and the Philippines, respectively. However, both PNG and Australia exhibit higher percentage in endemic species surpassing all countries. (Table 1).

Further, most of these mega-biodiversity countries also possess rich cultural heritage, and are ecologically and ethnically diverse. The natives here have been, and are still dependent on indigenous wild, semi-domesticated and domesticated diversity largely of

| Table 1. Species richness and endemic species of higher plants in mega-biodiversity countries |
|---------------------------------|-----------------|-----------------|
| **Country**                     | **Total plant species** | **Endemic plant species** |
| Brazil                         | ~50,000 – 56,000 | ~16,500 – 18,500 |
| Colombia                       | 45,000 – 51,000 | 15,000 – 17,000 |
| Indonesia                      | ~37,000          | 14,800 – 18,500 |
| China                          | 27,100 – 30,000  | ~10,000          |
| South Africa                   | 23,420           | 16,500          |
| USA                            | 18,956           | 4,036           |
| Mexico                         | 18,000 – 30,000  | 10,000 – 15,000 |
| Peru                           | 18,000 – 20,000  | 5,356           |
| Ecuador                        | 17,600 – 21,070  | 5,000 – 8,000   |
| India                          | >17,000          | 7,025 – 7,875   |
| Venezuela                      | 15,000 – 21,070  | 5,000 – 8,000   |
| Australia                      | 15,638           | 14,458          |
| Papua New Guinea               | 15,000 – 21,000  | 10,500 – 16,000 |
| Malaysia                       | 15,000           | 6,500 – 8,000   |
| Philippines                    | 8,000 – 12,000   | 3,800 – 6,000   |
| Madagascar                     | 11,000 – 12,000  | 8,800 – 9,600   |
| Democratic Republic of Congo   | 11,000           | 3,200           |

Source: Mittermeier et al. (1997); countries are listed in order of species richness
edible less-known, underutilized plants and other economic plants for their daily needs of food, feed, shelter and health care.

Harnessing underutilized plant species diversity

It has been estimated that humans directly modify and use more than 40% of the earth’s terrestrial ecosystems, harnessing their productivity for human benefit and modifying their composition, so as to meet their needs. Thus, the traditional agro-ecosystems have been sustained by native farming societies to their benefit under subsistence farming with a wide variety of major and minor food species. Understandably, the role of underutilized species has evolved over time and as it is today, it adds to the quality of life besides meeting needs of the rural poor in particular.

The positive effect of this diversity is that it sustains itself in the local habitats providing benefits to with local farmers, occupying marginal lands. However, the level at which such diversity is identified, protected, domesticated and used varies, depending on the food habits of the native communities and their cultural and aesthetic needs.

Cultivated plant diversity vis-à-vis underutilized species

The quest of man to explore and use plant wealth is as old as the history of civilization and the origin and domestication of cultivated plants (Vavilov, 1951; Burkhill, 1952; Hyam, 1971; Harlan, 1975; Zeven and de Wet, 1982; Hawkes, 1983; Zohary and Hoff, 1992; Damania et al., 1998; Arora, 2002). Also, in the regions of crop-plant diversity, native communities as per their food-needs, domesticated widely available diversity from native, wild habitats. Species adapted to, and occupying a wide geographical range, were domesticated at different places, depending on the need (choice) of local inhabitants for various usages i.e. Amaranth as a grain crop in South America and more as a pot-herb/vegetable in Asia; Corchorus as pot-herb in Africa and for fibre in Asia; Lepidium for salad in the Near East and as a root crop in the Andes (Harlan, 1975).

In human history, plant wealth of about 80,000 species has been used by human beings for food, fibre, industrial, cultural and medicinal purposes (Kermali et al., 1997). Of these, 30,000 species so far have been identified as edible and about 7,000 species have been cultivated and/or collected for food at one time or another (Wilson, 1992). Kunkel (1984) listed 12,650 edible plants species and Tanaka (1976) about 10,000 species. The ‘Dictionary of Economic Plants’ includes about 9,000 species (Uphof, 1968) and the publication on World Economic Plants (Wiersema and Leon, 1999) deals with over 9,500 species, and ‘Flora Dietica’, includes about 3,087 edible species (Hedrick, 1972). Further, Bailey (1951) lists 5,347 species of food
plants and Zeven and de Wet (1982) list 2,489 species from 12 regions of diversity of cultivated plants, while Arora (1985) has enumerated 992 species of less known/underutilized food plants assessing their distribution as per use category in different regions of diversity of cultivated plants (Box 1).

Against this relatively large number, presently, only 30 crops are reported to feed the world (Harlan, 1975), of which 10 crops, namely, wheat, rice, maize, sorghum, millet, potato, sweet potato, soybean, sugarcane and sugarbeet, provide 75% of the total plant-derived energy (calorie) intake. While according to Prescott-Allen and Prescott (1990), 90 per cent of the food plant supplies are provided by only 103 plant species, FAO (1996) limits this estimate to about 80 crop plants. Thus, globally, there is narrowing down in the number of crops upon which worlds’ food security and economic growth depends for sustainable livelihood (Box 2).

It is estimated that among the 55 plant families which have contributed to the supply of domesticated species (Harlan, 1975), the grass family, Poaceae/ Gramineae, has contributed 29 cereals (and sugarcane), Fabaceae/ Leguminosae - 41 crops (pulses, beans, tuberous types), Solanaceae - 18 crops (fruits, vegetables, spices, and one tuberous type), Cucurbitaceae - 13 crops (pumpkin, squash, varieties of gourds and cucumber), Rosaceae - 11 crops (fruits), Liliaceae - 11 crops (edible bulbs), Umbelliferae/ Apiaceae

| Box 1. Number of economic plant species including edible plant species |
|-----------------------------|------------------|--------------------------------------------------|
| Kermali                     | 1997  80,000     | - Overall economic plant species wealth          |
| Wilson                      | 1992  30,000     | - do; more food plant species                    |
| Kunkel                      | 1984  12,650     | - do                                             |
| Tanaka                      | 1976  10,000     | - do; mainly food plants                         |
| Wiersema and Leon           | 1999  9,500      | - Economic plants; includes 1,049 food plants    |
| Bailey                      | 1957  5,347      | - Mainly food plants                             |
| Uphof                       | 1968  9,000      | - Economic plant species including edible plants |
| Hedrick                     | 1972  3,087      | - Food and other cultivated plants               |
| Zeven and de Wet            | 1982  2,489      | - do                                             |
| Arora                       | 1985  992        | - less known cultivated food plants              |
Diversity in UnderUtilized Plant Species - An Asia-Pacific Perspective

- 9 crops (salad, condiment, spice) and Araceae - 8 (tuber crops). Among the cultivated plant diversity of 2,489 species distributed in different regions of the world (Zeven and de Wet, 1982) and belonging to 167 families, Poaceae (359 species), Leguminosae (323 species), Rosaceae (154 species) and Solanaceae (100 species) are well represented. Interestingly, most of this crop plant wealth is located in the developing world/countries (Table 1) and includes rich diversity of underutilized plant species/native domesticated plant wealth.

Concerns on underutilized species

The overall analysis of species diversity of well known and less known wild and cultivated plants makes us realize that humankind’s agricultural successes have stemmed from its ability to use biological diversity to its advantage to meet its diverse needs, and that: (i) much efforts have been made, particularly in the past 30 years, to enumerate plants useful for human welfare, (ii) enormous species diversity exists in different agro-ecological regions of cultivated plants and in the floristic regions for both wild and semi-wild, domesticated species; (iii) humanity globally, depends now on a very narrow range of about 10 crops, or at the best 20-30 crops (Harlan, 1975) to meet its food and other needs; (iv) meeting production-oriented goals through development and adoption of advanced technologies has narrowed down crop diversification in major cultivation areas with focus on a few crops and in this process, much native diversity has been eroded, and (v) the value of this underutilized plant diversity for human welfare is enormous (Padulosi et al., 2002; Joshi et al., 2002, Arora, 2002; Arora et al., 2006).

Box 2. Narrowing of food basket world wide

- Prescott-Allen and Prescott (1990) point out that 90% of the food plant supplies are produced by only 103 plant species; FAO (1996) lists about 80 crop plant species.
- 30 crops are reported to feed the world (Harlan, 1975) of which 10 crops - wheat, rice, maize, sorghum, millet, potato, sweet potato, soybean, sugarcane and sugarbeet provide 75% of the total plant derived energy (calorie) intake. And three crops, namely, wheat, rice and maize are most important.
- Widening of this food basket is considered imminent and in this diversification process, there is an important role of underutilized crops/species, contributing to food security, income generation and poverty reduction - meeting the Millennium Development Goals (MDGs).

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The above concerns on crop diversification through exploitation of underutilized, neglected and less-known species, life support species and new crop resources have been well highlighted in several national, regional and international meetings (Paroda et al., 1988; Paroda and Bhag Mal, 1989; Cooper et al., 1992; de Groot and Haq, 1995; Quah et al., 1996; Bhag Mal et al., 1997; Smartt and Haq, 1997). There is increased focus on exploring opportunities to tap the potential of such valuable plant species which have high genetic diversity, low pest-risk, multipurpose use and scope for value addition, and are well-tuned to native/traditional farming practices with low inputs, and provide security to rural communities (Evy, 2000). Also, many of these are rich sources of protein, amino acids, minerals and vitamins (Annexures I, II; Chapter IV). There is thus a growing realization of the need to enlarge/diversify the food basket of potential, promising underutilized species for food and nutritional security in the global context (FAO, 1996; Padulosi, 1999; MSSRF, 1999; Evy, 2000; Padulosi et al., 2002). Moreover, there has been a greater upsurge in research and development activities associated with diversification of such underutilized species and their suitability for different agro-ecosystems, specifically focussing on the needs of rural farmers in marginal agro-habitats with limited livelihood options. Equally important in this context have been the global developments such as the Convention on Biological Diversity (CBD) and the FAO International Technical Conference on Plant Genetic Resources for Food and Agriculture held in Germany in 1996 (ref. Activity 12: promoting development and commercialization of underutilized crops and species); Global Plan of Action (GPA) includes this as one of its 20 priorities; the Global Forum on Agricultural Research (GFAR) has also emphasized on the role of underutilized species in income generation of the rural poor (Padulosi et al., 2002).

**Major thrust for R&D: Institutions involved**

The research and development in underutilized plant species/crops has gained momentum particularly in the last few decades, and the opportunities and avenues have widened with better communication/information dissemination. The crop introduction and exchange across continents has also helped in the build-up of such promising diversity and in the process of diversification, provided a wider choice of species/varieties tuned to diverse habitats, and their acclimatization, cultivation and spread. In this endeavour, the role of international organizations such as Bioversity International (formerly International Plant Genetic Resources Institute, IPGRI), International Centre for Underutilized Crops (ICUC), Food and Agriculture Organization of the United Nations (FAO), Global Forum on Agricultural Research (GFAR), and more recently of the Global Facilitation Unit (GFU) on underutilized species needs special emphasis. Equally important
has been the committed involvement of other organizations, funding/major donor agencies such as the German Federation Ministry for Economic Cooperation and Development (BMZ), International Fund for Agricultural Development (IFAD), Consultative Group on International Agricultural Research (CGIAR); and in Asia-Pacific region, the Asian Development Bank (ADB) and Australian Centre for International Agricultural Research (ACIAR), Ausaid and Nzaid (ACIAR, 2001). Also, there has been a change in the mind-set of interested organizations towards better networking among international, regional and national programmes (AVRDC - vegetables; IPGRI and ICUC - tropical fruits) with emphasis on making National Agricultural Research Systems (NARS) more supportive of the use of such underutilized diversity to meet challenges of food security and poverty reduction and contribute towards agricultural sustainability. Several recent publications have very effectively contributed to raise concerns in the above context, on providing thrust to research and development of underutilized species as per needs of national programmes within the regional as well as global perspective (FAO, 1996; Williams and Haq, 2002; IPGRI, 2002; Gundel et al., 2003; GFU, 2005; CGIAR, 2005; Jaenicke and Hoschle-Zeledon, 2006; Bala Ravi et al., 2006). Also, some specific information published by National Academy of Sciences, USA (1975), FAO/ RAPA (Bhag Mal, 1994) on underutilized grain legumes and pseudocereals, and during 1998-2000, a series of over 20 monographs on selected underutilized species published by Bioversity International and Institute of Plant Genetics and Crop Plant Research in Gatersleben, Germany with financial support from BMZ; work on tropical fruit species in Asia under ABD Project (IPGRI, 2003, Bhag Mal et al., 2007); monographs on Fruits for the Future published by ICUC during 1999-2006 by PROSEA (Pulses, 1991: Fruits 1992; Vegetables, 1996), and on underutilized pulses and vegetables, and cereals and pseudocereals (Williams 1993; 1995) has further raised concerns on underutilized species and to promote their research and development. More recent developments are given in Chapter V on ‘Emerging Concerns’.

Criteria for identifying underutilized species/crops

A review of the published literature points out that a wide range of terms are used for underutilized plant species, which include minor, neglected, local, traditional, under-exploited, underdeveloped, orphan, lost, new, promising and alternative plant species. However, the most widely used among these is ‘underutilized’. Underutilized crops/plant species are those that many communities traditionally use for food, fibre, animal fodder, oil or for medicine, but that have further undeveloped potential uses. However, presently this group often deals only with food plant species and crops. Chapter III discusses this, providing diverse views on prioritising these species for research and development.
**Importance of underutilized species**

As pointed out above, underutilized species have great potential. Investigating these species is likely to uncover new ways in which these could be used more effectively. They could provide new or additional foods, contributing to food security. They may be rich in minerals or vitamins, and contribute to human nutrition and improving human health. They might be marketed in new ways as novel food and help raise incomes for those that gather, grow and process them. Or they may enhance environmental services by filtering and processing toxic substances, preventing soil erosion and restoring degraded soils. Many underutilized species broadly also cover several of the neglected crops grown primarily in their centre of origin by traditional farmers. Overall, many of these are considered as minor crops in terms of their production and market value though these assume high priority/importance to feed the rural poor. The major constraints in promoting R&D initiatives in this group of crops/species highlighted in the FAO State of the World’s Plant Genetic Resources for Food and Agriculture are: limited germplasm availability, lack of national policy, technical information and interest and focus by researchers, agriculturists, extension workers and producers (FAO, 1996). These have been further elaborated with focus on policy framework, germplasm availability, crop acceptability, diverse uses, production and product promotion and post-harvest handling (Williams and Haq, 2002).

In a wider context, for the choice of underutilized species, the following criteria overweight other generalizations — underutilized species/crops are those that are: (i) of local importance in consumption and production systems; (ii) highly adapted to agro-ecological niches/marginal areas, (iii) receive scarce attention by national agricultural and biodiversity conservation policies/programmes on research and development, (iv) largely represented by ecotypes/landraces, native local diversity (v) cultivated and utilized, relying on indigenous knowledge, and (vi) poorly represented in ex situ collections. (Padulosi et al., 2002; Williams and Haq, 2002). Von Maydell (1989) listed 12 criteria for the selection of underutilized food-producing trees and shrubs in semi-arid regions. However, such criteria will vary with local, national and regional needs and policy for promoting specific species. These criteria are: species should meet demand, solve problems, are accepted by people, have low risk, are free of negative properties or effects, adapted to site conditions, easy and safe to establish with less inputs, are fast growing, produce high yield, and good quality product; and such species/crops should be compatible with land use, and there should be no legal restrictions in working on these (Padulosi et al., 2002; von Maydell, 1989).

There are four major areas wherein underutilized species can make
significant contribution to sustainable agriculture, namely, food security and better nutrition, increased income for the rural poor, ecosystem stability and cultural diversity associated with local food habits and religious and social rituals (Jaenicke and Hoschle-Zeledon, 2006). Besides, there has been increased emphasis on the role of underutilized species to safeguard artistic landscape and cultural values of these species, and the concerns generated thereof in the international workshop organized by the Italian National Research Council (NRC) held in Naples (Monti, 1997). Obviously, wider avenues for use of these species await their future role vis-a-vis increased importance and impact. Thus overall, harnessing diversity of these underutilized species has enormous potential with much diversity for exploitation, and equally enormous range of choices.

**Synthesis/Information presented**

In the above context, this publication attempts to enumerate the diversity in underutilized food plant species of the Asia-Pacific region. It provides synthesized information on over 587 species used in diverse ways—edible grains, root/tubers, leafy and other vegetables, fruits and nuts, as spices and condiments, besides medicinal uses. Tabulated information on native indigenous, and of exotic diversity of underutilized species in Asia-Pacific region and the priority species for research and development, with data on nutritional aspects and use has been provided. It also brings out several emerging concerns for their further promotion for human welfare, meeting the millennium development goals (MDGs) to address food security, malnutrition, poverty reduction and income generation. Thus, the publication may be useful to provide inputs on underutilized species used as food plants to national programmes and in further planning of R&D initiatives by regional and international programmes.

The wide range of species listed points out that there is still an urgent need to broaden this base of species in an effective and sustainable manner to protect and enhance the use of such locally important species that can also be deployed more widely in agricultural and environmental management. Their neglect has led to erosion of the available genepools in their areas of diversity and cultivation. Equally important is the need for capturing the associated indigenous knowledge-base held by traditional farmers on the important traits these species/crops possess, including agronomic/cultivation practices followed, and their diverse native uses. The R&D focus must thus lay emphasis on the use of this diversity to increase the agricultural productivity of the food insecure farmers who are the custodians of this diversity, by widening their choice of crops and their improvement. A very good example of such a collaborative effort is the MSSRF project with Bioversity International (formerly IPGRI) supported
by IFAD – namely, on “Revitalization of neglected nutritious millets towards the food and income security of the rural poor” in parts of India and Nepal – a project that has shown effective results (MSSRF, 2002; Bala Ravi et al. 2006) through participatory farmer-centred approach. Overall, appropriate strategies are required to address the improvement of less known, underutilized species. These address food needs in a substantial way and their diversification and use adds to self sustainability particularly in the remote, marginal areas, under subsistence agriculture.
II. Underutilized Species in Asia-Pacific: Distribution, Diversity and Use

A review of literature points out that there is very scanty, largely scattered information available with national/international programmes on the underutilized species/crop diversity occurring in the Asia-Pacific region and the range of its distribution. Much of this information was pooled in by Arora (1985) on less known food crops in the global context earlier. Considering the role of underutilized species, in the regional context, need was felt to synthesize such information for the Asia-Pacific region, using the older publication (Arora, 1985) as the basis. This publication provides an updated account of the plant genetic resources of cultivated underutilized species of the Asia-Pacific region and information has been synthesized from various publications, particularly those listing such cultivated economic plant wealth distributed world-wide, or providing region-specific synthesis such as different floras, economic plants/cultivated plants dictionaries and other such treatises (Chapter 1). Besides providing a list of such underutilized and less known food plants, this account also provides details on the distribution and diversity of these genetic resources, of great use for current and future needs in crop improvement and for screening useful species for direct use vis-à-vis commercial use.

Table 2 gives the distribution of less known cultivated plants in the 12 regions of diversity on a world basis (Arora, 1985). This analysis points out that of the 402 species enumerated for the four Asia-Pacific regions, maximum species diversity occurs in the Chinese-Japanese and the Indo-Chinese/Indonesian regions, relatively less in the Hindustani/Indian region and least in the Australian Pacific region. Diversity in root and tuber crops is represented by 56 species; of vegetables by 99 species; fruits by 130 species; seeds and nuts by 46 species and miscellaneous types by 64 species (besides edible flowers representing 7 species).

The present revised account (Table 3) lists 778 species, 376 more species for the Asia-Pacific region than that given in Table 2 (402 species). This information has been tabulated for the eight categories of underutilized
Table 2. Distribution of less known cultivated food plants in different regions of diversity

<table>
<thead>
<tr>
<th>Food plants/Regions*</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roots/tubers</td>
<td>26</td>
<td>22</td>
<td>1</td>
<td>7</td>
<td>-</td>
<td>4</td>
<td>8</td>
<td>28</td>
<td>9</td>
<td>26</td>
<td>5</td>
<td>5</td>
<td>141</td>
</tr>
<tr>
<td>Vegetables</td>
<td>56</td>
<td>31</td>
<td>1</td>
<td>11</td>
<td>-</td>
<td>4</td>
<td>24</td>
<td>36</td>
<td>29</td>
<td>18</td>
<td>6</td>
<td>2</td>
<td>218</td>
</tr>
<tr>
<td>Flowers</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Fruits</td>
<td>50</td>
<td>61</td>
<td>2</td>
<td>17</td>
<td>19</td>
<td>13</td>
<td>5</td>
<td>13</td>
<td>14</td>
<td>69</td>
<td>36</td>
<td>38</td>
<td>337</td>
</tr>
<tr>
<td>Seeds/nuts</td>
<td>18</td>
<td>14</td>
<td>3</td>
<td>11</td>
<td>1</td>
<td>10</td>
<td>7</td>
<td>21</td>
<td>6</td>
<td>12</td>
<td>8</td>
<td>4</td>
<td>115</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>20</td>
<td>36</td>
<td>-</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>24</td>
<td>29</td>
<td>20</td>
<td>19</td>
<td>5</td>
<td>7</td>
<td>171</td>
</tr>
<tr>
<td>Total diversity*</td>
<td>172</td>
<td>166</td>
<td>8</td>
<td>56</td>
<td>21</td>
<td>33</td>
<td>70</td>
<td>127</td>
<td>78</td>
<td>144</td>
<td>61</td>
<td>56</td>
<td>992</td>
</tr>
</tbody>
</table>


Source: Arora, 1985; 2002

Plants (Table 3); number of families and genera, and total species diversity represented in each category are enumerated in the check-list of species. These categories are (i) Pseudocereals and millets-28, (ii) Grain legumes/Pulses-14, (iii) Root and tuber types-55, (iv) Vegetables-213, (v) Fruits-261, (vi) Nuts-34, (vii) Industrial crops-25 and (vii) Miscellaneous category -148. These include spices and condiments and species with multipurpose use also. In each category, species have been arranged alphabetically, genus-wise and species-wise and their popular, widely used names are also given. The

Table 3. Diversity in cultivated underutilized and less known species in Asia-Pacific regions

<table>
<thead>
<tr>
<th>Category</th>
<th>Families</th>
<th>Genera</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudocereals and millets</td>
<td>4</td>
<td>12</td>
<td>28</td>
</tr>
<tr>
<td>Grain legumes/Pulses</td>
<td>1</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Root/Tuber types</td>
<td>16</td>
<td>34</td>
<td>55</td>
</tr>
<tr>
<td>Vegetables</td>
<td>52</td>
<td>140</td>
<td>213</td>
</tr>
<tr>
<td>Fruits</td>
<td>45</td>
<td>106</td>
<td>261</td>
</tr>
<tr>
<td>Nuts</td>
<td>15</td>
<td>16</td>
<td>34</td>
</tr>
<tr>
<td>Industrial crops</td>
<td>18</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>Miscellaneous types</td>
<td>44</td>
<td>105</td>
<td>148</td>
</tr>
<tr>
<td><strong>Total species diversity</strong>*</td>
<td>-</td>
<td>-</td>
<td><strong>778</strong></td>
</tr>
</tbody>
</table>

(*: with overlap of species across crop-category)
area of origin, the broad distribution range within the Asia-Pacific region, and use is given for each species. The check list in each category includes underutilized species that are relatively widely grown and other native species locally grown, less known, or endemic to the area. Many of the species in the latter category also include several species confined to backyards/home gardens. Besides, exotic underutilized species now well acclimatized in Asia-Pacific region are also given.

1. Pseudocereals and Millets

The Asia-Pacific region holds rich diversity in cultivated species of pseudocereals and millets, both of indigenous and exotic origin. Most of these underutilized grain-crop species belong to 4 families/12 genera and 28 species (Table 4). Species diversity is more in the families, Poaceae, Polygonaceae and Amaranthaceae with restricted distribution in case of Chenopodiaceae. While most of these species are of Chinese origin, some like finger millet are tropical African, with a long history of cultivation and spread of diversity in the Indian sub-continent, which is also a secondary centre of diversity for this crop. Others like the grain amaranths-tropical American introduction are now well acclimatized to the Hindu Kush Himalayas; of late these are being grown in the western/central Indo-Gangetic plains of India. The cultivated diversity exhibits the following overall distribution pattern:

1. More diversity occurs in buckwheat, foxtail millet, and proso millet (all of Chinese origin), in China, Korea and Japan, and in the Hindu Kush Himalayas-Indian sub-continent, with sporadic distribution elsewhere.
2. Almost a similar pattern is exhibited by the three *Echinochloa* species, with Japanese barnyard millet having diversified in Japan, other species in China and as far as in peninsular India; with sporadic distribution in other areas.
3. Job’s tears/Adlay (*Coix lacryma-jobi*) as cultigen has more sporadic cultivation under subsistence agriculture, in parts of China, Korea, Japan, Philippines, Indo-

<table>
<thead>
<tr>
<th>Families</th>
<th>’Genera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amaranthaceae</td>
<td><em>Amaranthus</em> (6)</td>
</tr>
<tr>
<td>Chenopodiaceae</td>
<td><em>Chenopodium</em> (2)</td>
</tr>
<tr>
<td>Polygonaceae</td>
<td><em>Fagopyrum</em> (2)</td>
</tr>
</tbody>
</table>

*: Number of species in each genus is given in parenthesis
China and northeastern India; the soft-shelled cultivated type (var. mayuen) possibly got domesticated in the Indo-Chinese region.

4. Among the endemic crops, localized cultivation on a minor scale occurs in raishan (Digitaria cruciata var. esculenta) which got domesticated in northeastern India in hilly tracts of Khasi and Jaintia hills of Meghalaya. Relatively more widespread/distribution is of Panicum sumatrense, little millet of Indian origin, confined to the peninsular region and grown under subsistence farming. Also two other endemic minor local domesticates confined to South India (Tamil Nadu, Andhra Pradesh) are Brachiaria ramosa, Urochloa panicoides and Setaria glauca.

5. Among the introduced crops, finger millet, an old African introduction, has wider distribution, with more diversity in South Asian-Indian subcontinent in particular. Under cultivation, much crop improvement and diversification has led to build-up of varietal diversity both in plains and hilly tracts as far as the Himalayas.

6. Unlike finger millet, grain amaranth is a relatively recent introduction, possibly pre-Columbian, mostly grown in the Hindu Kush Himalayas. Both indigenous and exotic diversity occurs and is used for dual purpose as grain and as leafy vegetable; lately it has been cultivated in peninsular region of India. It has been particularly successful in western India and Indo-Gangetic region in diverse cropping systems.

7. Very limited diversity occurs in kodo millet (Panicum scrobiculatum) in drier peninsular tracts of India.

The above distribution of diversity also points out that the Asia-Pacific, the Chinese-Japanese and the Indian regions are important centres of diversity for pseudocereals and millets, with relatively sporadic cultivation in Indo-Chinese-Indonesian, and least in the Pacific/Australian region (Arora, 1985; Grubben and Soetjipto, 1996).

Check-list of species

Amaranthus angustifolius Lam. (Amaranthaceae). Asia upto India. India var. polygonides is cultivated.

Amaranthus caudatus L. (Amaranthaceae). South American origin, introduced mainly in temperate Asia. Grains are boiled and eaten as porridge. It leaves are also eaten.

Amaranthus cruentus L. (Amaranthaceae) Amaranth. Central American origin; introduced; cultivated mainly in hilly tracts of the Himalayas-India, Nepal, Bhutan, Myanmar and China; introduced into Japan, Korea, Philippines, Thailand. Grains are eaten boiled or roasted, also made into gruel, used as pot herbs also.

Amaranthus gangeticus L. (Amaranthaceae). Asia, Cultivated in India, Malaya, China and Japan as spinach.
Amaranthus hybridus L. (Amaranthaceae) Slim amaranth. Temperate Asia - derived from A. cruentus; occasionally grown in hilly tracts of the Hindu Kush Himalayas and leaves are used as vegetable, also as grain crops and ornamentals.

Amaranthus hypochondriacus L. Syn. Amaranthus leucocarpus S. Wats. (Amaranthaceae). An old cultigen of Mexican origin, derived from A. powellii; mainly adapted to hilly areas (also grown as ornamental). A pre-Columbian introduction into Europe from where it was introduced into South/Southeast, East Asia; has sporadic, scattered distribution. Pale-seeded and black-seeded forms occur and are edible like the above amaranths.

Brachiaria ramosa (L.) Stapf (Poaceae). South Asia, India. Grown in peninsular tracts of India; domesticated in parts of Karnataka and Tamil Nadu. Grains are edible, roasted, pounded and made into gruel.

Chenopodium album L. (Chenopodiaceae) Lamb’s quarters. Mainly South Asia; as a cultigen confined to the Hindu Kush Himalayan region. Sparingly grown as a grain crop and used as porridge. In Western Himalayas in Chamba/ Himachal Pradesh, India much variability occurs in grain colour - white, brown, red, earthen colour grains. Also grown in Myanmar and northern Thailand.

Chenopodium quinoa Willd. (Chenopodiaceae) Quinoa. Related to/or conspecific with C. nuttalliae. An introduction of South American origin, sparingly grown; tried as a grain crop in the Hindu Kush Himalayan region. Grains are used for making porridge or made into gruel.

Coix lacryma-jobi L. var. mayuen Stapf. (Poaceae) Adlay, Job’s tears. South, Southeast, East Asia; sporadic cultivation, mainly in northeastern India, Myanmar, Indo-China and Thailand. Seeds (kernel) are eaten raw or roasted, pounded and made into porridge with or without rice. Domesticated in northeast India/Indo-Burmese, Chinese region; widely spread; introduced elsewhere and cultivated in Japan/ East Asia, also in Philippines, Taiwan.

Digitaria cruciata (Nees) A. Camus var. esculenta Bor. (Poaceae) Raishan. South Asia, India, domesticated in Khasi and Jaintia hills of Meghalaya, northeastern India. Grains are eaten boiled; pounded and cooked like rice.

Digitaria sanguinalis (L) Scap (Poaceae). Cultivated in Kashmir and Afghanistan. It is a weed.

Echinochloa crus-galli (L.) P. Beauv. (Poaceae) Barnyard millet. East Asia - Japan, Korea, China; sparingly grown. Diversity represents the cultivar group esculenta. Grains are boiled and eaten.
Echinochloa crus-pavonis Schult. (Poaceae). East Asia mainly; domesticated in China, Yunnan, and is grown locally. Grains are eaten cooked.

Echinochloa frumentacea Link. (Poaceae) Japanese barnyard millet. East Asia-Japan, Korea, China; also South/Southeast Asia. Grains are boiled and eaten.

Eleusine coracana (L.) Gaertn. (Poaceae) Finger millet, Ragi. Introduced from Africa. South Asia, Hindu Kush Himalayas; peninsular region of India; recognised various types in India. Varieties developed for wider agroclimatic adaptability, cultivar groups/several types occur possessing incurved or open-fingered inflorescences. Grains are boiled, pounded and used as porridge; flour consumed likewise, also processed into several diverse preparations and value-added products.

Fagopyrum esculentum Moench. (Polygonaceae) Buckwheat, Sweet/Common buckwheat. East Asia and Hindu Kush Himalayas; a grain crop of cold hilly tracts. Much diversity occurs in India, Nepal, Bhutan; in East Asia in China, Korea, and Japan. Grains are pounded and boiled into gruel, also flour is made into a dough, cooked as leavened bread/chapatti in the Himalayas, processed into noodles for wider consumption in East Asia and elsewhere.

Fagopyrum tataricum (L.) Gaertn. (Polygonaceae) Tartary/Bitter buckwheat. Distribution as a cultigen similar to common/sweet buckwheat; more confined to high cold desert tracts of Hindu Kush Himalayas. Its use in similar to that of common buckwheat, but more as gruel.

Panicum antidotale Retz. (Poaceae). India, Introduced in Australia as a forage crop.

Panicum atrosanguineum Hochst. (Poaceae). An annual grass in Madhya Pradesh and upper Gangatic plain in India. The grains are eaten as food.

Panicum miliaceum L. (Poaceae) Proso millet. South and East Asia; commonly grown in cold hilly tracts of the Hindu Kush Himalayas; groups classified on basis of compact or lax inflorescence-much diversity occurs in compactum cultivar group. The crop is now adapted to subtropical, tropical plains of peninsular India; meagrely grown elsewhere. Grains are pounded and boiled into gruel.

Panicum sumatrense Roth ex Roem. & Schult. Syn. P. miliare Lamk. (Poaceae) Little millet. South Asia; Indian origin, related to P. psilopodium Trin. and sporadically grown in peninsular region; also in Sri Lanka, sporadic elsewhere in South/ Southeast Asia. More diversity in eastern, peninsular India of tall robust types, with more tillers and compact/semi-lax inflorescences. Grains are made into flour or are eaten boiled.

Paspalum distichum L. (Poaceae). Japan, valued as forage crop.
Paspalum scrobiculatum L. (Poaceae)  
Kodo millet. South Asia, mainly India.  
Cultivated in rainfed drier tracts of  
peninsular region. Grains are boiled  
and eaten; also made into flour.

Setaria glauca (L.) P. Beauv. (Poaceae)  
Yellow foxtail millet. South Asia-sporadic  
cultivation in drier parts of South India,  
in Tamil Nadu and Andhra Pradesh.  
Grains are eaten boiled, as in other  
small millets, also made into flour.

Setaria italica (L.) P. Beauv. (Poaceae)  
Italian millet, Foxtail millet. Hindu Kush  
Himalayas and East Asia; Chinese origin,  
adapted to cold hilly tracts of Hindu  
Kush Himalayas, and in other parts of  
China, Korea and Japan; less so in  
Southeast Asia, Indo-China. Diversity  
mainly of cultivar sub-group indica and  
maxima, the former more variable with  
awned/awnless inflorescence, variable in  
colour (creamish, black, purple-brown),  
grain boldness and colour. Grains are  
of similar use as in other small millets.

Panicum javanicum Poir. (Poaceae).  
South Asia - India, sporadically grown  
as minor millet. Grains are boiled and  
eaten; pounded and made into gruel-  
like preparations.

2. Grain legumes/Pulses

The grain legumes, popularly known as  
pulses, constitute an important group  
contributing towards nutritionally good  
protein-rich diet. Most of these grain  
legume species belong to single family  
with 7 genera and 14 species. Along  
with the pseudocereals and millets,  
this diversity provides staple or major  
supplementary food and also puts a  
curb on malnutrition among the rural  
poor, marginal farmers who grow many  
of these underutilized minor legume  
crops under subsistence farming. The  
Leguminosae with 10 species of genera  
such as Lathyrus, Macrotyloma, Vicia,  
and in particular Vigna, are usually  
grown as minor or occasionally as  
major crops in diverse agro-climates.  
Quite often, young parts of these  
species are consumed as vegetables.

While most of these species diversity  
is sporadically distributed throughout  
Asia-Pacific region, some species exhibit  
more restricted distribution.

1. Most widely distributed are the  
cultivated Vigna species of Asian  
origin, V. mungo/black gram in  
South Asia, particularly India and  
Nepal; V. umbellata rice bean in  
East Asia extending to South and  
Southeast Asia; V. angularis/adzuki  
bean more confined to East Asia  
and in the Hindu Kush Himalayas  
where it is sporadically grown.

2. More confined to semi-drier tracts is  
Vigna aconitifolia/moth bean, mainly  
grown in western India in Rajasthan  
and to a minor extent in Deccan  
peninsular region in Andhra Pradesh.  
Another legume of importance in  
drier tracts is Lathyrus sativus grass  
pea, with more cultivation in central  
India, in Madhya Pradesh, parts  
of drier Maharashtra, north east  
Uttar Pradesh and elsewhere in  
Bangladesh.
3. *Vigna trilobata* locally called pillepesara, is a minor cultigen that got domesticated in parts of Tamil Nadu in South India where it is sporadically grown.

4. *Macrotyloma uniflorum*/horse gram which possibly got domesticated in South India, is widely grown in this tract, with limited diversity of cold adaptable types in Western and Central Himalayas in India and Nepal.

5. *Psophocarpus tetragonolobus*/winged bean is considered to be of South Pacific/ Papua New Guinea origin, with more diversity in the Philippines, Thailand, Indonesia extending to Indo-China and northeastern India, to Southern India and Sri Lanka. It is more of a backyard cultigen for local consumption and not much grown nor successful as a field crop. In Myanmar, it is grown for grain and green pods and also for edible tubers.

6. Exotic legume diversity of underutilized species includes crops such as *Vicia faba* of West Asian origin, which is more cultivated (though sporadically) in India in the Himalayas, and in China. Further, efforts are on way to examine the potential of a African dryland crop, *Vigna subterranea*, being tried as an introduction to drier Western India in Gujarat. Diversity in some underutilized *Phaseolus* species of tropical American origin occurs sporadically throughout Asia-Pacific, such as of *P. coccineus*, *P. lunatus*, in backyards or homegardens in diverse tropical to temperate habitats, grown mainly for local consumption.

Overall, more diversity occurs in the Chinese - Japanese and Indian region of diversity of cultivated plants, less so in Indo-Chinese-Indonesian and least in the Australian/Pacific region; East Asia and South Asia are the regions of domestication and diversification of grain legumes in Asia-Pacific region (Arora, 1985; van der Maesen and Somaatmadja, 1991).

**Check-list of species**

*Lathyrus sativus* L. (Leguminosae) Grass pea. West Asian origin; sporadically grown in South Asia - in central India in drier tracts, and in Bangladesh; sporadically grown in Nepal; introduced into Australia. A minor pulse (cum fodder crop); grains are boiled for *dal-like* preparation; also made into flour and used in various ways.


*Psophocarpus tetragonolobus* (L.) DC. Winged bean, Goa bean (Leguminosae).
Originated in Papua New Guinea/East Africa (based on close relative *P. grandiflora*). All parts of this protein rich grain legume/vegetable crop are edible; tender pods, seeds, leaf as vegetable and tubers as salad.

*Pueraria thunbergiana* (Sieb. & Zucc.) Benth. (Leguminosae). China and Japan, cultivated as cover crop, green manure, also hay crop in New Guinea as tuber crop.

*Vicia faba* L. (Leguminosae) Broad bean, Faba bean. West Asian origin with diversity in the Himalayan region. Grown in South, Southeast and East Asia; mainly a cold weather crop in India, Nepal, China. Grown both for grains (as pulse) and for green pods used as a vegetable. Several cultivar groups identified based on broad, long or small sized pods, with variation in seed size, colour etc. (i.e. cv. groups major, minor).

*Vicia sativa* L. (Leguminosae) Common vetch. Mediterranean/West Asian origin; sparingly cultivated in hilly tracts of northwestern Himalayas and adjoining region. Grains are consumed as minor pulse (also used as a forage plant).

*Vigna aconitifolia* (Jacq.) Marechal Syn. *Phaseolus aconitifolius* Jacq. (Leguminosae) Moth bean. South Asia, mainly in drier tracts of Pakistan, India (western India particularly Rajasthan), also in Bangladesh, Sri Lanka, Myanmar, China. Grown as pulse crop. Grains are eaten boiled, roasted and as sprouted salad. High yielding types developed in India where maximum variability occurs in wild and domesticated forms.

*Vigna angularis* (Willd.) Ohwi & Ohashi Syn. *Phaseolus angularis* (Willd.) W.F. Wight. (Leguminosae) Adzuki bean. An old cultigen of East Asian origin-a native of Japan, much grown in China, Japan and Korea; South/Southeast Asia and in the Far East, sporadic in the Himalayas. Grains are boiled and eaten as pulse and tender pods as vegetable, in Japan as chatney. High yielding varieties developed in Japan/East Asia.

*Vigna mungo* (L.) Hepper. (Leguminosae) Black gram. Indian origin, mainly grown in South Asia - Pakistan, India, Nepal, Bhutan, Myanmar, introduced in Indo-China, Malaysia, Thailand, Philippines. Both bushy and spreading types occur with much variability in pod size, bearing, seed size, colour, etc. Several domesticated forms occur in Western Ghats/hilly tracts of India and are like the wild progenitor var. *sylvestris*. A highly nutritious pulse much preferred in north India, and Nepal.


*Vigna subterranea* (L.) Verdc. Syn. *Voandzeia subterranea* (L.) Thouars. (Leguminosae) Bambara groundnut. West African introduction, sparingly grown in South-Southeast Asia. Seeds are boiled and eaten as pulse, also consumed in
roasted form. It is under trial in hot, dry region of western Indian plains for its possible potential, also likewise in Indonesia, Malaysia, Philippines and Australia.


_Vigna umbellata_ (Thunb.) Ohwi & Ohashi Syn. _Phaseolus calcaratus_ Roxb. (Leguminosae) Rice bean. East Asian/Eastern Himalayan origin, grown in northeastern India, Hindu Kush Himalayas, East/Southeast Asia China, Japan, Korea, and in the Philippines; sporadically introduced in Malaysia and Indonesia, extending to the Pacific Islands. Much diversity in cultivated types occur for both viny and bushy types, pod size and seed size/colour. Grains are boiled and eaten as pulse usually with rice; young pods used as vegetable.

_Wisteria branchybotrys_ Sieb. & Zucc. (Leguminosae). China, Japan, cultivated for its fibrous bark.

### 3. Root and Tubers

The genetic diversity in underutilized edible root and tuber crops of the Asia-Pacific region belongs to 16 families, 34 genera and 55 species (Table 5). Among these, the Araceae, Compositae, Convolvulaceae, Dioscoreaceae, Euphorbiaceae, Labiatae, Leguminosae, Taccaceae and Umbelliferae hold more diversity (Arora, 1985). The edible starchy species, by and large, belong to the genera _Alocasia, Amorphophallus, Canna, Coleus, Colocasia, Dioscorea, Helianthus, Ipomoea, Maranta, Flemingia/Moghania, Pachyrhizus, Stachys, Tacca and Xanthosoma_. Most of this plant wealth is usually consumed after boiling; the tubers are eaten after cooking and only occasionally these are consumed raw, after peeling off the outer skin _e.g._ _Moghania vestita_ and _Pachyrhizus erosus_. The rhizomatous and bulbous types - _Allium, Curcuma, Zingiber_ and a few more, are invariably used in soups and curries, after boiling/ cooking, or often eaten raw as salad _e.g._ _Allium_ species, and have been included in category 4 on vegetables and category 7 for miscellaneous types. Much of the above diversity of both indigenous (_Alocasia, Colocasia, Dioscorea_) and exotic species (_Canna, Coleus, Maranta, Pachyrhizus_ and _Xanthosoma_) is confined to the humid tropical areas where these crops are grown mainly under subsistence farming, and in home gardens, backyards etc. The cold, temperate regions have only limited diversity such as of _Arracacia, Lathyrus, Sium_ and _Ullucus_. In the former group too, types adaptable to cold/sub-temperate climate occur in _Colocasia, Canna_, and to a lesser extent in _Xanthosoma_. Genetic wealth of these edible species is mainly distributed in the Chinese-Japanese, Indo-Chinese-Indonesian and the Hindustani/Indian region. The Pacific region is particularly rich in _taro/Colocasia_ and _Xanthosoma_.

Table 5. Families, genera and number of species with edible underground parts-roots/tubers etc.

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<thead>
<tr>
<th>Families</th>
<th>Genera (No. of species)</th>
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<td>Araceae</td>
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<tr>
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<td>Taccaceae</td>
<td>Tacca (1)</td>
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<td>Umbelliferae/Apiaceae</td>
<td>Arracasia (1), Chaerophyllum (1), Cryptotaenia (1), Pastinaca (1), Sium (1), Curcuma (5)</td>
</tr>
</tbody>
</table>

*: Number of species in each genus is given in parenthesis

The Chinese-Japanese region has only limited diversity in starchy tuberous types mentioned above - Alocasia, Colocasia, etc. but with more diversity in Xanthosoma. More confined to South China is Amorphophallus harmandii while A. konjac is distributed east of mainland China, with sporadic variability prevalent in Japan and the Philippines. Some species are distributed both in China and Japan and among these, more variability occurs in Dioscorea japonica. Another cultigen from this region is Eleocharis dulcis with variability in South China, extending to the Pacific Islands, and southwards in the Indo-Burmese region and in Southeast Asia. Still more widely distributed is Stachys affinis domesticated in China, and apart from China and Japan, also grown in Eastern Europe. Sporadically distributed cultigen is Sagittaria sagittifolia.

Much diversity occurs in Indo-Chinese-Indonesian and the Indian regions particularly for Alocasia, Colocasia, Asiatic Dioscorea spp., Tacca and Amorphophallus. More diversity occurs in South Asia in Alocasia cucullata, Amorphophallus paeonii folius and Moghania vestita (domesticated in
Eastern Himalayas/ northeast region in Meghalaya) and in Southeast Asia for *Dioscorea*. Of comparatively wider distribution in South and Southeast Asia is *Alocasia macrorrhiza*, *Coleus parviflorus*, *Colocasia esculenta*, *Dioscorea alata*, *D. bulbifera*, *D. esculenta* and *D. pentaphylla*. Also, limited variability prevails in *Cyrtosperma chamissonis* in this region, with its distributional range extending to the Pacific Islands. The Pacific Island, have rich diversity, besides *Colocasia*/*taro* and *Xanthosoma* spp., in *Pueraria montana* (domesticated here as a tuber crop). However, *Tacca leontopetala* has sporadic distribution all through the Asia-Pacific but with limited local diversity.

**Check-list of species**

*Alocasia cucullata* (Lour.) G. Don. (Araceae) Giant/ Chinese taro. East South/Southeast Asia; Indo-China; east India, Sri Lanka. Corms are eaten cooked as a vegetable.

*Alocasia indica* (Roxb.) Schott. (Araceae) Giant taro. South/Southeast Asia, used similar to the above species; corms boiled/fried. Cultivated for its stem which is eaten, also as ornamental.

*Alocasia macrorrhiza* (L.) G. Don. (Araceae) Giant alocasia. Southeast Asia/Pacific Islands. Grown in South, Southeast, East Asia, and in the Pacific, Oceania region where more diversity occurs. Corms are boiled and commonly eaten as a vegetable.

*Amorphophallus companulatus* (Roxb.) Blume (Araceae). SE Asia, cultivated as tuber crop.

*Amorphophallus harmandii* Engl. & Gehr. (Araceae). Southeast Asia, Tonkin; occasionally cultivated. Corms are consumed boiled by the natives.

*Amorphophallus konjac* K. Kach Syn. *A. rivieri* Dur. (Araceae). Indo-China, East/Southeast Asia; cultivated in the Philippines, China and Japan. Corms are boiled and eaten; also made into a flour (Konjaku flour, Konjaku powder).

*Amorphophallus paeoniifolius* (Dennst) Nicolson Syn. *A. campanulatus* (Roxb.) Blume ex Decne (Araceae) Elephant foot yam. South/Southeast Asia; grown in India. Cultivated in India and elsewhere as tuber crops. Large corms are eaten boiled or fried.

*Arctium lappa* L. (Compositae) Gobo, Greater burdock. European introduction into East/Southeast Asia-Japan, China, Vietnam, Philippines. It is a popular vegetable in Japan;
the fibrous roots are, consumed raw or cooked.

_Arracacia xanthorrhiza_ Bancroft. (Umbelliferae) Apiaceae Arracacia, Arracha. Tropical American origin, introduced into the Himalayas, India. Roots resembling parsnip are cooked as a vegetable.

_Calystegia sepium_ (L.) R. Br. (Convolvulaceae). East Asia, cultivated in China. Boiled roots are eaten in China (also young shoots).

_Canna indica_ L. Syn. _C. edulis_ Ker.-Gawl. (Cannaceae) Queensland arrowroot, Achira arrowroot Tropical American origin; introduced and sporadically grown as backyard cultigen in parts of Asia and the Pacific Islands. Tubers are boiled and eaten.


_Coleus forskohlii_ (Poir.) Briquet. Syn. _C. barbatus_ Benth. (Labiatae). South/South Asia; cultivated in South India. Roots are boiled and eaten.

_Colocasia esculenta_ (L.) Schott. Syn._C. antiquorum_ (L.) Schott. (Araceae) Dasheen, Taro. Tropical Asia and the Pacific/Oceania region. Much grown in India, Indo-China, Malaysia, Thailand, Philippines, Indonesia, and elsewhere in Papua New Guinea, and other islands. Much diversity occurs in PNG-Pacific Islands, Philippines, Indonesia; also grown in China. Tubers are boiled and eaten; var. _rosea_ and var. _multifolia_ occur; _C. gigantea_ Hook. f. is a variant. Edible diversity identified under two forms; dasheen, _esculenta_ types, with large central corm and eddoe types with small corms (may include wild _antiquorum_ types also) but with developed edible cormlets of variable size, flesh colour, taste, quality, etc.


_Crytotaenia canadensis_ DC. (Umbelliferae). North American origin, cultivated in Japan. Roots are boiled, also fried and eaten. Mitsube (_C. japonica)_ is a Japanese cultigen.

_Chaerophyllum bulbosum_ L. (Umbelliferae) Turnip-root chervil. Occasionally grown in West Asia, possibly a European introduction. Roots are boiled, eaten as a vegetable.
**Curcuma amada** Roxb. (Zingiberaceae). India and Pakistan, cultivated in India for mango ginger.

**Curcuma angustifolia** Roxb. (Zingiberaceae). East India Arrowroot. Himalayan area., cultivated for its edible starchy rhizome.

**Curcuma caesia** Roxb. Kalihaldi (Zingiberaceae). India (Bengal) grown for its edible rhizome.

**Curcuma domestica** Val. (Zingiberaceae). Turmeric. SE Asia, India, China. rhizome used as condiment.

**Curcuma zedoria** Rosc. (Zingiberaceae). SE Asia, Sri Lanka, Medagascar. young flowers are used for flavouring food.

**Cyrtosperma chamissonis** (Schott) Merr. (Araceae). Indo Malayan region, introduced in Pacific islands, cultivated for its tubers.

**Dioscorea alata** L. (Dioscoreaceae) White yam, Greater yam. South/ Southeast/ East Asia across the Pacific. Cultivated as a tuber crop; used as vegetable.

**Dioscorea batatas** Decne. Syn. *D. divaricata* Blanco. (Dioscoreaceae). Chinese potato, Chinese yam East Asia, China; Japan, Southeast Asia and Malaysia eastward. Tubers are very nutritious, boiled and eaten.

**Dioscorea bulbiëra** L. (Dioscoreaceae) Air potato, Potato yam. Mainly South/ Southeast Asia extending to the Pacific islands. Grown for its edible tubers, boiled/cooked as a vegetable.

**Dioscorea esculenta** (Lour.) Burkill. (Dioscoreaceae) Asiatic yam. South, Southeast Asia, Indo-China, and adjacent tracts. Tubers are huge as compared to other spp.; locally boiled and eaten.

**Dioscorea hispida** Roxb. (Dioscoreaceae). India & SE Asia, tubers edible.

**Dioscorea japonica** Thunb. (Dioscoreaceae). East Asia - cultivated in Japan, China and neighbouring regions. Tubers are eaten boiled.

**Dioscorea papuana** Rich. (Dioscoreaceae). Pacific Islands, Papua New Guinea; cultivated. Tubers are boiled and eaten.

**Dioscorea pentaphylla** L. (Dioscoreaceae). Southeast Asia - cultivated in Indonesia; also in the Pacific. Tubers are boiled and eaten.

**Eleocharis dulcis** (Burm. f.) Trinius ex Henstchel Syn *Eleocharis tuberosa* Schult. (Cyperaceae) Water chestnut. South/Southeast and East Asia; also sporadically grown in Pacific Islands. Semi-wild types occur in China, Japan, Philippines, Fiji, New Caledonia, also
Micronesia. Tubers are mainly eaten in China, where domestication may have taken place.

**Helianthus tuberosus** L. (Compositae) Jerusalem artichoke. North American introduction to tropical/sub-tropical Asia. Tubers are boiled, eaten as a vegetable or in pickled form.

**Ipomoea mamosa** Choisy (Convolvulaceae). Southeast Asia - cultivated in Indo-China, elsewhere in the Philippines. Roots are consumed as a vegetable (also leaves).

**Lathyrus tuberosus** L. (Leguminosae) Earth chestnut. Sparingly grown in West/temperate Asia. Tubers are eaten as a vegetable.

**Lilium auratum** Lindl. (Liliaceae). Japan, cultivated for its large bulbs.

**Lilium cordifolium** Thunb. (Liliaceae). Japan, cultivated for its starchy bulbs.

**Lilium maximowiczü** Regel. (Liliaceae). Japan, cultivated there as food crop.

**Maranta arundinacea** L. (Marantaceae) Bermuda/ West Indian arrowroot. Tropical American origin; grown in South, Southeast Asia - India, Philippines; also in the Pacific. Rhizomes are starchy, and made into soup.

**Moghania vestita** (Benth. ex Baker) O. Kuntze, (Leguminosae) Sophlong. Eastern Himalayas, northeastern India, domesticated/cultivated in Khasi and Jaintia Hills, Meghalaya. Tubers are eaten raw.

**Nelumbo nucifera** Gaertn. Syn. **Nelumbium speciosum** Willd. (Nymphaeaceae) East Indian lotus. South, Southeast/East Asia, as far as the Pacific, and in Australia. Rhizomes are eaten as vegetable (boiled, fried and pickled). Fruit/seeds, flowers leaves-all parts are edible (see miscellaneous category).


**Pachyrhizus tuberosus** Spreng. (Leguminosae) Yam bean. Tropical American introduction into South/Southeast, East Asia. Grown in eastern India, China, Indo-China, Indonesia, Philippines for the starchy and palatable tubers; eaten boiled/stewed, and as
Pachyrhizus erosus (courtesy: KC Bhatt and Anjula Pandey)

Salad; also candied, processed for sweet preparations. The starchy powder from tubers is used for custard-puddings (young pods and tubers are eaten as vegetable). Taxonomic identity uncertain, may be conspecific with *P. erosus*.

*Sagittaria sagittifolia* L. subsp. *leucopetala* (Miq.) Hartog Syn. *S. trifolia* L. var. *edulis* Siebold ex Miq. (Alismataceae) Chinese arrowhead. East Asia—cultivated in China, Korea, the Philippines and Japan. The starchy corms are boiled and cooked as a vegetable.

Sium sisarum L. (Umbelliferae) Skirret, Chervis. European introduction to East Asia. Tuberous roots are cooked and eaten; also used as salad.

Tragopogon porrifolius L. (Compositae)
Salsify, Vegetable oyster. European introduction into East Europe and temperate Asia; An old cultigen, introduced into Japan; sporadically grown. Tubers are eaten cooked, also shoots.

Ullucus tuberosus Caldas. (Basellaceae)
Ulluco. South American origin, introduced into East Asia, and Oceania; cultivated in Japan, New Zealand. Starchy tubers are edible; cold adaptable crop.

Vigna vexillata (Benth.) A. Rich (Leguminosae). South/Southeast Asia, hilly tracts, protected, semi-domesticated; tuberous roots are eaten raw or cooked, considered superior to sweet potato in flavour and nutrition.

Xanthosoma sagittifolium (L.) Schott. (Araceae) New cocoyam, Malanga balanca, Tania, Yellow tania. South American introduction, grown in South/Southeast Asia and the Pacific - Oceania region. Corms are starchy and eaten boiled (leaves used as vegetable).

Xanthosoma violaceum Schott. Syn. X. nigrum Mansf. (Araceae) Black malanga, Primrose malanga. South American introduction into South/Southeast Asia, and the Pacific; sporadically grown elsewhere. Roots are starchy and edible; said to be more nutritious than potatoes (leaves are also eaten cooked).

4. Vegetables

The underutilized vegetables form a large and widely distributed commodity group that has assumed great importance in providing nutritionally rich diet both to the rural and urban sectors. The genetic wealth of these species is increasing as more and more native diversity is being domesticated in different regions of diversity of crop plants (Arora, 2003; Chadha et al., 2007). It is estimated that in Asia, 422 species and in South Asia, 107 species of the 1600 species globally used (Prem Nath et al., 1987), are represented. The Netherlands-supported project on Plant Resource of South-East Asia (PROSEA) with its regional office based at Bogor, Indonesia, has documented the vegetable wealth particularly of Southeast Asia (Siemonsma and Piluekasern, 1994). This publication on ‘Vegetables’ provides well synthesized
information on about 225 species of which 100-120 are cultivated for market and home consumption; over 100 minor vegetables listed represent semi-domesticated/domesticated and even plants gathered for use from the wild. The cultivated category has larger percentage of introduced diversity, now well adapted into the cropping patterns, and occurring mostly in home gardens (Siemonsma and Piluekasern, 1994). AVRDC has, under the Asian Development Bank (ADB)-supported project, focused on indigenous vegetables in Southeast Asian region and promoted collection, conservation and use of such diversity involving national programmes (Engles and Altoveros, 1999). Also several vegetable networks operating under AVRDC in South/Southeast Asia have significantly contributed to enriching this diversity, its collection and use (APAARI, 2008; Chadha et al., 2007).

In the Asia-Pacific region, this diversity in leafy edible types and of fruits used as vegetables belongs to 52 families, 140 genera and 213 species (Table 6). Mainly, this plant wealth is confined to the Amaranthaceae, Chenopodiaceae, Cruciferae, Cucurbitaceae, Compositae, Gramineae, Labiatae, Leguminosae, Liliaceae, Polygonaceae, Portulacaceae, Malvaceae and Umbelliferae. The more important edible leafy types belong to the genera Amaranthus, Allium, Asparagus, Atriplex, Basella, Brassica, Chenopodium, Phytolacca, Pisonia, Polygonum, Portulaca, Rumex and Tetragonia; leaves/young shoots are eaten cooked or used in soup-like preparations or in salad. Another distinct category is of plants whose tender fruits/pods are eaten in cooked form as vegetable e.g. fruits-Abelmoschus, Benincasa, Coccinia, Curcubita, Luffa, Momordica, Solanum and Trichosanthes; pods of Canavalia, Dolichos, Mucuna, Vigna, and among the exotic types, Cyclanthera, Sechium, Sicana, Scorpiurus—all tropical American introductions; Sechium edule represents a secondary centre of diversity in the Eastern Himalayas/northeast region of India, Indo-Chinese region. Some cucurbit fruits are eaten raw e.g. Cucumis. Yet another group provides edible sprouts e.g. bamboos - young culms of Bambusa, Cephalostachyum, Dendrocalamus, Phyllostachys and Sinocalamus species are boiled/fermented and made into soup or eaten as vegetable. Several of these are also pickled and used as preserves.

The above diversity occurs in the tropical, sub-tropical and temperate areas. Allium, Amaranthus, Chenopodium, Brassica, Chrysanthemum, Cynara, Phytolacca and Rumex among leafy types and Cyclanthera and Sechium among fruit-types are cold adaptable, while most of the others are confined to humid/sub-humid tropical climate; particularly in bamboos, rich diversity occurs in humid tropical areas, with the exception of a few species of Phyllostachys, Sinocalamus and others, which also occur in colder climates. Much of the above diversity is distributed in the Chinese-Japanese, Indo-Chinese-Indonesian and the Indian gene centre, within the Asia-Pacific region.
**Table 6.** Families, genera and number of plant species-consumed as vegetables

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<th><em>Genera</em></th>
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<td>Rubiaceae</td>
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</tr>
<tr>
<td>Saururaceae</td>
<td>Houttuynia (1)</td>
</tr>
<tr>
<td>Scrophulariaceae</td>
<td>Veronica (1)</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Lycium (1), Solanum (5)</td>
</tr>
<tr>
<td>Tiliaceae</td>
<td>Corchorus (2)</td>
</tr>
<tr>
<td>Umbelliferae</td>
<td>Angelica (1), Apium (1), Centella (1), Cryptotaenia (2), Glechnia (1), Hydrocotyle (1), Oenanthe (1)</td>
</tr>
<tr>
<td>Urticaceae</td>
<td>Pilea (1), Pouzolzia (1),</td>
</tr>
<tr>
<td>Valerianaceae</td>
<td>Valerianella (1)</td>
</tr>
<tr>
<td>Verbenaceae</td>
<td>Clerodendrum (3), Premna (1),</td>
</tr>
<tr>
<td>Violaceae</td>
<td>Viola (1)</td>
</tr>
<tr>
<td>Vitaceae</td>
<td>Cissus (2)</td>
</tr>
<tr>
<td>Zingiberaceae</td>
<td>Curcuma (1)</td>
</tr>
</tbody>
</table>

*: No of species for each genus is given in parenthesis
The Chinese-Japanese region also holds much diversity in leafy types used as vegetable, and the distribution of this diversity is as follows: (i) the leafy vegetables more common to China are *Allium odorum*, *Angelica kiusiana*, *Brassica* spp. especially *alboglabra*, *parachinensis*, *pekinesis*, *Chrysanthemum segetum*, *Lactuca denticulata*, *Malva verticillata* and *Viola verucunda*; (ii) among the bamboos more confined to China are *Bambusa beecheyana*, *Phyllostachys aureosulcata*, *P. dulcis* and *P. nigra* and *Sinocalamus edulis*; (iii) comparatively wider distribution extending to East/Southeast Asia is represented by *Ipomoea aquatica* and *Nasturtium indicum*; (iv) in the Japanese region, more diversity occurs in *Aralia cordata*, *Cryptotaenia japonica*, *Bambusa multiplex*, *Chrysanthemum morifolium*, *Brasenia schreberi*, *Lactuca sativa*, and *Veronica anagallis-aquatica*; (v) several species occur both in China and Japan as cultigens, particularly bamboos like *Chimonobambusa quadrangularis*, *Phyllostachys bambusoides* and *P. pubescens*, and leafy types - *Brassica napobrassica*, *Chrysanthemum coronarium*, *C. sinense*, *Lactuca indica* and *Phytolacca acinosa*. Still wider distribution in China, Japan and Korea and sporadically in East/Southeast Asia, is noted in *Actinidia polygama*, *Lycium chinense* and *Lactuca* spp.

The Indochinese - Indonesian and the Indian regions are equally rich in diversity of vegetable types; broad distribution is as follows:

1. Among leafy types, more variability in *Basella alba* occurs in South Asia, particularly in Sri Lanka and in India (mainly in southern and the eastern region) extending further to Bangladesh. *Pentaphragma begoniaefolium* and *Pisonia alba* are more confined to Malaysia, while *Sauropus androgynus* extends its distributional range to Indonesia. Comparatively, wider distribution also occurs in *Houttuynia cordata*, *Hydrolea zeylanica*, *Enhydra fluctuans*, *Emilia sonchifolia*, *Sesuvium portulacastrum* and *Wolffia globosa*; *Ipomoea aquatica* exhibits rich variability.

2. As compared to the above types, *Amaranthus* species are more important, and much variability in these occurs in the Himalayan region in South Asia, and in humid tracts, for *A. dubius*, *A. tricolor* and *A. viridis*. About seven species are grown; sporadic variability of these leafy forms also occurs in Southeast Asia extending to the Philippines, and in the Pacific Islands in kitchen home gardens.

3. *Tetragona tetragonoides* native of Australia and New Zealand and cultivation extending to East Asia; *Talinum triangulare* is confined mainly to Sri Lanka.

4. Among species where immature fruits are consumed as vegetable, more diversity occurs in South Asia in *Abelmoschus esculentus*, *Momordica dioica*, *M. cochinchinensis*, with wider distribution of *M. charantia*, and in *Lagenaria siceraria*, *Luffa
acutangula, L. aegyptiaca and Trichosanthes cucumerina.

5. Another important species with rich diversity in South and Southeast Asia is Moringa oleifera. It is grown in East Asia also and as far as the Pacific in home gardens. Its region of domestication is possibly south India and Sri Lanka.

6. Abelmoschus manihot is more confined to East Asia, extending to the Philippines and neighbouring area of Southeast Asia, Indonesia, and as far as in the Pacific/PNG region where much diversity occurs.

7. Enormous diversity in cultivated bamboo species occurs in South/Southeast Asia as has been given above.

8. Among others some diversity occurs in Cyclanthera pedata and Sechium edule (wider but sporadic distribution in the former, and a secondary centre in the Eastern Himalayan region for the latter). Also limited diversity occurs in West Asian species such as Allium kurrat and A. fistulosum; and of the Mediterranean species, Allium porrum and Scorpiurus vermiculata.

The relative importance of over 100 vegetables sold in urban markets of Southeast Asian countries (Indonesia, Malaysia, Philippines, Thailand, Vietnam, also some in PNG) was assessed by PROSEA (Siemonsma and Kasern, 1994). These included many underutilized and minor vegetables, the latter more localized. This information has been abstracted as follows:

- More important, widely grown vegetables: Abelmoschus esculentus, Allium fistulosum, Amaranthus spp., Apium graveolens, Benincasa hispida, Brassica juncea, B. oleracea-broccoli, B. rapa - groups cainis and patchoi, Ipomoea aquatica, Luffa spp., bitter gourd, bottle gourd, banana flower, cayota/chow-chow, snake gourd, winged bean. Some minor types become important to varying degrees in the above countries (not in PNG); Basella alba, Chrysanthemum coronarium, Lactuca sativa, Rorippa spp. and Sauropus androgynus.

- Occurrence in some of the above countries was noted for Asparagus - Malaysia, Philippines; Lactuca indica, Limnocharis flava, Archidendron jiringa - Indonesia, Malaysia, the last also in Philippines; Meliantha - Thailand and Vietnam; Solanum torvum - Malaysia and Thailand.

- Others are more localized to: Indonesia - Hydrocotyle sibthorpioides; Malaysia, Thailand - Cleome gynandra; Thailand - Neptunia oleracea.

- More localized to PNG are - Abelmoschus manihot/abika, Rungia klossii, Polyscias spp., Saccharum edule/pitpit

Check-list of species

Leafy types

Abelmoschus manihot (L.) Medik. (Malvaceae) Abika. Widely distributed, mainly East/Southeast Asia– Pacific;
from south China to Papua New Guinea/Pacific Islands, and north Australia. East Indonesia, Philippines and PNG are important diversity regions, sporadic elsewhere. Grown as a leafy vegetable; cultivated forms belong to var. *manihot*. Cultivated for its immature fruits, young shoots/leaves are eaten cooked, boiled as soup.

*Acmella oleracea* (L.) R.K. Jansen Syn. *Spilanthes oleracea* var. *fusca* (Lam.) DC. (Compositae) Para cress, Akarkara. South/Southeast /East Asia – locally protected/domesticated diversity is grown in the Pacific Islands/PNG; used as a vegetable and as salad locally.

*Actinidia polygama* (Sieb. & Zucc.) Maxim. (Actinidiaceae) Silver vine. East Asia–north and west China, Korea and Japan. Leaves are boiled and eaten as vegetable.


*Allium ascalonicum* L. (Amaryllidaceae/Alliaceae) Shallot. West Asian origin, elsewhere introduced. Cultivated as a garden vegetable, boiled as soup, also used for flavouring and pickling more like onion.

*Allium chinense* G. Don. Syn. *A. bakeri* Regel. (Amaryllidaceae/Alliaceae) Chinese scallion, Rakkyo. East Asian origin - cultivated in China and Japan where several cultivars have been developed varying in bulb size, quality, taste, flavour etc. Bulbs are consumed as a vegetable; also made into pickle.

*Allium fistulosum* L. (Amaryllidaceae/Alliaceae) Welsh onion. Chinese origin; grown in East/Southeast Asia - China, Japan, Korea, Taiwan, Indonesia, Thailand, Vietnam, Philippines. Bulbs, shoots, and leaves are eaten raw, boiled as soup or cooked as a vegetable. Much variability occurs in East Asia, its region of diversity where several types are grown.

*Allium grayi* Regel (Amaryllidaceae/Alliaceae). East Asia-Korea, China/Manchuria. Leaves are used as pot herb/condiment.

*Allium ledebourianum* Schult. (Amaryllidaceae/Alliaceae). East Asia-Japan. Young bulbs and leaves are eaten raw or cooked, particularly in Japan.

*Allium nipponicum* Franch. & Savat. (Amaryllidaceae/Alliaceae). East Asia-China, Japan. Bulbs and leaves are used as salad.

*Allium porrum* L. (Amaryllidaceae/Alliaceae) Leek. Introduction to temperate Asia from the Mediterranean region;
sporadically grown. Bulbs and also lower parts of the leaves/shoots are used for flavouring - eaten boiled, as soup. The A. ampoloprasum group is included under this.

Allium ramosum L. (Amaryllidaceae/Alliaceae) Chinese leek. East Asia; much cultivated in north China. Bulbs, leaves/shoots are eaten boiled, as soup.

Allium schoenoprasum L. (Amaryllidaceae/Alliaceae) Chives. Temperate Asia, sporadically grown. Used as vegetable, for flavouring.

Allium stracheyi Baker. (Amaryllidae/Alliaceae) Jambu. South Asia-Western Himalayas, India. Several domesticated types occur, used as vegetable and for garnishing as its leaves are aromatic. A. victorialis has similar distribution and use.


Alternanthera philoxerodes Griseb. (Amaranthaceae). Southeast Asia - Thailand, Indonesia, Malaysia; used as leafy vegetable.

Alternanthera sessilis (L.) R. Br. ex DC. (Amaranthaceae) Ponnanganni. Tropical Asia; in South Asia, cultivated in southern India and in Sri Lanka as a leafy vegetable. Much variability occurs in domesticated/cultivated types; selections varying in growth habit, quality, yield etc. developed in Sri Lanka.

Amaranthus blitum. var. oleracea Duthie. (Amaranthaceae) Chulai. 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 - A. blitum, A. dubius, A. tricolor/gangeticus, A. graecizans, A. polygonoides, A. spinosus, A. viridis. Most of these have sporadic distribution with native or introduced diversity being grown for local use; some like A. paniculatus/A. tricolor are more popular with wider distribution and diversity of local and improved types.

Angelica kiusiana Maxim. (Umbelliferae). East Asia-China; an old cultigen. Grown as a leafy vegetable.

Apium graveolens L. var. dulce (Mill.) Pers. (Umbelliferae) Celery. European/Mediterranean origin; introduced into South/Southeast, East Asia. Chinese celery resembles leaf celery, var. sacalinum, already spread to Southeast
Asia in the Philippines, and to East Asia. Exotic introduction to India, Myanmar. Leaves are used as salad, and boiled, stewed and consumed as a vegetable. Introduced diversity belongs to several cultivar groups-leafy celery mainly diversified in China; another type is var. *rapaceurn* (root celery).

*Aralia cordata* Thunb. (Araliaceae) Udo. East Asia–Japan. Young shoots are cooked as a vegetable.

*Asparagus officinalis* L. (Liliaceae) Garden asparagus. European introduction to temperate Asia, more adapted to cold climate. Grown in the Himalayas extending eastwards, more in Thailand, Indonesia, also Philippines. Young fleshy shoots are boiled as soup; eaten as salad; also pickled.

*Atriplex hortensis* L. (Chenopodiaceae) Mountain spinach. Temperate Asia, introduced. Leaves are cooked as a vegetable.


*Bambusa blumeana* Schult. f. Syn. B. *spinosa* Roxb. (Gramineae). South/Southeast Asia, northeast India, Myanmar, Indo-China, extending to the Philippines, Indonesia. Young shoots are boiled and eaten as soup.

*Bambusa cornuta* Munro (Gramineae). Southeast Asia – Indonesia, Java. Tender shoots are boiled and eaten.

*Bambusa multiplex* (Lour.) Raesh. ex Schult. (Gramineae) Chinese dwarf bamboo. East Asia – China, Japan. Young buds/shoots are boiled/cooked as soup.

*Bambusa spinosa* Roxb. (Gramineae). Philippines and Indonesia, Tender shoots used as vegetables.

*Bambusa tulda* Roxb. (Gramineae) Tulda bans. South Asia, Northeast India, Myanmar, Indo-China and neighbouring tracts. Young buds/shoots are boiled and consumed as a vegetable, and also as soup.

*Bambusa tuldoides* Munro. (Gramineae) Verdant bamboo. South China, Indo-China region. Young shoots are eaten as a vegetable; protected, semi-domesticated types occur in backyards.

*Bambusa vulgaris* Schrad. ex Wendl. (Gramineae) Feathery bamboo. South/Southeast Asia – cultivated in northeastern India, Myanmar, Indo-China, Malaysia. Young shoots are cooked as a vegetable.

*Barbarea varum* (Miller) Asch. (Cruciferae) Winter cress. Southeast Asia, sparingly grown in Malaysia.

*Basella alba* L. Syn. B. *rubra* L. (Basellaceae) Vine spinach, Indian Ceylon spinach. South/Southeast Asia; India, Sri Lanka, Myanmar, Indo-China; popular in Malaysia and Philippines. Much variability occurs in Sri Lanka and southern India for both green and red pigmented types (possibly domesticated in this region). Young shoots and leaves are cooked as a vegetable.
Belosynapsis moluccana (L.) Fisher Syn. Cyanotis mollucana Roxb. (Commelinaceae). Native to the Molluccas, sparingly grown for local consumption in Borneo, Philippines, Indonesia/Java and in PNG/ Pacific Islands and highlands of New Guinea. Leaves and shoots are consumed as a vegetable.

Benincasa hispida (Thunb.) Cogn. (Cucurbitaceae). Cultivated throughout tropical Asia, Fruits used as vegetable, also to make sweetmeat.

Boerhaavia diffusa (L) (Nyctaginaceae). Throughout India, also in Sri Lanka, Malay Peninsular extending to China & Islands of Pacific. Leaves used as vegetable, in medicinal uses also.


Brassica chinensis L (Cruciferae). Chinese cabbage. China SE Asia, Used as vegetable, salad etc.

Brassica juncea (L.) Czern. (Cruciferae) Garden mustard. Several varieties grown; centre of diversity in northwest Himalayan region, further to northeast and in China. Grown in South Asia, Myanmar, Indo-China, Southeast Asia, East Asia-China, Korea, Japan. Several cultivar-groups have been developed with green and purple leaves. Used as leafy vegetable, as soup and also in fried form.

Brassica juncea (L.) Czern. var. japonica (Thunb.) L.H. Bailey. (Cruciferae) Japanese leaf mustard. East Asia, mainly grown in Japan. Leaves are consumed as salad. Young sprouts are eaten raw.

Brassica juncea (L.) Czern. var. multiceps M. Tsen & S.H. Lee (Cruciferae). East Asia mainly Japan, China. Leaves are boiled as soup. The var. tumida is also confined to China.

Brassica narinos a L. (Cruciferae). East China around Shanghai, introduced to Japan, used as vegetable.

Brassica oleracea L. (Cruciferae). East Asia-China is the main region of diversity; several cultivar groups occur such as Brussels sprouts- var. gemmifera; cauliflower- var. botrytis; broccoli- var. italic a; Chinese kale- var. albo glabra. Several initial introductions to Asia-Pacific came from Europe/ Mediterranean region and diversity in specific types developed in different parts, more in China, Korea, Japan, also Philippines, Vietnam and Thailand. Broccoli types and forms like Pakchoi evolved in China and spread to Japan;
cultivated in Philippines, Malaysia, Indonesia, Thailand, sporadically elsewhere. Several types are grown and used as salad, cooked as soup, also fried and eaten.


*Brassica rapa* L. subsp. *pekinensis* (L.) Hanelt. Syn *B. pekinensis* (Lour.) Rupr. (Cruciferae) Pe-tsai, Chinese cabbage. East Asia, China; an old cultivar. Its loose heads are used as a vegetable.


*Brynopsis laciniosa* (L) Naudin (Cucurbitaceae). Throughout India except dry areas. Leaves cooked as vegetables in Papua New Guinea, Indonesia & India

*Cajanus cajan* (L) Millspaugh (Leguminosae). India & Africa considered as its origin. Immature buds are used as vegetables.

*Celosia argentea* L (Amaranthaceae). Tropical Asia. Its leaves & tender stems used as leafy vegetables. As medicinal also.

*Centella asiatica* (L.) Urb. Syn. *Hydrocotyle asiatica* L. (Umbelliferae) Gotukola, Brahmi, Kungangal, Indian pennywort. South/Southeast Asia. Cultivated mainly in Sri Lanka as a leafy vegetable; also as pot herb in South India. Much variability in domesticated forms reported in Sri Lanka where local selections vary in growth habit, quality, yield, etc.

*Cheropogia bulbosa* L (Asclepiadaceae). Humid part of India. Fresh leaves and stem taste like purslane & roots like raw turnip.

*Chenopodium album* L. (Chenopodiaceae) Lamb’s quarters. Tropical and temperate South Asia-an old cultigen with more diversity in Western Himalayas/Hindu Kush Himalayas. Leaves and young shoots are boiled and consumed as a vegetable (also see under use category 1).

*Chimonobambusa quadrangularis* Makino (Gramineae). East Asia - China, Japan. Young shoots are boiled and eaten in stewed form.

*Chrysanthemum coronarium* L. var. *spaticosum* Bailey (Compositae). East Asia, grown in China, but more so in Japan, Korea, Taiwan, as a leafy vegetable, where much diversity occurs. Both small and large-leaved types are grown. Leaves, young shoots are boiled as soup, also eaten as cooked vegetable, possessing strong smell.

*Chrysanthemum segetum* L. (Compositae). East/Southeast Asia; cultivated in China, Indo-China, Malaysia. Grown as a leafy vegetable; boiled and eaten.
**Chrysanthemum sinense** Sabine Syn. *Pyrethrum sinense* DC. (Compositae). East Asia mainly China, Japan. Grown as a leafy vegetable; boiled and eaten.

**Cleome gynandra** L. (Capparidaceae). Occurs as a weed in Asia-Pacific. Possibly being domesticated as a vegetable in home gardens. It is seen in markets in Malaysia and Thailand; eaten fresh or boiled.

**Clerodendrum colebrookianum** Walp. (Verbenaceae). South/Southeast Asia. Domesticated as a leafy vegetable in northeastern India-Arunachal Pradesh and other states and neighbouring region. Leaves are boiled and eaten in soup, cooked as vegetable with rice; also mixed with other local leafy types, boiled and eaten.

**Clerodendron indicum** (L) Kuntze (Verbenaceae). Western peninsular region, eastern India, Kumaon & Khasi hills, Myanmar, Malay peninsula & Sumatra. Leaves are used as vegetables by Mikirs.

**Clerodendron serratum** (L) Moon (Verbenaceae). Throughout India, Sri Lanka and Malay peninsula. Leaves and flowers are edible, root as medicine. Santhal tribes use it in fermentation of rice beer.

**Commelina obliqua** Buch.Ham. ex D.Don (Commelinaceae). Throughout India. Leaves & shoots are used as vegetables.

**Corchorus capsularis** (L) (Tiliaceae). South Asia, India, Pakistan. Leaves used as vegetables.

**Corchorus trilocularis** L. (Tiliaceae). South Asia, northeast India. It is occasionally grown as leafy vegetable. Leafy types of *C. capsularis* are also grown as a pot herb; leaves boiled and eaten.

**Cosmos caudatus** Kunth. (Compositae). Tropical Asia, sporadic distribution as a cultigen. Locally grown in Southeast Asia in home gardens. Young leaves are used as a vegetable in Indonesia, Malaysia, and the Philippines; eaten raw, or cooked with coconut sauce, for chutney preparation.

**Cryptotaenia canadensis** (L.) DC. (Umbelliferae). North American introduction; cultivated in Japan. Young leaves are eaten as a vegetable (fried roots are also eaten).

**Cryptotaenia japonica** Hassk. (Umbelliferae) Japanese hornwort. East Asia mainly; grown as leafy vegetable in Japan, Korea, China, Taiwan; also in Indonesia, where a variant of this species occurs, consumed in cooked form, as soup.

**Curcuma mangga** Valeton & Zijp. (Zingiberaceae). Southeast Asia-Thailand, Malaysia, Indonesia. Young shoots of rhizomes are used as a vegetable, eaten raw or cooked.

**Cynara cardunculus** L. (Compositae) Artichoke thistle. Mediterranean origin; introduced possibly in East Asia. Leafy-stalks are cooked as a vegetable.

**Cynotis tuberosa** Roem. & Schultz. (Commelinaceae). Western & Eastern
Peninsular region. Leaves used as pot herbs.

*Dendrocalamus asper* (Schult.) Backer Syn. *Bambusa asper* Schult. (Gramineae). South/Southeast Asia; northeastern India. Malaysia, Indonesia and adjacent areas. Its young shoots are fried as a vegetable; also cooked as soup.

*Dendrocalamus latiflorus* Munro Syn. *Sinocalamus latiflorus* (Munro) McClure. (Gramineae) Sweet bamboo. Southeast/East Asia; Philippines, Japan, China, Taiwan, Indo-China and Myanmar. The sprouts are boiled and eaten.

*Dentella repens* L. (Rubiaceae). India, Indonesia, Polynesia. Leaves are edible.

*Embelia nagushia* D.Don (Myrsinaceae). NE Hills, lower part of eastern Himalaya, Khasi hills. Leaves and tender shoots are cooked and eaten.

*Emilia sonchifolia* (L.) DC. (Compositae) Sow thistle. South, Southeast, East Asia; sporadically grown as a leafy vegetable in home gardens, used as salad; boiled and eaten with rice.

*Enydra fluctuans* Lour. (Compositae) Buffalo spinach. Indo-Chinese origin, sporadically distributed in tropical Asia in wet habitats. Semi-domesticated/protected forms occur in home gardens or grown as a pot herb in northeast India, Myanmar, Indo-China, Thailand. Young leaves/shoots used as a vegetable; eaten raw or stewed, crushed leaves applied to herpetic skin eruptions.


*Erigeron annuus* Pers. (Compositae). East Asia-Korea, introduced into Japan. Young leaves are boiled and eaten.

*Eruca sativa* Mill. (Cruciferae) Rocket. European/West Asian introduction to northwestern India. Leaves used as salad (seeds yield oil).

*Gigantochloa thoi* K.M. Wong (Gramineae). Sparingly grown in Southeast Asia, used as a vegetable.

*Glechnia littoralis* Schmidt. ex Miq. (Umbelliferae). East Asia-cultivated in China as a leafy vegetable.

*Glochidion blancoi* Low (Euphorbiaceae). East, Southeast Asia; cultivated in East Asia and the Philippines. Young shoots/leaves are cooked and eaten.

*Gymnema syringaefolium* (Decne) Constantin (Asclepiadaceae). Southeast Asia-Malaysia. Leaves are cooked and used as a leafy vegetable; also eaten raw as salad.

*Gynura bicolor* DC. (Compositae). East Asia-Japan; also in Micronesia; introduced elsewhere. Grown as a leafy vegetable.

*Hemerocallis fulva* L. var. *aurantiaca* (Baker) Hotta. (Liliaceae) Golden summer day-lily. East Asia - Japan, China; grown as a leafy vegetable.
Hibiscus acetosella Welw. ex Hiern. (Malvaceae) Red leafed hibiscus. Tropical African; introduced in South/Southeast/East Asia and elsewhere as far as the Pacific. Grown as a leafy vegetable. Leaves and young shoots are eaten raw; acidic/sour in taste.


Houttuynia cordata Thunb. (Saururaceae) Tri-okudami, Tsi. South/Southeast/East Asia - northeastern India, Myanmar, Indo-China, Vietnam and elsewhere in China and Japan. Cultivated particularly in Indo-Chinese region and Thailand. Leaves are used as salad; also boiled and consumed as soup (roots are also edible).

Hydrocotyle sibthorpioides Lam. (Umbelliferae). South/Southeast/East Asia - sporadically grown in Philippines, Indonesia, Malaysia, also China and Sri Lanka. Leaves are eaten raw or boiled; also used as condiment.

Hydrolea zeylanica (L.) Vahl (Hydrophyllaceae). South/Southeast Asia-Northeast India, Indo-China, also Java; cultivated. Young leaves/shoots are eaten/cooked as a vegetable.

Hygrophilia salcifolia Nees (Acanthaceae). Throughout India. Leaves eaten as pot herb.

Ipomoea aquatica Forssk. Syn. I. reptans (L.) Poir. (Convolvulaceae) Kangkong. Much cultivated in Southeast/East Asia - Indo-China, Vietnam, Thailand, Philippines, Malaysia, Indonesia, China, Hong Kong, Taiwan, Korea, Japan; also grown in South Asia-northeast India, Bangladesh and in Sri Lanka. Young leaves and shoots of green and pigmented red leaf types are consumed as vegetable. Stem is also pickled.

Lactuca denticulata Maxim. (Compositae). East Asia-China, Japan. A home garden cultigen; the leaves are eaten as vegetable.


Lactuca sativa L. (Compositae) Garden lettuce, Stem lettuce. European introduction, sporadically grown in Southeast/East Asia; cultivated in China, Taiwan and Japan where much diversity occurs; several forms of stem lettuce of Chinese origin have been developed, and have subsequently spread to Southeast Asia; grown in the Philippines; different cultivar groups exhibit much leaf variation in button and curl types. Leaves and young shoots are edible. About five varieties including asparagus lettuce are grown.

Lepidium sativum L. (Cruciferae) Garden cress, Pepper grass. European, North African introduction into temperate Asia, in India and elsewhere; cultivated
sporadically as a leafy vegetable. Pigmented, red-leaved varieties also occur.

*Leucas lantana* Benth. (Labiatae). Western Himalayas, Myanmar, South China. Leaves are edible, used as vegetable in Bihar (India).

*Limnocharis flava* (L.) Buch. (Limnanthaceae) Sarawat lettuce. Possibly introduced to Southeast Asia and diversity in cultivated forms developed in Malaysia, Indonesia, Thailand; also sparingly grown in South Asia. In Sri Lanka, northeast India, Myanmar, and Indo-China. Leaves are cooked as vegetable; also pickled. A local market vegetable in Malaysia and Indonesia; also much relished in Thailand.

*Lycium chinense* Mill. (Solanaceae) Chinese wolf berry, Chinese matrimony vine. East, Southeast Asia – China, Japan, Korea, Taiwan, Vietnam, Indonesia, Malaysia; introduced into the Pacific. Grown as a leafy vegetable; its green leaves are cooked and dried leaves are eaten in soup preparations; young shoots used for flavouring.

*Lysimachia candida* Lindl. (Primulaceae). Eastern Himalayas, Myanmar extending to China, Japan & Java. Herb eaten as vegetable by Manipur tribals in India.


*Malva verticillata* L. var. *crispa* L. (Malvaceae) Curled mallow. East Asia—an old cultigen of Chinese origin introduced into Japan, also Australia and elsewhere. Both green and pigmented types are grown as leafy vegetable. Leaves are boiled and eaten; also used for garnishing, and made into soup.


*Melilotus altissimus* Thuill. Syn *M. macrorrhizus* Pers. (Leguminosae). Possibly introduced from Europe; grown in East Asia, China. Young shoots are eaten boiled.

*Merremia emarginata* Hall f. (Convolvulaceae). Peninsular India, Sri Lanka, upper Myanmar. Plant used as pot herb.

*Mollugo cerviana* Seringe (Aizoaceae). Drier parts of India, also Thailand. Tender shoots used in curry.

*Nasturtium indicum* DC. (Cruciferae). Subtropical to temperate Asia, widely distributed. More variability in China; India (in Himalayan region), Vietnam, Indo-China and eastwards also in the Pacific Islands. Grown as a leafy vegetable.


**Neptunia prostrata** (Lam.) Baill. Syn. *N. oleracea* Lour. (Compositae) Water cress. Aquatic plant; occurs sporadically in South/Southeast, East Asia. Cultivated for local consumption-northeast India, Indonesia, Thailand. Young shoots and leaves are eaten raw or cooked. Finds place in Thai culinary dishes.

**Nothopanax fruticosum** Miq. (Araliaceae). Southeast Asia, Polynesia, Java to Pacific Islands. Leaves are boiled into soup (roots are also edible).

**Nothopanax guilfoylei** Merr. (Araliaceae). Distribution as of the above species; Pacific Islands, used here as a vegetable; related to the above species.

**Nothopanax pinnatum** Miq. (Araliaceae). Southeast Asia-Moluccas and as far as Papua New Guinea. Used as a leafy vegetable.

**Oenanthe javanica** DC. (Umbelliferae). Indo-china to Malaya. Philippines, China, Korea, Japan and Java. A leafy vegetable often occur as weed.

**Parkia roxburghii** G.Don (Leguminosae). Spread from India to New Guinea. Brunei, Indonesia. Long tender pods used as vegetable in Manipur, several other preparations also.

**Parkia roxburghii** (courtesy: KC Bhatt)

**Pentaphragma begoniaefolium** Wall. (Pentaphragmaceae). Southeast Asia-Malaysia. A fleshy herb, cultivated as a vegetable in home gardens.

**Perilla frutescens** (L.) Britt. (Labiatae). Native of India, China or Japan, NE Himalayas. Leaves used in curry.


**Phyllostachys aureosulcata** McClure, (Gramineae) Yellow grove bamboo. East Asia – China, cultivated; shoots/sprouts are edible, cooked as a vegetable.

**Phyllostachys bambusoides** Sieb. & Zucc. (Gramineae) Giant timber bamboo. East Asia mainly. Widely cultivated in China and Japan for its edible young
sprouts/shoots; Castillon type produces small sweet culms.

*Phyllostachys dulcis* McClure. (Gramineae) Sweet shoot bamboo, Vegetable bamboo. East Asia, mainly grown in Central China. Young shoots are edible.

*Phyllostachys makinoi* Hayata (Gramineae). East Asia - Japan, Taiwan- cultivated. Young shoots are boiled and eaten.

*Phyllostachys nigra* (Lodd. ex Lindl.) Munro, (Gramineae) Hainan bamboo. East Asia – South China, Japan. Young buds/shoots are consumed as vegetable.

*Phyllostachys praecox* C.D. Chu & C.S. Chao (Gramineae). East Asia - mainly China, used as a vegetable. *P. vivax* McClure of Chinese origin is also grown as a vegetable.

*Phytolacca acinosa* Roxb. (Phytolaccaceae). South/Southeast Asia, sporadically grown as a leafy vegetable in the Himalayan tract. *P. americana* is a north-American introduction, also sparingly grown.

*Phytolacca esculenta* Van Houtte (Phytolaccaceae). East Asia. Occasionally cultivated in China and Japan; leaves are used as vegetable.

*Pilea melastomoides* (Poir.) Wedd. Syn *P. trinervia* Wight (Urticaceae). South Asia-India, Sri Lanka; East Asia in Taiwan, Japan, Southeast Asia - Philippines, Indonesia. Cold adaptable and locally grown in Indonesia-Java, and elsewhere more as a pot herb in home gardens. Its aromatic leaves are eaten raw or stewed and much relished. *P. glaberrima* (Blume) Blume grown for similar use in Java, for flavouring.


*Plantago major* L. (Plantaginaceae) Plantain ripple grass. Temperate Asia- Himalayas, naturalized. Cultivated in China as a leafy vegetable, largely eaten as salad.

*Plumbago zeylanica* L. (Plumbaginaceae). Native eastern India. Delicious vegetable in Manipur.

*Polygonum hydropiper* L. (Polygonaceae). East Asia – China, Japan; var. *maximowiczii* (*P. maximowiczii*) is eaten as a vegetable; leaves possess acrid taste.

*Polygonum meximowiczü* Regel (Polygonaceae). Japan, cultivated there as vegetable.
Polygonum plebejum R.Br. (Polygonaceae). East Asia, India. Leave used as vegetables.


Portulaca quadrifida L. (Portulacaceae). Tropical Asia, domesticated diversity with similar distribution as of P. oleracea. Fleshy leaves are cooked as a vegetable.

Pouzolzia viminea Wedd. (Urticaceae). Western Himalayas, Malay Peninsula & adjacent Islands. Leaves eaten as vegetables.

Premna latifolia Roxb. (Verbanaceae). Outer Himalayan ranges to Bhutan, India. Tender shoots used in curries.

Pterococcus corniculata (Sm.) Pax & K. Hoffm. Syn. Plukenetia corniculata Sm. (Euphorbiaceae) Pina-pina. Southeast Asia - Malaysia, Indonesia; Young sweet leaves/sprouts are eaten cooked with milk.

Pugionum cornutum Gaertn. (Cruciferae) Sagri. East Asia - China/Mongolia. Locally grown as a leafy vegetable.

Rivia hypocrateriformis (Lamk.) Choisy (Convolvulaceae). Throughout India. Its leaves & young shoots boiled with salt & chillies, used as vegetables.

Rorippa schlechteri (O.E. Schulz) P. Royen (Cruciferae). East Asian origin, sporadically grown in East-Southeast Asia, Myanmar and neighbouring areas as far as in Philippines for its leaves, eaten raw or cooked.

Rumex acetosa L. (Polygonaceae) Garden sorrel. Mediterranean introduction, grown in temperate Asia; variety hortensis is cultivated. Leaves are eaten raw, or with spinach.


Rungia klossii S. Moore (Acanthaceae). Pacific Islands-highlands of PNG, also in Irian Jaya, Indonesia. Grown as a pot herb; as a leafy vegetable; cooked with leaves of pit pit; sometimes eaten raw. A popular vegetable of the PNG highlands, cold adaptable, grown upto 2700 m.

Saccharum edule Hassk. (Gramineae) Pit pit. Origin unknown; cultivated in Borneo, Java, more in the Pacific Islands - PNG in particular for its edible compact inflorescences which are covered in leaf sheaths; each of the size of banana. Traded in local market, also in Indonesia, New Guinea, Malacca, northern Melanesia.

Salsola foetida Del.ex Spreng. (Chenopodiaceae) India, Baluchistan, Afghanistan. Leaves used as vegetables.

Sauropus androgynus (L.) Merr. Syn. S. albicans Blume (Euphorbiaceae)
Star gooseberry. Cultivated in South/Southeast Asia-India, Sri Lanka, Indo-China. Indonesia, Malaysia; also in southern China; Grown as a hedge, a home garden cultigen. Leaves are also much used as a leafy vegetable in Java; eaten with rice or boiled into soup.

Sesuvium portulacastrum L. (Aizoaceae) Sea purslane. Tropical Asia, mainly coastal areas; semi-domesticated/protected and grown in home gardens. Fleshy leaves are eaten as a vegetable.

Schefflera aromatica (Blume) Harms. (Araliaceae). Southeast Asia, native to Java, Indonesia. Young leaves are aromatic and eaten raw and as cooked vegetable. Grown as a hedge plant.

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Sonchus oleraceus L (Compositae). North India throughout plains and hills. Leaves consumed raw or cooked as vegetables, popular in Kashmir.

Sphenoclea zeylanica Gaertn. (Companulaceae). Native of Tropical Africa, distributed throughout South-east Asia. Young shoots bitter, eaten in Java & Thailand.

Suaeda maritima (L) Dumortier (Chenopodiaceae). Originated in India. Leaves boiled and eaten as vegetable in India and Indonesia (Java).


Taraxacum officinale Weber. (Compositae) Dandelion. Temperate Asia; sporadically grown elsewhere. Leaves are eaten as salad. Much variability occurs in West Asia.


Trianthema portulacastrum L. Horse purslane (Aizoaceae). Tropical Asian weed; grown in Sri Lanka as a leafy vegetable, where several domesticated types occur, also in south India.

Trigonella foenum-graecum L. Fenugreek (Leguminosae). East Europe/central Asian introduction to South Asia; grown in north India and much liked as a leafy vegetable (also medicinal for diabetes cure).

Valerianella locusta (L.) Betke Corn salad (Valerianaceae). European introduction to Asia, occasionally cultivated. Introduced in PNG; used as salad. Needs to be popularized in temperate, cool region for cultivation.

Veronica anagallis-aquatica L. (Scrophulariaceae). East Asia – Japan; mainly consumed as salad; more like lettuce.
Viola verecunda A. Gray. (Violaceae). East Asia - China. An old cultigen grown as a leafy vegetable.

Vollaris solanacea (Roth.) O. Kuntze (Apocynaceae). India, Sri Lanka, also Myanmar. Flowers & fruits edible.

Wolffia globosa (Roxb.) Hartog & Plas (Lemnaceae). South/Southeast Asia-Bangladesh, India and Myanmar; cultivated mainly in Indo-China, Laos and northern Thailand. A leafy (aquatic) nutritious vegetable, rich in protein.

Zizania latifolia Turcz. ex Stapf. Water rice (Gramineae). Widely distributed; sporadically grown in South/ Southeast and east Asia-northeast India, Malaysia, Thailand, Philippines, Indonesia, China, Korea, Japan. Fleshy swollen basal shoots, infected and sweet, are eaten as a vegetable (also an obsolete cereal of North China). More grown for local consumption.

**Fruit types**


*Abelmoschus moschatus* Medikus (Malvaceae). Indo-China to Indonesia & SW Pacific Island to New Guinea & N. Australia. Grown for immature fruits used as vegetable.

Benincasa hispida (Thunb.) Cogn. Ash gourd (Cucurbitaceae). South/Southeast Asia mainly. Both ridged, non-rigged smooth types occur. More popular as vegetable in northeast India, Indo-China, Myanmar, Thailand, sporadically elsewhere; also used for preparing sweets. From South/Southeast Asia, cultivation spread to East Asia-Japan, China.

*Canavalia ensiformis* (L.) DC. Sword Bean. (Leguminosae) South/Southeast Asia - cultivated as a kitchen garden crop. Young pods are cooked as vegetable. Roasted seeds are edible. C. gladiata/Jack bean is also distributed/grown likewise and has similar use.

*Canavalia cathartica* Thouars Syn. *C. polystachya* (Forsk.) Schweinf. (Leguminosae). South/East Asia-China (Yunnan), India. Young pods are cooked as vegetable. Unripe seeds are eaten boiled.

*Cissus javana* DC. Mirah (Vitaceae). Southeast Asia - Indonesia, Java, Sparingly cultivated for its sour leaves and fruit used as vegetable.

*Cissus repens* Lamk. (Vitaceae). Occurs in India to Southern China including SE Asia. Young shoots and leaves eaten with other vegetables.

*Coccinia grandis* (L.) Voigt Syn. *C. indica* Wight & Arn. (Cucurbitaceae). South Asia - mainly India, Sri Lanka, Myanmar, Pakistan extending to Southeast Asia, Malaysia, Thailand, Indonesia. Fruits are often cooked and eaten as vegetable (also young shoots),
roots & leaves used in folk medicine for diabetes and skin eruptions.

*Cucumis melo* L. subsp. *agrestis* Pang. Weedy field melon, Cantaloupe (Cucurbitaceae). South/Southeast Asia. Fruits are eaten raw or cooked when ripe; also occasionally used as preserves. Several other varieties are also grown—var. *momordica*, *utilissimus*, *conomon*—more diversity in western and northern India; var. *conomon* is pickled, grown in south India.


*Cyamopsis tetragonolaba* (L) Talbert. (Leguminosae). Origin is in vogue, cultivated in India & Java also. Mature pods used as vegetables.

*Diplocyclos palmatus* (L.) Jeffrey (Cucurbitaceae). South/Southeast Asia. Occasionally cultivated in Indonesia and PNG; scarce elsewhere. Young fruits and leaves eaten as vegetable.

*Enhydra fluctuens* Lour. (Compositae). India, Indo-china, Thailand, China, Indonesia. A water plant cultivated for its leaves, used as vegetable.

*Lablab purpureus* (L.) Sweet Syn. *Dolichos lablab* L. Hyacinth bean (Leguminosae). East South Southeast Asia; across Pacific. Largely grown as a vegetable, but with potential as grain legume; bushy types developed for use as a pulse crop in South India on a minor scale.

*Lagenaria siceraria* (Molina) Standley. Bottle gourd (Cucurbitaceae). South/ Southeast/East Asia; widely grown as a vegetable; tender fruits are cooked and eaten, also made into soup.

*Luffa acutangula* (L.) Roxb. Ridged gourd, Ribbed gourd (Cucurbitaceae). South/Southeast/East Asia, as far as the Pacific. Much variability in Eastern India, Myanmar and China. Tender fruits are cooked as a vegetable.

*Luffa aegyptiaca* Mill. Syn L. *cylindrica* (M.) Roem. Sponge gourd (Cucurbitaceae). Distribution under cultivation and use is similar to *L. acutangula*. However, it is more popular as a vegetable and much grown in central and north India, also in Myanmar, Indo-China extending eastwards, often as a backyard cultigen, as far as Pacific/Oceania region.

*Luffa hermaphrodita* Singh & Bhandari. Satputiya (Cucurbitaceae). India (Bihar and West Bengal), Bangladesh. Fruits in clusters, used as vegetable.

*Momordica charantia* L. Bitter gourd (Cucurbitaceae). Tropical Asia-South/ Southeast/East Asia; sporadic; grown more in South Asia-India, Nepal, Sri Lanka, Bangladesh. Tender bitter fruits are cooked and eaten; they are of medicinal value in diabetes.

*Momordica cochinchinensis* (Lour.) Spreng. Sweet gourd (Cucurbitaceae). South/Southeast Asia - Probable origin as cultigen in eastern, northeast India/Indo-China; semi-domesticated/domesticated small and large fruit types occur in this region and have sporadically spread to...
other parts of Southeast Asia and East Asia. Fruits are cooked as a vegetable and pulp made into soup.

*Moringa oleifera* L. Syn. *M. pterygosperma* Gaertn. Horse radish tree (Moringaceae). Tropical Asia, widely distributed; grown mainly in home gardens as far as the Pacific; more in South/Southeast Asia - India, Sri Lanka, Indo-China, Vietnam. Thailand, Malaysia, Philippines, also in Indonesia. Ripe in fruits are used as a vegetable, gruel form; in sambar-like dishes in South India. In Sri Lanka and elsewhere, unripe fruits pickled and; also seeds roasted and eaten, and young leaves used as vegetable. An important multi-usage tree, fruits rich in vitamins.

*Mucuna pachylobia* (Piper & Tracy) Rock. Syn. *Stizolobium pachylobium* Piper & Tracy. Velvet Bean (Leguminosae). An introduction to South/East Asia-eastern India, Japan; also Micronesia. Young pods are cooked and eaten as a vegetable. May be conspecific with *M. complux* (var. *utilis*).

*Mucuna pruriens* (L.) DC. var. *utilis* (Wall. ex Wight) Baker ex Burck (Leguminosae). South Asia - mainly south and east India; domesticated in this region. Grown by tribals/locally.

*Mucuna capitata* (Roxb.) Wight & Arn. (Leguminosae). South/Southeast Asia - India, Indo-China, Indonesia-Java. Young pods are cooked as a vegetable; seeds also edible.

*Mucuna cochinchinensis* (Lour.) A. Cheval Syn. *M. nivea* DC. (Leguminosae). South/Southeast Asia-south and east India. Young pods are cooked as a vegetable.
Young pods are used as vegetable (seeds also edible).

*Musa* spp. (Musaceae). Diversity region for several domesticated/protected native species is in South/Southeast Asia with wider distribution of *M. acuminata* and *M. balbisiana*. Both gathered and backyard, home garden diversity occurs for edible inflorescences which are fried, boiled in different ways and consumed as a vegetable; much sold in local markets.

*Parkia javanica* Merr. Syn. *P. roxburghii* G. Don, Tree bean (Leguminosae). South, Southeast Asia; native of northeastern India; grown widely; also in Myanmar, Malaysia, Indonesia-Borneo; introduced into South Pacific. Young pods are cooked as a vegetable; seeds are eaten raw, popped or roasted, possess garlic-like flavour. (*P. speciosa* and *P. timoriana* have similar use (see under miscellaneous category).

*Phaseolus coccineus* L. Syn. *P. multiflorus* Willd. Scarlet runner bean (Leguminosae). Central American introduction to temperate Asia; sporadically grown in hills for its immature pods, eaten cooked as a vegetable (also seeds are boiled and eaten).

*Praecitrullus fistulosus* (Stocks) Pang. Round gourd (Cucubitaceae). Cultivated in northern India. A popular vegetable, grown for its tender fruits, cooked as a vegetable, and also made into soup-like preparation.

*Prosopis cineraria* (L) Druce (Leguminosae). Dry and arid regions of India. Tree bears edible pods. Immature pods used as vegetable, medicinal purposes also

*Psophocarpus tetragonolobus* (L.) DC. Winged bean, Goa bean (Leguminosae). Sporadically grown but spread widely under cultivation, more as a kitchen garden crop in Asia-Pacific region; grown for its pods, used as vegetable; seeds are very nutritious, protein-rich; boiled, used as pulse; grown for edible tuberous roots in Myanmar.

*Quisqualis indica* L. (Combrataceae). SE Asia, cultivated as vegetables, ornamental also.

*Sauropsus albicans* Blume. (Euphorbiaceae). SE Asia, cultivated as vegetable.

*Scorpiurus vermiculatus* L. Common caterpillar plant (Leguminosae). Mediterranean introduction to East Asia, mainly Japan. Young pods of this species and of *S. muricatus* are consumed as a vegetable.

*Sechium edule* (Jacq.) Swartz. Chayote, Cho-cho (Cucurbitaceae). Central American introduction to sub-tropical/temperate Asia, cold adaptable. Fruits are cooked as vegetable (roots are also consumed likewise). Much variability in northeast India and Nepal all through the Himalayas. R & D efforts in Nepal led to build-up of introduced and local diversity from India, Nepal and adjacent regions and selections were made.

*Sicana odorifera* (Vell.) Naud. Casa banana, Curaba (Cucurbitaceae).
Tropical American introduction into Sri Lanka; also in eastern peninsular India. Fruits are eaten cooked as vegetable.

*Solenan amplexicaulis* (Lamk.) Gandhi (Cucurbitaceae). India, China, South east Asia but not Philippines. As vegetable, salad, tender shoots & leaves also as vegetable.

*Solanum aviculare* G. Forst. Kangaroo apple (Solanaceae). Australia, Pacific Islands. Fruits are cooked as a vegetable, and also consumed raw.

*Solanum ferox* L. (Solanaceae). South/Southeast Asia; protected and grown locally and several domesticated forms occur - spiny (India) and non-spiny (Thailand, PNG) with much variation in taste. Cooked as vegetable. Several other species also occur in semi-domesticated form and fruits are sold in local markets-spiny and non-spiny types viz. *Solanum violaceum*, *S. nigrum*, *S. torvum*, *S. villosum*.

*Solanum indicum* L (Solanaceae). India, Sri Lanka, Malaysia, China, Philippines. Fruits used as vegetable.

*Solanum torvum* Swartz (Solanaceae). Distributed in South, South East & East Asia. Young immature fruits used as vegetable

*Solanum verbascifolium* L (Solanaceae). Throughout India, Sri Lanka, Malaysia. Berries used as vegetable (curry); roots, leaves medicinal.

*Spilanthes paniculata* Wall. ex DC (Compositae). S.E Asia and New Guinea, Cultivated as a vegetable or salad.

*Trichosanthes cucumerina* L. var. *anguina* Haines (Maxim.) Snake gourd (Cucurbitaceae). South/Southeast Asia. Much variability in South India and Sri Lanka in China/Japan also in Indo-China and neighbouring areas, also in the Pacific. Unripe fruits are eaten as a vegetable and ripe fruits as preserve.

*Trichosanthes dioica* Roxb. Pointed gourd (Cucurbitaceae). South/Southeast/East Asia; Mainly South Asia; possibly of east Indian origin where maximum diversity occurs in fruit size, shape, surface-smooth or striped. Used as a cooked/fried vegetable; also popular in northern India to prepare sweetmeats.

*Trichosanthes ovigera* Bl. Syn. *T. cucumeroides* (Ser.) Maxim. (Cucurbitaceae). East Asia- India, Indo-China, Malaysia and elsewhere. Grown in China and Japan; fruits are eaten as vegetable.


5. Fruits

The diversity in underutilized and less-known edible fruit-types belongs to 45 families, 106 genera and 261 species (Table 8). More prominent species belong to the Actinidiaceae, Anacardiaceae, Annonaceae, Bombacaceae, Euphorbiaceae, Flacourtiaceae,
### Table 8. Families, genera and number of plant species whose fruits are edible.

<table>
<thead>
<tr>
<th>Families</th>
<th>Genera</th>
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<tbody>
<tr>
<td>Actinidiaceae</td>
<td>Actinidia (5)</td>
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<td>Anacardiaceae</td>
<td>Bouea (2), Chaerospondias (1), Dracontomelon (1), Mangifera (5), Semecarpus (1), Sorindeia (1), Spondias (3)</td>
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<td>Bombacaceae</td>
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<td>Flacourtiaceae</td>
<td>Dovyalis (1), Flacourtia (4), Oncoba (1)</td>
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<td>Leguminosae</td>
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<td>Oxalidaceae</td>
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<td>Sapotaceae</td>
<td>Chrysophyllum (1), Madhuca (1), Manilkara (1), Pouteria (3)</td>
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<td>Tiliaceae</td>
<td>Grewia (1)</td>
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<tr>
<td>Vitaceae</td>
<td>Vitis (2)</td>
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</table>

Guttiferae, Grossulariaceae, Lauraceae, Malpighiaceae, Meliaceae, Moraceae, Myrtaceae, Musaceae, Myricaceae, Oxalidaceae, Palmae, Passifloraceae, Rhamnaceae, Rosaceae, Rutaceae, Sapotaceae, Sapindaceae, Solanaceae, Tiliaceae, Vaccinaceae and Vitaceae (Arora, 1985; Pareek et al., 1998). Among these, more diversity occurs in species of the following genera:

(a) Largely tropical/sub-tropical: Annona, Artocarpus, Averrhoa, Baccaurea, Carissa, Cordia, Citrus, Chrysophyllum, Cynomorita, Diospyros, Durio, Emblica, Elaeagnus, Elaeocarpus, Flacourtia, Ficus, Garcinia, Grewia, Lansium, Litchi, Mangifera, Manilkara, Morus, Musa, Passiflora, Phoenix, Nephelium, Salacca, Salvadoria, Sandoricum, Spondias, Syzygium, Tamarindus and Ziziphus.

(b) Largely temperate/sub-temperate: Actinidia, Crataegus, Fortunella, Fragaria, Hippophae, Malus, Myrica, Physalis, Prunus, Pyrus, Punica, Rhodomyrtus, Ribes, Rubus and Sorbus.

This diversity is largely concentrated in the Indo-Chinese-Indonesian, Hindustani/Indian and the Chinese-Japanese regions with several prominent
species from the central and south American regions such as of Annona, Passiflora, Pouteria and Physalis. Overall distribution pattern of prominent fruit species diversity grown in Asia-Pacific is as follows:

- The Chinese-Japanese region holds rich diversity both in sub-tropical and temperate types, the distribution of species exhibiting wide variation:


  2. More diversity in Citrus (bred types/selections, with distinct identity) occurs in Japan and several cultigens, viz. C. canaliculata, C. funadoko, C. glaberrima, C. hassaku, C. iyo, C. leucocarpa, C. mediglobosa (also occurring in the Philippines) have been recognized (Tanaka, 1976); this also is the case in Fortunella japonica and Stauntonia hexaphylla. Comparatively very few species are confined/localized in the Philippines, viz. Artocarpus camansi, A. odoratissimus, Citrus mitis (also in Japan), Dracontomelon edule, Garcinia dulcis and G. lateriflora (also in Java) and Garcinia binuoco (introduced into the Pacific), and Syzygium cumini.

  3. A good number of species exhibit diversity both in China and Japan, viz. Prunus mume, Chaenomeles speciosa, Citrus spp., Fortunella crassifolia, F. hindsii, F. margarita, Malus micromalus, Prunus salicina and Pyrus sinensis. Species such as Crataegus pentagyna occur both in China and Korea, while several others are widely distributed in China, Korea, and Japan - Actinidia callosa, Citrus junos, Crataegus cuneata, Chaenomeles sinensis and Macrocarpium officinale.

- Both the Indo-Chinese-Indonesian and the Hindustani/Indian region of diversity hold rich wealth of fruit species. Several tropical fruits were domesticated in south and southeast Asia. Overall distribution of diversity is as follows:

  1. More diversity occurs in south Asia in Artocarpus heterophyllus, A. lacucha/lakoocha, Aegle marmelos, Carissa congesta, Citrus indica, C. macroptera, C. pseudo-limon, Chaerospondias axillaris, Dovyalis hebecarpa, Elaeocarpus floribundus, Emblica officinalis, Feronia limonia, Flacourtia ramontchii, Garcinia indica, G. gummi-
gutta, Grewia subinaequalis, Manilkara hexandra, Morus spp., Spondias oleoides, S. pinnata, Salvadora persica, Syzygium cumini, Rhodomyrtus tomentosa, Rubus ellipticus and Ziziphus mauritiana.


3. As compared to above some species have more diversity in the Indonesian region-Java, viz. Garcinia dulcis, G. lateriflora; still others in the Philippines such as Dracontomelon edule and Syzygium cumini, and some like Pometia pinnata and Triphasia aurantifolia, also occurring in the Pacific Islands. Overall, several species in this region exhibit a relatively wider distribution within south and southeast Asia i.e. Artocarpus heterophyllus, bilimbi, A. carambola, and several species/varieties in Citrus, Garcinia, Manilkara, Musa, Syzygium, Ziziphus and Mangifera.

Apart from the information synthesised specifically on underutilized fruits and nuts (Pareek et al., 1998), and less known food plants (Arora, 1985), well synthesised information, species-wise, on edible fruits and nuts is published by Plant Resources of South East Asia-PROSEA (Verheij and Coronel, 1992), which identifies several underutilised fruit species, and this has been included in this account.

**Check-list of species**


*Actinidia callosa* Lindl. Syn. A. arguta Planch. ex Miq. (Actinidiaceae). East Asia - native of China, grown in temperate region mainly in China, Japan and Korea. Juicy sour berries are eaten raw, also used to prepare jam and brewed for wine; flavour superior to kiwi fruit (frost resistant types used in breeding with *A. delicosa*).

cooked, preserved and used in pies; rich in Vitamin A and C.

**Actinidia kolomikta** (Maxim. & Rupr.) Maxim., may be conspecific with A. callosa. Kolomikta vine (Actinidiaceae). East Asia - domesticated in north China and grown in China, Korea and elsewhere. Fruits are eaten fresh, dried or preserved in salt.

**Actinidia rubicaulis** Dunn. (Actinidiaceae). East Asia - domesticated in west China and cultivated for its fruits; sporadically grown.

**Adenia heterophylla** (Bl.) Koord. (Passifloraceae). India-Andamans. Juicy aril is edible.

**Aegle marmelos** (L.) Correa. Bengal quince, Bael (Rutaceae). Native of north India, Himalayan foothills of India/Indo-Burmesian region to Indo-China; grown in plains and submontane regions of southeast Asia. Fruits possess aromatic pulp, eaten as such or processed as sherbet/squash, have medicinal value and cure chronic diarrhoea and dysentery. Tolerant to alkaline and saline soils. Used as rootstock, induces precocity in citrus.

**Allaeanthus luzonieus** F. Vill. (Moraceae). Philippines. Fruits are sweet and eaten raw when ripe.

**Annona atemoya** Host. ex Wester (Annonaceae). South American introduction into southeast Asia – Philippines, also northeastern Australia; hybrid types yield fruits that are pulpy, sweet, of excellent quality and eaten raw.

**Annona cherimola** Mill. Cherimoya (Annonaceae). Tropical American; sparingly grown in warmer humid parts of Asia. Fruits are of good quality-pulpy, sweet to subacidic, and eaten raw, and prepared as a cool, refreshing drink in form of sherbet, in south India.
Annona glabra L. Alligator pear, Alligator apple (Annonaceae). Central American introduction into tropical Asia, grown mainly in home gardens, meagrely grown in southeast Asia, in eastern Taiwan. Fruits are eaten raw. A potential graft stock.


Annona muricata L. Soursop (Annonaceae). Central American origin; introduced into Asia-Pacific; sporadic cultivation mainly in backyards. Fruit of good quality, edible.

Annona reticulata L. Bullock’s heart (Annonaceae). Tropical American introduction into south/southeast/east Asia, also in Oceania; sporadic cultivation. Several varieties are grown. Fruits possess sweet, pulp with good flavour and are eaten raw and also preserved.

Annona squamosa L. Custard apple (Annonaceae). Tropical American introduction, more popular in Asia and with similar distribution as the above species. Several selections/varieties are grown. Fruits are very tasty, sweet and with distinct aroma; eaten raw or occasionally preserved.

Antidesma bunius (L.) Spreng. Chinese laurel (Euphorbiaceae/Stilaginaceae). South/southeast/east Asia, also in Pacific/Oceania - Australia. Cultivated sparingly in Indo-China, Vietnam and Malaysia. Red berries are eaten raw or used in syrups/brandy; also made into jellies.

Antidesma ghaesembilla Gaertn. Black currant tree (Euphorbiaceae/Stilaginaceae). With similar distribution as A. bunius (L.) Spreng; fruits of better quality - good potential for improvement.

Armeniaca dasycarpa (Erhr.) Boikh (Rosaceae). Central Asia. Fruits used for making marmalade.

Artocarpus altilis (Parkinson ex. F.A. Zom) Fosberg Syn. A. communis Forst.; A. incisa L.f. Breadfruit (Moraceae). Native of the Pacific Islands, grown in southeast Asia; more diversity in the Pacific and southeast Asia than in south Asia; mainly in home gardens. Fruits are rich in carbohydrates, eaten raw or cooked. Flour is made from pulp; seeds are nutritious and are roasted and eaten. A. meriannensis is an allied species, more confined to the south Pacific.


Artocarpus camansi Blanco. Kamansi (Moraceae). Southeast Asia. May be a form of A. altilis Philippines; cultivated near Manila and elsewhere. Fruits are usually eaten after boiling.

Artocarpus heterophyllus Lamk. Jackfruit (Moraceae). Native of Western Ghats, India; much grown in south/southeast Asia. Variability occurs in central and south India, Sri Lanka, Myanmar, Indo-China extending eastwards. Ripe fruits are eaten raw, but unripe ones are cooked as vegetable.

Artocarpus integer (Thunb.) Merr. Syn. A. champeden (Lour.) Stokes. Chumpedak (Moraceae). Southeast Asia, Indo-China and western Malaysia. Fruits are eaten when ripe; young fruits are boiled into soup like preparation.

Artocarpus integer (Thunb.) Merr. (IBPGR 1980).
Artocarpus lacucha Buch.-Ham. Syn. A lakoocha Roxb. Monkey jack (Moraceae). South/southeast Asia, India, Indo-China, Malaysia. More diversity in humid tracts of peninsular India as a protected cultigen; possibly domesticated in sub-Himalayan-terai region. Fruits are ovoid, sweet/sub-acidic and edible raw, also pickled.

Artocarpus odoratissimus Blanco Syn. A. tarap Becc. Marang, (Moraceae). Southeast Asia - Native of Sulu in southern Philippines, domesticated types occur; grown in Borneo, elsewhere introduced. Fruits are smaller than those of jackfruit, sweet and juicy; fruit rind and roasted seeds also eaten.

Artocarpus rigidus Bl. Monkey jack (Moraceae). Southeast Asia - Indo-China, Malaysia and elsewhere; sporadically grown. Fruits are sweet and aromatic, and are eaten raw.

Averrhoa carambola L. Carambola, Kamrakh, Star fruit (Oxalidaceae/Averrhoaceae). Southeast Asia; native of Indo-China. More variability is found in Indo-China, Malaysia and Indonesia, China, Taiwan; sporadic elsewhere. Fruits are acidic with quince-like flavour, eaten raw or made into jam, jelly, syrup/drinks, also sliced and served as salad; rich source of Vitamin A and minerals. Sweet types occur in China.

Averrhoa bilimbi L. Bilimbi, Cucumber tree (Oxalidaceae/Averrhoaceae). Native of Indo-Chinese region; much grown in northeastern India, Myanmar, Malaysia, Thailand, Philippines, also in Singapore and Australia. Sour fruits are used for culinery purpose; also in drinks, marmalade, jelly and syrup; also candied and pickled.

Baccaurea dulcis (Jack) Muell.-Arg. (Euphorbiaceae). Southeast Asia; occasionally cultivated in Myanmar, Vietnam, Thailand, Malaysia,
Philippines and Indonesia. Fruits are normally sweet, sometimes acidic, eaten fresh.

Baccaurea motleyana Muell.-Arg. Rambai (Euphorbiaceae). Southeast Asia; cultivated in Vietnam, Malaysia, Philippines. Fruits are eaten fresh, made into drinks or preserves, pulp also stewed and eaten. Fruit has good potential for improvement.

Baccaurea racemosa (Reinw. ex Blume) Muell.-Arg. Meteng (Euphorbiaceae). Southeast Asia-Indo-China to Indonesia. Fruits are sweet or acidic, eaten raw, also served as table fruit. Good potential for improvement.
**Baccaurea ramiflora** Lour. Syn. B. sapida Muell.-Arg. Latka (Euphorbiaceae). South/southeast Asia - eastern India, Indo-China, also occurs in the Andamans. Large gooseberry-size fruits with arillate pulp are delicious and eaten raw. Fruit has good potential for improvement.

**Bouea macrophylla** Griff. Ganiaria (Anacardiaceae). Southeast Asia - Myanmar, Indo-China, and Indonesia; semi-domesticated/domesticated types occur, sporadically grown. Fruits, resembling plum, are eaten raw or cooked, also pickled.


**Capparis spinosa** L. Caperbush (Capparidaceae). Wider, sporadic distribution in Asia-Pacific; fruits have similar use as of ker/dela.
Carissa congesta Wight Syn. C. carandas L. Karonda (Apocynaceae). South Asia; native to humid tracts of western India, with much diversity of domesticated types in Western Ghats, also in eastern India, West Bengal and Assam. Fruits are eaten raw, used as preserves, for tarts, jams and chutneys, the latter product exported to Bangladesh.

Carissa congesta - fruits (Arora and Pandey, 1996)


Cecropia peltata L. Snakewood tree (Myrtaceae). Central/south American origin, introduced into Taiwan and Malaysia; localized/sparse cultivation. Fruits are eaten raw.

Chaenomeles japonica (Thunb.) Lindl. ex Spach. Japanese quince (Rosaceae). Mainly confined to East Asia - Japan; sporadically grown, protected. Fruits are eaten raw.

Chaenomeles speciosa (Sar.) Nakai. Japanese quince (Rosaceae). East Asia - China, Japan. Fruits are cooked or made into a beverage; also eaten raw, more so in Japan.

Chaenomeles sinensis (Thounin) Koehne, Chinese quince (Rosaceae). East Asia - China, Korea Japan, cultivated sporadically. Fruits are eaten raw or preserved in syrup, also candied. Juice mixed with ginger is used as beverage, also made into liquor.

Chaenomeles sinensis (Thounin) Koehne, Chinese quince (Rosaceae). East Asia - China, Korea Japan, cultivated sporadically. Fruits are eaten raw or preserved in syrup, also candied. Juice mixed with ginger is used as beverage, also made into liquor.

Chrysophyllum cainito L. Star apple (Sapotaceae). Central American, introduced into southeast Asia. Fruits have agreeable pulp and pleasant flavour, and are eaten raw and used as preserves.

Citrus amblycarpa (Hassk.) Ochse. Dieruk lemon (Rutaceae). Southeast Asia - Java/Indonesia. Fruits are mainly used to flavour beverages.

Citrus aurantiifolia (Christm) Swing (Rutaceae). Probably Malaysian Archipelago or North India. Cultivated for its fruits.

Citrus cambara Rafin (Rutaceae). Indo-China, India. Fruits are eaten raw.

Citrus grandis (L) Osbeck (Rutaceae). SE Asia, spread to China, India, Iran etc. Cultivated for its fruits.

of Japan and a popular orange among the Japanese; fruits eaten raw.

*Citrus hystrix* DC. (Rutaceae). Southeast Asia – Myanmar, Indo-China, Malaysia, Philippines. Fruits are edible, acidic in taste.

*Citrus ichangensis* Swingle (Rutaceae). South/southeast/east Asia - India, Myanmar, Indo-China, central and southwestern China, sub-tropical mountain zone. Domesticated/protected types occur. Fruits are sour and pickled, crossed with cultivated *Citrus* species; frost resistant, and used as rootstock.

*Citrus junos* Siebold ex Tanaka. Yuzu (Rutaceae). East Asia, cultivated for fruits in China and Japan.

*Citrus latifolia* Tanaka. Tahiti lime (Rutaceae). Probably of east Asian origin; only cultivated.

*Citrus limetta* Risso. Sweet lemon (Rutaceae). South/southeast Asia, sporadically grown. Fruits are sweet but insipid, with slightly lemon flavour and made into drinks.

*Citrus limettioides* Tanaka. Indian sweet lime (Rutaceae). South Asia; grown in central and northern India. Fruit are acidic and used in salad, also in cooked dishes. Variation occurs in shape, nipple size and rind thickness.

*Citrus limonia* Osbeck, Rangpur lime, Marmalade orange (Rutaceae). South Asia; native of north India, in the Himalayan foothills. Fruits are mandarin-like, edible, juice adds sour taste to dishes. Probably a hybrid between mandarin and a lemon-like species; an important citrus rootstock.

*Citrus mitis* Blanco (Rutaceae). Philippines, introduced in Japan. Fruits eaten as raw.

*Citrus macroptera* Montrouz. Melanesian papeda (Rutaceae). South/southeast Asia - widely distributed in northeast India, Indo-China, Thailand, Philippines; also in Pacific-Papua New Guinea, New Caledonia and Polynesia, sporadically grown. Fruit juice forms a refreshing drink. Very vigorous, immune to wither tip and resistant to canker; most promising species as rootstock and for breeding citrus varieties.

*Citrus madurensis* Lour. Syn. *C. mitis* Blanco, *Citrofortunella mitis* (Blanco) J.W. Ingram & H.E. Moore. Calomondin (Rutaceae). East/southeast Asia; grown in China, Taiwan, Philippines, Indonesia-Java. Fruits are bright orange, with thin peel and loose skin resembling the tangerine. Valued for highly acidic juice processed...
as concentrate. Used as rootstock for citrus, resistant to gummosis, nematodes and highly tolerant to calcareous soils.

*Citrus maxima* (Burm.) Merr. Syn. *C. grandis* Osbeck Pummelo, Shaddock (Rutaceae). Native of Malaysia and/or Polynesia; grown in India, Nepal, Thailand, Philippines, and south China. Fresh juicy pulp vesicles are edible and used in fruit salad.

*Citrus medica* L. Citron (Rutaceae). South Asia - native of India, northeastern hills. Large orange-size berries have juicy, acidic pulp, which is made into marmalade and preserves.


Cultivated in north/northeastern India, Myanmar and adjoining regions, also in Sri Lanka. Fruit are very large, but not very fleshy; juice is acidic and used for making pickle.


*Citrus unshiu* Marc. Japanese mandarin, Satsuma mandarin (Rutaceae). East Asia-native of China, and Japan, also grown in Taiwan, Philippines, sporadically elsewhere. Developed in Japan, locally called mikan; commercially cultivated. The small fruit is seedless, easily peeled and eaten fresh. Pulp is processed, canned and bottled as frozen juice.
Clausena lansium (Lour.) Skeels Syn. C. wampi (Blanco) Oliver. Wampi (Rutaceae). East/southeast Asia-native of China. Grown in southern China and elsewhere. Fruits have a refreshing aroma and subacidic flavour and are eaten fresh or used for marmalade.

Cordia dichotoma G. Forst. Syn. C. myxa L. Indian cherry, Sebesten (Boraginaceae). Mainly south Asia/India; sporadic elsewhere. Domesticated in northwestern semi-dry parts of India; much grown in northwestern plains and in the central region. Ripe yellowish brown fruits with mucilaginous sweet pulp are edible. Unripe fruits are used as vegetable and also pickled. C. gharaf Ehrenb. ex Asch. is also grown in northwest India.

Cordia gharaf (Forst.f.) Ehrenb. and Asch. syn. C. rothii Roem. and Schult. (Maheswari 1966)

Crataegus azarolus L. Azarole, Mediterranean medlar (Rosaceae). Introduction from West Asia and sparingly cultivated for edible fruits. More variability in Uzbekistan.

Crataegus cuneata Sieb. & Zucc. Nippon hawthorn (Rosaceae). East Asia-Korea, China, and introduced into Japan. Fruits are eaten raw.


Crataegus pinnatifida Bunge var. major N.E. Br. (Rosaceae). East Asia - China and Korea. The fruits are edible, made into preserves, also cooked/stewed.

Crataegus wattiana Hemsl. & Lace (Rosaceae). Temperate Asia and elsewhere, sparingly grown for edible fruits.

Cynometra cauliflora L. Nam-nam (Leguminosae). Southeast Asia - grown in Malaysia and Indonesia, sporadically elsewhere, as far as the Pacific. Fruits are olive brown, very juicy, fragrant, sub-sweetish and eaten fresh. The fruit pulp is commonly used locally for rujak (a fruit salad with spicy sauce, pickled) and asinan (pickled vegetables or fruits in brine or vinegar). In Sulawesi, Indonesia, there are two cultivars, one producing sweet fruits and the other sour. Both are equally important and much relished.
Diversity in Underutilized Plant Species - An Asia-Pacific Perspective

**Cyphomandra betacea (Cav.) Sendtn.**
Tree tomato (Solanaceae). South American origin, introduced to Asia; mainly in mountain regions as in the eastern Himalayas and also in tropical hills in India, Sri Lanka and elsewhere. Fruits are eaten raw and as preserves.

**Davidsonia pruriens** F. Muell. Davidsonia plum (Cunoniaceae). Australia. A minor underutilized edible fruit. Other species are *D. jersceyena* and *D. johansonii*.

**Dillenia indica** L. Chalta (Dilleniaceae). South/southeast Asia. Mainly occur in east India, and Indo-China in home gardens/backyards. Large fruits are with sweet/sub-sweetish pulp, eaten raw.

**Dimocarpus longan** Lour. Syn. *Euphoria longan* Steud., *E. longana* Lam., Longan (Sapindaceae). East/southeast Asia-cultivated in south China, Indo-China, Malaysia, Thailand, Vietnam, Indonesia, and sporadic elsewhere. Sweet, juicy aril is eaten fresh or dried, also canned or frozen. The variety-kohola is more cold tolerant than litchi.

**Cynometra cauliflora** L. (IBPGR 1980).

**Dimocarpus longan** (IPGRI 1998).


**Diospyros ebenaster** Retz. Black sapote (Ebenaceae). Central American introduction into Indonesia; sparingly grown. Fruits are eaten raw.

**Diospyros kaki** L.f. Japanese persimmon, Kaki (Ebenaceae). East Asia - native of China; mainly cultivated in China, Korea and Japan (national fruit of Japan); introduced in India in western Himalayas and elsewhere. Pulp is eaten fresh, dried, preserved; good source of Vitamin A; dried fruit also eaten as dessert in Japan.

**Diospyros lotus** L. Caucasian persimmon (Ebenaceae). Temperate Asia, Himalayas; sporadically grown in the western Himalaya/Hindu Kush Himalayan region including China. Fruits are eaten raw or as preserves and in beverages.


**Diospyros kaki** Linn.f. (IBPGR 1980).
Docynia indica Decne. Syn. Pyrus indica Wall. Indian crab apple (Rosaceae). South Asia—more diversity in north eastern India, and adjoining hilly tracts. Fruits have quince-like flavour and are eaten raw.

Dovyalis hebecarpa (Gardn.) Warb. Ceylon gooseberry (Flacourtiaeae). South Asia, cultivated in Sri Lanka and South India. Round brownish purple berries are edible, made into excellent jelly; juice is red coloured and used as beverage/drink. D. caffra Warb (Kei apple), an African introduction grown in south India is also used likewise.

Dracontomelon dao (Blanco) Merr. & Rolfe Syn. D. mangiferum (Blume) Blume, D. edule (Blanco) Skeels. Dao (Anacardiaceae). Southeast Asia, sporadically grown; extending eastwards to the Philippines; also in south Asia in Andaman Islands, India. The yellowish plum-sized fruits are eaten raw; flowers and leaves are used as vegetable.

Duchesnea chrysantha Miq. (Rosaceae). East Asia - China, Japan, Korea, also in Malaysia. Fruits are eaten raw, made into jam.

Duchesnea filipendula (Hemsl.) Focke Syn. Fragaria filipendula Hemsl. (Rosaceae). East Asia – China. Fruits are like strawberries and eaten raw.

cultivated in low hilly areas. Fruit are eaten fresh, but not very juicy.

**Durio oxleyanus** Griff. (Bombacaceae). Southeast Asia - Malaysia, Indonesia - Borneo. Fruits are eaten raw. Semi-domesticated forms occur such as in *D. dulcis, D. grandiflorus, D. graveolens* in this region of diversity and distribution of *Durio* species.

**Durio zibethinus** L. Durian (Bombacaceae). Southeast Asia - native of Malaysia, mainly cultivated in Malaysia, Philippines, Thailand, Indonesia, sporadic elsewhere. Introduced in Sri Lanka and India. Large fruits with edible aril; pulp possesses pungent smell, is rich in carbohydrates - Himalayan region. Protected semi-domesticated forms occur in home gardens. Fruits are with sweetish pulp, sub-acidic flavour, and used for making tarts and jellies.

**Elaeagnus pungens** Thunb. (Elaeagnaceae). East Asia - northern China and Japan. Fruits are eaten raw.

**Elaeocarpus floribundus** Blume. Jalpai (Elaeocarpaceae). South/southeast Asia - more variability occurs in northeastern India, Myanmar, Bangladesh and Indonesia-Java. Cultivated sporadically; fruit pulp is edible and also used for pickles and preserves.

**Emblica officinalis** Gaertn. Syn. *Phyllanthus emblica* L. Indian gooseberry, Aonla (Euphorbiaceae). South Asia - native of peninsular India, where several varieties are grown, as also in southern China; sporadic elsewhere in southeast Asia and the Pacific; introduced. Fruits are pickled, and fat; locally much relished, also fried and processed into chips.

**Elaeagnus angustifolia** L. Oleaster, Jerusalem willow (Elaeagnaceae). West Asian/Himalayan origin. Grown sparingly in India, China and Japan. Fruits are eaten raw.

**Elaeagnus latifolia** L. Bastard oleaster (Elaeagnaceae). South/southeast Asia
made into syrups, jams, preserves, diverse medicinal uses as diuretic and laxative and in dried form in diarrhoea and dysentery; widely used for its medicinal properties in indigenous system of medicine in India.

*Eremocitrus glauca* (Lindl.) Swingle, Australian desert lime, Australian desert kumquat (Rutaceae). Pacific/Oceania-native of Australia, particularly confined to central and southern Queensland, northern New South Wales. Fruits are small, juicy, thin skinned and pleasantly acidic, like lime and occasionally used for making jams and drinks, A xerophytic species, it can withstand severe drought and hot dry winds; also tolerant to high salinity and boron; can serve as rootstock for sour orange and other *Citrus* species.

*Eriobotrya japonica* (Thunb.) Lindl. Loquat (Rosaceae). Sub-temperate/sub-tropical south/southeast/east Asia - sporadically grown, cold adaptable. More diversity in eastern China, Japan, Korea, Taiwan, grown in Australia; also in India. Fruits are sweetish, juicy, delicious, occasionally made into jams, etc.


*Eugenia polycephala* Miq. (Myrtaceae). Borneo, South Asia. Fruits eaten raw, also made into jellies.

*Eugenia uniflora* L. Syn. *E. michelli* Lam. Brazil cherry, Pitanga (Myrtaceae). Tropical American introduction into Asia; grown in Japan. Fruits are eaten raw.


*Feronia limonia* (L.) Swingle Syn. *F. elephantum* Correa. Wood apple, Elephant apple (Rutaceae). South/southeast Asia-Indian subcontinent mainly; also in Sri Lanka, Myanmar, Indo-China, Malaysia and Indonesia; domesticated in south India and Sri Lanka where much diversity occurs. Fruits are with sweet aromatic pulp and eaten fresh, also made into drinks, chutneys, jellies and preserves.

*Feroniella lucida* Swingle. Java feroniella (Rutaceae). Southeast Asia mainly; sporadic cultivation elsewhere. Fruits are sub-acidic and eaten raw.

Ficus auriculata Lour. Syn. F. roxburghii Wall. ex Miq. Gular (Moraceae). Indian subcontinent - sub-Himalayan region, northeastern hills, eastern India extending to southeast Asia. Fruits are with edible pulp.

Ficus carica L. Common fig (Moraceae). West Asian introduction in subtropical tracts of Asia, sparingly grown in Maharashtra and Karnataka in India. Fruits are sweet, delicious, eaten raw, dried, preserved and also made into syrup/drinks. These are nutritive and medicinal, rich in iron/minerals.

Flacourtia indica (Burm. f.) Merril. Syn. F. ramontchi L. Ramon-tchi (Flacouriaceae). South/southeast Asia under sporadic cultivation. Fruits are eaten raw or made into jams and preserves.

Flacourtia jangomas (Lour.). Raeuschel Syn. F. cataphracta Roxb. ex Willd. Paiala, Indian plum (Flacourtiaaceae). South Asia-eastern and western India, Assam and adjoining tracts, grown in backyards or as border hedge. Fruits possess a tarty flavour, eaten raw but more in use locally for jams, marmalades and preserves.

Flacourtia ramontchi L’Her. Butoko plum, Medagascar Plum, Malaya & Medagascar (Flacouriaceae). Cultivated for its fruits.

Flacourtia rukam Zoll. & Mor. Indian prune, Rukam (Flacouriaceae). Southeast Asia-mainly grown in Malaysia and the Philippines. Ripe sub-acidic fruits are eaten fresh or made into rujak (a fruit salad with spicy sauce, pickled). Young fruits are also used as medicine.
Fortunella obovata Tanaka. Long life kumquat (Rutaceae). East/southeast Asia-China, Japan, Taiwan and Vietnam. Fruits are eaten raw.

Garcinia atroviridis Griff. (Guttiferae). South/southeast Asia-Indo-China, Malaysia. Fruits are sour and taken with sugar; excellent for making jelly; also stewed, dried and boiled into soup.

Garcinia binuoa Choisy. Binukau (Guttiferae). Southeast Asia-Philippines; introduced elsewhere. Fruits are eaten raw.

Garcinia cochinchinensis (Lour.) Choisy (Guttiferae). Southeast China. The plum-size fruits are eaten raw.

Garcinia dulcis (Roxb.) Kurz. Baiti, Gourka (Guttiferae). South/southeast Asia-mainly grown in Malaysia, Philippines and Java, Indonesia; and

Flacourtia rukam Zoll and Mor. (IBPGR 1980).

Fortunella crassifolia Swingle. Kumquat (Rutaceae). East Asia-China and Japan. Fruits are eaten raw.

Fortunella hindsii Swingle, Hong Kong wild kumquat (Rutaceae). East Asia-South China and Japan. Fruits are eaten raw.

Fortunella japonica (Thunb.) Swingle Syn. Citrus japonica Thunb. Masumi kumquat (Rutaceae). East Asia - Japan. Fruits are eaten raw; also used for jams, jellies and preserves.

Fortunella margarita (Lour.) Swingle. Wagami kumquat (Rutaceae). East Asia-China and Japan; cultivated. Fruits with sour taste are eaten raw; also used for jams, jellies and preserves.

Garcinia dulcis (Roxb.) Kurz. (IBPGR 1980).
also in southern India. Fruits are sub-acidic, locally eaten raw and used to prepare jams and for flavouring food; rich in citric acid.

*Garcinia gummi-gutta* (L.) Robs. Malabar tamarind (Guttiferae). More diversity in south India, grown in home gardens. Dried fruits are acidic and used for culinery purposes and for flavouring curries.

*Garcinia indica* Choisy. Kokam (Guttiferae). South Asia-India. Mainly cultivated in Western Ghats, where domesticated forms occur in home gardens/backyards. Fleshy ripe purple fruits are sub-sweetish to acidic and made into a drink, much relished locally. Dried fruit/pulp is used in curries as a substitute for tamarind.

*Garcinia lateriflora* Blume. Kariis, Djawura (Guttiferae). Southeast Asia-Indonesia, Philippines, sporadic elsewhere. The mandarin-shaped plum-size fruits are eaten raw.

*Garcinia mangostana* L. Mangosteen (Guttiferae). Native of Malaysia, Indonesia where its allied species *G. hombroniana*, *G. malaccensis* occur. Cultivated on a commercial scale in orchards and in home gardens mainly in southeast Asia - Malaysia, Indonesia, Thailand, also in Philippines, Vietnam and Myanmar. Introduced into south Asia, India in lower slopes of the Nilgiris, and grown in Sri Lanka. It is the national fruit of Thailand. Fruits mainly purple, sometimes yellow, delicious, consumed fresh and also cooked, or made into preserves. ‘Jole’ is a large fruited variety.


*Garcinia paniculata* Roxb. Sochopatenga (Guttiferae). South/southeast Asia-eastern Himalaya and northeastern hills of India/Myanmar, Indo-China, south Vietnam. Fruit are large, cherry-like and edible, pulpy aril possessing good flavour, also used to prepare vinegar.

*Garcinia pedunculata* Roxb. Tikul (Guttiferae). North east India and Bangladesh. Fruits are acidic and eaten raw or made into drinks.
Garcinia tinctoria (DC) W.F. Wight (Guttiferae). India and Malaya. Cultivated for its fruits.

Garcinia xanthochymus H.f. ex T. Anderson Syn. G. tinctoria Dunn, G. tinctoria (DC.) Dunn. Gamboge tree (Guttiferae). South/southeast Asia-sparingly grown in India, eastern Himalayas, Peninsular India, Andamans; also in Myanmar, Indo-China, Malaysia and Thailand. Fruit are acidic, edible, made into preserves and jams.

Grewia subinaequalis DC. Syn. G. asiatica L. Phalsa (Tiliaceae). South Asia - mainly in semi-arid western India. Fruits are eaten raw, or used as beverages.

Hamelia patens Jacq. (Rubiaceae). South American introduction into south Asia - India. Fruits are eaten raw.

Hancornia speciosa Gomei. (Apocynaceae). South American introduction into tropical Asia. Fruits are eaten raw and made into preserves.

Hippophae rhamnoides L. Seabuckthorn (Elaeagnaceae). South/east Asia - Hindu Kush Himalayan region, cold arid/temperate tracts, domesticated in western and eastern Himalayas and adjoining Chinese region. Fruits are small, rounded, orange coloured with edible, sub-sweetish/acidic pulp; eaten raw or made into drinks and also processed as jam, jelly; many diverse uses in China. H. salicifolia D. Don is allied to this and distributed in the Himalayas and used likewise.

Hovenia dulcis Thunb. Japanese raisin tree (Rhamnaceae). South/east Asia - Himalayas, also in Japan. The sub-acidic fruits are eaten in China and Japan, and in the northeastern hills of India and adjoining areas.

Lansium domesticum Correa Syn. Aglaia domestica (Correa) Pellegrin. Langsat, Duku (Meliaceae). Southeast Asia - mainly in Malaysia, Philippines and Indonesia - in Java and Sumatra. Fruit aril is eaten fresh or in preserved form in syrup, also candied.

Limonia acidissima L Syn Feronia elephantum L Elephant apple (Rutaceae). Malaysia and Indonesia. Fruits are eaten raw.

Litchi chinensis (Gaertn.) Sonn. Litchi (Sapindaceae). South/southeast/
east Asia; grown in southern China, northeast India, foothills of the Western Himalayas and in the eastern region; sporadic cultivation in Myanmar, Indo-China, Thailand, and Philippines; also introduced into Australia. Fruits are with fleshy aril, sweet, juicy and delicious, eaten raw, also canned.


*Litsea cubeba* (Lour.) Pers. Syn. *L. citrata* Blume (Lauraceae). East/southeast Asia - mainly grown in Indonesia-Java; also in China, Taiwan, Vietnam and India. Scented young fruits are used as sambal (chilli-based sauce used as condiment) in Java; they have a spicy taste and are used for flavouring goat meat. Fruits also yield an essential oil which is a source of citral.


*Macrocarpium mas* Nakai. Cornelian cherry (Cornaceae). European introduction to West Asia and Japan. Fruits are sub-acidic and used for making tarts; also eaten raw.

*Macrocarpium officinale* Nakai (Cornaceae). East Asia - Korea, China, Japan. Fruits are eaten raw, though sour.

*Madhuca indica* Gmelin Mahua (Sapotaceae). India. Cultivated for its flowers and fruits, tender fruits used as vegetables also.

*Malpighia coccigera* L. (Malpighiaceae). Central/south American introduction into India, sporadic elsewhere. Fruits are eaten raw, and are rich in Vitamin C.

*Malpighia emarginata* DC. Syn. *M. punicifolia* auct. Barbados cherry, West Indian cherry (Malpighiaceae). Tropical American introduction into Asia; occasionally grown. The fruits possess juicy acidic pulp and are eaten raw or used in jelly and preserves, jams, sauces, etc.

*Malus asiatica* Nakai (Rosaceae). East Asia. Sparingly cultivated; fruits are edible.

*Malus baccata* (L.) Borkh. var. *baccata*. Siberian crab apple (Rosaceae). East Asia - north China. Fruits are hard, edible, often preserved by drying; species resistant to frost.

*Malus baccata* (L.) Borkh. var. *mandshurica* (Max.) Schneid. Syn. *Pyrus baccata* L. Manchurian crab apple (Rosaceae). East Asia - northern China and neighbouring tracts. Fruits are edible; often dried and preserved, boiled and stewed. It is resistant to frost and used as a rootstock for apple.

*Malus halliana* Koehne (Rosaceae). East Asia - China; introduced into Japan. Fruits are edible.

*Malus kirghizorum* Al. & Feb. (Rosaceae). West Tienshan. Fruits are edible.
Malus micromalus Makino (Rosaceae). East Asia-China and Japan. Fruits are edible.

Malus platycarpa Rehd. var. hoopesii Rehd. (Rosaceae). East Asia-China; introduced elsewhere. Fruits are dried, primarily used as preserves.

Malus prunifolia (Willd.) Borkh. Syn. Pyrus prunifolia Willd. Chinese apple (Rosaceae). East Asia - China and Japan. Fruit is edible; preserved in sugar; resistant to drought and frost, used as a parent for developing several improved cultivars. M. prunifolia var. viaki with sub-sweetish fruits is localized to northwestern China.

Malus pumila Mill. (Rosaceae). Native of Europe and south west Asia; also in East Asia - China and Japan; conspecific with M. sylvestris with which it hybridizes. Fruits are edible.

Malus sieversii (Leleb) N Roem. (Rosaceae). West Tien Shan & Altai hills. Fruits are edible.

Malus spectabilis (Ait.) Borkh. Chinese flowering apple (Rosaceae). Central China, probably a parent of M. micromalus. Fruits are edible; ornamental.

Mangifera caesia Jack. Binjai, Kemang (Anacardiaceae). Southeast Asia- sparingly grown in Indo-China, Malaysia and Indonesia. Ripe fruits are eaten fresh, half-ripe fruits are often used in making rujak or asinan. Sweet fruited types exist locally.

Mangifera caesia Jack. (IBPGR 1980).

Mangifera casturi Kosterm. Kalimantan mango (Anacardiaceae). Southeast Asia; cultivated in Indonesia- Borneo. Fruits are eaten raw.

Mangifera foetida Lour. Bachang mango (Anacardiaceae). Southeast Asia - Indo-Burma, Indo-China, Malaysia and Indonesia. Fruits are edible; much variability occurs in Indonesia/ Java in natural and domesticated types.

Mangifera odorata Griff. Kuwini (Anacardiaceae). Southeast Asia- mainly grown in Malaysia and Indonesia, with much variability in Java. Ripe fruits are eaten raw or
fruit is considered the best within the Mangifera genepool, after M. indica. Improved varieties can be developed; several local selections of native types grown in Malaysia.

*Mangifera pajang* Kosterm. Bambangan (Anacardiaceae). Southeast Asia - Borneo in Sabah, Sarawak and Brunei; endemic cultigen. Fruits are large with thick rind which can be peeled off like banana; edible pulp is yellowish white, sweet/sub-acidic, esteemed much as a fruit. Good varieties can be developed by seedling selection.

*Manilkara elengii* (L) Chev. (Sapotaceae). Malaysian Archepelago. Fruits are eaten raw.

*Manilkara hexandra* (Roxb.) Dub. Syn. *Mimusops hexandra* Roxb. Khirni (Sapotaceae). South/southeast Asia, mainly India, in north-western, central tracts and Deccan plateau to northeastern region, and Indo-China. Fruits are fleshy, small, yellow, olive like, very sweet and eaten raw. *M. kaki* with similar distribution is also used likewise.

made into syrup, jams and sweets; unripe fruits used for making *rujak* (spicy sauce) and *asinan*. Edible

Mespilus germanica L. Medlar (Rosaceae). West Asia-sporadic distribution as cultivated type. It crosses with Sorbus aucuparia in its region of distribution and much variation occurs.

Morinda citrifolia L (Rubiaceae). South India, Andamans, Malaysia. Fruits has multi purpose use.


Morus multicaulis Perr. Syn. M. latifolia Poir. (Moraceae). East Asia-Japan and China; introduced elsewhere; fruits are dark black, sweet and eaten raw.

Morus nigra L. Black mulberry (Moraceae). West/south/southeast Asia, Grown/domesticated at relatively high altitude in West Asia and also in the Himalayan tracts. Fruits are eaten raw.

Muntingia calabura L. Panama berry, Capulin (Elaeocarpaceae). Tropical American introduction into south/southeast/east Asia as far as the Pacific. Well adapted to coastal habitats and sporadically grown all through. Berries are eaten raw, much variation in fruit colour (yellow and white), taste and sweetness occurs.

Musa acuminata Colla (Musaceae). India, widely occurring in Assam. Used as fruits. Fruits are pickled also.

Musa troglodytarum L. Syn. M. fehi Bert. ex Vieill. Féi banana (Musaceae). South Pacific Islands, New Caledonia, also Tahiti. Fruit is starchy, edible; pulp is cooked and eaten.

Myrica esculenta Buch.-Ham. ex D. Don Syn. M. nagi Hook. f. non Thunb. Bayberry, Kaphal, Box myrtle (Myricaceae).
Nephelium mutabile Bl. (IBPGR 1980).  

Nephelium lappaceum (IPGRI 1998).  

East/ south Asia - China and Japan and Himalayan tract to northeastern India. Fruits are sub-sweetish and eaten raw, also made into a refreshing drink or liquor. Kernel is also edible.


Nephelium lappaceum L. Syn. N. hypoleucum Kurz. Rambutan (Sapindaceae). Southeast Asia mainly; much grown in Malaysia, Thailand and Indonesia, also in the Philippines and in Taiwan in home gardens, orchards, elsewhere sporadic; Indo-China, Vietnam, Sri Lanka, introduced in the Nilgiris in south India. Edible aril is white and juicy, and consumed fresh, stewed or canned. Both fresh fruit and processed products have high export demand. Rich variation reported in seedling and budded forms. Seed kernel contains 37-43 per cent edible, solid fat which can be used for making soaps and candles.

Nephelium rambutan-ake (Labill.) Leenhi. Syn. N. mutabile Blume. Pulasan (Sapindaceae). Southeast Asia, with distribution as of rambutan; much cultivated in Malaysia, Java and Borneo. Fruits are larger than that of rambutan with thick pericarp, less juicy but sweet, and with good flavour. Aril is eaten fresh as dessert; also cooked and made into jams.


Opuntia ficus-indica (L.) Miller. Indian fig (Cactaceae). Mexican introduction to southwest Asia, also in Australia-cultivated sporadically in southeast/south Asia. Fruits are eaten raw.
Opuntia tuna Mill. (Cactaceae). Mexican introduction into Japan. Fruits are eaten raw, cooked.

Pachira macrocarpa (Schlecht & Cham.) Walp. Cayenne nut (Bombacaceae). Central American/Mexican introduction into Taiwan. Fruits are eaten raw.

Pandanus spp. (Pandanaceae). Southeast Asia and the Pacific Islands. Fruit pulp is eaten locally by native islanders. The fleshy pericarp is edible; this is oily in P. conoideus and rich in carbohydrates in P. tectorius. Other species are P. lerum with wider distribution and P. brosimos, more confined to PNG.


Passiflora caerulea L. Blue-crown passion flower (Passifloraceae). South American introduction into east Asia and the Pacific Islands. Fruits are eaten raw and also made into drinks.

Passiflora edulis Sims. Passion fruit (Passifloraceae). South American introduction into Asia and the Pacific/Oceania region; more popular in southeast/east Asia-Thailand, Philippines, China and Japan; also grown in south India and in Sri Lanka. Fruits are eaten raw/fresh; also made into juice.

Passiflora laurifolia L. Water lemon, Yellow granadilla (Passifloraceae). South American introduction into tropical Asia, extending to the Pacific. Fruits are acidic and eaten raw.


Passiflora quadrangularis L. Giant granadilla (Passifloraceae). East/south/southeast Asia, across Pacific, more popular than other species grown in tropics/sub-tropics. Fruits are eaten fresh, processed, made into beverage.

Pereskia grandiflora Haw. Rose cactus (Cactaceae). South American introduction into Asia. Fruits are sub-acidic and eaten raw.
Passiflora quadrangularis L. (IPBGR 1980).

**Phoenix dactylifera** L. Date palm (Palmae). West and south Asia - semi-arid tracts; the Thar desert and northwestern plains of India. Fruits are sweet and much relished, nutritious, eaten raw, made into beverages.

*Phoenix sylvestris* (L.) Roxb. Wild date palm, Khajur (Palmae). South Asia - India, semi-arid north western plains. Tasty, sweet, pulpy fruits are very nutritious, and eaten fresh/raw or dried/preserved.

*Phyllanthus emblica* L (Euphorbiaceae). Tropical Asia-India. Cultivated for its fruits.

*Phyllanthus acidus* (L.) Skeels. Syn. *P. distichus* (L.) Muell.-Arg. (Euphorbiaceae). Tropical Asia-India and Malaysia. Fruits are acidic; used for pickles and preserves.

*Physalis peruviana* L. Cape gooseberry (Solanaceae). Tropical American introduction into south/ southeast/ east Asia, sporadically grown. Fruits (berries) are juicy, sub-sweetish/ sweetish, rich in Vit. C, and eaten raw.

*Pometia pinnata* J.R. Forst & G. Forst. Taun (Sapindaceae). Southeast Asia, Pacific Islands. Sporadically grown in Malaysia, Indonesia, Philippines, Papua New Guinea, across Pacific Islands. Fruits are eaten raw/boiled; seeds are also edible.

Passiflora quadrangularis L. (IPBGR 1980).
**Poncirus trifoliata** Rafin. (Rutaceae). 
East Asia mainly; elsewhere introduced. 
Fruits are occasionally eaten; used for marmalades and drinks. Cold resistant types are used in breeding, also for disease resistance.


**Passiflora edulis** Sims (IBPGR 1980).

**Pouteria campechiana** (Kunth) Baehni (PROSEA No. 2 1992).

**Prunus amygdalus** L. Almond (Rosaceae). 
Afghanistan & West Tien Shan. Nuts are edible.

**Prunus armeniaca** L. Apricot (Rosaceae). 
West/central Asia-Hindu Kush Himalayas are the regions of domestication and diversity. Sweet-pulp varieties are widely grown and cold adaptable. Fruits are eaten fresh, dried, processed into jams. Nuts are also edible, nutritious like almond.

**Prunus cantabrica** Stapf. Chinese sour cherry (Rosaceae). East Asia-China. Cultivated for fruits that are acidic in taste and eaten raw; also used as preserves and for preparing jams.
Prunus cerasifera Ehrh. Cherry plum (Rosaceae). East Asia-north China mainly. Fruits are edible. Much variability occurs in east Asia of domesticated and improved types with high yield, early maturity and wider adaptability (good rootstock for grafting plum cultivars). *Prunus ferganica* Lincz. is a hybrid between *Amygdalus communis* and *P. cerasifera.*

*Prunus domestica* L. subsp. *insititia* (L.) C.K. Schneid. Damson plum (Rosaceae). European introduction into east Asia; an old cultigen. Green and yellow/reddish fruited frost resistant types occur. Fruits are eaten raw, cooked or as preserves.

*Prunus mume* Sieb. & Zucc. Syn. *Armeniaca mume* (Sieb. & Zucc.) Sieb. ex Curr. Japanese apricot, Chinese almond (Rosaceae). East Asia-China and Japan. Taiwan; cultivated more in Japan. Fruits are edible, usually pickled, or preserved as jam, and used to flavour candies, for liquor and vinegar. Salted and dried fruits are popular in Japan.

*Prunus salicina* Lindl. Syn. *P. triflora* Roxb. Chinese plum, Japanese plum (Rosaceae). East Asia-region of diversity in north China, Japan; introduced elsewhere. Fruits are eaten raw or in cooked form. Several crosses have been developed i.e. *P. salicina* x *Amygdalus persica* (Plum peach), *P. salicina* x *Armeniaca vulgaris* (Plumcot); fruits are edible. A new stone fruit ‘cherry plum’ has been derived from crossing the wild *P. cerasifera* with *P. salicina* var. *barbanki,* which is winter hardy.

*Prunus sargentii* Rehd. Mountain Cherry (Rosaceae). Japan, Manchuria, Korea, rarely in the far east of Russia. Fruits are edible.


*Prunus tomentosa* Thunb. Nanking cherry, Manchur cherry (Rosaceae). East Asia - China, Japan, and in the Himalayas. Sparingly grown in Japan. The sweet, juicy fruits are eaten raw.


Punica granatum L. Pomegranate (Punicaceae). Centre of diversity in West Asian and much natural diversity occurs in the Himalayan foothills; much grown in south Asia, in India, Pakistan; introduced into east, southeast Asia, also China, Japan, Thailand under sporadic cultivation. Fruits with sweet pulp are edible, unripe ones are acidic, dried and used in various ways in dishes; and also for medicinal use.


Pyrus prunifolia Willd. Syn. Malus prunifolia (Willd.) Borkh. Chinese apple (Rosaceae). East Asia - highlands of China. Fruits are eaten raw or as preserves; types resistant to drought and frost occur.

Pyrus pyrifolia (Burm.) Nakai var. cultura Syn. P. serotina var. cultura. Rehd. Sand pear (Rosaceae). East Asia, highlands of north and central China; crosses with P. communis; very variable; Chinese varieties have high preservation quality and drought resistance. Fruits are eaten raw or as preserve. Var. pyrifolia is the progenitor of oriental pear.


Pyrus sinensis Spreng. Sand pear, Chinese pear, Japanese pear (Rosaceae). East Asia- highlands of north, central and south China, also in Japan, Taiwan and in the Himalayas, in south Asia-India. In China, several cultivars have been developed by crossing with P. communis, with high preservation quality and drought resistance. A popular dessert fruit, also canned, processed into nectar and preserved.

Pyrus sagdiana S.Kudr. (Rosaceae). Russia, Central Asia, Fruits edible.

Pyrus syriaca Boiss. (Rosaceae). China (Colder Region). Fruits eaten raw or as preserves.

Pyrus vavilovü M. Pop. (Rosaceae). Russia. Fruits edible.

Rhodomyrtus tomentosa (Aiton) Hassk. Downy rose myrtle, Hill guava (Myrtaceae). South/southeast/east Asia-India and Malaysia; in humid tropics-subtropics as a protected/semi-domesticated type as in the Nilgiri hills of south India. Fruits are eaten raw; used for preparing jams and jelly-like preparations.

Ribes acicularis Smith (Grossulariaceae). Siberian mountain, Altai. Fruits edible.

Ribes longeracemosum French (Grossulariaceae). East Asia-west China. Fruits are eaten locally.

Rubus albescens Roxb. (Rosaceae). Mountains of India, Sri Lanka, Malaya and Indonesia. Fruits are eaten.

Rubus ellipticus Smith. Yellow Himalayan raspberry (Rosaceae). South Asia, mainly Himalayan ranges and in peninsular hills
of India. Raw fruits are sweet, edible and also used as preserves.


*Rubus phoenicosius* Maxim. Wine raspberry (Rosaceae). East Asia-north China and Japan. Fruits are eaten raw.

*Rubus probus* Bailey. Queensland raspberry (Rosaceae). Oceania - Australia; possibly a cross between *R. ellipticus* x *R. rosifolius*. Fruits are sweet, eaten raw.

*Rubus rosaefolius* Smith. Mauritius raspberry (Rosaceae). Temperate Asia; introduced elsewhere. Fruits are sweet and eaten raw.

*Salacca zalacca* (Gaertn.) Voss Syn. *S. edulis* Reinw., *Zalacca edulis* Reinw. Salak (Palmae). Southeast Asia - native of Moluccas in tidal habitats, where rich diversity occurs; cultivated in Indonesia - north Sulawesi, Bali, Java, Sumatra, and in the Philippines; sporadic elsewhere as far as the Pacific. Fruits are eaten fresh or used in making *asinan* (pickled fruits) and *rujak* (a delicacy made of sliced unripe fruits into vegetables) and eaten with prawn or fish paste. Ripe fruits are used to make refreshing drink, also stewed or pickled. Seeds are also eaten. *S. wallichiana* C. Mart. is another potential fruit species from Indo-Chinese/Malaysian region.

*Salvadora oleoides* Decne. Tooth-brush tree, Pilu (Salvadoraceae). Tropical/south Asia, variability in protected types occurs in drier regions of India and Pakistan, where the species got domesticated and has multipurpose use. Fruits are sweet, pulpy and large, and eaten raw; leaves are used as fodder. Suitable for wasteland development.
Salvadora oleoides (courtesy: SK Malik and OP Dhariwal).

Salvadora persica L. Pilu (Salvadoraceae). A tree with similar distribution and use as the above species. Fruits are small, sweet, pulpy and edible.

Sambucus canadensis L. American elder, Sweet elder (Sambucaceae/Caprifoliaceae). North American origin; introduced into Japan. Fruits are eaten in pies and as preserves.

Sambucus nigra L. European elder (Sambucaceae/Caprifoliaceae). European introduction to East/southeast Asia. Fruits are preserved and also made into wine (alcohol-free beverage).

Sandoricum koetjape (Burm. f.) Merr. Syn. S. indicum Cav. Santol (Meliaceae). Southeast Asia, grown in Indo-China, the Philippines, Malaysia and Indonesia. Much variability occurs in domesticated types. Seedless types occur, providing good potential for wider cultivation of superior selections. Fruits are eaten fresh, dried, candied or cooked with fish; also fermented into a drink.

Semicarpus cassuvianum Roxb. (Anacardiaceae), Malaysia. Freshly receptacles, eaten locally.
Solanum muricatum Aiton. Pepino (Solanaceae). South American introduction to Asia. Sparingly grown in Malaysia, New Zealand and elsewhere. Ripe fruits are eaten as dessert; young/ fruits cooked as a vegetable.

Sorbus aucuparia L. Syn. Pyrus aucuparia Gaertn. Mespilus aucuparia All. Rowan tree, European mountain ash (Rosaceae). East Asia - northern China and adjoining region; many local forms occur. Fruits are used in making jellies and other preserves.

Sorbus domestica L. Service tree (Rosaceae). West Asia and in the Himalayas. Fruits are eaten raw. Several local types occur, sweet and pulpy, with much variation in bearing and fruit size. S. torminalis (L.) Crantz. has similar distribution and use.


Spondias dulcis Soland. ex Park. Syn. S. cytherea Sonn.f. Golden apple, Ambarella, Makopa (Anacardiaceae). Diversity occurs in south Pacific Islands and also in southeast Asia; introduced in South Asia-Sri Lanka, India and other parts. Fruits are eaten fresh; also made into jams, chutney, marmalades and other preserves.

Spondias laosensis Pierre (Anacardiaceae). Southeast Asia; Tonkin, endemic to this tract. Fruits are eaten raw.

Spondias pinnata (L.f.) Kurz Syn. S. acuminata (Roxb.) non Gamble, S. mangifera Willd. Ambarella, Great hog plum, Amra (Anacardiaceae). South/southeast Asia-Indian subcontinent, Indo-China and grown elsewhere in humid regions. Fruits are with flavour like that of mango or pineapple; eaten raw, also as preserves and used for making juice, squash and jam.


Water apple, Watery rose-apple (Myrtaceae). South/southeast Asia. across Pacific - sporadically grown. Fruits are eaten raw; also made into a syrup.

Syzygium cumini (L.) Skeels Syn. Eugenia cumini (L.) Druce, E. jambolana Lam. Jamun, Jambolan (Myrtaceae). Native of Indian subcontinent, much grown in south Asia - India, Bangladesh, Nepal, extending to southeast Asia - Myanmar, Indo-China, and Malaysia, elsewhere sporadic. Fruits are eaten raw or

used to prepare juice, jelly, wine and vinegar. Much diversity in south Asia, northwestern India in size of fruits and pulpiness. Several varieties/selections are grown.


Syzygium jambos (L.) Alston Syn. Eugenia jambos L. Rose apple, Jambos
Syzygium malaccense (L.) Merr. & Perry Syn. Eugenia malaccensis L., E. domestica Bailey. Mountain apple, Malay apple (Myrtaceae). Southeast Asia - Malaysia, Thailand, Indonesia and Philippines; introduced into India, and Sri Lanka. Fruits are large, edible, used in salad, for cocktails, pickled, and also used for preparing jam and syrup. 

Syzygium samarangense (Blume) Merr. & Perry Syn. S. javanicum Miq., Eugenia javanica Lam. Wax jambu, Java rose apple (Myrtaceae). Southeast Asia, across the Pacific Islands; introduced into south Asia - Sri Lanka, south India, also in the Andaman islands. Fruits are eaten fresh, are sweet, juicy and refreshing, also preserved. 

Tamarindus indica L. Tamarind (Leguminosae). South/ southeast Asia; much grown in India, Sri Lanka, also in Thailand, Indonesia and Philippines, elsewhere sporadic. Sub-acidic fruits are much relished, pulp made into chutneys, concentrates; selections developed in India for sweet pulp types; also diversity occurs in Thailand and Indonesia. These are much demand, marketed, diverse products traded; used locally for culinary purposes. An excellent tree for semi-arid and sub-humid tracts.
Terminalia edulis Blanco, Beach almond (Combretaceae). Native of east Indian Archipelago. Philippines, Malaysia and Indonesia. Mainly in coastal habitats. Grown in home gardens; fruits are eaten raw, also made into jelly, used as preserves.

Terminalia microcarpa Decne. Kalumpit (Combretaceae). Southeast Asia - grown in Indonesia, Timor Islands, and in Philippines. Dark red fruits are fleshy and with edible pulp; sun dried and eaten; also boiled and cooked with sugar.

Triphasia trifolia (Burm. f.) Wilson (Rutaceae). East Asia-China, elsewhere introduced as far as the Pacific. Fruits are eaten raw, cooked or preserved.

Vaccinium corymbosum L. Blueberry (Ericaceae). Temperate Asia, Himalayas and elsewhere. Fruits are eaten raw; also canned. Other edible fruit species are V. oxycoccos L. and V. vitis-idaea L.

Vitis amurensis Ruprt. Amur grape (Vitaceae). East Asia - northeast China. Fruits are eaten raw; source of winter hardiness for V. vinifera; withstands very low temperatures, upto - 40°C.


Ziziphus jujuba Mill. non Lam. Syn. Z. vulgaris Lam. Chinese jujube, Common jujube (Rhamnaceae). East Asia - cultivated in Japan, Korea and China. Fruits are eaten fresh, also dried or cooked in honey. Dried fruits are roasted or fried, sometimes made into sweetmeats.

Ziziphus mauritiana Lam. Syn. Z. jujube Lam. non Mill. Ber, Indian jujube (Rhamnaceae). South Asia-adaptable to drier tracts. Fruits are sweet/subsweetish, eaten raw, and can be preserved by drying; made into candy-like products.

Ziziphus nummularia (Burm.f.) Wight & Arn. Syn. Z. rotundifolia Lam. Jherberi (Rhamnaceae). South Asia-Indian sub-continent, mainly in western semi-arid tracts, often grown as a hedge for multipurpose use. Brownish red fruits are sweet and edible, dried/semi-dried fruits also are eaten, and used for medicine.
6. Nuts

The Asia-Pacific region is a centre of domestication for several indigenous nutritious nuts and also holds rich diversity in such species introduced in distant past from different geographical areas. Presently, the genetic wealth in this group belongs to 15 families, 16 genera and 34 species (Table 9). Among these much variability occurs in the Anacardiaceae, Burseraceae, Combretaceae, Corylaceae, Fagaceae, Juglandaceae, Lecythidaceae, Proteaceae, Pinaceae and Rosaceae. This diversity is well represented in native species of the genera Amygdalus, Buchanania, Canarium, Caryocar, Corylus, Castanea, Juglans, Macadamia, Pinus, Pistacia and Terminalia. Genetic diversity in Castanea, Corylus, Juglans, Pinus and Pistacia is mainly concentrated in cold/temperate regions of west, south and east Asia. Overall, this diversity is more confined to the Hindustani/Indian region for both sub-tropical and temperate types, and in humid tropical types in Indo-Chinese-Indonesian and the Australian Pacific region. The distribution of species diversity for different regions (Arora, 1985; Verheij and Coronel, 1992; Pareek et al., 1998) is as follows:

1. In the Chinese-Japanese region more diversity occurs in China for Prunus/Amygdalus tangutica, Castanea mollissima, Corylus chinensis, C. sieboldiana and Juglans ailantifolia.

Table 9. Families, genera and number of plant species whose nuts/kernels are edible

<table>
<thead>
<tr>
<th>Families</th>
<th>Genera</th>
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<tr>
<td>Anacardiaceae</td>
<td>Pistacia (1), Buchanania (2)</td>
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<tr>
<td>Barringtoniaceae</td>
<td>Barringtonia (3)</td>
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<td>Burseraceae</td>
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<td>Proteaceae</td>
<td>Macadamia (2)</td>
</tr>
<tr>
<td>Rosaceae</td>
<td>Prunus/Amygdalus (1)</td>
</tr>
</tbody>
</table>

For other fleshy nuts/kernels-Euryale, Nelumbo, Trapa, see under miscellaneous category.
A few species exhibit still wider distribution, occurring in China, Japan and Korea such as Corylus heterophylla.

2. Diversity in Indo-Chinese-Indonesian region is represented by Terminalia spp., and in Gnetum gnemon melinjo; Anacolosa frutescens galonut; and Canarium ovatum pili nut. C. ovatum was domesticated in the Philippines and G. gnemon in the Indonesian region.

3. In the Indian region, much native diversity occurs in Terminalia catappa in south India, for Buchanania lanzan in central India, and in Pinus gerardiana (providing the chilgoza nut) in the western Himalayas, mainly confined to high altitudes in Pangi valley and neighbouring tracts, which also holds rich diversity in Juglans regia (walnut).

4. The Pacific region also holds rich endemic wealth of nuts. In Papua New Guinea/South Pacific Islands several species of domesticated Canarium provide several selections. Also diversity occurs in okari nut - Terminalia kaernbachii. In the Australian region, Macadamia, a native domesticated nut, is widely grown and now introduced elsewhere. The species Macadamia tenuifolia is more promising and grown commercially. Also, the Polynesian nut- Inocarpus fagifer, a domesticate of this region possesses much native diversity. Limited diversity also occurs in Barringtonia spp. Among the exotic types is the paradise nut – Lecythis zabuajo, a tropical American introduction.

5. A distinct category is of fleshy-nuts, kernels of which are equally delicious, eaten raw or made into different preparations. These include aquatic types such as Euryale ferox, Nelumbo nucifera and Trapa natans and other species; diversity is more in Euryale/makhana nut in eastern India, and for others, both in India and China and sporadic elsewhere (see under miscellaneous category).

Check-list of species

Anacolosa frutescens (Blume) Blume Syn. A. luzoniensis Merr. Galo nut (Olacaceae). Native to the Philippines, mainly grown in northern Luzon to Mindanao. Nuts edible, taste like a mixture of sweet corn and chestnut, fruit pulp also edible.

Barringtonia edulis S a e m. (Barringtoniaceae/Lecithidaceae) Pacific Islands, Melanesia, Fiji, Solomon Is. A multipurpose tree grown in home gardens; useful is agroforestry; nuts are edible.

Barringtonia procera (Miers) R. Kunth. Cutnut (Barringtoniaceae/Lecithidaceae). South Pacific, multipurpose agroforestry species; grown in PNG for its edible nuts.

Barringtonia racemosa Roxb. (Lecithidaceae). West coast India. Seeds yield starch, used as food.

Buchanania laciolata Wt. (Anacardiaceae). Western peninsular India. Kernals are eaten.
**Buchanania lanzan** Spreng. Syn. *B. latifolia* Roxb. Chironji, Cuddapah almond (Anacardiaceae). Native of subtropical India, distributed in the sub-humid tracts, also in Myanmar, Laos, Indo-China, Thailand and Malaysia. Kernels/nuts are edible and nutritious; used as dry fruit and in confectionery preparations. Dark coloured ripe fruits are also eaten.

**Canarium commune** L. Java Almond (Burseraceae). Indonesia, Malaysia. Kernals edible.

**Canarium indicum** L. (Burseraceae). Southeast Asia-Moluccas, and New Guinea, and the Pacific in west Polynesia; cultivated in Malaysia for its edible kernel/nuts.

**Canarium ovatum** Engl. Pilinut, Philippine nut (Burseraceae). Native of southeast Asia, diversity high in Philippines, and south Pacific. Mainly grown in the Bicol Lumon, Philippines, south Pacific islands and northern Australia. Several varieties/selections are available. Kernel is superior to almond, used in confectionery/ bakery products and for flavouring ice cream.

**Canarium moluccanum** Bl (Burseraceae). New Guinea, cultivated in Malaysia. Seeds edible.

**Canarium vulgare** Leen Syn. *C. commune* auct. Java almond, Canary nut (Burseraceae). Native of southeast Asia (Moluccas), with good diversity in Polynesia, Pacific islands, and Malaysia; cultivated in Papua New Guinea. Kernel is small, edible and with good flavour; contains 72 per cent fat (oil).

**Caryocar nuciferum** L. Butter nut, Guiana nut (Caryocaraceae). Tropical American introduction in humid tropical tracts. Nuts are nutritious, rich in edible fat.

**Caryocar villosum** (Aubl.) Pers. Piequi (Caryocaraceae). Tropical American introduction into Malaysia. Nuts are eaten and nutritious.

Castanea mollissima Blume. Chinese chestnut (Fagaceae). East Asia-native of northwestern China; introduced elsewhere. Large brown nuts are starchy and oily, and of good quality, and high in carbohydrates (32-42 per cent).

Corylus colurna L. var. chinensis (Franchot) Burkill (Corylaceae/Betulaceae). West and east Asia, Hindu Kush Himalayas - China, Yunnan. Nuts are eaten raw.


Corylus mandshurica Maxim. Manchurian hazel nut (Corylaceae/Betulaceae). East Asia - China, Japan; much cultivated in China. Nuts are eaten raw.

Gnetum gnemon L. Melinjo (Gnetaceae). Native of southeast Asia, mainly cultivated in Indonesia-Java and Sumatra. Roasted seeds/nuts are nutritious; eaten fresh, sliced and fried like potato wafers; sold in local markets, much relished and popular as snacks. The inflorescences, young leaves and ripe fruits are cooked as vegetable.

**Juglans ailantifolia** Carr. var. cordiformis (Makino) Rehden Syn. *J. sieboldiana* Maxim. Japanese walnut, Giant walnut (Juglandaceae). East Asia - Japan. Nuts are eaten raw, soaked or used in confectionery; also young buds and peduncles are boiled and eaten.


**Juglans manschurica** Maxim. Manchurian walnut (Juglandaceae) East Asia - Korea, China. Nuts are edible; also a source of edible oil.

**Juglans regia** L. Walnut (Juglandaceae). West Asian origin, sporadic cultivation in the Himalayan tract. Hard and soft shelled types occur; nuts nutritious, and edible. Much diversity available; selections vary in yield/quality, and there is much scope for further improvement.

**Lecythis zabucajo** Aubl. Paradise nut, Monkey pot, Sapucaja nut (Lecythidaceae). Tropical American, introduced into Pacific Islands. Nuts are superior to Brazil nut, *Bertholletia excelsa*. Diversity offers scope for further improvement.

**Macadamia integrifolia** Maiden & Betche. Macadamia nut, Queensland nut (Proteaceae). Pacific Islands/Oceania. Australia, Queensland—much grown for commercial production; varietal diversity occurs in Hawaiian and Australian types. Introduced elsewhere. Kernels/nuts are rich in fat and protein; very tasty, and nutritious.
kernels eaten raw and in desserts, cocktails or used in confectionery, in chocolates, icecream and bakery products.

**Macadamia tetraphylla** L.A.S. Johnson. Rough shelled macadamia (Proteaceae). Pacific Islands, Oceania and east Australia; cultivated. Kernels are nutritious and eaten fresh or roasted.

**Pinus armandii** Franch. Chinese white pine (Pinaceae). East Asia - China, Taiwan; sparingly grown. Nuts are edible, tasty and esteemed as a delicacy.

**Pinus gerardiana** Wall. Chilgoza, Neoza (Pinaceae). Localized to western Himalayans, in high altitudes of Pakistan, India; domesticated here and is cultivated for its very tasty, nutritious nuts, highly priced; one of the costliest edible nuts. Narrow range of diversity/represented in small area of its cultivation; much scope for improvement/selection, quality, production, etc.

**Pinus koraiensis** Sieb. & Zucc. Korean pine (Pinaceae). East Asia - Korea, Japan. Nuts are oily, and eaten like walnut.

**Pistacia vera** L. Pistacio nut (Anacardiaceae). West Asia- grown in the Hindu Kush Himalayas in cold arid belt. Nuts are very tasty, eaten raw or roasted, as dessert, also as ingredient in sweetmeats, confectionery and icecreams.

**Prunus tangutica** (Batalin) Koehne Syn. **Amygdalus tangutica** Korsh. (Rosaceae). East Asia - western China; cultivated. Kernel is eaten raw.

**Terminalia catappa** L. Indian almond (Combretaceae). South/ southeast Asia widely grown in coastal region as far as the Pacific islands. Kernel with 55 per cent oil is nutritious and eaten raw.

**Terminalia kaernbachii** Warb. Syn. **T. okari** C.T. White. Okari nut (Combretaceae). South Pacific islands/ Papua New Guinea. Kernel rich in protein is eaten fresh or roasted; used to flavour food.
7. Miscellaneous

The diversity in underutilized species are largely used as spices and condiments, or for other indirect food usages viz. source of sugar/sweetening agents/as beverages/masticatories/cooking oil, etc. Others are a source of industrially or potentially important products. Multipurpose types belong to 44 families, 106 genera and 148 species (Table 10a). More

Table 10a. Families, genera and number of plant species of multipurpose use as spices, condiments, masticatories, beverages, etc........

<table>
<thead>
<tr>
<th>Families</th>
<th>Genera*</th>
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<tr>
<td>Alismataceae</td>
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<td>Cucurbitaceae</td>
<td>Hodgsonia (1), Trichosanthes (1)</td>
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<td>Gramineae</td>
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<td>Families</td>
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<td>Themadaceae</td>
<td><em>Daphne</em> (1)</td>
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<tr>
<td>Trapaceae</td>
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<tr>
<td>Apiaceae</td>
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</tbody>
</table>

*(No. of species in each genera is given in parenthesis)*

Important genetic wealth belongs to the Compositae, Leguminosae, Labiatae, Palmae, Piperaceae, Umbelliferae and Zingiberaceae (particularly well represented in the last three families). This information is largely synthesized from Arora (1985), and broadly, species diversity in this group is distributed as follows:

1. The Indo-Chinese, Indonesian region and the Hindustani/Indian region hold more diversity in species used
as spices, condiments, particularly species of *Alpinia*, *Amomum*, *Curcuma*, *Zingiber* and *Piper*. More confined to south Asian region are *Amomum xanthioides*, *Murraya koenigii*, *Piper longum*, and to southeast Asia, *Alpinia conchigera*, *A. officinarum*, *Amomum compactum*, *A. kravanh*, *A. maximum*, *Boesenbergia rotunda*, *Cinnamomum burmani*, *Plectranthus amboinicus*, *Curcuma pierreana* and *Polygonum odoratum*.

2. The Chinese-Japanese region holds much diversity. More confined to China are *Amomum globosum* and *Zanthoxylum simulans*; in Japan more variability occurs in *Gardenia jasminoides*, *Zingiber mioga*/Japanese ginger; in both China and Japan of *Fritillaria thunbergii* and *Perilla arguta*; Japan and Korea possess more variability in *Allium grayi* and *Panax ginseng*/ginseng. *Wasabia japonica* is grown in Japan.

3. Wider distribution is of species such as *Amomum aromaticum*, *Anethum sowa*, *Kaempferia galanga*, *Eltingera elatior*, *Trachyspermum roxburghianum*, *Zingiber purpureum* and *Z. zerumbet*.

4. Relatively narrow range of distribution and diversity occurs in *Piper cubeba*, *P. retrofractum*, *P. saigonense* and *Polyscias fruticosa*.

5. *Piper methysticum* got domesticated in the Pacific region, with its cultivation/distribution more confined to home gardens for local consumption; commercial demand is growing.

**Check-list of species**


*Alpinia chinensis* Rosc. (Zingiberaceae). China and Indo-china. Rhizome is used in chinese medicine, leaves for fibre.

*Alpinia conchigera* Griff. Greater galangal (Zingiberaceae). Southeast Asia - Indo-China, Malaysia. Rhizomes are used as condiment. Grown in home gardens.

*Alpinia galanga* (L.) Willd. (Zingiberaceae). South/southeast Asia; dark brown rhizomes are a source of galangal; dry rhizomes are used as condiment.

*Alpinia malaccensis* (Burm.f.) Rosc. (Zingiberaceae). South/southeast Asia - Indo-China, Malaysia, Indonesia, also in northeastern India. Rhizomes are a source of galangal; dry rhizomes are used as condiment.

*Alpinia officinarum* Hance. Lesser galangal (Zingiberaceae). East/southeast Asia; dark brown rhizomes are a source of galangal; dry rhizomes are used for flavouring dishes as a condiment.
Amomum aromaticum. Roxb. Bengal cardamom, Nepal cardamom (Zingiberaceae). South/southeast Asia - Nepal, northeastern India, Myanmar and Indonesia. Rhizomes are used as a condiment and the flowering shoots in preparing curries.


Amomum globosum Lour. Chinese cardamom (Zingiberaceae). East Asia - China. Seeds are used as condiment.

Amomum kravanh Pierre. White fruit amomum (Zingiberaceae). Southeast Asia - Cambodia, Indo-China. Fruits are used as condiment to flavour curries, sausages and drinks.

Amomum maximum Roxb. Java cardamom (Zingiberaceae). Southeast Asia-Indonesia; grown in Java as home garden cultigen; used in Malaysia as a local condiment.

Amomum xanthioides Wall. Siamese cardamom (Zingiberaceae) - Southeast Asia - Myanmar, Indo-China, also in northeast India; Nepal. Cultivated in home gardens and used as condiment.

Anethum graveolens L. Dill (Umbelliferae). European introduction to east/southeast/south Asia. Fruits are used for flavouring foods and pickling. Anethum sowa (Sowa) grown in India/tropical Asia, is also used likewise; leaves used for garnishing.


Angelica archangelica L. var. himalaica (C.B. Clarke) Krishna & Badhwar, Angelica (Umbelliferae). Temperate Asia, Himalayas, semi-domesticated, backyard cultigen. The aromatic petioles/leaf stalks are candied, and leaves are used as condiments. The roots yield oil used for flavouring liquors.


Anthriscus cerefolium (L.) Hoffm. Garden chervil (Umbelliferae). European introduction to Oceania - Australia and New Zealand, also in east Asia. Grown in home gardens. Leaves are used for flavouring dishes.


Arenga pinnata (Wurmb) Merr. Syn. A. saccharifera Lab. ex DC. Sugar palm (Palmae). Native of southeast Asia, grown more in Malaysia, the Philippines, and also in India. Fruits are edible; the fleshy kernels of young fruits are cooked and eaten, or made into sweets, and are rich in crude protein (10.03 per cent). The male spadix is tapped for palm sugar and palm wine.

Bauhinia malabarica Roxb. Amli (Leguminosae). South Asia-mainly a backyard cultigen in Western Ghats, south India and also in northeast, elsewhere sporadic. Tender leaves, young shoots and tender seeds used as vegetable; leaves also used for flavouring dishes. Leaves and flower buds of B. variegata and B. purpurea are also used as vegetable.

Blumea balsamifera (L) DC. (Compositae). Himalaya India, Malaysia, S. China, Taiwan. Cultivated in Java as medicinal crop.


Bunium persicum (Boiss.) Fedts. (Umbelliferae). Temperate Asia, mainly in the Himalayas. An obsolete cultigen. Tubers are boiled and consumed as a vegetable; aromatic seeds are used in flavouring dishes as a condiment; high priced and tried as a commercial crop.

Carex dispalata Boott. (Cyperaceae). Japan. Cultivated in rice field, leaves used to make hats.

Caryota urens L. Fish-tail palm (Palmae). South/southeast Asia - mainly India, Sri Lanka, Indo-China and eastwards, sporadically grown in backyards/home gardens. Stem is a source of starch/sago; juice from the trunk is fermented to make an alcoholic beverage.


Cichorium endivia L. Endive (Compositae). European/west Asian introduction, sporadically grown in temperate Himalayas and elsewhere; broad leaved varieties are used for stews; the curled leaved ones for garnishing salad. Roasted seeds of C. intybus L. (chicory) are a substitute for coffee; leaves are used as salad; roots are also boiled and eaten.
Cinnamomum burmanii Bl. Batavia cinnamon (Lauraceae). Southeast Asia-Malaysia, Indonesia, Java. Bark is used as spice.

Cinnamomus camphora (L) Nees & Eberm. Camphor tree (Lauraceae). China, Japan, Taiwan. Bark used as spice.

Cinnamomum cassia Bl. Syn. C. obtusifolium Nees var. cassia Perrot & Ebern. (Lauraceae). May be conspecific with C. aromaticum Nees. East Asia, southern China. Bark is used as spice; immature fruits also used for flavouring dishes.

Clausena lansium (Lour.) Skeels (Rutaceae). South China. Small fruit tree of S. China.


Coix gigantea Koenig et Roxb. (Graminae). South Asia. Seed used as poultry feed.

Coix lacryma jobi L Job’s tear (Graminae). NE India & SE Asia. Cultivated as cereal and eated by tribals.


Curcuma amada Roxb. Mango ginger (Zingiberaceae). South Asia-eastern, central, southern/northeast to Indo-China, India. Rhizomes have an odour of raw mangoes and are used as spice and condiment.

Curcuma angustifolia Roxb. east Indian arrowroot (Zingiberaceae). Himalayan region. Rhizomes -locally called tikur, yield starch.


Curcuma xanthorrhiza Roxb. (Zingiberaceae). Southeast Asia-Java, Indonesia; Malaysia. The rhizomes are a source of starch, boiled and eaten.

Curcuma zedoaria Rosc. Zedoary (Zingiberaceae). South/southeast Asia-northeast India, Indo-China and Sri Lanka. Dried rhizomes are used as condiment and as source of starch; also young flowers are used for flavouring dishes.


Inflorescences are dried and used as condiment and for flavouring dishes.

*Enhydra fluctuans* Lour. (Compositae). India, Indo-China, Thailand, China and Indonesia. A water plant cultivated in Cambodia and Malaya for its leaves.


*Euryale ferox* Salisb. Gorgon nut, Makhana (Euryaleaceae). East/south Asia-India, an aquatic plant, much grown in eastern region. Seeds are boiled and eaten; also fried; and mixed in vegetable preparations.


*Gardenia jasminoides* J. Ellis Syn. *G. augusta* Merr. Cape jasmine (Rubiaceae). Southeast/east Asia-cultivated in Japan, Taiwan and elsewhere. Flowers are used for flavouring tea.

*Gigantochloa ligulata* Gamble (Graminae). Malaya peninsula and Thailand. Shoots are eaten, used as tumber also.

*Glochidion blancoi* Low (Euphorbiaceae). Philippines. Cultivated for young leaves and shoots.

*Hibiscus sabdariffa* L. Roselle, Jamaica sorrel (Malvaceae). South/southeast/east Asia- widely distributed as far as the Pacific; mainly grown as a backyard cultigen. The fleshy calyces have acidic taste and eaten as chutney; leaves and shoots as used as vegetable; also a fermented beverage is made from the juice.

*Hodgsonia macrocarpa* (Bl.) Cogn. Syn. *H. heteroclita* Hk. f. & Thoms. Chinese lard fruit (Cucurbitaceae). East Asia. Grown as a protected cultigen in backyards in Yunnan, China, also in adjoining areas i.e. northeast India; Indo-China. Seeds are roasted and eaten, nutritious; seed-oil is used for cooking.

*Euryale ferox* (courtesy: K Pradheep)

*Euterpe edulis* C. Mart. Assai palm (Palmae/Arecaceae). Tropical American introduction into Malaysia, India and Sri Lanka. Fruits are used to make beverages; stem tips are cooked as a vegetable.

Hovenia dulcis Thunb. Japanese resin tree (Rhamnaceae). China, Korea, Japan. Cultivated in east Asia up to India for its edible inflorescence and as ornamentals.


Hydnocarpus alcalae C.DC. (Flacourtiaceae). Philippines. Seed used to cure leprosy.


Hydnocarpus kurzü (King) Warb. (Flacourtiaceae). Myanmar, Thailand. Seed-source of oil to cure leprosy.

Illicium verum Hook. f. Chinese anise, Star anise (Illiciaceae). Sporadically grown in east/southeast Asia. Seed oil is used in flavouring dishes.

Impatiens balsamina L. Balsum (Bolasaminaceae). Indo-Malaya, China. Cultivated in China as cosmetic plant and elsewhere as ornamental.


Kaempferia galanga L. (Zingiberaceae). South/southeast Asia - cultivated in northeastern India, Indo-China, Vietnam, Malaysia and elsewhere in home gardens. Rhizomes known as galanga are used as condiment.


Laurus nobilis L. Laurel, True bay, Sweet bay (Lauraceae). Mediterranean introduction into Japan and elsewhere. Leaves are used as condiment.

Lepidium sativum L. Garden cress (Cruciferae). Temperate zone; introduced
elsewhere. Seeds yield edible oil and leaves are eaten as salad.


*Lilium cordifolium* Thunb. (Liliaceae). East Asia – Japan; an ornamental plant. Cultivated for its starchy roots, used as food (leaves are cooked as vegetable); also in *L. davidii*, *L. lancifolium*, *L. maximowiczii* and *L. pumilum*.


*Allium maximowiczii* Regel (Liliaceae). Japan, cultivated as food crop.


*Lupinus albus* L. Syn. *L. sativus* Gaertn. White lupine (Leguminosae). East Asia - introduced from Europe into China, sporadic elsewhere. Seeds are used for flavouring; also roasted and eaten.


*Metroxylon sagu* Rottb. Syn. *M. rumphii* Mart. Sago palm (Palmae). Widely distributed in Southeast Asia, coastal belt of Indonesia, Borneo, Philippines; more diversity and the Pacific Islands Papua New Guinea; also as a plantation crop in Malaysia. Stem marrow yields starch for use as food, and for industrial purposes; much valued regionally. Its R&D potential as an industrial/commercial crop needs to be fully exploited.


*Murraya koenigii* (L.) Spreng. (Rutaceae). Kari patta. South/southeast/east Asia. A home garden cultigen widely grown in humid regions. Leaves are used in curries for flavouring, also medicinally important.


Nelumbo nucifera Gaertn. Syn. Nelumbium speciosum Willd. Indian lotus, Kamal (Nymphaeaceae). South, southeast Asia/east Asia, as far as the Pacific, also in Australia. Rhizomes are eaten as vegetable (boiled, fried and pickled). Fruit is used as source of flour. The oblong glossy kernels (twice as large as peas) are sweet, very tasty, nutritious and eaten raw.

Nypa fruticans Wurmb. Nipa palm (Palmae). South/southeast Asia as far as the Pacific, also in Australia; in India in tidal swamps of Sunderbans in West Bengal and in Andaman Islands. Inflorescences are a source of sugar sap made into vinegar and alcohol. Seeds are used for sweetmeats. Immature fruits are boiled with sugar and used as preserves.


Osmanthus fragrans Lour. (Oleaceae). East/southeast Asia - Japan, China, Vietnam, also northeastern India. The leaves are used to flavour tea in China; fruits are edible. Variety aurantiacus Makina is a source of essential oil in Japan.

Panax ginseng C.A. Meg. Asiatic Ginseng (Araliaceae). East Asia - northern China, Korea, Japan. Roots are used in preparing liquor; also for preparing tea.

Panax pseudoginseng Wall. var. notoginseng (Burkill) G. Hor & C.J. Tseng (Araliaceae). East Asia grown in south China.

Pandanus spp. (Pandanaceae). Widely distributed in coastal areas throughout Asia-Pacific. Several species are grown for leaves used as condiment and protected in backyards/home gardens (also see under fruits).

Pandanus leram Jones. Nicobar breadfruit (Pandanaceae). South Asia - Coastal region. Andaman and Nicobar Islands and Sri Lanka. Ripe fruits are boiled, mashed, and made into marmalade-like preparation, pulp edible; lower portion of fleshy fruit also made into flour for making bread by the locals.

Pandanus fascicularis Lam. (Pandanaceae). South/southeast Asia, and the Pacific Islands - Malaysia, Myanmar, Indonesia, Australia and
Andaman and Nicobar Islands. Lower part of fruits and seeds are eaten. Spadices yield ittar (a perfume) used for scenting clothes, bouquets, lotions, cosmetics, soaps, hair oils and incence sticks. Much diversity exists based on usage.

*Parkia speciosa* Hassk. Petai, Sataw (Leguminosae). Southeast Asia - native of Malaysia, Indonesia-Borneo, grown in home gardens. Immature seeds, young leaves and flower stalks are eaten raw; pods/seeds fried or cooked as vegetable, made into chutney; tastes like garlic and used as a condiment for flavouring dishes with rice. Large and small seeded forms with much variation in pod size are reported in Thailand, varying in taste and flavour. *Parkia roxburghii* with wider distribution in northeast India, Myanmar and from eastwards Indo-China is grown in home gardens and is used locally in the same way.

*Peltophorum pterocarpum* Backer (Leguminosae). Asia to Australia. Cultivated in Java for its bark- a source of brown dye.


*Perilla arguta* Benth. Shisho (Labiatae) Japan, China. Leaves used for flavouring food.


*Piper cubeba* L.f. Cubeb (Piperaceae). Southeast Asia- Malaysia, Singapore, Indonesia-Java. Fruits are used as a spice; oil is used for flavouring food.

*Piper longum* L. Long pepper (Piperaceae). South Asia - eastern Himalayas, northeastern hills. Cultivated in India and Sri Lanka, also in southeast Asia - Indonesia. Fruits are used as a spice and condiment.

*Piper methysticum* G. Forst. Kava pepper (Piperaceae). Pacific islands, widely grown. A popular kitchen/home garden cultigen and partly also commercially cultivated. Roots/rhizomes are used as spice; leaves as a vegetable.

*Piper retrofractum* Vahl. Javanese long pepper (Piperaceae). Southeast Asia-Indo-China, Malaysia; resembles *P. longum*. Fruits are used as condiment especially in curries and pickles.
*Piper saigonense* (C. DC.) Lolo (Piperaceae). Indo-China, Vietnam, endemic and closely related to *P. lohot* (Tonkin region). The fruits are locally used as condiment.

*Pisonia alba* Span. Lettuce tree (Nyctaginaceae). Malaya. Leaves used as vegetables.

*Pithecellobium bigeminum* Mart. (Leguminosae). East and southeast Asia; cultivated in Indonesia-Java for its edible seeds.


*Pithecellobium lobatum* Benth. (Leguminosae). South/southeast Asia – northeastern India, Myanmar, Indo-China, Malaysia and Indonesia; much cultivated in Java. The leaves, flowers and fruits are eaten as vegetable.

*Platycodon grandiflorum* DC (Companulaceae). China & Japan. Cultivated as medicinal crop.

*Plectranthus amboinicus* (Lour.) Spr. Syn. *Coleus amboinicus* Lour., *C. aromaticus* Benth. Indian borage (Labiatae). Southeast Asia-native of Indonesia; grown in Malaysia and also in India for its aromatic leaves used for flavouring dishes. A home garden cultigen.

*Pluchea indica* Less. (Compositae). Indonesia. Young leaves eaten as vegetable, also used to prepare medicinal tea.

*Plukenetia corniculata* Smith (Euphorbiaceae). SE Asia. Cultivated as vegetable.


*Pueraria thunbergiana* (Sieb. & Zucc.) Benth. Kudzu (Leguminosae). China, Japan. Cultivated for green manure, as tuber crop also.

*Quercus aliena* Blume (Fagaceae). Japan, Korea, China. Cultivated as food.

*Rheum × hybridum* Murray Syn. *R. rhaponticum* auct. Garden rhubarb (Polygonaceae). Related to *R. palmatum*. Temperate Himalayas; cultivated as a vegetable; stewed leaf stalks/ stems are eaten; used in pies, as juice or drink, or made into wine.


Sandoricum koetjape (Burm.f.) Merrill (Meliaceae). Malaysia & Indo-china. Cultivated for its fruits.

Scirpodendron ghaeri (Gaertn.) Merr. (Cyperaceae). Asia, Samoa. Cultivated in Sumatra for mat making.

Semecarpus anacardium L.f. Cashew marking nut tree. (Anacardiaceae). Tropical Asia and Australia. Cultivated and used as marking by washerman.

Sesbania grandiflora (L.) Pers. Agati (Leguminosae). Tropical Asia as far as the Pacific Islands in humid tracts; mainly grown in home gardens. Young fruits, leaves, flowers are used as a vegetable; sold in local markets.

Sinapis alba L. Syn. Brassica alba (L.) Boiss. White mustard (Cruciferae). East Asia, and south Asia in the Hindu Kush Himalayas, sporadic and grown in home gardens. Young seedlings are used as salad; seeds are used as condiment.

Stachys sieboldii Miq. Chinese artichoke (Labiatae). Domesticated in China, grown for its tubers

Spilanthes paniculata Wall. Ex DC (Compositae). SE Asia & New Guinea. Cultivated as vegetable or salad.


Thymus vulgaris L. Thyme (Labiatae). Mediterranean introduction into east Asia - Japan. Dried leaves are used as condiment for flavouring dishes.

Trachyspermum roxburghianum Craib. (Umbelliferae). East Asia. Seeds are used for flavouring, also medicinal.

Trapa bicornis Osbeck (Trapaceae). East Asia - grown in Japan, also grown in southeast Asia. Kernels are used in various food preparations, preserved with honey as a delicacy, also made into starch.

Trapa natans L. var. bispinosa (Roxb.) Makino Syn. T. bispinosa Roxb. Water chestnut, Singhara nut (Trapaceae). East Asia - grown in China, Japan; elsewhere in south Asia - India, Bangladesh; also introduced into Australia. Seeds are eaten raw or cooked, also dried to make flour.

Trapa natans (courtesy: Anuradha Agrawal)

Trichosanthes cucumeroides Max (Cucurbitaceae). Japan and China. Roots used for starch.

Trigonella coerucla (L.) Ser. Sweet trefoil (Leguminosae). Mediterranean introduction into Asia; sparingly grown for its aromatic leaves, used for flavouring soups and for making tea.
Trogonella foenum-graecum L. Fenugreek (Leguminosae). West Asian spice; popular vegetable in northern India (see under vegetable category). Seeds are used as condiment; possess great medicinal value as a cure in diabetes.


Vicia unijuga A. Braun. Two-leaved vetch (Leguminosae). East Asia - eastern Manchuria/China, Japan. Grains are eaten occasionally; mainly grown for forage.

Vigna dalzelliana (O. Kuntze) Verdc. (Leguminosae). South/southeast Asia - India, Thailand, Cambodia, Indonesia, Vietnam. Philippines. A minor pulse crop used like green gram; also used as fodder.

Wasabia japonica (Miq.) Matsum Syn. Eutrema wasabi (Sieb.) Maxim. (Cruciferae). East Asia-cultivated in Japan, and sporadically elsewhere. Roots, twigs and petioles are used as condiment.

Zanthoxylum simulans Hance Syn. Z. bungei Planch (Rutaceae). East Asia-China. Seeds are used as condiment.

Zingiber mioga (Thunb.) Rosc. Japanese ginger, Mioga ginger, Myoga (Zingiberaceae). East Asia - Japan. Rhizomes are a source of Japanese ginger; flowers, fruits and shoots are eaten locally.


Zingiber zerumbet (L.) Smith. Martinique ginger, Zerumbet ginger (Zingiberaceae). Southeast Asia - cultivated in Indo-China, Cambodia, elsewhere sporadic. Rhizomes are used as condiment, also boiled and made into soups, much like the Japanese ginger (Z. mioga).

8. Industrial crops

Diversity in this group is largely of industrial use as fibres, tea, medicinal, seed oil for industrial use, biofuel, health products, rubber yielding plants, agroforestry, edible oil belong to 18 families, 23 genera and 25 species (Table 10b). Among the important families Asteraceae, Fabaceae, Malvaceae, Pedaliaceae, Simmondsiaceae, and Santalaceae have contributed in this group of industrial under-utilized species. Diversity in families, genera and number of plant
### Table 10b. Families, genera and number of plant species of industrial use

<table>
<thead>
<tr>
<th>Families</th>
<th>Genera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asteraceae</td>
<td>Carthamus (1), Guizotia (1), Parthenium (1)</td>
</tr>
<tr>
<td>Compositae</td>
<td>Vernonia (1)</td>
</tr>
<tr>
<td>Cucurbitaceae</td>
<td>Citrullus (1)</td>
</tr>
<tr>
<td>Euphorbiaceae</td>
<td>Jatropha (1)</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>Cyamopsis (1), Pongamia (1)</td>
</tr>
<tr>
<td>Gramineae</td>
<td>Sinocalamus (1), Schizostachyus (1)</td>
</tr>
<tr>
<td>Lamiaceae</td>
<td>Perilla (1)</td>
</tr>
<tr>
<td>Liliaceae</td>
<td>Taetsia (1)</td>
</tr>
<tr>
<td>Malvaceae</td>
<td>Hibiscus (2)</td>
</tr>
<tr>
<td>Musaceae</td>
<td>Musa (1)</td>
</tr>
<tr>
<td>Palmae/ Arecaceae</td>
<td>Metroxylon (1), Nypa (1)</td>
</tr>
<tr>
<td>Pedaliaceae</td>
<td>Pedalium/ Sesamum (1)</td>
</tr>
<tr>
<td>Rubiaceae</td>
<td>Morinda (1)</td>
</tr>
<tr>
<td>Santalaceae</td>
<td>Santalum (2)</td>
</tr>
<tr>
<td>Simaroubaceae</td>
<td>Simarouba (1)</td>
</tr>
<tr>
<td>Simmondsiaceae/Buxaceae</td>
<td>Simmondsia (1)</td>
</tr>
<tr>
<td>Theaceae</td>
<td>Camelia (2)</td>
</tr>
<tr>
<td>Urticaceae</td>
<td>Boehmeria (1)</td>
</tr>
</tbody>
</table>

Species of industrial use are discussed below:

1. Tropical areas of African region hold diversity in *Citrullus colocynthis* and *Hibiscus cannabinus*, with more diversity in cultivation in south/southeast, east Asia. *Guizolia abyssinica* of Ethiopian origin and *Sesamum indicum* with centre of diversity in India; enormous diversity occurs in *Cyamopsis tetragonoloba* in India.

2. Diversity occurs in *Boehmeria nivea* (L.) and *Perilla frutescens* in east Asia in Indo-Burmese/Indo-China, Korea, Japan. *Carthamus tinctorius* with diversity build-up in south Asia and Indo-Chinese region.


4. Domesticated/cultivated type *Musa textilis* in Philippines, *Santalum*
spicatum and S. acuminatum mainly in Pacific/Oceania.

5. Tropical American species, Simarouba glauca, Parthenium argentatum, Jatropha curcas and Simmondsia chinensis are introductions into south/southeast asia regions.

Check-list of species

Boehmeria nivea (L.) Gaud. Ramie, Rhea (Urticaceae). Chinese origin where more diversity occurs; cultivated for fibre in east Asia - China, Japan; southeast Asia - Malaysia, Thailand, Philippines; south Asia - India and Nepal. Mainly var. nivea, white ramie is grown; the broad leaved type - var. tenacissima - green ramie is also reported.

Camelia oleifera Abel. (Theaceae). China. Cultivated there and Indo-china to yield “Tea Oil”.

Camelia sinensis (L) O. Kuntze (Theaceae). Mountains of China, NE India, spread to SE China, Indo-China, India, Sri Lanka. Leaves are used to make tea.

Carthamus tinctorius L. Safflower (Compositae). West Asia eastwards, south Asia. Much grown in China, India, sporadically elsewhere; diversity region-India, China. Grown for seed-oil, for preparing tea, medicinal and other diverse plant uses in China.


Cyamopsis tetragonoloba (L.) Taub. Cluster bean, Guar (Leguminosae). African origin; much grown in India; enormous variability occurs; several varieties have been developed for edible pod as food (vegetable), fodder and as industrial crop for seed gum.

Guizotia abyssinica (L.f.) Cass. Niger (Compositae). Ethiopian origin, with centre of diversity in India. Grown in south Asia - India, Nepal; also sporadically in Myanmar/southeast/east Asia, China. Seeds yield oil of excellent quality, for food and industrial use.

Hibiscus cannabinus L. Kenaf (Malvaceae). Tropical African introduction into south, southeast/east Asia. Grown in India, Philippines, China, sporadically elsewhere. Fibre is of industrial use, much valued. H. sabdariffa (roselle) is also being grown on a small scale for a similiar purpose.

Jatropha curcas L. Physic nut, Purging nut (Euphorbiaceae). Mexican origin; introduced into Asia, in India and elsewhere in Philippines, Malaysia and Vietnam. Grown for its oil; used as biofuel plant in industry, and considered of great potential.

Metroxylon sagu Rottb. Sago palm (Palmae). Widely distributed in southeast Asian coastal belt. Indonesia-Borneo, Philippines, Pacific Islands have more diversity, as also Papua New Guinea;
also a plantation crop in Malaysia. Stem marrow yields starch for use as food in diverse preparations and for industrial purpose; much valued regionally; improvement needed to exploit its full potential.

*Morinda citrifolia* L. Indian mulberry, Noni (Rubiaceae). Important crop of the Pacific islands and in south/southeast Asia. Distributed sporadically in India, Sri Lanka, Myanmar, Indo-China, Malaysia, Thailand and across Pacific. The tree has diverse medicinal uses. World Noni Research Foundation based in Chennai, India is engaged in its R&D aspects and has developed several health-welfare products. Plantations have been established in Andaman Islands and peninsular India in Western Ghats.

*Musa textilis* Née. Manila hemp, Abaca (Musaceae). Indigenous to the Philippines where rich diversity occurs in domesticated/cultivated types; several varieties commercially grown for fibre; introduced in Malaysia, as also in East Asia-Thailand, Indonesia, and in other parts; grown sporadically. Fibre is of industrial use for cordage, pulp and paper manufacture and in the fibre craft industry with diversified uses particularly in the Philippines.

*Nypa fruiticans* Wurmb. (Palmae). SE Asia up to Australia. Cultivated in Sumatra for its leaves and for wine production.

*Parthenium argentatum* A. Gray. Guayule (Compositae). Tropical American/Mexican introduction, introduced as a rubber-yielding plant; tried in India, has possible potential for industry.

*Perilla frutescens* Britton Syn. *P. ocyoides* L. Perilla (Labiatae). East Asia - grown in China, Japan, Korea (more in Japan). Several varieties have been developed; also grown in Indo-Burmese/Indo-China tract in home gardens; much variability in seed-oil quality and yield of great potential value to industry; also a useful medicinal plant. Seeds are locally used in making chutney-like preparations.


*Santalum acuminatum* (R. Br.) DC. (Santalaceae). Mainly distributed in Pacific-Oceania; cultivated in Australia, mainly in Queensland. A good substitute to sandalwood, for commercial exploitation; large plantations taken up for industrial use for oil and wood. Other useful species are *S. lanceolatum* and *S. austro-caledonium*, the latter in Vanuatu/south Pacific - an agroforestry species.

*Santalum spicatum* (R. Br.) A. DC. Australian sandal wood (Santalaceae). Pacific-Oceania; Semi-arid tracts of Australia. The tree yields sandalwood oil of commercial value; grown more in in gold fields region of western Australia.


**Simarouba glauca** DC. Paradise tree (Simaroubaceae). Central American introduction into south/southeast Asia. In India, tried as an oil crop for industrial purposes; and found to be promising. The National Oilseeds and Vegetable Oil Development Board (NOVOB), Ministry of Agriculture has identified *S. glauca* as a tree bearing oilseed (TBO); also grown as agroforestry tree.

*Simmondsia chinensis* (Link) Schneid. Jojoba (Simmondsiaceae/Buxaceae) Tropical American/Mexican/Californian introduction to Asia; tried successfully in western India and in less humid peninsular region for its great potential as an industrial oil crop; yields jojoba oil of commercial use.

**Sinocalamus latifolius** (Munro) McClure (Graminae). Myanmar, Thailand, Taiwan and Philippines. Its stem are used as building material, young shoots are eaten, canned also.

*Taetsia fruiticosa* (L) Merr. (Liliaceae). Pacific islands and Malaya. The leaves are used for clothes.

III. Priority Species for Research and Development

The choice/identity of priority species for research and development would vary depending on several factors, particularly the needs of the national programmes and wider development role of such species at sub-regional and regional levels (Williams and Haq, 2002; Arora et al., 2006). The following criteria will serve well in ascertaining the choice of such species:

- National programmes recognize species/crops of importance and are committed to promote their research and development.
- Germplasm diversity has been and is being collected, characterized and evaluated as an on-going activity.
- Potential diversity areas having desirable genes are to be re-visited for collection of genetic material.
- Plant improvement research focuses on and leads to identification and development of promising selections varieties suited to diverse agro-climates/ecosystems.
- Enormous scope for exploiting utilization-potential of identified/priority species exists.
- Seed multiplication and supply system is in place, as also infrastructure for the supply of planting material.
- Post-harvest technology application is feasible/available to meet R&D needs.
- Focus on product development, diversification and value addition is duly recognized and technology available.
- Increased consumption and production is well addressed for need-based species, particularly for rural, poor farming communities.
- Market outlets/channels exist – linking farmers to markets; efforts are being streamlined for farmers’ benefit.
- Development efforts on the importance of underutilized species address food security, poverty alleviation, malnutrition and income generation, vis-à-vis rural development.
- Overall R&D efforts are well directed involving diverse expertise/emphasising wider participation; research agenda are well set with focus on meeting the millennium development goals, in national and regional context.
Based on the overall existing knowledge as presented on the diversity of underutilized species enumerated in the foregoing chapter, Table 11 provides the list of suggested priority species arranged according to their use. The species are placed into three categories on the basis of their relative importance as per the criteria listed above. Category A includes underutilized species important in national, sub-regional and regional development. Category B is of species equally important but more so at sub-regional and national level, as per their distribution and category C, includes species that need more research focus, as for many of these species germplasm diversity is narrower or wanting and has not been characterized, and evaluated. These species are more important locally and their potential is not well known. These are grown by native farming communities under subsistence/traditional farming systems. They assume importance for research, germplasm enhancement/improvement, utilization and more so, conservation of diversity.

Also, there are several endemic species - both with a very narrow range of distribution as cultigens, and with a relatively wider distribution; but these have very local use by the native communities which grow them as protected, semi-domesticated, domesticated types in marginal habitats, and more so in backyards and home gardens. Diversity in this category of underutilized species of less known genetic resources is listed in Table 12 indicating their distribution in South Asia, Southeast Asia, East Asia and in the Pacific/Oceania region. Apart from their minor use as edible species, much of their hidden potential lies in identification and use for specific traits in crop improvement (such as root stocks in fruits for disease resistance/stress tolerance; many of these species occupy ecologically specific niches, stress prone habitats, such as extremely hot and extremely cold arid regions, water logged and tidal, coastal regions, saline habitats, acidic soils etc. Unlike the priority species listed in Table 11, these species have not been collected within the native areas of their distribution/cultivation and thus information on their diversity-assessment is not available. The use and conservation of this diversity by and large is thus wanting. So, they have high conservation and use value, like the category C in Table 11.
<table>
<thead>
<tr>
<th>Priority categories suggested</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Pseudocereals and Millets</strong></td>
<td></td>
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<tr>
<td>Amaranthus spp., Eleusine coracana, Fagopyrum esculentum</td>
<td>Fagopyrum tataricum, Panicum milaceum, Setaria italica</td>
<td>Coix lacryma-jobi var. mayuen, Chenopodium album, Echinochloa spp, Paspalum scrobiculatum, Panicum sumatrense</td>
<td></td>
</tr>
<tr>
<td><strong>2. Grain legumes/Pulses</strong></td>
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<tr>
<td>Vigna mungo, V. umbellata</td>
<td>Macrotyloma uniflorum, Vicia faba, Vigna angularis, V. aconitifolia</td>
<td>Lathyrus sativus</td>
<td></td>
</tr>
<tr>
<td><strong>3. Roots/Tubers</strong></td>
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<td></td>
</tr>
<tr>
<td>Alocasia spp., Colocasia esculenta, Dioscorea alata</td>
<td>Xanthosoma ssp.</td>
<td>Amorphophallus paeoniifolius, Crytosperma chamissonis, Maranta arundinacea</td>
<td></td>
</tr>
<tr>
<td><strong>4. Vegetables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Leafy types</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abelmoschus manihot, Brassica spp., Ipomoea aquatica, bamboos</td>
<td>Amaranthus spp., Basella alba, Lepidium sativum, Nasturtium indicum</td>
<td>Lactuca sativa, Rungia klossii, Sauropus androgynus, Sesbania grandiflora, Trigonella foenum-graecum</td>
<td></td>
</tr>
<tr>
<td>(b) Fruit types</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abelmoschus esculentus, Lablab purpureus, Luffa aegyptiaca, Momordica charantia, Moringa oleifera</td>
<td>Praecitrullus fistulosus, Momordica dioica, Trichosanthes spp.</td>
<td>Psophocarpus tetragonolobus</td>
<td></td>
</tr>
<tr>
<td><strong>5. Fruits</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>6. Nuts</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inocarpus lagifer, Canarium ovatum, Pinus gerardiana, Pistacia vera</td>
<td>Anaclosa frutescens, Castanea mollissima</td>
<td>Barringtonia edulis, Buchanania lanzan, Gnetum gnemon, Terminalia kaernbachii</td>
<td></td>
</tr>
</tbody>
</table>

Table 11. Priority underutilized species for research and development in Asia-Pacific region
Table 12. Endemic underutilized and less known species and their distribution as cultigens in Asia-Pacific region

<table>
<thead>
<tr>
<th>Species</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>South Asia</td>
</tr>
<tr>
<td>1. <em>Pseudocereals and Millets</em></td>
<td></td>
</tr>
<tr>
<td>Brachiaria racemosa</td>
<td>South India, Tamil Nadu,</td>
</tr>
<tr>
<td>Digitaria cruciata var. esculenta</td>
<td>Northeast India, Meghalaya</td>
</tr>
<tr>
<td>Echinochloa crus-pavonis</td>
<td>-</td>
</tr>
<tr>
<td>Panicum sumatrense</td>
<td>Peninsular India</td>
</tr>
<tr>
<td>Urochloa panicoides</td>
<td>South India</td>
</tr>
<tr>
<td>Setaria glauca</td>
<td>South India</td>
</tr>
<tr>
<td>2. <em>Grain legumes/Pulses</em></td>
<td></td>
</tr>
<tr>
<td>Vigna trilobata</td>
<td>South India</td>
</tr>
<tr>
<td>3. <em>Roots/Tubers</em></td>
<td></td>
</tr>
<tr>
<td>Amorphophallus hermandii</td>
<td>-</td>
</tr>
<tr>
<td>Calystegia sepium</td>
<td>-</td>
</tr>
<tr>
<td>Dioscorea papuana</td>
<td>-</td>
</tr>
<tr>
<td>Moghania vestita</td>
<td>-</td>
</tr>
<tr>
<td>Pueraria montana</td>
<td>-</td>
</tr>
<tr>
<td>4. <em>Vegetables</em></td>
<td></td>
</tr>
<tr>
<td>Allium ladebourianum</td>
<td>-</td>
</tr>
<tr>
<td>Allium ramosum</td>
<td>-</td>
</tr>
<tr>
<td>Allium stracheyi</td>
<td>India, Western Himalayas</td>
</tr>
<tr>
<td>Amaranthus blitum var. oleracea</td>
<td>Northern India</td>
</tr>
<tr>
<td>Alternanthera sessilis</td>
<td>South India, Sri Lanka</td>
</tr>
<tr>
<td>Angelica kiusiana</td>
<td>-</td>
</tr>
<tr>
<td>Species</td>
<td>South Asia</td>
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<tr>
<td>---------</td>
<td>------------</td>
</tr>
<tr>
<td>Aralia cordata</td>
<td>-</td>
</tr>
<tr>
<td>Centella asiatica</td>
<td>South India, Sri Lanka</td>
</tr>
<tr>
<td>Clerodendrum colebrookianum</td>
<td>Northeastern India</td>
</tr>
<tr>
<td>Glechnia littoralis</td>
<td>-</td>
</tr>
<tr>
<td>Gymnema reticulata</td>
<td>-</td>
</tr>
<tr>
<td>Nothopanax guilfoylei</td>
<td>-</td>
</tr>
<tr>
<td>Pentaphragma begoniaefolium</td>
<td>-</td>
</tr>
<tr>
<td>Polyscias restoralis</td>
<td>-</td>
</tr>
<tr>
<td>Pugionum cornutum</td>
<td>-</td>
</tr>
<tr>
<td>Rorippa schlechteri</td>
<td>-</td>
</tr>
<tr>
<td>Rungia klossii</td>
<td>-</td>
</tr>
<tr>
<td>Sechium edule</td>
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<td>Talinum triangulare</td>
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<tr>
<td>Trianthema portulacastrum</td>
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### 5. Fruits

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<td>Musa troglodytarum</td>
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<td><em>Rhodomyrtus tomentosa</em></td>
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<td><em>Rubus phoenicosius</em></td>
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<td>North China, Japan</td>
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<td>Laos, Indo-China</td>
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<td><em>Stauntonia hexaphylla</em></td>
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<td><em>Syzygium curranii</em></td>
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<td><em>Vitis amurensis</em></td>
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6. Nuts

<table>
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<td><em>Barringtonia procera</em></td>
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<td>Pacific, PNG</td>
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<td><em>Buchanania lanzan</em></td>
<td>Peninsular/central India</td>
<td>-</td>
<td>-</td>
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<td><em>Juglans atlantifolia</em></td>
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<td><em>Macadamia tetraphylla</em></td>
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<td><em>Pinus armandii</em></td>
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<td>Japan</td>
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<td><em>Pinus gerardiana</em></td>
<td>Northwestern Himalayas</td>
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<td>-</td>
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<td><em>Prunus tangutica</em></td>
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<td>-</td>
<td>Western China</td>
<td>-</td>
</tr>
<tr>
<td><em>Terminalia kaernbachii</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Pacific, PNG</td>
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</table>
IV. Nutritional Aspects

One of the major concerns addressed by promoting the use of underutilized, neglected and other less known plant species is the role of their food/ nutritional value in alleviating malnutrition particularly in the marginal, subsistence farming systems where these are grown (such as pseudocereals and grain legumes, and many of the vegetables and tuber crops). In a similar context, there is need for providing further thrust to underutilized fruits and protein-rich nuts. Even some of the multipurpose species used as spices, condiments deserve this attention. Annexures I and II provide some data on the nutritional/food value of some selected species (Pareek et al., 1998, for information on fruits and nuts; Peter, 2007 on underutilized and underexploited horticultural crops; Gopalakrishnan, 2007, for vegetables; Radha and Mathew, 2007 for fruits). Relative importance of some of these species for their specific nutritional properties vis-a-vis their importance is discussed below.

Pseudocereals and Millets

The composition of some important underutilized pseudocereals and millets is given in Table 13 which points out to their richness in carbohydrates, protein (high in Job’s tears and grain amaranths, followed by proso millet, buckwheat and foxtail millet, barnyard millet: relatively low in finger millet), fat (relatively high in Job’s tears and grain amaranths), fibre (high in barnyard millet and buckwheat and grain amaranths), calcium (very high in grain amaranths, high in Job’s tears and buckwheat), iron (high in foxtail millet, finger millet followed by barnyard millet, grain amaranths and buckwheat), vit. B₁ (high in foxtail millet, Job’s tears and buckwheat followed by finger millet, barnyard millet), vit. B₂ (high in grain amaranths, buckwheat, foxtail millet), and niacin (higher in barnyard millet and proso millet than in Job’s tears, foxtail millet and buckwheat). Compared to rice, finger millet grain is eight times richer in calcium, four times in minerals and two times in phosphorus-protein components and has a well-balanced amino-acid profile. It is a good source of methionine, cystine, and lysine, and is also rich in important vitamins such as thiamin, riboflavine, folin and niacin (MSSRF, 2002). Further, studies on buckwheat pointed out that essential amino acid
Table 13. Composition of buckwheat (per 100 g) compared with other food grains

<table>
<thead>
<tr>
<th>Food grain</th>
<th>Food energy (cal.)</th>
<th>Moisture (%)</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
<th>Total carbohydrates (g)</th>
<th>Calcium (mg)</th>
<th>Iron (mg)</th>
<th>Phosphorus (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buckwheat</td>
<td>355</td>
<td>11.0</td>
<td>12.0</td>
<td>7.4</td>
<td>72.9</td>
<td>114</td>
<td>13.2</td>
<td>282</td>
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<tr>
<td>Amaranth</td>
<td>391</td>
<td>9.3</td>
<td>15.3</td>
<td>7.1</td>
<td>63.1</td>
<td>490</td>
<td>22.4</td>
<td>453</td>
</tr>
<tr>
<td>Corn meal</td>
<td>335</td>
<td>12.0</td>
<td>9.2</td>
<td>3.9</td>
<td>73.7</td>
<td>20</td>
<td>3.5</td>
<td>256</td>
</tr>
<tr>
<td>Rye grain</td>
<td>334</td>
<td>11.0</td>
<td>12.1</td>
<td>1.7</td>
<td>73.4</td>
<td>38</td>
<td>5.3</td>
<td>376</td>
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<tr>
<td>Whole wheat flour</td>
<td>333</td>
<td>12.0</td>
<td>13.3</td>
<td>2.0</td>
<td>71.0</td>
<td>41</td>
<td>10.5</td>
<td>372</td>
</tr>
</tbody>
</table>


composition of buckwheat compared to other cereals was relatively high as a percentage of protein (IPGRI 1998-2000; Tables 14 & 15) for lysine and leucine (comparable to amaranths) and low in methionine. Also both grain amaranths and buckwheat compared to other food grains (per 100 g) possess more protein, total carbohydrates, calcium, iron and phosphorus (Grubben and Soetjipto, 1996; Tables 13 & 14).

- **Buckwheat** (whole plant): Protein (11.6 g), fat (2.78 g), fibre (7.4 g), carbohydrates (83.28 g), energy (1586 kJ), Ca (50 mg), Fe (3.4 mg), Vit. B₁ (0.41 mg), Vit. B₂ (0.20 mg), niacin (2.3 mg)

- **Grain amaranth** (whole grains): Protein (14.7 g), fat (8.2 g), fibre (7.6 g), carbohydrates (74.2 g), energy (2006 kJ), Ca (282 mg), Fe (3.8 mg), Vit. B₁ (0.16 mg), Vit. B₂ (0.36 mg), niacin (1.1 mg)

- **Quinoa** (whole grain): Protein (13.8 g), fat (6.9 g), fibre (4.3 g), carbohydrates (88.4 g), energy (1640 kJ), Ca (128 mg), Fe (5.3 mg), Vit. B₁ (0.15 mg), Vit. B₂ (0.43 mg), niacin (1.2 mg)

- **Finger millet**: Protein (7.0 g), fat (16.0 g), fibre (1.4 g), carbohydrates (88.6 g), energy (1573 kJ), Fe (6.0 mg), Vit. B₁ (0.37 mg), Vit. B₂ (0.11 mg), niacin (1.5 mg)

- **Barnyard millet**: Protein (11.0 g), fat (4.4 g), fibre (8.1 g), carbohydrates (81.7 g), energy (1611 kJ), Ca (96 mg), Vit. A (0.36 mg), Vit. B₁ (0.11 mg), Vit. B₂ (4.5 mg)

- **Job’s tears**: Protein (14.1 g), fat (7.9 g), fibre (0.9 g), carbohydrates (76.4 g), energy (150 kJ), Ca (54 mg), Fe (0.8 mg), Vit. B₁ (0.48 mg), Vit. B₂ (0.10 mg), niacin (2.7 mg)
Table 14. Essential amino acid composition of buckwheat compared with other cereals (as percentage of protein).

<table>
<thead>
<tr>
<th>Food grain</th>
<th>Lysine</th>
<th>Methionine</th>
<th>Tryptophane</th>
<th>Leucine</th>
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</thead>
<tbody>
<tr>
<td>Buckwheat</td>
<td>5.9</td>
<td>3.7</td>
<td>1.4</td>
<td>5.8</td>
</tr>
<tr>
<td>Amaranth</td>
<td>5.0</td>
<td>4.4</td>
<td>1.4</td>
<td>4.7</td>
</tr>
<tr>
<td>Wheat</td>
<td>2.6</td>
<td>3.5</td>
<td>1.2</td>
<td>6.3</td>
</tr>
<tr>
<td>Rice</td>
<td>3.8</td>
<td>3.0</td>
<td>1.0</td>
<td>8.2</td>
</tr>
<tr>
<td>Maize</td>
<td>1.9</td>
<td>3.2</td>
<td>0.6</td>
<td>13.0</td>
</tr>
<tr>
<td>FAO/WHO recommendation</td>
<td>5.5</td>
<td>3.5</td>
<td>1.0</td>
<td>7.0</td>
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</table>

Source: Proceedings of Second Amaranth Conference (1979), USA; IPGRI (1998)

Table 15. Comparison of the food value of Himalayan chenopods and other crops

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Himalayan chenopods</th>
<th>Quinoa</th>
<th>Amaranth</th>
<th>Wheat</th>
<th>Barley</th>
<th>Rice</th>
<th>Maize</th>
<th>Finger millet</th>
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</thead>
<tbody>
<tr>
<td>Proteins (%)</td>
<td>16.0</td>
<td>15.0</td>
<td>16.0</td>
<td>12.0</td>
<td>11.0</td>
<td>6.8</td>
<td>11.1</td>
<td>7.3</td>
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<tr>
<td>Carbohydrates (%)</td>
<td>66.0</td>
<td>68.0</td>
<td>62.0</td>
<td>69.0</td>
<td>69.0</td>
<td>78.0</td>
<td>66.0</td>
<td>72.0</td>
</tr>
<tr>
<td>Lipids (%)</td>
<td>7.0</td>
<td>5.0</td>
<td>8.0</td>
<td>1.7</td>
<td>1.3</td>
<td>0.5</td>
<td>3.6</td>
<td>1.3</td>
</tr>
<tr>
<td>Minerals (%)</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.7</td>
<td>1.2</td>
<td>0.6</td>
<td>1.5</td>
<td>2.7</td>
</tr>
<tr>
<td>Energy (Kcal/100 g)</td>
<td>395</td>
<td>391</td>
<td>376</td>
<td>341</td>
<td>336</td>
<td>345</td>
<td>328</td>
<td>328</td>
</tr>
<tr>
<td>Amino acids (g/100 g protein)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leucine</td>
<td>5.7</td>
<td>6.5</td>
<td>4.7</td>
<td>5.8</td>
<td>7.5</td>
<td>8.5</td>
<td>13.0</td>
<td>-</td>
</tr>
<tr>
<td>Isoleucine</td>
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<td>5.8</td>
<td>3.0</td>
<td>3.3</td>
<td>4.0</td>
<td>4.5</td>
<td>4.1</td>
<td>-</td>
</tr>
<tr>
<td>Lysine</td>
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<td>6.0</td>
<td>5.0</td>
<td>2.2</td>
<td>3.0</td>
<td>3.8</td>
<td>2.9</td>
<td>-</td>
</tr>
<tr>
<td>Arginine</td>
<td>6.9</td>
<td>6.7</td>
<td>6.6</td>
<td>3.6</td>
<td>3.8</td>
<td>3.7</td>
<td>2.9</td>
<td>-</td>
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<tr>
<td>Histidine</td>
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<td>2.6</td>
<td>2.5</td>
<td>1.7</td>
<td>1.9</td>
<td>1.9</td>
<td>1.8</td>
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<tr>
<td>Methionine</td>
<td>2.2</td>
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<td>4.0</td>
<td>2.1</td>
<td>3.2</td>
<td>3.0</td>
<td>3.4</td>
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<tr>
<td>Phenylalanine</td>
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<td>3.2</td>
<td>6.4</td>
<td>4.2</td>
<td>8.2</td>
<td>8.4</td>
<td>6.4</td>
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<tr>
<td>Threonine</td>
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<td>3.9</td>
<td>2.9</td>
<td>2.8</td>
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<td>3.9</td>
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<td>Valine</td>
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<td>4.7</td>
<td>6.7</td>
<td>5.6</td>
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<tr>
<td>Tyrosine</td>
<td>3.2</td>
<td>3.2</td>
<td>6.4</td>
<td>8.6</td>
<td>8.2</td>
<td>9.1</td>
<td>4.6</td>
<td>-</td>
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<tr>
<td>Cysteine</td>
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<td>3.7</td>
<td>3.7</td>
<td>3.0</td>
<td>3.4</td>
<td>-</td>
</tr>
</tbody>
</table>

**Nutritional Aspects**

- **Proso millet:** Protein (12.3 g), fat (1.7 g), fibre (0.9 g), carbohydrates (84.4 g), energy (1720 kJ), Ca (13 mg), Fe (2.1 mg), Vit. B₁ (0.17 mg), Vit. B₂ (0.06 mg), niacin (3.5 mg)

- **Foxtail millet:** Protein (10.7 g), fat (3.3 g), fibre (1.4 g), carbohydrates (84.8 g), energy (1736 kJ), Ca (37 mg), Fe (6.2 mg), Vit. B₁ (0.48 mg), Vit. B₂ (0.14 mg), niacin (2.4 mg)

Much research on chenopods was carried out by Partap and Kapoor (1987) and this information has been well synthesized in a monograph on promoting the use and conservation of underutilized crops (IPGRI, 2000). The Himalayan chenopod grains are nutritionally rich (Table 16) and contain a whole set of essential amino acids; they are not only protein-rich but also of good quality. Table 16 provides the comparison of the food value of Himalayan chenopods with other cereal grain crops.

Additional information abstracted from PROSEA - Vegetables (1990) is as follows; all values as per 100 g of edible portion.

**Grain legumes/Pulses**

Table 16, provides the average composition of legume seeds (van der Maesen and Somaatmadjo, 1991). Winged bean has high protein content, and also cystine and threonine. Winged bean appears to be promising as dry grain, though it is not used as a pulse, but more as a vegetable (similar is the case of lablab bean). Other protein rich pulse crops are *Vigna* spp., faba bean and grass pea/*Lathyrus sativus*.

**Vegetables**

Vegetables are the best source for overcoming micronutrient deficiencies. Many indigenous vegetables, especially the leafy vegetables, are rich sources of vitamin A and vitamin C, and minerals like calcium, phosphorus, and sodium, potassium, and many others. Apart from the widely grown species such as *Amaranthus* spp. (amaranth), *Ipomoea aquatica* (kangkong), *Brassica* spp., *Basella alba* (Ceylon spinach), *Moringa oleifera* (drumstick), some less known species viz. *Saururupus androgynus* (chekkurmanis in South India), *Alternanthera sessilis* (ponnanganni greens in South India), *Centella asiatica* (Indian pennywort in South India and Sri Lanka). *Sesbania grandiflora* (agathi in South and east India) are gaining popularity. *Pisonia grandis*, the tree lettuce also falls in this category more as a protected, semi-domesticated, backyard cultigen. Nutritional values varied among the species and depending on the part used. Less known species often recorded high values of some nutrients; similarly values of vitamins and minerals too were high (as compared to reference values in Annexures 1A & 1B). Nutritional values of some of these vegetables are given (per 100 g edible portion) (Gopalakrishnan, 2007; Chadha et al.,
Table 16. Underutilized pulses—composition of legume seeds (per 100 g edible portion) as mass fraction (g/100 g) or for limiting amino acid in total nitrogen (mg/g N) and energy value

<table>
<thead>
<tr>
<th>Pulse/Legume crop</th>
<th>Mass fraction</th>
<th>Limiting amino acids</th>
<th>Energy (kJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>water</td>
<td>protein</td>
<td>fat</td>
</tr>
<tr>
<td>Lablab purpureus</td>
<td>9.6</td>
<td>24.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Lathyrus sativus</td>
<td>10</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Macrotyloma uniflorum</td>
<td>10</td>
<td>22</td>
<td>0.5</td>
</tr>
<tr>
<td>Phaseolus coccineus</td>
<td>12.5</td>
<td>20.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Psophocarpus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tetragonolobus</td>
<td>9.7</td>
<td>32.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Vicia faba</td>
<td>10</td>
<td>26</td>
<td>1</td>
</tr>
<tr>
<td>Vigna aconitifolia</td>
<td>10.8</td>
<td>23.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Vigna angularis</td>
<td>10.8</td>
<td>19.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Vigna mungo</td>
<td>10</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>Vigna umbellata</td>
<td>13.3</td>
<td>20.9</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Source: van der Maesen. and Somatmadja (1991)
Met = Methionine, Cys = Cystine, Thr = Threonine, Try = Tryptophan, Val = Valine, - data not available.
Sauropus androgynus (chekkurmanis): It is commonly known as a multivitamin and multimineral packed leafy vegetable, with high nutritive value. It contains per 100 g edible portion: 6.8 g protein, 3.2 g fat, 1.4 g fibre, 11.6 g carbohydrates, 5706 µg carotene, 247 mg vit. C, 0.48 mg thiamine, 0.32 mg riboflavin, 2.6 mg niacin, 3.4 g minerals, 570 mg Ca, 200 mg P and 28 mg Fe.

Basella alba (Ceylon spinach, malabar spinach, poi): Both green and red leafy types occur; the latter contain per 100 g edible portion: 1.2 g protein, 0.19 g fat, 1.55 g fibre, 0.63 g soluble carbohydrates, 1.8 g minerals, 13.42 mg Ca, 6.48 mg P and 5.16 mg Fe and 113 mg vit. C. The essential amino acids present include arginine, leucine, isoleucine, lysine, threonine and tryptophan.

Alternanthera sessilis (ponnanganni greens): It is of good nutritional value. The greens contain per 100 g edible portion: 5 g protein, 0.7 g fat, 2.8 g fibre, 11.6 g carbohydrates, 1926 µg carotene, 17 mg Vit. C, 0.14 mg riboflavin, 1.2 mg niacin, 60 mg P, 1.6 mg Fe, 2.5 g minerals and 510 mg Ca.

Ipomoea aquatica (water convolvulus): It contains per 100 g edible portion: 2.9 g protein, 1.2 g fibre, 110 mg Ca, 46 mg P, and 3.9 mg Fe, 1980 µg β carotene and 37 mg vitamins. The leaves are a good source of minerals and vitamins especially carotene. The carotenoids include β carotene, xanthophylls and traces of taraxanthin.

Trigonella foenum-graecum (fenugreek, methi): The leaves contain per 100 g edible portion: 4.4 g protein, 0.9 g fat, 1.1 g fibre, 6.0 g carbohydrates, 1.5 g minerals, 395 mg Ca, 51 mg P, 1.93 mg Fe, 33.8 mg Mg, 76 mg Na, 31 K, 96 mg Cu, 229 mg Mn, 400 mg Mo and 358 mg Zn. 2340 µg carotene, 52 mg vit. C, 0.04 mg vit. B1, 0.31 mg vit. B2, 0.8 mg niacin, Flavanoids like taemferol are reported in fenugreek leaves.

Centella asiatica (Indian pennywort): The edible leaves contain per 100 g edible portion: 2.46 g protein, 0.39 g fat, 4.08 g fibre, 2.12 g soluble carbohydrates, 50.85 mg Ca, 7.18 mg P, 20.33 mg Fe, 4007 µg carotene, 127 mg vit. C, 0.69 g oxalate and 0.32 g nitrate (Maya in Chadha et al., 2007). The tender leaves and shoots are used as vegetable in several delicious preparations.

Talinum triangulare (water leaf, Ceylon spinach): It contains per 100 g edible portion: 1.3 g protein, 4.3 g fat, 0.9 g fibre, 31 g carbohydrates, 19 g minerals, 120 mg Ca and 0.9 mg Fe, and 102 mg vit. C.

Sesbania grandiflora (agathi): It is nutritionally valued for its leaves and

2007); values for South Asian vegetables are given by Ghosh and Kalloo (2000, Tech. Bull. 4: 64).
flowers (white and red flowered types occur). The leaves and flowers are rich in minerals and vitamins. The leaves contain per 100 g edible portion 8.4 g protein, 1.4 g fat, 2.2 g fibre, 11.8 g carbohydrates, 3.1 g minerals, 1130 mg Ca, 80 mg P and 3.9 mg Fe, 5400 µg carotene, 169 mg vit. C, 0.21 mg vit. B₁, 0.09 mg vit. B₂ and 1.2 mg niacin.

- **Pisonia grandis/P. alba** (lettuce tree, pisonia): The nutrient content varies with maturity of leaves. The mature leaves contain per 100g edible portion: 5.1 g protein, 2.6 g fat, 10.2 g carbohydrates, 2.6 g minerals, 320 mg Ca, 80 mg P and 2.6 mg Fe. The tender leaves contain 3.6 g protein, 2.2 g fat, 3.2 g carbohydrates, 0.2 g minerals, 170 mg Ca, 60 mg P and 3.6 mg Fe.

The carotene content of leafy vegetables varies from 1926 mg in *Alternanthera sessilis* (ponnanganni greens) to over 10,000 mg in *Colocasia* leaf; agathi and amaranths are also rich in carotenes (5400-5500 mg), as also *Sauropus* (5706 mg), drumstick (6780 mg) and curry leaf (7,500), vit. C from 17 (ponnanganni greens) to 247 mg in *Sauropus androgynus* (chekkurmanis) and iron from 0.9 mg in *Talinum triangulare* (water leaf) to 34.8 mg in *Ipomoea aequatica* (water convolvulus) per 100g edible portion. The antinutrient factors, oxalates and nitrates are present in traces in a few of these minor crops.

- **Abelmoschus manihot** (abika) : Protein (4.1 g), fat (0.4 g), fibre (1 g), carbohydrates (4 g), energy (150 kJ), Vit A (900 IU), Vit C (118 mg), Ca (580 mg), Fe (3 mg).

- **Archidendron jiringa** (jiringa)/pods: Protein (3.09 g), fat (0.1 g), carbohydrates (7 g), Ca (2.1 mg), P (25 mg), Fe (0.7 mg), Vit A (240 IU), Vit. C (20 mg), energy (92 kJ)

- **Asperagus officinalis** (asparagus) shoots : Protein (2.8 g), fat (0.7 g), carbohydrates (2.2 g), Vit. A (980 IU), Vit. B₁ (0.23 mg), Vit. B₂ (0.15 mg), niacin (2.2 mg), Vit. E (48 mg), Ca (24 mg), Fe (1.5 mg), P (52 mg), energy (113 kJ)

- **Canavalia gladiata** (sword bean)/pods : Protein (2.7 g), fat (0.2 g), carbohydrates (0.4 g), fibre (1.5), Vit. A (40 IU), energy (160 kJ)

- **Chrysathemum coronarium** : Protein (1.2-2.7 g), fat (35 g), Vit. A (300 mg), Vit. B₁ (5.15 mg), Vit. B₂ (0.30 mg), Vit. C (17-45 mg), Fe (2.7-4.3 mg)

- **Cichorium endivia** (endive) : Protein (1.2 g), fat (0.1 g), carbohydrates (1.5 g), K (300 mg), Ca (20-80 mg), P (20-70 mg), Mg (14-20 mg), Fe (0.7-2 mg), Vit. A (1600-3200 IU), Vit. B (0.2 mg), Ca (5.6 mg), niacin (0.4-0.5 mg)

- **Limnocharis flava** (Yellow Sawah lettuce) : Protein (1 g), fat (0.3 g) carbohydrates (0.5 g), Vit. A (5000 IU), Vit. B₁ (0.7 mg)
- *Lycium chinense* (Chinese wolfberry): Protein (3.9 g), fat (0.6 g), carbohydrates (3.9 g), fibre (1.9 g), Vit. B₁ (0.08 mg), Vit. B₂ (0.3 mg), Vit. C (8 mg), Ca (142 mg), P (41 mg), Fe (5.2 mg), niacin (184 mg), K (498 mg), energy (158 kj/100 g)

- *Melianthus suavis*: Protein (8.2 g), carbohydrates (10.0 g), fibre (3.4 g), Ca (2.6 mg), Vit. C (115 mg), energy (300 kj/100 g)

- *Neptunia prostrata*: Protein (6.4 g), fat (0.4 g), carbohydrates (0.4 g), fibre (1.8 g), Ca (2.87 mg), P (7 mg), Fe (5.3 mg), Vit. A (5155 IU), Vit. B₁ (0.12 mg), Vit. B₂ (0.14 mg), niacin (3.2 mg), Vit. C (1.8 mg), energy (134 kj/100 g)

- *Parkia speciosa* (seeds): Protein (5 g), fat (0.4 g), carbohydrates (11 g), Ca (20 mg), P (83 mg), Fe (1 mg), Vit. A (234 IU), Vit. B₁ (0.5 mg), Vit. B₂ (0.01 mg), niacin (1 mg), Vit. C (6 mg), energy (130 kj/100 g)

- *Portulaca oleracea* (purslane): Protein (1.7 g), fat (0.4 g), carbohydrates (3.8 g), Ca (103 mg), P (39 mg), Fe (3.6 mg), Vit. A (2550 IU), Vit. B₁ (0.03 mg), Vit. C (25 mg), energy (825 kj/100 g)

- *Rorippa heterophylla* (a medicinal plant): Protein (1.7-209 g), fat (0.1-0.3 g), carbohydrates (30-40 mg), fibre (0.8-1.1 g), Ca (64-182 mg), P (27-46 mg), Fe (1.22-5 mg), Vit. A (2420 IU), Vit. B₁ (0.03-0.08 mg), Vit. B₂ (0.22-0.27 mg), Vit. C (45-50 mg), energy (70-118 kj/100 g)

- *Rungia klossii*: Protein (25-5 g), Ca (272 mg), energy (138 kj/100 g)

- *Sechium edule* (pitpit, chow-chow): Protein (3.8-4.1 g), carbohydrates (6.7-7.6 mg), fibre (0.7 g), Ca (90 mg), Fe (0.4-2.1 mg), Vit. C (21 mg), energy (143-160 kj/100 g)

- *Talinum triangulare*: Protein (1.9-2.4 g), fat (0.4-0.9 g), carbohydrates (3.2-4.0 g), fibre (0.6-1.1 g), Ca (90-135 mg), Fe (4.8-5.0 mg), Vit. B₁ (0.8 mg), Vit. B₂ (1.8 mg), niacin (0.30 mg), Vit. C (31 mg), energy (105 kj/100 g)

- *Tetragonia tetragonoides* (New Zealand spinach): Protein (1-2 g), fat (0.3 g), carbohydrates (3-5 g), Ca (58-180 mg), Fe (2.5-3.8 mg), Vit. B₁ (0.08 mg), Vit. B₂ (0.20 mg), niacin (0.5 mg), Vit. C (25-50 mg), energy (80 kj/100 g)

- *Zizania latifolia*: Protein (1.7 g), carbohydrates (4.2 g), fibre (cellulose 1.6 g), Ca (2.1 mg), P (80 mg), Fe (1.2 mg), Vit. C (2.0 mg), energy (109 kj/100 g)

The proximate principles in vegetables viz., vitamin contents also vary much among vegetable species. Information synthesised is as follows (all values given are per 100 g of edible portion, Annexures 1a & b).

- *Rich in protein* (g): Leafy types *Sesbania grandiflora* (8.4), *Amaranthus* and Chenopods,
Diversity in Underutilized Plant Species - an Asia-Pacific Perspective

- Fenugreek and brassica (3.0-5.2), Sauropus androgynus (6.8), Murraya koenigii (6.1), Moringa oleifera leaves (6.7), garden cress (5.8), mananthakali/Solanum leaves (5.9), fruit types: Phaseolus coccineus (7.4), Vicia faba (4.5), field bean (3.8), cluster bean (3.2).

- Rich in fats (g): Sesbania grandiflora (1.4), Sauropus androgynus (3.2), Colocasia leaves (black 2.8, green 1.5), Murraya koenigii (1.0), Moringa oleifera (1.7), Trigonella foenum-graecum (0.9), garden cress (1.0), lettuce tree (2.2), celery (2.1), mananthakali/Solanum leaves (0.9-1.2); in fruit-types: Momordica charantia (1.0), Phaseolus coccineus (1.0).

- Rich in carbohydrates (g): Sesbania grandiflora (11.8), Amaranthus sp. (7.0-8.5), Colocasia leaves (6.8, 8.1), Murraya koenigii (18.7), Moringa oleifera (12.5), garden cress (8.7), Sauropus androgynus (11.6), mananthakali (8.9), Alternanthera sessilis (11.6); fruit-types: guar (10.6), Abelmoschus esculentus (6.4), faba bean/lablab (6.7-7.2), Phaseolus coccineus (29.8).

- Rich in minerals (g): Chenopodium album (2.6), Sesbania grandiflora (3.1), Sauropus androgynus (3.4), Amaranthus sp. (2.8-3.6), Colocasia leaves (black 2.5, green 2.2), Murraya koenigii (4.0), Ipomoea aquatica (2.1), Moringa oleifera (2.3), garden cress (2.2), Pisonia (2.2), Mananthakali leaves (2.1) Alternanthera sessilis (2.5); fruit-types: Phaseolus coccineus (1.6), Momordica charantia (1.4), Trigonella foenum-graecum (1.5), Cyamopsis tetragonolobus (1.9), Moringa oleifera (2.0).

- Rich in fibre (g): Sesbania grandiflora (2.2), Amaranthus spp. (1.5-6.1), Colocasia leaves (2.9), Murraya koenigii (6.4), Sauropus androgynus (1.4), Alternanthera sessilis (2.8); fruit-types: Cyamopsis tetragonoloba (3.2), Moringa oleifera (4.8), Phaseolus coccineus (1.9), Momordica charantia (1.7), broad bean (2.0).

- Rich in calcium (mg): Sesbania grandiflora (1130), Sauropus androgynus (570), Amaranthus spp. (200-800), Colocasia leaves (480), Moringa oleifera (440), Trigonella foenum-graecum (395), Murraya koenigii (830), garden cress (380), mananthakali leaves (410), Alternanthera sessilis (510).

- Rich in phosphorus (mg): Sesbania grandiflora (80), Amaranthus gangeticus (83), Chenopodium album (80), Sauropus androgynus (200), Colocasia leaves (125), Murraya koenigii (57), Moringa oleifera (70), mananthakali (70), Alternanthera sessilis (51), Phaseolus coccineus (160), Momordica charantia (70), Vicia faba (64), Cyamopsis tetragonoloba (57), Moringa oleifera (110), Abelmoschus esculentus (56), Allium leaves (70).
Rich in iron (mg): Sesbania grandiflora (3.9), Amaranthus sp. (8.7-38.5), Chenopodium album (4.2), Sauropus androgynus (28.0), Colocasia leaves (10.0), garden cress (28.6), Ipomoea aquatica (3.9), mananthakali leaves (20.5), Brassica spp./ mustard leaves (16.3); fruit-types: Phaseolus coccineus (2.6), Momordica charantia (2.0).

Energy (K cal) Sesbania grandiflora (93), Sauropus androgynus (103), Colocasia leaves (77), Murraya koenigii (108), Moringa oleifera (92), garden cress (67), mananthakali leaves (68), Alternanthera sessilis (73), fruits type: Phaseolus coccineus (158), Momordica charantia (60), Moringa oleifera (50), jackfruit (51), broad bean/field bean (48).

Rich source of vitamins (values per 100 g of edible portion)

Rich in Vit. C (mg): Sesbania grandiflora (169), Amaranthus viridis (179), A. gangeticus (99), Sauropus androgynus (247), drumstick (leaves 200: fruit 120), Momordica charantia (96).

Rich in thiamine (mg): Sauropus androgynus (0.48), Sesbania grandiflora (0.21), Colocasia leaves (0.22), Phaseolus coccineus (0.34), Allium leaves (0.59).

Rich in niacin (mg): Sauropus androgynus (2.6), Colocasia leaves (1.9), Murraya koenigii (2.3), relatively low in Sesbania grandiflora, Amaranthus gangeticus, Alternanthera sessilis (1.2).

Rich in carotene (µg): Sesbania grandiflora (5,400), Amaranthus gangeticus (5,520), Sauropus androgynus (5,706), Colocasia leaves (black 12,000, green 10, 278), Murraya koenigii (7,560), Moringa oleifera (6,780), relatively low in Trigonella foenum-graecum (2,340), Ipomoea aquatica (1,980), Brassica/mustard (2,620), Alternanthera sessilis (1,926).

Rich in folic acid (mg): free- Amaranthus gangeticus (41.0), Murraya koenigii (23.5); total - A. gangeticus (149.0), M. koenigii (93.1), Colocasia leaves (54.0), Cyamopsis tetragonoloba (50.0), Abelmoschus esculentus (25.3).

Rich in proline (mg): Amaranthus gangeticus (31), Lactuca sativa (178).

Fruits and Nuts

Underutilized fruits and nuts are rich sources of protein, fat, carbohydrates, minerals and vitamins. Annexure II lists selected species for Asia and the Pacific region (abstracted from Pareek et al., 1998). Some promising species with specific properties/ nutritive values (per 100 g) are dealt with below. For botanical names refer Chapter II and Annexure II.

Rich in protein (g): gallo nut (10.7), breadfruit seed (5.25-
• **Rich in fat (g):** gallo nut (7.5), breadfruit seeds (2.59-29.0), chironji (59.1), pili nut (73.2-75.9), hazelnut (54-62.4), durian (2.5-3.0), wood apple (pulp 1.2-3.47, seeds 27.0), Lecythis (62.0), macadamia nut (71.0), madhuca kernel (51.0), chilgoza pine nut (49.9), pistachio (54.09), Indian almond (52-56).

• **Rich in fibre (g):** gallo nut (7.2), chempadak (3-4), chironji (38), pili nut (2.3-3.8), ker/unripe (12.32), carob tree (7.7), wood apple (5.0), tahiti chestnut (4.4), Lecythis (8), Indian almond (1.80-4.6).

• **Rich in carbohydrates (g):** gallo nut (765), chempadak (84-87), ker (71) chinese hazelnut (832), sweet chestnut (42.1), carol tree (80.7), gorgan nut (76.9), melingo (50.0-52.9), tahiti chestnut (82.8), lotus seeds (70.2-76.2), date palm (39.8), tamarind (61.4).

• **Rich in calcium (mg):** bael (85), monkey jack (58), chironji (2791), pili nut (130-180), ker (210-360), carob tree (352), hazelnut (201-209), longan dry (95), kumquat (266), khirni (83), lotus (139-330), chilgoza pine nut (90.8), pistachio (140), pilu (630), tamarind (pulp 99, seed 170), Indian almond (up to 957).

• **Rich in phosphorus (mg):** kiwi fruit (64), bael (50), breadfruit (52-88), chironji (528), pili nut (71-591), ker (60), chinese chestnut (168), hazelnut (337-462), longan dry (196), gorgan nut (90), macadamia nut (161), chilgoza pine nut (929), pilu (167), tamarind (pulp 98, seed 110), Indian almond (950).

• **Rich in iron (mg):** custard apple (0.28-1.34), breadfruit (0.4-1.5; seed 3.78-6.7) chironji (8.5), pili nut (3.9-4.8), chinese chestnut (3.8), hazelnut (3.4-4.5), longan dry (5.4), Ceylon gooseberry (0.81-1.4), mangosteen (392 µg carotene), macadamia nut (20), lotus (7.1), chilgoza pine nut (3.6), pistachio (14.0), pilu (8.0), tamarind (10.9), Indian almond (9.2).

• **Rich in vitamins:** durian (208-593), kumquat (2550), seabuckthorn (6833) kuwini (600), khirni (675), passion fruit (700), pistachio (100-240), canestal (550-2000), Pouteria (1500), zapote (75-1108), water apple (253), rose apple (235).

• **Vit. A (IU):** kiwi fruit (175), soursop (180), breadfruit (280), jackfruit (100-540), carambola (upto 920), ker (500, unripe-900), karonda
Nutritional Aspects

Vit. C, ascorbic acid (mg): kiwi fruit (105), monkey jack (182), ker (119-233), sour lime (308), Indian gooseberry (500-625), kumquat (151), seabuckthorn (750), malabar tamarind (138) jujube (76), tamarind (fruit 0.10-0.14; seed 33).

Riboflavin (mg): bael (1.19-1.2), breadfruit (0.25-0.88), jackfruit seed (0.95-1.04).

Thiamin (mg): cherimoya (0.13-0.14), custard apple (0.11-0.17).

Niacin (mg): bael (1.1), sour sop (0.8-1.26), custard apple (0.5-1.2), breadfruit (0.7-1.5), chironji (1.5), Chinese chestnut (194), camino star apple (0.8-1.39), tree tomato (1-10-1.38), lotus (1.9-2.8), banana passion fruit (2.5), chilgoza pine nut (3.6), canistel (3.72), zapote/ sapota (258).

Calories (K cal): bael (137), custard apple (80-101), breadfruit (112-160), jackfruit (72-94), marang (63-122), chironji (654), pili nut (699-714), Chinese chestnut (403), sweet chestnut (174), hazelnut (620-632), longan dry (286), durian (144), wood apple (97-174), tahiti chestnut (246), macadamia nut (691), lotus seed (318-390), date palm (144), chilgoza pine nut (615), pistachio (626), ambarella/ Spondias (95-157.3), tamarind (115-214), Indian almond (574-607), jujube (105).
V. Emerging Concerns

The account presented provides a synthesis of available information on the plant genetic wealth of underutilized and less known cultivated food plants for different geographical regions of crop plant diversity within the Asia-Pacific region, based on plant-part used i.e. grain, roots/tubers, leaves, fruits and nuts. It is evident from this account that only limited diversity is widely grown; many of these plants as cultigen are still confined to home gardens/backyards. Also several of these are still under domestication within the narrow range of their distribution. Many of such little known food plants present cases of folk domestication and a large percentage of such species occurs in areas rich in endemic plant wealth and are grown by native inhabitants. The widely grown category is of species with local selections well adapted to diverse habitats, to suit specific agro-eco-climates. Often, this diversity may exhibit a sporadic and discontinuous distribution. In a distinct category is represented by species, comparatively better known and introduced from one region to another; much selection have taken place consciously or otherwise, depending on the need of the society utilising such food plants. Thus, genetic diversity exploited differs in different regions, depending upon native richness of useful food plant resources. By and large, local/ native edible types still constitute a rich reservoir of underutilized diversity, awaiting exploitation and chapter II and III provide a broad perspective of assessment of diversity of such species with emphasis on their and distribution utilization and developmental aspect. The potential of some selected species is further highlighted in chapter IV with emphasis on their food/nutrition value. This chapter highlights the associated emerging concerns in promoting these underutilized plant species which have been receiving due emphasis by Bioversity International, and ICUC in particular (William and Haq, 2002; Padulosi et al., 2002; Jaenicke et al., 2006; Abeyrathne et al., 2006; Dawson and Jaenicke, 2006; Dhaeranath et al., 2006; Barry, 2007; Danieys et al., 2007; Dawson et al., 2007). An overview is presented in this chapter.

1. Diversity distribution/assessment

The plant diversity of underutilized species, minor crops, etc. dealt with
in chapter II, recording 588 species, mainly exhibits the following distribution patterns:

(a) Species that have narrow range of distribution as cultigens within their distributional range.

(b) The geographical range is wide and the species are grown within this range exhibiting continuous or sporadic distribution.

(c) The exotic species after introduction mostly got adapted to regions away from their place of origin, but in similar agroclimates (chapter II). In the region of introduction, depending on their acceptability and local needs, the cultigens either got diversified increasing their agro-ecological range vis-à-vis distribution or gradually shrank in their distributional range remaining localized to their initial area of introduction, with sporadic distributional range.

The analysis of distribution for each category of underutilized species is given in chapter II (pseudocereals and millets, grain legumes/pulses, roots and tubers, vegetables, fruits, nuts and those used as spices and condiments). However, assessment of diversity both for widely grown and sparsely cultivated types by and large is still not well documented. This information is important and constitutes a pre-requisite for planning further collecting and prioritization/identity of future priority species for R&D needs in national and regional context.

Also, this documentation assumes concern for the rare, less grown species as listed in Table 12. The diversity in these is not well assessed and if national programmes are not taking care of such species, these may be under threat. Safeguarding/conserving such diversity in national seed/field genebank is of prime importance.

2. Biotechnology applications

The wider application of biotechnology can provide ample scope to realize the full potential of underutilized species in achieving increased yield and production, better quality, improve disease/pest resistance and improvement for desirable traits/components including nutritional aspects, improved post-harvest technology and shelf-life, storage of produce and products, and in underutilized species of commercial value and meeting market needs. However, the initial major role of biotechnology is to: (i) enhance availability of material for use through tissue culture and micropropagation and (ii) through molecular marker studies to characterize genetic diversity. Some of these concerns have been highlighted by Dawson and Jaenicke (2006):

- **Tissue culture and micropropagation:**
  This study assumes importance in the above context in addressing the application of biotechnology. Activities have been undertaken on a number of underutilised species, including *in vitro* propagation
Diversity in Underutilized Plant Species - An Asia-Pacific Perspective

(normally via microcuttings, somatic embryogenesis) of *Abelmoschus manihot* (abika), *Aegle marmelos* (bael), *Lablab purpureus* (hyacinth bean), *Plectranthus esculentus* and *Sesamum indicum* (sesame). Distribution of virus-free planting materials has been achieved as for example in taro, and cryopreservation techniques have been applied such as in jackfruit.

- **Characterizing genetic diversity:** Another application of biotechnology that would need focus is genetic diversity studies, and some such examples are of: *Artocarpus heterophyllus* (jackfruit; isozyme study, among accessions), *Diospyros kaki* (persimmon; SSR development), *Eleusine coracana* (finger millet; a wide variety of techniques, including isozymes, ISSRs, RAPDs and RFLPs, among accessions and related species; EST-SSR and EST-SNP development), *Metroxylon sagu* (sago palm; AFLPs, among accessions, and population combined with morphological analysis; *Sesamum indicum* (sesame; AFCP, among accessions; SSR development).

Biotechnology is a rapidly developing field and possibly the applications of available techniques is to be carefully conceived for specific priority species on one hand to achieve the above goals, and, on the other differently applied to rare and endangered, less known underutilized species and narrow endemic-taxa as listed in Table 12, to take care of their multiplication-conservation needs through diverse biotechnologies. Also, vegetatively propagated species of tuber crops, fruits, bamboos, etc. would need special focus.

Overall, practical applications of biotechnology are to be given high priority, taking farmers’ needs for greater access to selected material of underutilized species of proven potential, and to fit into suitable agricultural diversification systems to enhance food and agricultural production. Greater focus on biotechnology will thus include: (i) new methods for collecting and storing genetic materials as seed and tissue culture, (ii) detection and elimination of diseases/pests, (iii) identification of useful promising genes, (iv) improved techniques for long-term storage, and (v) safe and more efficient distribution of germplasm to users. In achieving these objectives, both the approaches – application of conventional technology and the modern biotechnological tools, as required need to be promoted (Dawson and Jaenicke, 2006).

3. Documenting indigenous knowledge/Ethnobotanical information

It is a known fact that native, rural, traditional communities have been and still are, the custodian of indigenous knowledge (IK) on the biodiversity maintained by them for their livelihood. Farmers have managed diverse plant
species under subsistence agriculture for their multifarious needs, including nutritional and social needs as food preferences and customs of plant use are deeply embedded in their culture. The immense diversity of traditional farming systems is the product of human innovation, more based on local experimentation. This includes their farming techniques, harvesting and using plant diversity and also conserving this diversity. In their ‘use’ efforts, there are different local preparations and oral knowledge about all these aspects that reflects value additions as well, and this knowledge has been passed on from generation to generation and is held by the communities and/or elderly individuals and these needs to be recorded. Some efforts have been done on this aspect. Overall, this accumulated indigenous knowledge on underutilized plant species needs to be tapped and well documented and scientifically authenticated for its wider application and use by society. For generations, under subsistence agriculture, farmers have been selecting and gathering plants from the wild/semi-wild habitats that have long been accepted as ‘food’, and protecting these. At least 1000 million people are estimated to use such traditional plants to meet their daily needs. These are essential to the rural households (FAO, 1993). In centres of diversity of crop plants in particular, semi-domesticated and gathered diversity from natural habitats still helps support household food security and also healthcare through use of indigenous/herbal medicines. However, this local knowledge on use of species over past generations has fast eroded vis-à-vis information on traditional use of such diversity of locally grown underutilized species in centres of diversity of crop plants. In locating and assessing such diversity, more focus needs to be given to the wider role of ethnobotany (Barrau, 1989; Jain, 1996; Arora, 1996; 1997). The role of ethnobotany/application of ethnobotany in conservation of native plant genetic diversity and use, and in community development has been highlighted by Martin (2007) by focusing on the ways the local cultures classify, manage and use plant genetic resources or locating new and more valued use of these resources. Ethnobotany is directly linked to promote the role of local people in the management of agribiodiversity through more participatory approaches in ethnobotanical studies. Wider applications of ethnobotany in human welfare have been well addressed by Jain (1996).

4. Ecological security/habitat protection

Human destruction of natural habitats, whether exploited for commercial growing needs or subsistence cultivation, is presently one of the major ecological threats. As a result, there has been pressure on natural/wild vegetation sites and due to ecological imbalance the original habitats are lost, and so also the native plant diversity occurring here. In each of such habitats, several underutilized, minor, less known species
occur (see chapter II) and these need to be collected and conserved, and studied for their use to meet social and economic needs of the rural poor. Many of these species are well-adapted to wastelands, non-agricultural land, thus adding to local village/state development needs in a cost-effective manner as these can be grown under local low input conditions. Also, new crops, with good economic returns need to be identified for such habitats e.g. *Jatropha* crop for industrial oil use.

5. Utilization and conservation aspects

Use as food

In the enumeration of underutilized species (chapter II), about 100 species are such for which one or more plant-parts are used as food. This is particularly so in case of root/tuber and vegetable crops. The native communities helped to assess/identify the edible kinds which initially got into the folk domestication process and gradually spread. Eventually, some of these were accepted by the urban society as well and put to more than one use depending on their need/food habit. Thus, the cultivation-utilization linked trend that evolved through overall choice of plant diversity by the native, rural, and urban communities has gradually increased diversity within species and different species for the specific kind of material required to be grown, but the initial need was for multipurpose use. Among the root/tuber/bulbous types, several *Allium* species apart from their bulbs, are used as vegetable i.e., *Allium fistulosum*, *A. ascalonicum*, *A. tuberosum*. In *Calystegia sepium* and *Tragopogon* spp., young shoots are cooked into vegetable; in *Nelumbo nucifera*, apart from rhizome, cooked as vegetable and also pickled, leaves are cooked as vegetable and in *Sagittaria sagittifolia*, young sprouts are utilised. Even in the more acceptable types like taros and *Xanthosoma*, several locally improved types are grown where besides tubers; leaves are also cooked as vegetable. Dual purpose types occur in *Amaranthus* spp., where apart from edible grains, leaves are also consumed i.e. *Cryptotaenia canadensis* and *Houttuynia cordata*. In several species both young pods/fruits and roots are used, as in *Mucuna* spp., *Phaseolus coccineus*, *Psophocarpus tetragonolobus* and *Sechium edule*. In others, young pods are cooked as vegetable i.e. *Canavalia ensiformis*. Further, some types are put to multipurpose usages i.e. *A. grayi*, where leaves are used as a pot herb and for flavouring as condiments, *A. kurrat* shoots are used in soups and salad, in *Asparagus officinalis* leaves are used as vegetable and shoot/stem is eaten boiled and also/pickled. Several vegetables-*Lepidium*, *Lactuca*, *Brassica* spp. are consumed as salad. Among fruits, apart from the sweet pulp, seed/kernel is eaten raw i.e. *Prunus armeniaca*, *P. mume* or roasted-*Artocarpus camansi,*
jackfruit and other Artocarpus spp. and in some, apart from fruit, leaves are used as vegetable i.e. Salvadorapersica. Fruits of many species apart from being eaten raw, are also pickled i.e. Artocarpus, Bouea, Capparis, Cordia, Carissa, Mangifera, and are also made into preserves i.e., Carissa congesta; and in others apart from being eaten raw, made into beverage/sharbat/drinks i.e., Aegle marmelos, Averrhoa spp., Feronia limonia, Garcinia indica, Grewia subinaequalis and Chaenomeles speciosa. The berries of Crataegus pentagyna are eaten raw, stewed and also preserved; fruits of Emblica officinalis are both pickled and preserved, of Dovyalis spp., eaten raw and made into jelly/preserves. In some species, the fruit is used for pickles as in Elaeocapus floribundus, or is only edible when ripe in Eugenia, Fortunella and/or is used in salad in Averrhoa carambola, Citrus spp.

**Nutrition and healthcare: Quality of produce**

The underutilized species provide rich nutritional foods and need to be promoted. As pointed out by Padulosi et al. (2002), a change in attitude has been noticed over the last 5-10 years among policy makers and the public with regard to the quality of life as related to the quality of food as well as diverse sources of food, vitamins and other micronutrients. These are, for instance, being searched for in crops and plant species with greater emphasis, much more than in the past, in recognition of their role in combating diet imbalances. Chapter IV on nutritional aspects amply supports the need to exploit underutilized species as these are nutritionally rich and this concern is of national/regional and international interest. However, much work is required towards standardization of produce/products; nutritional analysis composition for which varying figures have been repeated. Another concern is on healthcare, and underutilized crops are often presented as new crops (Vietmeyer, 1990), when interest of researchers, and the commercial sector focus on these to exploit their potential, for use in healthcare/medicine. In this context much focus is also on emerging indigenous underutilized species as crops (Considine, 1996; Arora, 1997).

**Promising as breeding material**

Several of these less known food plants possess specific/desirable attributes of utility in breeding programmes. These species are related to other cultivated types and can be crossed; are tolerant to pests and diseases and possess promising yield and quality traits. Particularly, being adapted to diverse eco-climates/extreme climatic stress, these provide useful germplasm for introducing tolerance to drought and cold. Broadly, such plant genetic wealth belongs to the following categories:

1. Many species possess good quality fruits/nuts and after selection directly or through breeding can be improved for full exploitation. Artocarpus odoratissimus, Casimiroa edulis, Chrysophyllum cainito,
Dovyalis caffra, Dimocarpus longan, Pouteria spp., Garcinia indica, G. gummi-gutta, Malpighia spp., Nephelium rambutan-Ake, Passiflora spp., (P. multiflora, P. caerulea), Sandoricum koetjape, Spondias spp., Syzygium spp., Buchanania lanzan, Gnetum gnemon, Juglans ailantifolia, and Terminalia catappa are some of the species that deserve prominence. In several of these, locally improved types also occur. Besides several of such species possess specific traits and act as donors for introducing such useful attributes; Nephelium rambutan-ake fruits have excellent flavour; Artocarpus odoratissimus fruits are small, sweet and juicy. Prunus salicina has been much used in improving fruit quality by crossing with other Prunus spp.

2. Some species provide useful rootstocks i.e., Citrus ichangensis (frost hardy type), C. junos (frost resistance), Malus sylvestris (winter hardy), Prunus cerasifera (for grafting plum cultivars).

3. More important are species which can be crossed with others and utilised as breeding material viz. Actinidia callosa crosses with A. deliciosa, Mespilus germanica with Prunus spp., Pyrus pyrifolia with other related taxa/species and species within the Mangifera gene pool with M. indica complex. Among other promising material, Citrus junos deserves special mention, where by introgression, characters of 12 Japanese and Chinese wild types of citrus have been utilized in Zuzu (Tanaka, 1976).

4. As many of these species occur in diverse and harsh climates and under ecological stress, these provide sources of resistance to drought and cold/frost such as Pyrus communis and P. pyrifolia, drought and/ or heat resistance in Pyrus prunifolia; frost resistance in Actinidia callosa, A. mandschurica, Malus baccata (withstands -40°C) and extreme cold tolerance, and in Vitis amurensis can be utilized for such specific traits.

5. Several types exhibit disease resistance-mildew resistant types in Ribes spp., and aphid resistant and rust resistant types in Rubus spp. Resistance to Phylloxera occurs in Vitis spp.

This amply points out to the importance of less known, minor species grown sparingly, often in backyards/home gardens and marginal lands, and such protected diversity maintained by native farmers.

**Conservation aspects**

A holistic approach to conservation of undertutilized species needs to be effectively planned following both the ex situ and in situ techniques and complementary conservation strategies. As pointed out by Padulose et. al. (2002), a very meagre collection of these species is currently held in genebanks worldwide. Thus this aspect
emerging concerns

assumes global concern and for the Asia-Pacific region, this responsibility needs to be shared collectively by well established national programmes and regional and international organizations. In the last few decades good work has been carried out in India, Nepal (South Asia); Malaysia, Thailand, Vietnam, Philippines, Indonesia (southeast China, Japan, South Korea East Asia/ PNG, and Vanuatu in the South Pacific and also in Australia; the national programmes of these countries have laid due priority on R&D. Some of the countries such as India have a separate coordinated programme on underutilized crops involving several species and a separate Indian Institute for Vegetable Research (IIVR) and Indian Institute of Horticultural Research (IIHR) among so many others. Specific crop institutes and PGR-related institutes exist in Thailand, Indonesia, Philippines, Vietnam and in PNG etc. also to take care of some important underutilized crops as per national needs. As these crops are difficult to maintain, particularly roots/tubers, fruits and nuts, being largely vegetatively propagated, diverse in vitro, cryopreservation techniques are to be followed in India and China. Good field genebanks exist in the above countries/institutes and can share responsibilities to safeguard such diversity of the sub-region/region; international organisations such as Bioversity International, ICUC, AVRDC, ICRISAT can help provide funding support and expertise; and national programmes can also be directly given such support by GCDT for regeneration, maintenance and conservation of the germplasm held by them. Capacity building in this sector is much needed and training aspects at regional levels need more focus.

Also, special focus is to be given to conserve priority species/underutilized diversity as already stressed in chapter III/ see tables 11 & 12.

A regional frame work can be developed for crops, regions and countries/national programmes involved, and sub-regional workshops be organized and working groups identified to assess needs; participating organizations invited in a networking, collaborative mode to prioritise diverse conservation approaches for effective implementation in the regional context.

6. Benefits and constraints

The above synthesis amply brings out that man’s exploitation of economic plants to provide him with food has extended to different geographical areas and in this continuing effort, more information is now available on newer areas of distribution of such plants and on new/less known plant resources. The number of such exploitable kinds will obviously increase as more areas are tapped for germplasm collection and utilization, particularly the underexplored regions of diversity of crop plants. Such areas which hold rich reservoir of diverse gene pools of underutilized species need to be explored for their eventual utility vis-à-vis conservation for posterity.
Williams and Haq (2002) point out to the following major benefits of underutilized species and constraints in their use.

- **Underutilized species contribute to:**
  - Household livelihoods; alleviating poverty, generating income and strengthening local economies; maintaining biodiversity; maintaining traditional subsistence farming systems; sustaining the environment; saving lives during calamities; maintaining social structures.

- **Use of underutilized species is hampered by:**
  - Poor information on production, nutritional value, consumption patterns and use; poor information on economic benefits and market opportunities; few improved planting materials; lack of improved production technologies leading to low yields; post-harvest and transport losses; lack of marketing channels; discouraging national policies; unsupportive extension services, poor credit and investment services.

Padulosi et al. (2002) also pointed out to many of these diverse constraints that are linked to the promotion of underutilized species: low competitiveness, lack of knowledge on genetic diversity assessment and use, loss of traditional knowledge, lack of market, poor commercialization demand/limitations, low income generation, lack of propagation techniques, less knowledge on cultural practices, lack of attractive traits and above all national policy and legislation. Further, they also stressed for greater emphasis on R&D to generate technologies, more effective utilization of species’ use, diverse use, production-consumption aspects, better management and marketing system, storage and conservation, and effective partnership/coordination/ linkage. The international workshop on underutilized species and poverty alleviation by Capacity Building International (Gundel et al., 2003) discussed specific concerns on (i) promotion and development of underutilized plant species vis-à-vis their contribution to food security and healthcare; (ii) income generation and local economies; (iii) non-material benefits; and (iv) biodiversity and environmental services.

The workshop identified range of strategic measures for the promotion and sustainable utilization of underutilized plant species, namely, conservation, improvement and access; post-harvest handling and processing; policy and legislation; awareness creation; marketing; capacity building; information generation and management and inter-sectoral interventions.

The workshop on underutilized species organized by ICUC (Jaenicke et al., 2006), in the above context pointed to the following key areas for providing thrust to promote development and utilization of underutilized species vis-à-vis their sustainability (rearranged here):
(i) **Management concerns**: such as greater awareness, strong policy support, more focussed research and development activities to promote underutilized species and funding for greater coordination with stakeholders.

(ii) **Research thrust**: participatory approaches, increase in production and local consumption, increase in processing and marketing.

(iii) **Operational mechanism in place**: institutional vehicles established, strong national commitment, knowledge sharing strengthened, better interaction and collaboration.

(iv) **Diversifying use**: value chains well established, underutilized species used for food and also for medicine, cosmetics and supplements, underutilized species available in mainstream commercial sector.

(v) **Other benefits**: greater opportunities of income generation with more product development, underutilized species contributing significantly to the national agricultural GDP, to food security and poverty reduction, supporting livelihoods.

Taking an overall view, some of the common major constraints for underutilized species development in achieving desired goals pertain to: lack of awareness, marketing, coordination, policy/legal framework, resources, knowledge and information, apart from others, many of which have been, to some extent, addressed by the national programmes.

7. **Networking and partnership**

The two leading organizations engaged in this activity for promoting underutilized species are Bioversity International (formerly IPGRI) and International Centre for Underutilized Crops (ICUC), and their efforts over the past two decades have been successful particularly in addressing/providing thrust on conservation, and use of underutilized tropical fruits (IPGRI, 2003; ICUC, 2006). Still ample promotional activities are needed.

Participatory research should be actively pursued among stakeholders in areas such as constraint analysis/production to consumption, evaluation of material with farmers and local NGOs, strengthening seed supply system, educating farmers and involving them in promoting participatory plant breeding activities (Padulosi et al., 2002). There is thus need for development of sustainable linkages between organizations, farmers, and consumers. Efforts are required to address constraints through networking and coordination. ICAR system also has been instrumental in reaching to farmers a great deal through its National Agriculture Innovation Project recently. Significant progress has been achieved by IPGRI managed networks/coordinated programmes (see expert consultation proceedings APAARI, 2007) also, R&D thrust needed at national, regional and international levels, keeping interests of the poor farmers and meeting their needs. This effort is well linked to maintenance of diversity vis-à-vis...
use and strengthening sustainability of production. A good monitoring system has to be in place for assessing the impact of such improvement/promotion process through appropriately addressing conservation and utilization aspects, agronomic aspects, policy-level aspects (IPGRI, 2002; ADD final project report on tropical fruits), and the ongoing programme of ICUC/UTFANET in the Asia-Pacific region.

8. Further thrust

The International Symposium on “Underutilized Plants for Food, Nutrition, Income and Sustainable Development”, in Arusha, Tanzania from 3-7 March 2008, and its follow through on electronic discussion forum mainly focussed on four themes:

1. **Climate change**: Potential of underutilized plant species as risk buffers in times of climate change

2. **Nutrition**: Underutilized plant species to improve nutrition and health

3. **Market access**: Underutilized plant species for diversification of farm income

4. **Agrobiodiversity**: Underutilized plant species for diversification of agricultural systems

To increase the contribution of underutilized plant species, further action/collaboration is required as follows (information taken from GFU note).

- Create and manage a bibliography and database of underutilized plant species, nutritive values, successful and unsuccessful case studies, resilience to climate change and information on genetics.
- Involve communities and research scientists in conservation and crop improvement, including information gathering, knowledge sharing and dissemination.
- Implement a global breeding initiative for a selected set of underutilized crops.
- Create awareness on underutilized plant species contribution to local nutrition, income, ecosystem health and farm productivity.
- Implement and document economic and market studies of different aspects of value chains for underutilized plants, and pilot a number of global marketing initiatives in public-private partnerships.
- Develop guidelines of best practices for sustainable use of underutilized plant species.
- Identify, publish and disseminate case studies illustrating successful approaches in sustainable use of such species to improve rural health and economies.
- Pursue funding for research and development of underutilized plant species.

Working together across the full spectrum of disciplines, from crop breeding to socio-political policy, it is believed that underutilized plant species can contribute to the food, nutritional and developmental needs of future
communities in the face of economic instability, climate change and food insecurity (ICUC brief article by Hannah Jaenicke: Bioversity International APO Newsletter No. 52, 2008).

9. Crops for the future: New global initiative

New developments: global efforts to strengthen R & D in underutilized species -

Global Facilitation Unit for Underutilized Species (GFU) and International Centre for Underutilized Crops (ICUC) join hands to promote underutilized crops

A new global body, provisionally called ‘Crops for the Future’, will spearhead the drive to bring underutilized crops into the mainstream. Underutilized crops are crops for the future. Around the world, species that are little used, or which were grown traditionally but have fallen into disuse, are being revived, especially for use by the poor. Over 7,000 plant species have been grown or collected for food. But worldwide, less than 150 have been commercialized and just three crops - maize, wheat and rice - supply half of the daily proteins and calories.

In the last couple of decades it has become abundantly clear that there is a great deal of interest scattered around the globe in underutilized species. There is growing recognition that they diversify systems and, so, contribute to more secure livelihoods. Two organizations, the Global Facilitation Unit for Underutilized species (GFU) and the International Centre for Underutilized Crops (ICUC), and many groups and individuals, have done much to stimulate and feed this interest. But GFU and ICUC believe that there is enormous value in creating a single champion, ‘Crops for the Future’. Considerable thought and widespread consultation has already gone into formulating a global strategy for underutilized crops. ‘Crops for the Future’ will focus on the following five key areas of this strategy: (i) Information and communication; (ii) Market analysis and market research; (iii) Policy research (iv) Public awareness and (v) Capacity building. For more information visit at http://www.icuc-iwmi.org/Our Future.htm (Bioversity International, APO Newsletter No. 52, 2008).

Further to this, more recent development pertain to the launching of the above programme (ICUC News 80). Report from the Crops for the Future official launch event; the launching having taken place on 30 November 2008 at a specially organized seminar during the CGIAR Annual General Meeting in Maputo, Mozambique, Africa. A strategic plan (2009-2013) has been developed produced/(for more details see ICUC website).
The Asia-Pacific region holds rich biodiversity in underutilized plant species. It is a centre of diversification and domestication of crop plants. Being culturally, ethnically and ecologically very diverse, several underutilized species are grown here and maintained by native farmers under subsistent agriculture. Four regions of diversity, namely, Chinese-Japanese, Indochinese-Indonesian, Australian/Pacific and Indian region are located in this region. Also, eight out of the 17 mega-biodiversity countries namely Indonesia, Australia, China, India, Malaysia, PNG, Philippines and Thailand are in this region.

Mankind depends on a narrow range of crop diversity to meet its food and other needs, and globally, it is considered important to widen this food-base to serve the growing population. In this context, underutilized species offer a great potential to provide better livelihoods. This information documentation, distribution and assessment of diversity, therefore, assumes high importance.

This publication deals with the enumeration of 778 species of underutilized and less known minor food plants grown in different regions of Asia-Pacific. Information presented has been classified under use-based categories such as cereals/pseudocereals, grain legumes/pulses, roots, tubers, vegetables, fruits, nuts, and those providing spices, condiments, and of multi-purpose use including agroforestry species and environment friendly species. The choice for the priority species for R&D needs has been suggested/discussed and the role of native/endemic diversity dealt with. Also information has been added to provide relative analysis of food/nutritional values of selected underutilized species. A thought-provoking need-based focus is also given for the use of other disciplines in meeting the growing need to promote and assess this diversity: use of biotechnology, ethnobotany and documenting indigenous knowledge, diverse uses and conservation of such species. The greater need for partnership/networking at national, regional and international level for realizing the full potential of underutilized species has been stressed to address the Millenium Development Goals (MDGs).

VI. Epilogue
In view of the developments in global content, to merge ICUC and Global Facilitation Unit (GFU)/Bioversity programmes into one setup, presently named as ‘Crops for the Future’ this publication will be found very useful to the national/regional programmes. It is felt that APAARI member-NARS and other members including concerned CG centres will find this well documented/synthesised information both useful and rewarding.
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Dr. R.K. Arora has published over 200 articles in National and International journals, besides making several presentations in conferences and seminars. Some selected publications are listed below:

**Selected Research Papers & Other Publications of Dr. R.K. Arora**

Dr. R.K. Arora has published over 200 articles in National and International journals, besides making several presentations in conferences and seminars. Some selected publications are listed below:

**Research papers**


Puri GS and RK Arora. 1962. Some medicinal forms from Western India. *Indian For.* 87: 179-83.


Chandel KPS, BS Joshi, RK Arora and KC Pant. 1978. Rice bean - A new
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**Proximate principles in vegetables** (per 100 g of edible portion)

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<th>Protein (N x 6.25) (g)</th>
<th>Fat (g)</th>
<th>Minerals (g)</th>
<th>Fibre (g)</th>
<th>Carbohydrates (g)</th>
<th>Energy (Kcal)</th>
<th>Calcium (mg)</th>
<th>Phosphorus (mg)</th>
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<td>Fat (g)</td>
<td>Minerals (g)</td>
<td>Fibre (g)</td>
<td>Carbohydrates (g)</td>
<td>Energy (Kcal)</td>
<td>Calcium (mg)</td>
<td>Phosphorus (mg)</td>
<td>Iron (mg)</td>
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<td>0.1</td>
<td>2.0</td>
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<td>26</td>
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<td>110</td>
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<td>Protein ($\times 6.25$) (g)</td>
<td>Fat (g)</td>
<td>Minerals (g)</td>
<td>Fibre (g)</td>
<td>Carbohydrates (g)</td>
<td>Energy (Kcal)</td>
<td>Calcium (mg)</td>
<td>Phosphorus (mg)</td>
<td>Iron (mg)</td>
</tr>
<tr>
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<td><em>Lablab purpureus</em> (Field bean)</td>
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<td>0.7</td>
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<td>6.7</td>
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<td>0.7</td>
<td>1.2</td>
<td>6.4</td>
<td>35</td>
<td>66</td>
<td>56</td>
<td>0.4</td>
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<td><em>Luffa</em> (Ridged gourd)</td>
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<td>0.5</td>
<td>3.4</td>
<td>17</td>
<td>18</td>
<td>26</td>
<td>0.4</td>
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<tr>
<td><em>Trichosanthes anguina</em> (Snake gourd)</td>
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<td>0.3</td>
<td>0.5</td>
<td>0.8</td>
<td>3.3</td>
<td>18</td>
<td>26</td>
<td>20</td>
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<td><em>Canavalia</em> (Sword bean)</td>
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<td>7.8</td>
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**Roots and tubers**

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<th>Fat (g)</th>
<th>Minerals (g)</th>
<th>Fibre (g)</th>
<th>Carbohydrates (g)</th>
<th>Energy (Kcal)</th>
<th>Calcium (mg)</th>
<th>Phosphorus (mg)</th>
<th>Iron (mg)</th>
</tr>
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<td><em>Arctium</em> (Artichoke)</td>
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<td>1.8</td>
<td>1.2</td>
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<td>0.1</td>
<td>-</td>
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<td>1.7</td>
<td>1.0</td>
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<td>40</td>
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<td>0.8</td>
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Source: Gopalan et al. (2000); Gopalakrishnan (2007)
# Nutritive value of some indigenous vegetables of South Asia

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<th>Vegetable</th>
<th>Moisture (%)</th>
<th>Carbohydrate (%)</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
<th>Beta carotene µg</th>
<th>Vitamin B (mg)</th>
<th>Thiamine</th>
<th>Vitamin C (mg)</th>
<th>Riboflavin</th>
<th>Minerals Ca (mg)</th>
<th>Fe (mg)</th>
<th>Calories kcl (mg)</th>
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<td>Amaranthus spp. (Amaranth)</td>
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<td>0</td>
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<td>Carbohydrate (%)</td>
<td>Protein (g)</td>
<td>Fat (g)</td>
<td>Beta carotene (µg)</td>
<td>Thiamine (mg)</td>
<td>Riboflavin (mg)</td>
<td>Vitamin C (mg)</td>
<td>Minerals Ca (mg)</td>
<td>Fe (mg)</td>
<td>Calories kcal</td>
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<td>0.06</td>
<td>0</td>
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Source: Ghosh and Kalloo (2000).
## Annexure II

### Food value of some promising underutilized fruits and nuts (per 100 g edible portion)

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<th>Calories (g)</th>
<th>Protein (Kcal)</th>
<th>Fat (g)</th>
<th>Carbohydrates (g)</th>
<th>Fibre (g)</th>
<th>Calcium (mg)</th>
<th>Phosphorus (mg)</th>
<th>Iron (mg)</th>
<th>Vitamin A (IU)</th>
<th>Thiamine (mg)</th>
<th>Riboflavin (mg)</th>
<th>Niacin (mg)</th>
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<td>Anacolosa frutescens</td>
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<td>Annona cherimola</td>
<td>82</td>
<td>1.1-1.9</td>
<td>0.1-0.2</td>
<td>18.2-21.3</td>
<td>1.9-2.0</td>
<td>21.7-34</td>
<td>35-37</td>
<td>0.5-0.6</td>
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<tr>
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<td>(Cherimoya)</td>
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<td>Annona muricata L.</td>
<td>53.1-93</td>
<td>1.0</td>
<td>0.4-0.97</td>
<td>14.63-22</td>
<td>0.79-1.1</td>
<td>10.3-25</td>
<td>27.7-28</td>
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<td>180</td>
<td>0.10-0.11</td>
<td>0.05-0.08</td>
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<td>29.6-30</td>
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<tr>
<td></td>
<td>(Sour sop)</td>
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<td>Annona reticulata.</td>
<td>80-101</td>
<td>1.17-2.47</td>
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<td>17.6-27</td>
<td>14.7-32.1</td>
<td>0.42-1.14</td>
<td>11-30</td>
<td>0.08-0.12</td>
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<td>(Custard apple)</td>
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<td>Annona squamosa L.</td>
<td>88-96</td>
<td>1.53-2.38</td>
<td>0.26-1.10</td>
<td>19.25-2.50</td>
<td>1.14-2.50</td>
<td>19.4-44.7</td>
<td>23.6-55.3</td>
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<td>5.7</td>
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<td>(Sugar apple)</td>
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<tr>
<td>(g)</td>
<td>Ascorbic acid</td>
<td>Nicotin (mg)</td>
<td>Riboflavin (mg)</td>
<td>Thiamine (mg)</td>
<td>Vitamin A (IU)</td>
<td>Folate (μg)</td>
<td>Carbohydrates (g)</td>
<td>Fat (g)</td>
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<td>Calories (Kcal)</td>
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<td>1</td>
<td>Artocarpus altilis (Parkinson) Fosb. (Breadfruit)</td>
<td>Artocarpus heterophyllus Lam. (Jackfruit)</td>
<td>Artocarpus integer (Thumb.) Merr. (Chempedak)</td>
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<tr>
<td></td>
<td>Row</td>
<td>Pulp</td>
<td>Pulp (ZMB)</td>
<td>Seed</td>
<td>Seed (fresh)</td>
<td>Seed (dried)</td>
<td>Artocarpus integer (Thumb.) Merr. (Chempedak)</td>
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<td>Plant Species</td>
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<td>Protein (Kkal)</td>
<td>Fat (g)</td>
<td>Carbohydrates (g)</td>
<td>Fibre (g)</td>
<td>Calcium (mg)</td>
<td>Phosphorus (mg)</td>
<td>Iron (mg)</td>
<td>Vitamin A (IU)</td>
<td>Thiamine (mg)</td>
<td>Riboflavin (mg)</td>
<td>Niacin (mg)</td>
<td>Ascorbic acid (mg)</td>
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<tr>
<td><em>Artocarpus odoratissimus</em> Blanco</td>
<td>63-122</td>
<td>0.8-1.47</td>
<td>0.2-0.3</td>
<td>32.4</td>
<td>0.6-0.77</td>
<td>279</td>
<td>528</td>
<td>8.5</td>
<td>-</td>
<td>0.69</td>
<td>0.53</td>
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<tr>
<td><em>Averrhoa carambola L.</em> (Carambola)</td>
<td>35.7</td>
<td>0.38-0.75</td>
<td>0.08</td>
<td>9.38</td>
<td>0.7-0.9</td>
<td>130-180</td>
<td>71-591</td>
<td>2.9-4.8</td>
<td>43-58</td>
<td>0.75-1.04</td>
<td>0.07-0.13</td>
<td>0.44-0.58</td>
<td>25</td>
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<tr>
<td><em>Buchanania lanzan</em> Spreng. (Chironji)</td>
<td>656</td>
<td>19.0-21.6</td>
<td>59.1</td>
<td>12.1</td>
<td>3.8</td>
<td>153.8</td>
<td>50.8</td>
<td>2.0</td>
<td>8,600 µg</td>
<td>-</td>
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</tr>
<tr>
<td><em>Canarium ovatum</em> Engler (Pili nut)</td>
<td>Seed (ZMB)</td>
<td>699-714</td>
<td>12.2</td>
<td>73.2</td>
<td>6.0-10.0</td>
<td>2.3-3.5</td>
<td>130-180</td>
<td>71-591</td>
<td>2.9-4.8</td>
<td>43-58</td>
<td>0.07-0.13</td>
<td>0.44-0.58</td>
<td>25</td>
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<tr>
<td><em>Capparis decidua</em> (Forsk.) Edgew (Ker)</td>
<td>Ripe</td>
<td>-</td>
<td>17.0</td>
<td>71 (ZMB)</td>
<td>1.0 (ZMB)</td>
<td>210 (ZMB)</td>
<td>360 (ZMB)</td>
<td>6.0 (ZMB)</td>
<td>35000</td>
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<td>Unripe</td>
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<td>14.88</td>
<td>7.43 (ZMB)</td>
<td>59.41 (ZMB)</td>
<td>12.32 (ZMB)</td>
<td>90 (ZMB)</td>
<td>779 (ZMB)</td>
<td>3.5 (ZMB)</td>
<td>9000 (ZMB)</td>
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<td>Fruit</td>
<td>70</td>
<td>100</td>
<td>5.9</td>
<td>1.23</td>
<td>20.87</td>
<td>153.8</td>
<td>50.8</td>
<td>2.0</td>
<td>8,600 µg</td>
<td>-</td>
<td>-</td>
<td>133</td>
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<td><em>Carissa congesta</em> Wight (Karonda)</td>
<td>42-59.4</td>
<td>0.39-1.1</td>
<td>2.57</td>
<td>0.51</td>
<td>0.62</td>
<td>21</td>
<td>28</td>
<td>-</td>
<td>1619</td>
<td>0.04</td>
<td>0.07</td>
<td>0.6</td>
<td>9.11</td>
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<td><em>Carya illinoensis</em> (Wangh.) K. Koch. (Pecan)</td>
<td>687</td>
<td>9.2</td>
<td>71.2</td>
<td>14.6</td>
<td>-</td>
<td>73</td>
<td>289</td>
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<td>0.86</td>
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<td>Calories (g)</td>
<td>Protein (Kcal)</td>
<td>Fat (g)</td>
<td>Carbohydrates (g)</td>
<td>Fibre (g)</td>
<td>Calcium (mg)</td>
<td>Phosphorus (mg)</td>
<td>Iron (mg)</td>
<td>Vitamin A (IU)</td>
<td>Thiamine (mg)</td>
<td>Riboflavin (mg)</td>
<td>Niacin (mg)</td>
<td>Ascorbic acid (mg)</td>
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<td><strong>Castanea mollissima</strong></td>
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<td>7.4-17.3</td>
<td>0.20-0.68</td>
<td>9.0-22.0</td>
<td>0.01-0.08</td>
<td>0.01-1.34</td>
<td>0.8-3.0</td>
<td>0.14-0.55</td>
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<td>Blume (Chinese chestnut) (ZMB)</td>
<td>403</td>
<td>11.9</td>
<td>2.7</td>
<td>83.2</td>
<td>-</td>
<td>36</td>
<td>168</td>
<td>3.8</td>
<td>360</td>
<td>0.29</td>
<td>0.32</td>
<td>1.44</td>
<td>65</td>
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<td><strong>Castanea sativa Mill</strong></td>
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<td>2.9</td>
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<td>42.1</td>
<td>27</td>
<td>88</td>
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<td>0.22</td>
<td>0.22</td>
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<tr>
<td>(Sweet chestnut)</td>
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<td>7.7</td>
<td>352</td>
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<td>(Spanish Carob)</td>
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<tr>
<td><strong>Chrysophyllum cainito L</strong></td>
<td>67.2</td>
<td>0.72-2.33</td>
<td>0.6-1.6</td>
<td>14.65-17.4</td>
<td>0.55-3.30</td>
<td>7.4-17.3</td>
<td>9.0-22.0</td>
<td>0.20-0.68</td>
<td>3.8</td>
<td>0.01-0.08</td>
<td>0.01-1.34</td>
<td>0.8-3.0</td>
<td>3.0-30.4-15.2</td>
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<td>Star apple (Caimito)</td>
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<tr>
<td><strong>Citrus grandis (L.)</strong></td>
<td>25-58</td>
<td>0.5-0.74</td>
<td>0.20-0.56</td>
<td>6.3-12.4</td>
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**ANNEXURES | 167**
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<th>Protein (Kcal)</th>
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<th>Fibre (g)</th>
<th>Calcium (mg)</th>
<th>Phosphorus (mg)</th>
<th>Iron (mg)</th>
<th>Vitamin A (IU)</th>
<th>Thiamine (mg)</th>
<th>Riboflavin (mg)</th>
<th>Niacin (mg)</th>
<th>Ascorbic acid (mg)</th>
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<td>Correa (Langsat, Duku)</td>
<td>-</td>
<td>16-20</td>
<td>62</td>
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<td>Lecythis usitata Mires</td>
<td>-</td>
<td>16-20</td>
<td>62</td>
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<tr>
<td>(Sapucaia, Monkey pot)</td>
<td>-</td>
<td>16-20</td>
<td>62</td>
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<tr>
<td>Macadamia integrifolia</td>
<td>691</td>
<td>7.8-8.7</td>
<td>71.0-71.6</td>
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<td>2.5</td>
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<td>Maiden et Betch (Macadamia nut)</td>
<td>-</td>
<td>16-20</td>
<td>62</td>
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<tr>
<td>Maduca indica J.F. Gmel.</td>
<td>Flower</td>
<td>-</td>
<td>4.4-6.4</td>
<td>0.4-0.5</td>
<td>1.7</td>
<td>140</td>
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<td>15</td>
<td>39</td>
<td>0.03</td>
<td>0.87</td>
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<tr>
<td>Fruit</td>
<td>-</td>
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<td>1.61</td>
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<td>45</td>
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<tr>
<td>Mangifera odorata Griff.</td>
<td>69.3</td>
<td>0.9</td>
<td>0.1</td>
<td>18.5</td>
<td>-</td>
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<td>600</td>
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<td>0.06</td>
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<tr>
<td>(Kuwini)</td>
<td>-</td>
<td>0.48</td>
<td>2.42</td>
<td>27.74</td>
<td>-</td>
<td>83</td>
<td>17</td>
<td>0.92</td>
<td>675</td>
<td>0.07</td>
<td>0.077</td>
<td>0.66</td>
<td>15.67</td>
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<tr>
<td>Manilkara hexandra (Roxb.) Dubard (Khiri)</td>
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<td>0.48</td>
<td>2.42</td>
<td>27.74</td>
<td>-</td>
<td>83</td>
<td>17</td>
<td>0.92</td>
<td>675</td>
<td>0.07</td>
<td>0.077</td>
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<td>Protein (Kcal)</td>
<td>Fat (g)</td>
<td>Carbohydrates (g)</td>
<td>Fibre (g)</td>
<td>Calcium (mg)</td>
<td>Phosphorus (mg)</td>
<td>Iron (mg)</td>
<td>Vitamin A (IU)</td>
<td>Thiamine (mg)</td>
<td>Riboflavin (mg)</td>
<td>Niacin (mg)</td>
<td>Ascorbic acid (mg)</td>
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<tr>
<td>Moringa oleifera Lam.</td>
<td>-</td>
<td>2.5</td>
<td>0.1</td>
<td>3.7-8.5</td>
<td>4.8</td>
<td>30</td>
<td>110</td>
<td>5.3</td>
<td>184</td>
<td>0.05</td>
<td>0.07</td>
<td>0.2</td>
<td>120</td>
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<td>(Drumstick)</td>
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<tr>
<td>Nelumbo nucifera Gaertn. (Lotus) Seeds (ZMB)</td>
<td>318-390</td>
<td>16.6-24.2</td>
<td>1.0-2.7</td>
<td>70.2-76.2</td>
<td>2.5-13.1</td>
<td>139-330</td>
<td>298-731</td>
<td>6.1-7.1</td>
<td>58</td>
<td>0.65-0.75</td>
<td>0.18-0.26</td>
<td>1.9-7.8</td>
<td>0-44</td>
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<td>Seeds (FWVB)</td>
<td>-</td>
<td>17.2</td>
<td>2.4</td>
<td>66.6</td>
<td>-</td>
<td>196</td>
<td>294</td>
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<tr>
<td>Nephelium lappaceum L. (Rambutan)</td>
<td>63-64</td>
<td>0.46-0.9</td>
<td>0.1</td>
<td>14-16</td>
<td>0.24-1.1</td>
<td>10.6-20</td>
<td>12.9</td>
<td>1.9-3.0</td>
<td>4</td>
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<td>20.45-31</td>
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<tr>
<td>Nephelium mutabile Blume (Phulasan)</td>
<td>-</td>
<td>0.82</td>
<td>0.55</td>
<td>12.86</td>
<td>0.14</td>
<td>0.01-0.05</td>
<td>-</td>
<td>0.02</td>
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<tr>
<td>Passiflora edulis Sims (Passion fruit)</td>
<td>90.92</td>
<td>2.22-2.3</td>
<td>0.7-2.0</td>
<td>16-21.2</td>
<td>3.5</td>
<td>10-13</td>
<td>64-78</td>
<td>1.0-1.6</td>
<td>20-700</td>
<td>0.10-0.13</td>
<td>1.5</td>
<td>20.30</td>
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<tr>
<td>Passiflora mollissima (H.B.K.) Bailey (Banana passion-fruit)</td>
<td>25</td>
<td>0.6</td>
<td>0.1</td>
<td>6.3</td>
<td>0.3</td>
<td>4</td>
<td>20</td>
<td>0.4</td>
<td>-</td>
<td>-</td>
<td>0.03</td>
<td>2.5</td>
<td>70</td>
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<tr>
<td>Phoenix sylvestris Roxb. (Wild date palm)</td>
<td>144</td>
<td>1.25</td>
<td>0.4</td>
<td>39.8</td>
<td>3.7</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Pinus gerardiana Wall. (Chilgoza nut)</td>
<td>615</td>
<td>15.9</td>
<td>49.9</td>
<td>21.6-29</td>
<td>2.2</td>
<td>90.8</td>
<td>92.4</td>
<td>2.4-3.6</td>
<td>-</td>
<td>0.32</td>
<td>0.32</td>
<td>3.6</td>
<td>0</td>
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<tr>
<td>Pistacia vera L. (Pistachio)</td>
<td>626</td>
<td>20.0</td>
<td>54.0</td>
<td>15-16</td>
<td>2.0</td>
<td>140</td>
<td>-</td>
<td>14.0</td>
<td>100-240</td>
<td>0.70</td>
<td>0.03-0.20</td>
<td>1.4-1.5</td>
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<tr>
<td>Species</td>
<td>Calories (g)</td>
<td>Protein (Kcal)</td>
<td>Fat (g)</td>
<td>Carbohydrates (g)</td>
<td>Fibre (g)</td>
<td>Calcium (mg)</td>
<td>Phosphorus (mg)</td>
<td>Iron (mg)</td>
<td>Vitamin A (IU)</td>
<td>Thiamine (mg)</td>
<td>Riboflavin (mg)</td>
<td>Niacin (mg)</td>
<td>Ascorbic acid (mg)</td>
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<tr>
<td><em>Pithecellobium dulce</em> (Roxb.) Benth (Manila tamarind) Aril</td>
<td>78.8</td>
<td>23.3</td>
<td>0.4-0.5</td>
<td>18.2-19.6</td>
<td>1.1-1.2</td>
<td>13</td>
<td>42</td>
<td>0.5</td>
<td>25</td>
<td>0.24</td>
<td>0.1</td>
<td>0.6</td>
<td>138</td>
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<tr>
<td><em>Pouteria campechiana</em> (Kunth.) Baehni (Canistel, eggfruit)</td>
<td>138.8-150</td>
<td>1.68-2.5</td>
<td>0.13-0.6</td>
<td>36.69-39</td>
<td>0.10-7.5</td>
<td>26.5-40</td>
<td>30-37.3</td>
<td>0.92-1.1</td>
<td>533-2000</td>
<td>0.02</td>
<td>0.01</td>
<td>2.5-3.72</td>
<td>43-58.1</td>
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<tr>
<td><em>Pouteria obovata</em> Baehni (Lucuma)</td>
<td>-</td>
<td>1.5</td>
<td>0.5</td>
<td>25</td>
<td>1.3</td>
<td>16</td>
<td>-</td>
<td>4.6</td>
<td>1500</td>
<td>0.01</td>
<td>0.14</td>
<td>-</td>
<td>5</td>
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<tr>
<td><em>Pouteria sapota</em> (Jacq.) Moore Stearn (Mamey sapote, Sapote)</td>
<td>114.5-125</td>
<td>0.18-1.7</td>
<td>0.09-0.5</td>
<td>1.41-32</td>
<td>1.23.2</td>
<td>20</td>
<td>22.9-121.0</td>
<td>0.52-2.62</td>
<td>75-1108</td>
<td>0.01</td>
<td>0.02</td>
<td>1.57-2.58</td>
<td>8.8-40</td>
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<tr>
<td><em>Punica granatum</em> L. (Pomegranate)</td>
<td>63-77</td>
<td>0.05-1.6</td>
<td>0.1-0.9</td>
<td>14.5-19.6</td>
<td>0.25-1</td>
<td>3-12</td>
<td>8.37-8.71</td>
<td>trace</td>
<td>0.02-0.03</td>
<td>0.012</td>
<td>0.18-0.18</td>
<td>-</td>
<td>4-18</td>
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<tr>
<td><em>Rhodomyrtus tomentosa</em> (Aiton) Hassk. (Hill gooseberry)</td>
<td>47</td>
<td>0.6</td>
<td>0.2</td>
<td>10.7</td>
<td>5.6</td>
<td>-</td>
<td>-</td>
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<tr>
<td><em>Salvadora oleoides</em> Decne (Pilu)</td>
<td>-</td>
<td>6.0</td>
<td>2.0</td>
<td>76</td>
<td>2.0</td>
<td>630</td>
<td>167</td>
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<td>2.0</td>
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<tr>
<td><em>Sandoricum koelzjape</em> (Burm.f.) Merr. (Santol)</td>
<td>46-65.4</td>
<td>0.12-0.8</td>
<td>0.10-1.0</td>
<td>11-13.7</td>
<td>0.1-1.1</td>
<td>4.3-11</td>
<td>17.420</td>
<td>0.42-1.2</td>
<td>5</td>
<td>0.05</td>
<td>0.03</td>
<td>0.74</td>
<td>14-86</td>
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<tr>
<td><em>Santalum acuminatum</em> R.Br. (Quandong, Native peach) Fruit</td>
<td>82.4</td>
<td>1.7</td>
<td>0.2</td>
<td>19.3</td>
<td>-</td>
<td>42</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>Fruit</td>
<td>Calories (g)</td>
<td>Protein (Kcal)</td>
<td>Fat (g)</td>
<td>Carbohydrates (g)</td>
<td>Fibre (g)</td>
<td>Calcium (mg)</td>
<td>Phosphorus (mg)</td>
<td>Iron (mg)</td>
<td>Vitamin A (IU)</td>
<td>Thiamine (mg)</td>
<td>Riboflavin (mg)</td>
<td>Niacin (mg)</td>
<td>Ascorbic acid (mg)</td>
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<tr>
<td>Santalum lanceolatum R.Br. (Bush plum) Fruit</td>
<td>154.3</td>
<td>4.8</td>
<td>4.8</td>
<td>24.4</td>
<td>2.5</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>16</td>
<td></td>
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<tr>
<td>Spondias cytherea Sonn. (Ambarella, Otaheite apple)</td>
<td>95-157.3</td>
<td>0.5-1.0</td>
<td>0.28-1.79</td>
<td>23</td>
<td>0.6-3.6</td>
<td>20</td>
<td>-</td>
<td>1.2</td>
<td>50</td>
<td>0.10</td>
<td>0.04</td>
<td>1.0</td>
<td>40</td>
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<tr>
<td>Syzygium aqueum Alston (Water apple)</td>
<td>19</td>
<td>0.3</td>
<td>0</td>
<td>3.9</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>253</td>
<td>trace</td>
<td>trace</td>
<td>-</td>
<td>0.1</td>
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<tr>
<td>Syzygium cumini (L.) Skeels (Jambolan, jamun)</td>
<td>62</td>
<td>0.7</td>
<td>0.15-0.3</td>
<td>14.16</td>
<td>0.3-0.9</td>
<td>8.15</td>
<td>15-16.2</td>
<td>1.2</td>
<td>1.62</td>
<td>80</td>
<td>0.01-0.03</td>
<td>0.01</td>
<td>0.2-0.29</td>
<td>5.7-18</td>
</tr>
<tr>
<td>Syzygium jambos (L.) Alston (Rose apple)</td>
<td>56</td>
<td>0.5-0.8</td>
<td>0.2-0.3</td>
<td>9.7-14.2</td>
<td>0.7-1.9</td>
<td>10.45-11.73</td>
<td>0.45-1.2</td>
<td>123-235</td>
<td>0.01-0.19</td>
<td>0.03-0.05</td>
<td>0.3</td>
<td>3-37</td>
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<tr>
<td>Tamarindus indica L. (Tamarind)</td>
<td>-</td>
<td>2.3</td>
<td>0.6</td>
<td>41.1-61.4</td>
<td>2.9</td>
<td>34.94</td>
<td>34.78</td>
<td>0.20-0.9</td>
<td>-</td>
<td>0.33</td>
<td>0.1</td>
<td>1.0</td>
<td>44</td>
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<tr>
<td>Pulp</td>
<td>115-214</td>
<td>2.3-3.10</td>
<td>0.1</td>
<td>56.7-67.4</td>
<td>1.9-5.6</td>
<td>35-170</td>
<td>54-110</td>
<td>1.3-10.9</td>
<td>15</td>
<td>0.16-0.22</td>
<td>0.08</td>
<td>0.6-1.10</td>
<td>0.73-0.8</td>
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<tr>
<td>Seed</td>
<td>-</td>
<td>20</td>
<td>5.5</td>
<td>59</td>
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<td>-</td>
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</tr>
<tr>
<td>Terminalia catappa L. (Indian almond)</td>
<td>Seed</td>
<td>574-607</td>
<td>19.1-25.4</td>
<td>52.56</td>
<td>14.9-17.2</td>
<td>1.8-14.6</td>
<td>32.497</td>
<td>789-957</td>
<td>2.4-9.2</td>
<td>-</td>
<td>0.32-0.71</td>
<td>0.08-0.28</td>
<td>0.6-0.7</td>
<td>0</td>
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<tr>
<td>Vegetable</td>
<td>1</td>
<td>2</td>
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Source: Pareek et al. (1988)
Annexure-III

Promising introductions of underutilized species in Asia-Pacific region

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<tr>
<th>Species</th>
<th>Centre of origin</th>
<th>Region of introduction/spread</th>
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<tbody>
<tr>
<td><strong>Pseudo-cereals and millets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Amaranthus cruentus</em></td>
<td>Central America</td>
<td>Hindu Kush Himalayas, South Asia, East Asia</td>
</tr>
<tr>
<td><em>Chenopodium quinoa</em></td>
<td>South America</td>
<td>Hindu Kush Himalayas</td>
</tr>
<tr>
<td><em>Eleusine coracana</em></td>
<td>Tropical Africa</td>
<td>Peninsular India, Hindu Kush Himalayas, mid-mountains</td>
</tr>
<tr>
<td><strong>Grain legumes/Pulses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Lathyrus sativus</em></td>
<td>West Asia</td>
<td>South Asia, central India, Nepal, Bangladesh, also Australia</td>
</tr>
<tr>
<td><em>Vicia faba</em></td>
<td>West Asia</td>
<td>Hindu Kush Himalayas, South Asia, East Asia, Northwestern cold/mid Himalayas in India, sporadic in Southeast Asia, Australia</td>
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<tr>
<td><strong>Vegetables Leafy type</strong></td>
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<tr>
<td><em>Amaranthus caudatus, other spp.</em></td>
<td>South America</td>
<td>Hindu Kush Himalayas</td>
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<tr>
<td><em>Asparagus officinalis</em></td>
<td>Europe, Mediterranean</td>
<td>Hindu Kush Himalayas, South/Southeast Asia-Thailand, Philippines</td>
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<tr>
<td><em>Hibiscus acetosella</em></td>
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<td>South/Southeast/East Asia, Pacific Is.</td>
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<tr>
<td><em>Lactuca sativa</em></td>
<td>Europe</td>
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<td><em>Lepidium sativum</em></td>
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<td><em>Trigonella foenum-graecum</em></td>
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<td>South Asia, North/Central India plains</td>
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<td><strong>Roots/Tubers</strong></td>
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<td><em>Arctium lappa</em></td>
<td>West Africa</td>
<td>East/Southeast Asia, China, Japan, Philippines, Vietnam; more in Japan</td>
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<tr>
<td><em>Canna edulis</em></td>
<td>Tropical America</td>
<td>Sporadic all through Asia-Pacific/Oceania</td>
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<tr>
<td><em>Cyrtosperma chamissonis</em></td>
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<td>Species</td>
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<td>Region of introduction/spread</td>
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<td>Maranta arundinacea</td>
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<td>South/Southeast Asia, Pacific Is.-coastal region</td>
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<td>Pachyrhizus erosus, P. tuberosus</td>
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<td>South/Southeast Asia-Pacific Is.</td>
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<tr>
<td>Pastinaca sativa</td>
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<td>Temperate Asia, Oceania/ Australia, New Zealand</td>
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<td>Xanthosoma atrovirens/</td>
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<td>X. sagittifolium, X. violaceum</td>
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<tr>
<td>Cyclanthera pedata</td>
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<tr>
<td>Sechium edule</td>
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<td>Central Himalayas (Northeast India/Nepal sub-montone tropical hills)</td>
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<td>Annona atemoya</td>
<td>South America</td>
<td>Southeast Asia-Phillippines</td>
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<td>Annona cherimoya</td>
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<td>Annona montana</td>
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<td>Annona squamosa</td>
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<td>Southeast Asia</td>
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<td>Cyphomandra betacea</td>
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<td>Central Himalayas, Temperate/sub-tropical Asia; South/Southeast/East Asia sporadic</td>
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<td>Eriobotrya japonica</td>
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<td>Feijoa sellowiana</td>
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<td>Ficus carica</td>
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<td>Macrocarpium mas</td>
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- **Nuts**

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<td><em>Lecythis zabucajo</em></td>
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<td>Pacific Is.</td>
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- **Industrial**

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<td><em>Citrullus colocynthis</em></td>
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<td>South Asia, semi-arid India</td>
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<td><em>Cyamopsis tetragonolobus</em></td>
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<td><em>Hibiscus cannabinus</em></td>
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- **Condiments, spices, flavouring-types**

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<td>South Asia, Western India-drier tracts</td>
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<td>Alternanthera blitum</td>
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