Important Plant-Based Phytonutrients

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List of Abbreviations

\begin{itemize}
  \item ALL Acute Lymphoblastic Leukaemia
  \item CAD Coronary Artery Disease
  \item CML Chronic Myeloid Leukaemia
  \item DNA Deoxyribonucleic acid
  \item FDA Food and Drug Administration
  \item HDL High Density Lipoprotein
  \item IDDM Insulin Dependent Diabetes Mellitus
  \item IHD Ischemic Heart Disease
  \item LDL Low Density Lipoprotein
  \item MDA Malondialdehyde
  \item NIDDM Non-Insulin Dependent Diabetes Mellitus
  \item UV Ultraviolet
\end{itemize}
1.1 Introduction

Present-day consumers are more nutrition savvy. Each year, health magazines and articles in the newspapers are increasingly dedicated to the relationship between health and diet, especially to plant-based nutraceuticals, functional foods and value-added food products. Additionally, health-related research journals, magazines, books and television programmes tackle topics of treatment and prevention of diseases more than ever. The advent of the internet has acted as an active super highway for free information and has contributed significantly as one of the momentous events influencing communal knowledge and awareness across the planet (Wildman & Kelley 2007). In addition, powerful tools such as publicly available technical and non-technical search engines and social media have further strengthened the global community in the realm of knowledge empowerment. Several international food companies are also taking full benefit of the increasing health awareness and have contributed millions of dollar into the study of nutraceutical compounds, marketing and development of new products and have recognised a quickly developing new market with remarkable pledge. These products fall in the category of immense deemed functional foods. These manufactured food products or natural foods (vegetables and fruits) that can definitely influence human physiology action have bioactive compounds (Wildman 2001).

The term ‘nutraceuticals’ was first coined by Stephen DeFelice, founder and chairman of the Foundation for Innovation in Medicine, in the United States in 1988. The definition given by the organisation was ‘products isolated and purified from foods that are generally sold in medicinal forms and are usually associated with food.’ However, another definition was given by Health Canada in 1998. The same organisation coined a definition for the term ‘functional foods,’ which defined it as ‘similar in appearance to, or may be, conventional foods that are consumed as part of a usual diet, and have demonstrated physiological benefits and/or reduce the risk of chronic diseases beyond the basic nutritional functions.’ Hence, there exists a fine line of demarcation between the two terms (Acharya et al. 2008).

The global market of nutraceuticals and functional foods is on the rise with the United States and Japan being the top two countries having the biggest share of it. However, in other countries, the expansion of the market is being restricted due to stringent laws governing food labelling, formulation, processing, packaging and marketing. Such issues need to be dealt with properly to facilitate the growth of functional food markets in every other country (Basu et al. 2007). Two more countries that are likely to emerge as promising markets for nutraceuticals in the near future are India and China. Both these countries have a rich source of herbs and trees, which have formed an essential part of traditional Indian and Chinese medicines. Even today, such traditional medicines play an important role in keeping the lives of a major part of the enormous population in both these countries. Moreover, the lion share of India’s people live in the rural areas where there is almost no access to standard conventional health care centres providing modern day drugs. Hence, they depend on the local herbal products for cure of diseases (Basu et al. 2007). In both the countries, there are no strict government
regulations pertaining to the sale and consumption of these traditional medicines. They are available to the people as over-the-counter drugs without the need for any prescription. These facts point to their potential to grow as leaders in market for nutraceuticals and functional foods and thus contribute significantly to the export industry (Basu et al. 2007). This review aims at providing a detailed coverage of health as well as industrial aspects of plant-based nutraceuticals, functional foods and value-added food products to the readers as to understand: what they are and their applications in human health from a global perspective.

1.2 Nutraceuticals and Functional Foods in Human Health

Plants have always been a significant source of trace elements in our diet (Aberoumand 2012). They not only help us by meeting our optimum nutrient requirements but also provide an effective barrier to the occurrence of several morbid conditions (Aberoumand 2012). Many of these medicinal plants produce a number of different phytonutrients that play an important role in maintaining our very own physiological system. But most of those underlying biochemical processes still remain obscure (Thomas 2012). However, rapid development in the field of deoxyribonucleic acid (DNA) sequencing and other biotechnological know-hows are slowly paving the way to unlocking these secrets and will one day make plants a more indispensable part of human life than they were once thought to be (Thomas 2012).

With the growth of different pharmaceutical companies, the use of traditional medicinal plants has indeed received a severe blow. But in the last few decades, there has been a turn in the tide. Scientists and health experts have started to recognise the value of the plants in human health and this has thus led to the positive growth of nutraceuticals and functional food markets all over the globe. The National Centre for Traditional Medicine has been set up in Cambodia to provide medical care to people in traditional medicine yet with scientific means. Several medicinal plants (Tables 1.1–1.5) with nutraceutical values have been identified and the proper dosage forms have been prepared after carefully designed and repeated clinical trials. The use of traditional medicines in the country is under strict regulation of the Ministry of Health to ensure quality and safety of the products (Kraisintu 2003).

Community health study and investigation in metabolic syndrome of poor nutrition, dyslipidemia, hepatic derangement and associated cardiovascular risk factors are of immense importance in the present time. In concurrence with technological advancements, occupational and dietary lifestyles in all ages of both the sexes of men and women, irrespective of racial and ethnic differences are rapidly changing. Habitual changes of lifestyle of people in both urban and rural settings are also of no great difference like before. Adults (18 years and above) of both sexes are affected by this massive pathos of psychosomatic disorders. Clinical manifestation of early age of onset of atherosclerosis, ischemic heart disease along with hepatic derangements and dyslipidemia are the most common health disorders prevalent in every society. Data on health-related issues and nutrition from developed countries are easily available, but, unfortunately, the data from under developed and developing nations in Asia, Africa and Latin America are remarkably lacking. In addition, survey records and information are also less available from rural sectors and least from the tribal/aboriginal/first nation
Table 1.1 Medicinally important plants from Africa that are commonly used by local tribes as nutraceutical sources and as potential functional food components in their daily diets.

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<tr>
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<th>Scientific name</th>
<th>Nutraceutical / Phytochemical</th>
<th>Habit</th>
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<th>Medicinal properties</th>
<th>Tribes using the plant</th>
<th>References</th>
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<td>Iwongewonge</td>
<td>Indian liquorice, White thorn apple</td>
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<td>Herb</td>
<td>Leaves, seeds</td>
<td>Tuberculosis, asthma, cough, convulsions, antibacterial, insanity, catarrh, diarrhoea, hysteria, rheumatic pains</td>
<td>Sukuma (Tanzania)</td>
<td>Bharathi <em>et al.</em> (2010), Kokwaro (1993), Siva Sakthi <em>et al.</em> (2011)</td>
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<td>Acak-acak</td>
<td>Asthma herb,</td>
<td>Euphorbiaceae</td>
<td>Euphorbia hirta L.</td>
<td>Flavonoids (Quercitrin, Myricitrin), Sterols (Cycloarternol,</td>
<td>Herb leaves, latex (whole plant) Asthma, colic</td>
<td>Chen (1991), Chitra <em>et al.</em> (2011), Kokwaro</td>
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<td>24-methylene-cycloarternol, β-sitosterol, euphorbol hexacozone</td>
<td>troubles, dysentery, cough, worms and vomiting,</td>
<td>(1993), Lee (2011), Shih <em>et al.</em> (2010),</td>
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<td></td>
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<td>pill bearing</td>
<td>Euphorbiaceae</td>
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<td>nate, 1-hexacosanol, tinhaloxy, campesterol, stigmastrerol),</td>
<td>antibacterial, molluscicidal activity, anti-</td>
<td>Shih and Cherng (2012)</td>
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<td></td>
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<td>tannins (1, 2, 3, 4, 6-penta-O-galloyl-β-D-glucose, 3, 4-di-O-</td>
<td>diarrhoeal, anti-inflammatory</td>
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<td>glucose, euphorbin A, B, E, triterpenoids (α-amyrin, β-amyrin,</td>
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<td>taraxerone, taxerol, β-amyrrin, acetate, taraxerone, 11α,</td>
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<td>Magwagwa</td>
<td>Tick berry</td>
<td>Verbenaceae</td>
<td>Lantana camara L.</td>
<td>Tannin, catachin, saponin, steroids, alakoids, phenol,</td>
<td>Shrub leaves, roots, flowers</td>
<td>Luo (Kenya)</td>
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<td>Tick berry</td>
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<td>anthroquinone, protein and reducing sugar</td>
<td>Coughs, antibacterial, antihypertensive,</td>
<td>Kokwaro (1993), Mary Kensa (2011), Patel <em>et a</em></td>
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<td>Verbenaceae</td>
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<td>treatment of malaria, rheumatism, and skin</td>
<td>l (2011)</td>
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<th>Tribes using the plant</th>
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<td>Muvunza hukuma</td>
<td>African mistletoe, Dwarf red hibiscus, Poppy hibiscus</td>
<td>Malvaceae</td>
<td><em>Hibiscus micranthus</em> L. f.</td>
<td>Steroids, flavonoids, carbohydrates, phenols, tannins and few compounds like phenolic acids, flavonoids, β-sitosterol, alkanes, fatty alcohols, acids</td>
<td>Shrub</td>
<td>Roots, stems</td>
<td>Bronchitis, antimicrobial, antiviral, antitumour, antipyretic, anti-inflammatory, haematological effects</td>
<td>Pokomo (Kenya)</td>
<td>Kokwaro (1993), Kumar <em>et al.</em> (2010a, 2010b), Kumar <em>et al.</em> (2011)</td>
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<td>Oxindole (3-Hydroxy-3-methyl-4-methoxyoxindole), glucocapparin, gluconorcappasalin, benzylglucosinolates, rutin, fatty acids, hydrocarbons, sitosterol, β-carotene</td>
<td>Shrub, fruits, leaves (aerial parts)</td>
<td>Syphilis, skin irritant, antibacterial, spices, cough, infertility, impotence, anti-convulsant</td>
<td>Dekker et al. (1987), Kokwaro (1993), Tlili et al. (2011)</td>
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<td>Camphor, borneol, α-thujone, cineol, bornyl acetate and camphene</td>
<td>Herb</td>
<td>Flowers</td>
<td>Carminative, indigestion, edema, burns, skin infection gastric ulcer, antibacterial, anti-inflammatory, haemorrhage, dysmenorrhoea, enema, diarrhoea</td>
<td>Pirbalouti et al. (2010a), Rustaiyan et al. (1999), Zargari (1996)</td>
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<td>Panirak</td>
<td>Common Mallow</td>
<td>Malvaceae</td>
<td><em>Malva sylvestris</em> L.</td>
<td>Phenolics, flavonoids, carotenoids, ascorbic acid</td>
<td>Herb</td>
<td>Flowers, leaves, mature fruits and leafy flowered stems</td>
<td>Treatment of various ailments, including cold, cough and burn, and cut wound-healing</td>
<td>Zargari (1996)</td>
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<td>Zarrin giah</td>
<td>Lamiaceae</td>
<td><em>Dracocephalum multicaule</em> Montbr. &amp; Auch. ex Bentham</td>
<td>Limonene, α-pinene, methyl fgeraniate</td>
<td>Herb, flowers (aerial parts)</td>
<td>Foot pain, sedative, analgesia, inflammatory, antibacterial, antiseptic</td>
<td>Mojab <em>et al.</em> (2002), Pirbalouti <em>et al.</em> (2010a)</td>
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<td><em>Echinophora platyloba</em> DC.</td>
<td>Trans-β-ocimene, 2-furanone, myrcene, linalool and cis-β-ocimene</td>
<td>Shrub, Aerial parts</td>
<td>Antifungal, spice and culinary</td>
<td>Entezari <em>et al.</em> (2009), Pirbalouti <em>et al.</em> (2010a)</td>
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<td>Golpar</td>
<td>Apiaceae</td>
<td><em>Heracleum lasiopetalum</em> Boiss.</td>
<td>Flavonoids, tannins, saponins</td>
<td>Herb, Fruit</td>
<td>Antiseptic, spice, and condiment</td>
<td>Pirbalouti (2009), Pirbalouti <em>et al.</em> (2010a); Rohi Boroujeni <em>et al.</em> (2012)</td>
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<td>Bakhtyari karafs</td>
<td>Wild clery</td>
<td><em>Kelussia odoratissima</em> Mozaff.</td>
<td>E-ligustilide Phthalide, 3-e-butyldiene phthalide and z-ligustilide</td>
<td>Herb, Leaves</td>
<td>Edible as vegetable, flavouring, indigestion, rheumatism, also used to cure some rheumatism disorders, common cold, cough, blood pressure, blood lipid and stomachache</td>
<td>Pirbalouti <em>et al.</em> (2010a, 2010c); Rohi Boroujeni <em>et al.</em> (2012), Sedighi <em>et al.</em> (2012), Sultana <em>et al.</em> (2005)</td>
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<td>Sorya Ratanjot Boraginaceae</td>
<td>Arnebia euchroma (Royle) I.M. Johnston.</td>
<td>Naphthoquinone red pigments: ethyl 9-(2′,5′-dihydroxyphenyl) nonanoate, octyl ferulate, arnebabinone and isohexylnaphthazarins (e.g. acetylshikonin)</td>
<td>Herb</td>
<td>Roots, rhizome</td>
<td>Burn wound, anti-eczema, antimicrobial, anti-inflammatory, anti-viral, anti-tumour, cardiotonic and contraceptive properties</td>
<td>Damianakos et al. (2012), Kumar et al. (2011), Liu et al. (2010), Pirbalouti et al. (2010c)</td>
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<td>Golraye dayhimi Hypericaceae</td>
<td>Hypericum scabrum L.</td>
<td>α-pinene, thymol, carvacrol, spathulenol, p-Cymene</td>
<td>Herb</td>
<td>Flowers, aerial parts</td>
<td>Green tea, sedative, headache, analgesic, trauma, rheumatism, neuralgia, anti-inflammatory, antiseptic, gastroenteritis, ulcers, hysteria, bedwetting</td>
<td>Baser et al. (2002), Pirbalouti et al. (2010c)</td>
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<td>17</td>
<td>Mort Myrtle Myrtaceae</td>
<td>Myrtus communis L.</td>
<td>Acylphloroglucinols, phenolic compounds: phenolic acids, flavonol glycosides, volatile components: 1,8-cineole, α-terpineol, methyl eugenol, linalool</td>
<td>Tree</td>
<td>Leaves</td>
<td>Skin discords, digestive discords, astringent, good hair condition, bronchodilatator, anti-inflammatory</td>
<td>Messaoud et al. (2012), Pirbalouti (2009), Pirbalouti et al. (2010c)</td>
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<td>18</td>
<td>Pesteh Koohi (baneh)</td>
<td>Anacardiaceae</td>
<td><em>Pistacia atlantica</em> Desf.</td>
<td>Sterols (betasitosterol), triacylglycerol tocopherols (α-tocopherol), phenols (caffeic acid)</td>
<td>Tree, Fruit, resin</td>
<td>Indigestion, tonic, toothache, astringent</td>
<td>Pirbalouti (2009), Pirbalouti et al. (2010c), Pirbalouti et al. (2012), Saber-Tehrani et al. (2013)</td>
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<td>19</td>
<td>Gol-e Arooneh, (aruone)</td>
<td>Lamiaceae</td>
<td><em>Salvia hydrangea</em> DC. ex Bentham</td>
<td>β-caryophyllene, caryophyllene oxide, spathulenol, 1,8-cineole, α-pinene</td>
<td>Herb, Flowers, leaves</td>
<td>Cough, emollient, sore throat, antibacterial, antispasmodic, carminative and sedative</td>
<td>Barazandeh (2004), Pirbalouti et al. (2010c), Rustaiyan et al. (1997), Sonboli et al. (2009)</td>
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<td>20</td>
<td>Zalzalak Hawthorn</td>
<td>Rosaceae</td>
<td><em>Crataegus curvisepala</em> Lindm. (= <em>Crataegus oxyacantha</em> L.)</td>
<td>Sobutylamine, ursolic acid, oleanolic acid, crategolic acid, adenosine, adenine, guanine, caffeic acid, quercetin, hyperoside, rutin, vitexin-4′-rhamnoside, tyramine, flavonoglycosyls, epicatechol, saponins, tannins, o-ethoxy phenylethylamine</td>
<td>Tree, Fruits, flowers, leaves</td>
<td>Heart discords, edible as wild fruit, hypolipidaemic, anti-inflammatory, anti-anxiety, antimicrobial</td>
<td>Kashyap et al. (2012), Pirbalouti (2009), Verma et al. (2007)</td>
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<td>22</td>
<td>Mousir</td>
<td>Persian shallot</td>
<td>Alliaceae</td>
<td><em>Allium stipitatum</em> Regel (= <em>Allium hirtifolium</em> Boiss.)</td>
<td>Organosulphur, phenolic compounds, allicin, diallyl disulphide diallyl trisulphide, 9-hexadecenoic acid, 11,14-eicosadienoic acid, n-hexadecanoic acid, furostanol and spirostanol saponins, flavonol glycosides</td>
<td>Herb</td>
<td>Bulbs</td>
<td>Edible as vegetable, flavouring, antihypertensive, antibacterial, antioxidant</td>
<td>Barile <em>et al.</em> (2005), Ghahremani-Majd <em>et al.</em> (2012), Ismail <em>et al.</em> (2013), Pirbalouti (2009)</td>
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<td>23</td>
<td>Spand</td>
<td>Syrian rue</td>
<td>Nitrariaceae</td>
<td><em>Peganum harmala</em> L.</td>
<td>Alkaloids (β-carboline), reducing compounds, tannins, volatile oils, saponins, flavonoids, sterols (triterpenes), harmine, harmaline, anthraquinone</td>
<td>Shrub</td>
<td>Fruit, seed</td>
<td>Antimicrobial, anti-parasite, asthma, colic, anthelmintic, antiseptic, gastrointestinal, antispasmodic, antiperiodic,</td>
<td>Benbott <em>et al.</em> (2013), Dastagir <em>et al.</em> (2012), Pirbalouti (2009)</td>
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<td></td>
<td>Plantain</td>
<td>Plantaginaceae</td>
<td><em>Plantago psyllium</em> L.</td>
<td>Polyphenolic acid, flavonoids, mucilages (anionic polysaccharide of L-arabinose, D-xylose and D-galacturonic acid), iridoid glycosides</td>
<td>Herb</td>
<td>Seeds</td>
<td>Cough, emollient, cough, sore throat</td>
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<td>Spharzeh</td>
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<td>Naghdi <em>et al.</em> (2004), Pirbalouti (2009), Saeedi <em>et al.</em> (2010)</td>
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<td>25</td>
<td>Rivas</td>
<td>Polygonaceae</td>
<td><em>Rheum ribes</em> L.</td>
<td>Chrysophanol, physcion, rhein, aloe-emodin, physcion-8-O-glucoside, aloe-emodin-8-O-glucoside, Sennoside A, rhaponticin, flavonoids</td>
<td></td>
<td></td>
<td>Herb Leaves, root edible as vegetable, flavouring, jaundice, indigestion, skin discords, treatment of diabetes, haemorrhoids, ulcer, diarrhoea</td>
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<td>Oktay <em>et al.</em> (2007), Pirbalouti (2009), Sayyah <em>et al.</em> (2009)</td>
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<td>1</td>
<td>Bongkar</td>
<td>Aconite</td>
<td>Ranunculaceae</td>
<td><em>Aconitum orochryseum</em> Stapf</td>
<td>Diterpenoid alkaloids [Hetisine-type (orochrine, 2-O-acetylorochrine, 2-O-acetyl-7α-hydroxyorochrine), atisinium chloride and virescenine], flavonoids, flavonol glycosides, diterpenoid, norditerpenoid</td>
<td>Herb</td>
<td>Aerial parts</td>
<td>Antidote for poisons of scorpion and snake; cures contagious diseases and inflammation of intestines, common cough and cold, bilious fever, dysentery, febrifuge for fevers associated with malaria infection, kidney dysfunction and stomach ulceration, diarrhoea, dysentery, tonsillitis, headache, high altitude sickness, antimalarial</td>
<td>Gajalakshmi et al. (2011), Krug and Milliken (2008), Samten (2009), Wangchuk et al. (2007), Wangchuk et al. (2010)</td>
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<td>2</td>
<td>Bongnag,</td>
<td>Indian</td>
<td>Ranunculaceae</td>
<td>Diterpene alkaloids Herb Tubs, leaves, roots,</td>
<td>Anthelmintic, allays bone disease, mumps, gout, chronic</td>
<td>Gajalakshmi et al. (2011), Krug and Milliken (2008), Samten (2009),</td>
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<td></td>
<td>Bikh</td>
<td>Aconite</td>
<td>Aconitum</td>
<td>flowers</td>
<td>infection and leprosy, analgesic, anti-inflammation, used</td>
<td>Sarkar et al. (2012), Wangchuk et al. (2013)</td>
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<td></td>
<td></td>
<td></td>
<td>heterophyllloides</td>
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<td>for poison for arrows</td>
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<td></td>
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<td></td>
<td>(Brühl) Stapf</td>
<td>(= Aconitum laciniatum (Brühl) Stapf)</td>
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<td>3</td>
<td>Lug-mig</td>
<td>Weak violet</td>
<td>Asteraceae</td>
<td>Phenylpropanoids [(7'R, 8S)-9'-larciresinol-(alpha-methyl)-butanoate, 5,9-dimethoxy-7-(alpha-methyl)-butanoyl-phenyl-2E-propenol-(alpha-methyl)-butanoate], 2-oxo-isocotic acid, mussaenoside, kaempferol-3-O-β-D-glucopyranoside, 1β,6α-dihydroxyeudesm-4(15)-ene, 6β-propionyloxy-1,10-dehydrofuranoeremophil-9-on, indaconitine, lupeol, liquiritigenin, apigenin, tricine, coniferyl aldehyde, friedelin, apigenin, p-hydroxybenzoic acid, 2-O-β-D-glucopyranoside-vicodiol, 10-O-β-D-glucopyranoside-oplopanone</td>
<td>Useful for treating affliction by evil spirits, antitumour, bronchitis, cramps, common cold and relieves pain</td>
<td>Gan et al. (2006), Gangwar et al. (2010), Krug and Milliken (2008), Liu et al. (2010), Miao et al. (2012), Samten (2009)</td>
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<td>5</td>
<td>Yakima</td>
<td>Gold saxifrage</td>
<td>Saxifragaceae</td>
<td><em>Chrysosplenium nudicaule</em> Bunge</td>
<td>Triterpenoids, flavonol glycosides, volatile oil, hexadecanoic acid, ethyl ester, dibutyl phthalate, (Z, Z, Z)-9, 12, 15-octadecatrienoic acid, ethyl ester, 2, 6-butyalted hydroxytoluene, and 5, 6, 7, 7a-tetrahydro 4, 4, 7a-trimethyl-2(4H)-benzofuranone</td>
<td>Herb</td>
<td>Whole plant including aerial parts</td>
<td>Anti-inflammatory and cholagogue; for headaches, gall bladder problem</td>
<td>Krug and Milliken (2008), Samten (2009), Yanli (2006), Yunshang <em>et al.</em> (2004)</td>
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<td>6</td>
<td>Bashaka Primrose, Climbing corydalis</td>
<td>Corydalis cristata Prain</td>
<td>Isoquinoline alkaloids (protopine, 13-oxoprotopine, 13-oxocryptopine, stylopine, coreximine, rheagenine, ochrobirine, sibiricine, bicuculline)</td>
<td>Herb</td>
<td>Whole plant including roots</td>
<td>Used as tonic, promotes vigour, treatment of infections in the blood, liver and bile, antiplasmodial, antimicrobial, anti-inflammatory</td>
<td>Krug and Milliken (2008), Samten (2009), Wangchuk et al. (2012a)</td>
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<td>7</td>
<td>Re-skon Corydalis Papaveraceae</td>
<td>Corydalis dubia Prain</td>
<td>Dubiamine, and isoquinoline alkaloids (cheilanthifoline scolerine, protopine, capnoidine, bicuculline, hydastine, corydecumbine)</td>
<td>Herb</td>
<td>Whole plant including roots</td>
<td>Impure blood detoxifier and neuralgia, treatment of fever arising from affections of heart, lung, pancreas and kidney, antiplasmodial, antimicrobial, cytotoxicity and antiplasmodial activity</td>
<td>Krug and Milliken (2008), Samten (2009), Wangchuk et al. (2011), Wangchuk et al. (2012b)</td>
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<td>8</td>
<td>Dbang-lag Early Marsh Orchid</td>
<td>Dactylorhiza hatagirea (D. Don) Soó</td>
<td>Dactylorhins A-B-C-D-E, dactyloses A and B, lipids, glucoside</td>
<td>Herb</td>
<td>Tubers, roots</td>
<td>General tonic, promotes heat, dysentery, diarrhoea, chronic fever, cough, stomach ache, wounds, cuts, burns, fractures, general weakness, bone fracture</td>
<td>Krug and Milliken (2008), Kizu et al. (1999), Pant and Rinchen (2012), Samten (2009)</td>
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<td>9</td>
<td>Bya-rgod-spos</td>
<td>Delphinium glaciale</td>
<td>Ranunculaceae</td>
<td><em>Delphinium glaciale</em></td>
<td>Alkaloids</td>
<td>Herb</td>
<td>Aerial parts</td>
<td>For fever, loss of appetite, headache, dysentery, body swelling of wounds</td>
<td>Churyukanov (1986), Krug and Milliken (2008), Mashkovsky and Samten (2009)</td>
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<td>13</td>
<td>Parpata</td>
<td>Thinfruit Hypecoum</td>
<td>Hypecoum leptocarpum Hook. f. &amp; Thomson</td>
<td>Alkaloids (leptocarpinine, leptopine, leptopinine, leptopidine, leptopidinine), protopine, isohyperectine, oxohydrastinine (hypecoumine), cryptopine</td>
<td>Herb Whole plant</td>
<td>Useful in treating common cough and cold, skin diseases, blood pressure and poisonings</td>
<td>Chen and Fang (1985), Krug and Milliken (2008), Samten (2009), Zhou et al. (1999)</td>
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<td>15</td>
<td>Pang poe</td>
<td>Spikenard</td>
<td>Caprifoliaceae</td>
<td><em>Nardostachys jatamansi</em> (D. Don) DC. (= <em>Nardostachys grandiflora</em> DC.)</td>
<td>Pranocoumarin [E-2-methyl, 3-(5,9-dimethylbicyclo[4.3.0]nonen-9-yl)-2-propenoic acid and 2',2'-dimethyl-3'-methoxy-3',4'-dihydropranocoumarin], sesquiterpenes, lignans, neo-lignans, coumarins, terpenoid ester (nardostachysin)</td>
<td>Herb</td>
<td>Whole plant (rhizomes, roots)</td>
<td>Used for its astringent, diuretic, digestive, carminative and laxative properties, as liver stimulant, antipyretic and tonic, antiseptic, high blood pressure, insomnia, antispasmodic, treatment of epilepsy, hysteria, convulsions, heart palpitations and round worm</td>
<td>Chatterjee et al. (2000), Chatterjee et al. (2005), Krug and Milliken (2008), Mulliken and Crofton (2008), Samten (2009)</td>
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<td>16</td>
<td>Tsher-sngon</td>
<td>Prickly Blue Poppy</td>
<td>Papaveraceae</td>
<td><em>Meconopsis horridula</em> Hook. f. &amp; Thomson</td>
<td>Alkaloids [8, 9-dihydroprooxocryptochin, isoquinoline, protopine, (−)-reframoline, (−)-amurensinine], tricin, luteolin, apigenin, hydnocarpin, β-sitosterol, luteolin-7-O-β-D-glucopyranoside, kaempferol-3-O-β-D-glucopyranosyl(1→2)]-β-D-glucopyranoside, quercetin-3-O-β-D-galactopyranosyl(1→6)]-β-D-glucopyranoside, tricin-7-O-β-D-glucopyranoside, kaempferol-3-O-β-D-glucopyranoside, cinnamamide, N-p-hydroxyl-trans-coumaroyltaramine, quercetin, kaempferide, kaempferol, 3-(kaempferol-8-yl)-2,3-epoxyflavanone, Herb</td>
<td>Whole aerial part</td>
<td>Strong analgesic, strengthens bones and joints, treatment of headaches and fractures</td>
<td>Haifeng et al. (2009), Krug and Milliken (2008), Liu et al. (2014), Ming-Fang et al. (2009), Samten (2009)</td>
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<td>17</td>
<td>Kutki, putishing</td>
<td>Figwort Flower</td>
<td>Plantaginaceae</td>
<td><em>Neopicrorhiza scrophulariiflora</em> (Pennell) D.Y. Hong</td>
<td>Phenylpropanoid glycosides (scrophulosides A and B), androsin, picroside I, nonglycosidic iridoids, piscrocin (D, E, F, G), iridoid glycosides (piscrosides A and B)</td>
<td>Herb</td>
<td>Stolons, rhizomes, roots</td>
<td>Cold, cough and headache, also for problems related to bile, high blood pressure, sore throat, intestinal pain and conjunctivitis, fever</td>
<td>Kim et al. (2006), Krug and Milliken (2008), Rawal et al. (2009), Samten (2009), Wang et al. (2006)</td>
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<td>18</td>
<td>Drimug, muktsi</td>
<td>Tibetan Onosma</td>
<td>Boraginaceae</td>
<td><em>Onosma hookeri</em></td>
<td>Acetylshikonin, β, β-dimethylacrylshikonin, β, β-dimethylacrylalkannin or arnebin-1, shikonin, naphthaquinone pigments</td>
<td>Herb</td>
<td>Roots</td>
<td>To cure lung diseases, purify blood and stop vomiting of blood, also for tuberculosis, antimicrobial, anticancer, antithrombotic, anti-inflammatory, wound healing, skin rashes</td>
<td>Krug and Milliken (2008), Ning and Cao (1996), Papageorghiou <em>et al.</em> (1999), Samten (2009)</td>
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<td>20</td>
<td>Domnag domthri</td>
<td>Plantaginaceae</td>
<td>Veronica ciliata Fisch.</td>
<td>Iridoid glycosides, benzoic acid</td>
<td>Herb</td>
<td>Entire plant including roots Used as a substitute for bile, used to stop bleeding, wound treatment</td>
<td>Krug and Milliken (2008), Kun et al. (2003), Samten (2009)</td>
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<td>21</td>
<td>A-bhi-sha, Xiao bai he</td>
<td>Liliaceae</td>
<td>Lilium nanum Klotzsch &amp; Garcke</td>
<td>Not reported</td>
<td>Herb</td>
<td>Whole plant (bulbs as tonic) Antidote and allays head injuries, heels bone fracture</td>
<td>Chen et al. (2000), Krug and Milliken (2008), Samten (2009)</td>
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<td>22</td>
<td>Tsepara, lamichop</td>
<td>Crassulaceae</td>
<td>Rhodiola crenulata (Hook. f. &amp; Thomson) H. Ohba</td>
<td>Salidroside (rhodioloside), rosvins, p-tyrosol, 2-Methyl-3-buten-2-ol, 3-Methyl-2-buten-1-ol, n-Octanol, geraniol, citronellol, myrtenol, linalool, 1-Octen-3-ol, pyrogallol, gallic acid, β- sitosterol, crenulatin, ellagic acid kaempferol,</td>
<td>Herb</td>
<td>Fleshy stems (rhizomes), roots Alleviate depression , stimulation of nervous system, antioxidative</td>
<td>Krug and Milliken (2008), Qu et al. (2012), Samten (2009), Wang and Wang (1992)</td>
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<td>Laasona</td>
<td>Garlic</td>
<td>Amaryllidaceae</td>
<td><em>Allium sativum</em> L.</td>
<td>Saponins, sterols, tannins, proteins, carbohydrates, cardiac glycosides, sulphur compounds (trisulfide, di-2-propenyl; disulfide, di-2-propenyl; trisulfide, methyl 2-propenyl, diallyl disulide)</td>
<td>Herb</td>
<td>Bulb and oil</td>
<td>Anticancer, antimicrobial, reduces blood pressure and blood cholesterol, antiviral, antifungal, anti-inflammatory, stimulant, carminative, antiseptic, anthelmintic, expectorant, diuretic, diaphoretic, diuretic, antisorbutic aphrodisiac, antiasthmatic, pulmonary diseases</td>
<td>Douiri <em>et al.</em> (2013), Kadam <em>et al.</em> (2013), Mikail (2010)</td>
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<td>3</td>
<td>Balsana, Dendhu</td>
<td>Hypericaceae</td>
<td><em>Hypericum perforatum</em> L.</td>
<td>Dianthrone derivatives (hypericin, pseudohypericin, protohypericin), phloroglucinol derivatives (hyperforin, furohyperforin, adhyperforin), flavonoids (hyperoside, quercetin, quercetrin, rutin, biapigenin, kaempferol), flavonols (catechins), xanthones, n-Alkanols, Monoterpenes (α-pinene, β-Pinene, limonene), sesquiterpenes (caryophyllene, humulene)</td>
<td>Herb, leaves, flowers</td>
<td>Analgesic, anti-viral, anti-censor, antidepressant and antiviral activity, treatment of traumas, burns, scabs and ulcers</td>
<td>Basu <em>et al.</em> (2007), Vattikuti and Giddi (2005),</td>
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<td>4</td>
<td>Shimla mirch, hot peppers, chili pepper</td>
<td>Solanaceae</td>
<td><em>Capsicum annum</em> L.</td>
<td>Capsaicin, carotenoids (capsanthin, zeaxanthin, provitamin A carotenoids : β-cryptoxanthin, α-carotene, β-carotene), flavonoids (quercetin and luteolin), total soluble reducing equivalents, phenolic acids, ascorbic acid</td>
<td>Herb, fruit</td>
<td>Anticancer, anti-inflammatory, antiapoptotic, analgestic, carminative, rubefacient, anti oxidant, hypoglycemic, antifungal, antimicrobial, used as carminative, an appetiser and a stomachic. treatment of rheumatism, lumbago, neuralgia, and mental disorders</td>
<td>Howard <em>et al.</em> (2000), Laroche (2007), Sunil <em>et al.</em> (2012)</td>
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<td>Kali mirch</td>
<td>Black pepper</td>
<td>Piperaceae</td>
<td><em>Piper nigrum</em> L.</td>
<td>Piperine, alkaloids, coumarins, phenols, tannins, β-Elemene, tricyclo[6.2.1.0(4,11)]undec-5-ene,1,5,9,9-tetramethyl-(isocaryophyllene-II), β-caryophyllene, (+)-β-Selinene, eremophilene, nonacosane, methyl hexadecanoate, ethyl hexadecanoate, methyl 14-methyl heptadecanoate, methyl trans-8-octadecanoate, ethyl cis-9-octadecanoate, hexadecanoic acid, octadecanoic acid</td>
<td>Herb</td>
<td>Fruit</td>
<td>Helps in digestion, antimicrobial, antiapoptotic, antibacterial, anti-Colon toxin, antidepressant, antifungal, anidiarrhoeal, anti-inflammatory, antimitogenic, anti-metastatic activity, antioxidative, antihypertensive, antispasmodic, antispermatogenic, antithyroid, ciprofloxacin potentiator, cold extremities, gastric ailments, hepatoprotective, insecticidal activity, intermittent fever, larvicidal activity</td>
<td>Ahmad <em>et al.</em> (2012), Krishnaswamy (2008), Siddiqui <em>et al.</em> (2005), Trivedi <em>et al.</em> (2011)</td>
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<td>6</td>
<td>Kala-dhatura</td>
<td>Solanaceae</td>
<td><em>Datura metel</em> L.</td>
<td>Tropane alkaloids, flavonoids, glycosides, phenols, tannins, sterols saponins</td>
<td>Herb</td>
<td>All parts</td>
<td>In treatment of heart ailments, antibacterial, antifungal, asthma, cough, convulsion, insanity, anaesthetic, antispasmodic, bronchodilator and as hallucinogenic</td>
<td>Akharaiyi (2011), Dahanukar et al. (2000), Kiruthika and Sornaraj (2011)</td>
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<td>7</td>
<td>Vilayati pudina</td>
<td>Lamiaceae</td>
<td><em>Mentha × piperita</em> L.</td>
<td>Menthol (Monoterpenes), alkaloids, flavonoids, steroids, tannins, phenols</td>
<td>Herb</td>
<td>Leaves</td>
<td>Topical pain reliever &amp; antipyretic, antibacterial, common cold, musculoskeletal pain, to calm pruritus and relieve irritation, anti-inflammation</td>
<td>Galeotti et al. (2002), Herro and Jacob (2010), Pramila et al. (2012), Sujana et al. (2013)</td>
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<td>Scots pine (Pine oil)</td>
<td>Pinaceae</td>
<td><em>Pinus sylvestris</em> L.</td>
<td>Borneol (Monoterpenes: α-pinene, car-3-ene, β-pinene, β-phellandrene, camphene, myrcene, limonene, terpinolene), glycerol, 3′-O-methylcatechin, phenolic compounds</td>
<td>Tree</td>
<td>Needles (leaves)</td>
<td>Disinfectant, antibacterial, antifungal, antiviral, antiseptic (pulmonary, urinary, hepatic), antineuralgic, cholagogue, choleretic, diuretic, expectorant, hypertensive, cough, catarrh</td>
<td>Basu et al. (2007), Maciąg et al. (2007), Pan and Lundgren (1996)</td>
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<td>Serpana</td>
<td>Wormwood</td>
<td>Asteraceae</td>
<td><em>Artemisia absinthium</em> L.</td>
<td>Santonin (sesquiterpene), tannins, mucilages, reducing sugars, flavones, volatile oil (1,8-cineole, artemisia ketone, myrcene, (E)-sabinyl acetate, cis-chrysanthemyl acetate, germacrene D, linalool acetate, a dihydrochamazulene isomer, α-phellandrene, linalool, neryl 3-methylbutanoate, neryl 2-methylbutanoate, neryl butyrate, curcumene, carvone, trans-verbénol, trans-epoxyocimene, β-thujone sabine, chamazulene, α-thujone), resinic acids, carotenoids, coumarins, terpenoids, alkaloids, phenolic compounds (syringic acid, fisetin, isorhamnetin, kaempferol), phytosterols (β-sitosterol, stigmasteryl)</td>
<td>Herb</td>
<td>All parts</td>
<td>Photosensitizer, cytotoxic, anthepatotocic, antibacterial, antifungal, antioxidant, antimalarial</td>
<td>Basu et al. (2007), Bora and Sharma (2010), Iviánescu (2010), Orav et al. (2006), Sharopov et al. (2012b)</td>
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<td>10</td>
<td>Karpasa</td>
<td>Cotton</td>
<td>Malvaceae</td>
<td><em>Gossypium herbaceum</em> L.</td>
<td>Gossypol (sesquiterpene), tannin, starch, saponin, calcium, mucilage, carbohydrate, phenolic compounds</td>
<td>Shrub</td>
<td>Seeds, leaves, roots</td>
<td>Contraceptive-for males, wound healing, antimicrobial, menstrual disorders</td>
<td>Basu et al. (2007), Masram et al. (2012), Velmurugan et al. (2012)</td>
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<td>11</td>
<td>Haaliyna</td>
<td>Asparagus</td>
<td>Asparagaceae</td>
<td><em>Asparagus officinalis</em> L.</td>
<td>Steroidal saponins, vitamins, essential oils, asparagine, arginine, tyrosine, flavonoids (kaempferol, quercetin, rutin), resin, and tannin</td>
<td>Herb</td>
<td>Tuberous roots, young shoots, antioxidants, immunostimulants, anti-inflammatory, antihepatotoxic, antibacterial, antioxotyic, dysuria, diabetes, and dysentery, appetiser, antitumour, useful in biliousness, leprosy, epilepsy, and night blindness, disease of kidney and liver, tonic, astringent, vermifuge</td>
<td>Kaur and Kapoor (2002), Negi et al. (2010)</td>
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<td>12</td>
<td>Pyaja</td>
<td>Red onion</td>
<td>Amaryllidaceae</td>
<td><em>Allium cepa</em> L.</td>
<td>Flavonoid quercetin, carbohydrates, glycosides, cardiac glycosides, proteins, alkaloids, saponins, flavonoids, acid compounds, triterpenic acids, reducing sugars, oils, resin, seed constituents (thanshic acid, N-trans-feruloyl tyramine, β-sitosterol-3 β-glucopyranoside-6′-palmitate, sitosterol, daucosterol, tryptophane, adenine riboside), thiosulfimates (alkane(ene) thial-S-oxide)</td>
<td>Herb</td>
<td>Bulb</td>
<td>Wound healing, antimicrobial, common cold, heart disease, treatment of topical scars, antioxidant, cardiovascular disease, anticancer, to lowering blood pressure and cholesterol levels, anthelmintic, anti-inflammatory, antiseptic, antispasmodic, carminative</td>
<td>Benkeblia and Lanzotti (2007), Patwardhan et al. (2005), Sampath Kumar et al. (2010), Tatāringā et al. (2005), Yuan et al. (2008), Begum and Yassen (2015)</td>
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<td>Hathichak</td>
<td>Artichoke</td>
<td>Asteraceae</td>
<td><em>Cynara cardunculus var. scolymus</em> (L.) Fiori</td>
<td>Flavonoids and phenolic acids: apigenin, luteolin and their conjugates (luteolin 7-rutinoside, luteolin 7-malonylglucoside, luteolin aglycone, luteolin 7-glucoside), flavanones, aglycone apigenin, anthocyanins (cyanidin glycosides), chlorogenic acid, 1,5-O-dicaffeoylquinic acid, apigenin-7-O-glucuronide, quinic acid, 5-O-cafeoylquinic acid, 1,5-O-dicaffeoylquinic acid, 3-, 4-, and 5-cafeoylquinic acids, 1,3-dicaffeoylquinic acid (cynarin), 1,5-dicaffeoylquinic acid, ferulic acid, cumaric acid, inulin etc.</td>
<td>Herb</td>
<td>Inflorescences, leaves, stalks</td>
<td>Anti cancer, inhibition of UV-induced skin carcinogenesis (anticarcinogenic) and vasomodulating, cardiovascular disease, diuretic and liver protector, antioxidant, antiinflammatory, antimutagenic, anti-proliferative, antiatherosclerotic</td>
<td>Pandino <em>et al.</em> (2011), Pandino <em>et al.</em> (2012), Velez <em>et al.</em> (2012)</td>
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<td>Anaara</td>
<td>Pomegranate</td>
<td>Lythraceae</td>
<td><em>Punica granatum</em> L.</td>
<td>Carbohydrates, reducing sugars, sterols, glycosides, phenolics, tannins, flavonoids, proteins, saponins, triterpenoids, steroids, alkaloids, vitamin C, punicaflavone, punicaflavone, granatumoside</td>
<td>Small tree (shrub)</td>
<td>Root bark, dried fruit, stem bark, leaves, seeds, immature fruits, fruit rind</td>
<td>Blood purifier, treatment of dysentery, diarrhoea, nasal haemorrhage, helminthisis, acidosis, haemorrhage and respiratory pathologies, antibacterial, antifungal, antiprotozoal, antioxidant, antimicrobial, sore throat, haematuria, haemoptysis, against tapeworms, to relieve conjunctivitis</td>
<td>Ali and Sharma (2006), Bhandary <em>et al.</em> (2012), Hegde Chaitra <em>et al.</em> (2012)</td>
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<td>15</td>
<td>Ghrita-Kumari, Kumari</td>
<td>Strawberry</td>
<td>Rosaceae</td>
<td><em>Fragaria × ananassa</em> Duch. ex Rozier</td>
<td>Phenolic compounds (ellagic acid, p-coumaric acid), flavonoids (quercetin, kaempferol, myricetin), anthocyanins (pelargonidin 3-glucoside, cyanidin 3-glucoside, pelargonidin 3-rutinoside), aglycons [2,5-dimethyl-4-hydroxy-3(2H) furanone (furaneol), 2,5-dimethyl-4-methoxy-3(2H) furanone (mesifurane), 2,3-Dihydrobenzofuran, 3-Phenyl-2-propenoic acid, hexanoic acid etc.]</td>
<td>Herb</td>
<td>Fruit</td>
<td>antioxidant activity, antibacterial, antifungal</td>
<td>Filippone <em>et al.</em> (1999), Groyne <em>et al.</em> (1999), Panico <em>et al.</em> (2009)</td>
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<td>21</td>
<td>Methi</td>
<td>Fenugreek</td>
<td>Trigonella foenum-graecum L.</td>
<td>Coumarin, scopoletin, fenugreekine, trigonelline, glucosides, acubine type of glucosides, cyanogenic glucosides, phenol, flavanol, amino acids, alkaloids, tannin, steroids, volatile oil, proteins, polysaccharides, saponin, nicotinic acid, sapogenins, phytic acid, fibres, galactomannans</td>
<td>Whole plant and seeds</td>
<td>Hypoglycaemic effects, hypercholesterolemic, antioxidative, laxative and fungicide effects, appetite stimulant, tonic, blood sugar lowering, anti-diabetic, anti-fertility, anticancer, antimicrobial, anti-parasitic, anti-viral, anti-inflammatory</td>
<td>Acharya et al. (2006), Basch et al. (2003), Basu et al. (2007), Bukhari et al. (2008), Nandagopal et al. (2012), Shaikh et al. (2013)</td>
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<td>22</td>
<td>Lodhra, Tilva</td>
<td>Lodh Tree</td>
<td>Symplocaceae</td>
<td><em>Symplocos racemosa</em> Roxb.</td>
<td>Saponin, steroids, steroids, proteins, glycosides, carbohydrate, flavonoids, terpenoid, tannins (e.g., allergic acid), essential oil, alkaloid (e.g., loturine, loturidine, colloturine), symposide, anthrasinins (e.g., 3-mono gluco furanoside), betulin, butulnic acid, acetylolanolic acid, oleonolic acid, benzoysalireposide, salireposide, β-amyrin, β-sitosterol, β-sitosterol glycoside, symconoside A, symconoside B</td>
<td>Small tree (shrub)</td>
<td>Bark</td>
<td>Anti-inflammatory, antioxidant, diarrhoea, dysentery, in dropsy, eye disease, liver complaints, fevers, ulcers, scorpion-string, anticancer, antiulcerogenic activity, uterin stimulant</td>
<td>Ahmad et al. (2003), Ahmad et al. (2005), Gopala Krishna et al. (2013), Kambhoja and Keshava Murthy (2004), Krishnaraju et al. (2006), Viral (2010)</td>
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<td>23</td>
<td>Afeem, Khuskhus</td>
<td>Opium poppy</td>
<td>Papaveraceae</td>
<td><em>Papaver somniferum</em> L.</td>
<td>Alkaloids (morphine, codeine, thebaine, papaverine, noscapine, etc.)</td>
<td>Herb</td>
<td>Capsule, latex, seeds</td>
<td>Antidepressant, painkiller-nowadays especially for cancer patients, anti-cough, muscle relaxant agent, analgesic, CNS, stimulants</td>
<td>Akhtar et al. (2013), Basu et al. (2007), Dittbrenner et al. (2008), Dittbrenner et al. (2009), Krishnaraju et al. (2006)</td>
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Table 1.5 Medicinal plants from Latin American with potential for use as nutraceutical and as functional food component.

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<td>Altanisa</td>
<td>Mugwort</td>
<td>Asteraceae</td>
<td><em>Artemisia vulgaris</em> L.</td>
<td>Monoterpenes, polycetylenes, sesquiterpenes, quiterpenlactones, coumarins, flavonoids, oestrogenic, alkaloids</td>
<td>Herb</td>
<td>Roots, leaves, flowers, seeds</td>
<td>Abdominal pain, anti-parasites, diabetes, diarrhoea, hysterics, remedy to prevent vomiting, rheumatism</td>
<td>Govindaraj et al. (2008), Ikhsanova et al. (1986), Lee et al. (1986), Marco et al. (1991), Méndez-González et al. (2012), Näf-Müller et al. (1981), Rodríguez (2009)</td>
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<td>K´ab ché</td>
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<td>Ebenaceae</td>
<td><em>Diospyros anisandra</em> S. F. Blake</td>
<td>Naphthoquinone plumbagin</td>
<td>Shrub</td>
<td>Roots, stem bark, leaves</td>
<td>Antimicrobial, haemorrhaging, scabies</td>
<td>Ankli (2000); Borges-Argáez et al. (2007), Méndez-González et al. (2012)</td>
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<td>Chaksink'in</td>
<td>Cudjoe wood</td>
<td>Theophrastaceae</td>
<td><em>Bonellia macrocarpa</em> (Cav.) B. Ståhl &amp; Källersjö</td>
<td>Bonediol</td>
<td>Shrub</td>
<td>Roots, leaves, flowers, seeds</td>
<td>Anti-parasites, antitussive, asthma, catarrh, cough, dysentery, toothache, whooping cough</td>
<td>Argueta et al. (1994), Caamal-Fuentes et al. (2011), Méndez-González et al. (2012), Mendieta and Del Amo (1981), Pulido Salas and Serralta Peraza (1993)</td>
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<td>Nance blanco</td>
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<td>Malpighiaceae</td>
<td><em>Byrsonima bucidaefolia</em> Standl.</td>
<td>Methyl gallate, 3-gallate</td>
<td>Shrub</td>
<td>Stem bark</td>
<td>Diarrhoea, dysentery</td>
<td>Castillo-Ávila et al. (2009), Méndez-González et al. (2012)</td>
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<td>13</td>
<td>Analk’ak</td>
<td>Mexican Milkweed</td>
<td>Apocynaceae</td>
<td><em>Asclepias curassavica</em> L.</td>
<td>3,4-seco-triterpenoids, pregnanes and pregnane glycosides, 12b,14b-dihydroxy-3b,19-epoxy-3a-methoxy-5a-card-20(22)-enolide, coroglaucigenin, 12b-hydroxykoroglaucigenin, calotropigenin, uscharidin, asclepin, 16a-acetoxyasclepin, 16a-acetoxycalotropin, 16a-hydroxyasclepin, 12b-hydroxyasclepin</td>
<td>Herb</td>
<td>Leaves, fruit</td>
<td>Anticatharral, asthma, bile, catarrh, cysts, dental caries, gonorrhoea, grippe, headache, rheumatism, skin cancer, tumours</td>
<td>Abe et al. (1991), Abe et al. (1992), Ankli (2000), Argueta et al. (1994), Li et al. (2009), Méndez-González et al. (2012), Pulido Salas and Serralta Peraza (1993)</td>
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<td>Golden spoon</td>
<td><em>Byrsonima crassifolia</em> (L.) Kunth.</td>
<td>Tree or shrub, stem bark, leaves</td>
<td>Antidote for snake bites, antitussive, bile, constipation, diabetes, diarrhoea, dysentery, scabies</td>
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<td>Malva de monte</td>
<td>Malvaceae</td>
<td>Sleepy Morning</td>
<td><em>Waltheria indica</em> L.</td>
<td>Herb, leaves, stems</td>
<td>Amebiasis, diarrhoea, fungal infection on lips, renal insufficiency</td>
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<td>Guava</td>
<td><em>Psidium guajava</em> L.</td>
<td>Shrub, stem bark, leaves, flowers, fruit, seeds</td>
<td>Anti-inflammatory, anti-parasites, antitussive, diarrhoea, dysentery, haemorrhoids</td>
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<td>19</td>
<td>Sinanché</td>
<td>Prickly yellow</td>
<td>Rutaceae</td>
<td>Furoquinoline alkaloids, skimmianine, 5-Methoxycanthin-6-one and N-methylisocorydine</td>
<td>Stem bark, leaves</td>
<td>Epilepsy, headache, leprosy, rheumatism, scabies</td>
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<td>Chicozapote</td>
<td>Sapodilla</td>
<td>Sapotaceae</td>
<td>Fructose, galactose, glucose, glucuronic acid, myo-inositol, sucrose, flavonoids amelopsine, catechin, epicatechin, surbose, galloatechin, myricitrin, quercetin, chlorogenic acid methyl ester</td>
<td>Stem bark, leaves, fruits, resin, seeds</td>
<td>Antivenom, cholesterol, diabetes, diarrhoea, dysentery, haemorrhaging, kidney and liver disease</td>
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communities. For the poorer sections of the global community, the cost of modern synthetic drugs is high, and thus such drugs are often not readily accessible. Hence, the applications of plant-based nutraceuticals and functional food and value-added products are extremely important for general health of such communities (Sudip Datta Banik, personal communication).

With progress in the field of cellular-level nutraceuticals, the several scientific faculty communities arise working towards preparing templates into which they can integrate information from several clinical studies conducted on the topic of alternate medical therapies. This template can be further strengthened in near future to prepare standardised drug regimens and therefore, natural products could pose a tough competition to synthetic drug manufacturers globally (Gupta 2016). In India, the Coconut Development Board in Kochi, Kerala has equipped itself with the proper machineries and manoeuvres required for production of value-added products from coconuts. These products are believed to have immense potential for setting up of niche markets both in India and abroad. The proposed products are virgin coconut oil, spray dried coconut milk powder, coconut vinegar and so on (Kerala State Industrial Development Corporation 2013).

A new term introduced in the functional food and nutraceuticals industry is ethnopharmacognosy. What does ethnopharmacognosy mean? The term actually refers to the plant-derived medicines, which local people have used for treatment of diseases for hundreds of years. But these medical principles have been overshadowed by the rapidly growing pharmaceutical industries. However, recent revival of this nature-based drug industry has brought a new ray of hope to these local ethnic people who find it difficult to access and afford the expensive allopathic medications. This ethnopharmacognosy utilises sophisticated gadgets to analyse the nutrient composition of different species of plants with quite remarkable perfection (Windward Community College 2013).

Several clinical trials of functional foods have been carried out with satisfactory results in experimental animals and human volunteers. Cranberries (Vaccinium oxyccos L.) have been found to contain good amounts of tannins that can prevent attachment and colonisation of urothelial cells by Escherichia coli, and hence, are beneficial as a prophylactic agent against urinary tract infections. Consumption of garlic (Allium sativum L.) in the daily diet can be helpful in controlling blood pressure and also the occurrence of cancer due to the presence of certain organosulfur compounds viz. alli- cin. Lycopene in tomatoes (Lycopersicon esculentum Mill.) have shown a positive role in cancer chemoprevention (Hasler 2002).

The bioactive products in these functional food can, however, be increased in concentration through bio-engineering procedures. An example of such procedures includes preparation of ‘heart-healthy’ oils through enrichment with saturated fatty acids and Ω-3 unsaturated fatty acids along with low levels of α-linolenic acid. Gene silencing techniques to produce oleate and stearate rich cottonseed oil and genetically engineered tomatoes are other examples (Pew Initiative on Food and Biotechnology 2007).

However, it must be kept in mind that diet is just one part of a comprehensive approach towards a healthy life. Several other conditions must be fulfilled before one can assume functional foods to be at the helm of a new beginning. There are significant barriers to the progress in this field of technology (Gupta 2016; National Nutraceutical
Federal regulations and lack of sufficient manpower are just the two of the many factors that may impose a speed breaker in its expansion (Gupta 2016; National Nutraceutical Centre 2014). Even cultures and beliefs in several parts of the world can act as a challenge to the widening of the functional food market (Gupta 2016; National Nutraceutical Centre 2014). Rigorous investigative studies for finding out the adverse effects to such tampered natural products should be done every now and then to ensure minimum physiological turmoil upon their consumption (Hasler 2002). A well-known example is the St. John's wort that can significantly alter drug metabolism in liver and thus fail therapeutic benefits arising out of its administration in the human body (Hasler 2002).

However, the success of nutraceutical and functional food industry significantly depends upon the lifestyle of the people in that region. Those who are more conscious about health and keen on updating themselves on newer healthy food products will form the target consumer group for the market. But these products should not merely be sold en masse for the purpose of making profit for the industry with no concern about human health. There must be a proper integration of science and technology with marketing principles to ensure a healthy living (Kantatasiri 2012).

1.3 Plants with Potential for Use as Nutraceutical Source and Functional Food Component

A wide variety of medicinal plants are found in the continents of Africa (Table 1.1), Asia (Tables 1.2–1.4) and Latin America (Table 1.5) that have potent medicinal values and therefore could become an important component of nutraceuticals and functional food in the near future (Basu et al. 2007).

1.4 Nutraceutical Values of Fenugreek

Fenugreek (*Trigonella foenum-graecum* L.) is an annual herbaceous legume plant belonging to the dicot family Fabaceae and is grown commonly in the Southern European Mediterranean region. Both the seeds and leaves of the plant are used primarily as a culinary spice (Acharya et al. 2008). The seeds are reported as excellent nutritional supplement and frequently used by herbalists for the health benefits (Acharya et al. 2008; Zandi et al. 2015). The seeds are commonly used in India and other oriental countries as a spice due to the characteristic aroma attributed to curry preparations (Acharya et al. 2008). The seeds are reported to stimulate digestive processes, have antiatherosclerotic effects, and are also used in the treatment of diabetes, high cholesterol, wounds, inflammation and gastrointestinal ailments (Acharya et al. 2008; Ajabnoor and Tilmisany 1988; Basch et al. 2003; Khosla et al. 1995; Miraldi et al. 2001; Sharma and Raghuram 1990; Zandi et al. 2015). The medicinal, nutraceutical and functional food values of fenugreek hold great promises and can be easily examined in normotensive and hypertensive subjects along with the subjects/patients suffering from acute and chronic dyslipidemia and functional disorders of hepatic tissues (cirrhosis of liver) and hepatic enzymes (Sudip Datta Banik, personal communication).
1.4.1 *Fenugreek Possesses the Following Medicinal Properties*

1.4.1.1 *Antioxidant Activity*
Free radicals are known to initiate oxidative stress while searching for chemical stability via electron pairing with biological macromolecules (like proteins, lipids and DNA) in healthy cells of human and result in damages to DNA and proteins along with lipid peroxidation (Braca *et al.* 2002; Maxwell 1995). These changes are reported to cause atherosclerosis, cardiovascular diseases, ageing and inflammatory diseases and cancers (Braca *et al.* 2002; Maxwell 1995). The free radical damages in the cells are protected by functionally specialised enzymes like superoxide dismutase (SOD) and catalase; or compounds like ascorbic acid, tocopherol and glutathione (Choudhary *et al.* 2011). Often these protective defence systems are disrupted by different pathological processes, hence, antioxidant supplements are important to deal with such oxidative damages (Choudhary *et al.* 2011). Currently, different aspects of traditional ethnomedicines are being actively perused across the globe in search for better antioxidant properties with low cytotoxic levels (Krishnendu Acharya, personal communication). Fenugreek with its large array of important phytonutrients demonstrating antioxidant activities can easily play an important role as nutraceutical and functional food agent in the not-so-distant future (Acharya *et al.* 2011).

1.4.1.2 *Anti-leukemic Effect*
Leukaemias are a heterogeneous group of neoplasms arising from malignant transformation of haematopoietic cells, that is, blood forming cells (Van Der Velden *et al.* 2003). It is a disease of blood forming tissues in which the bone marrow is always involved and is characterised by overabundance of one cell type, usually an immature leukocyte (Pui and Crist 1995). Leukaemia is the most common childhood malignancy, representing 30% of all childhood cancers in children under the age of 15 years (Pui and Crist 1995). In India and as well as in the rest of the world, childhood acute lymphoblastic leukaemia (ALL) is the most prevalent form of leukaemia (Pui and Crist 1995). Many of the currently available anticancer therapies are inadequate in terms of their therapeutic efficacy and are known to have undesirable side effects (Smith 2001). However, phytonutrients have been reported to demonstrate anti-growth and chemopreventive properties against different types of cancers without demonstrating adverse side effects unlike chemotherapeutic treatments (Smith 2001). Recent researches indicate that fenugreek plant due to its important active constituents may possess potential anticarcinogenic properties (Santanu Paul, personal communication). The potential anti-leukemic properties of dietary fenugreek seed has been recently reported (Acharya *et al.* 2011).

1.4.1.3 *Anti-Hyperglycemic Effect*
Ingestion of unprocessed fenugreek seeds in diet by diabetic subjects has been found to significantly reduce blood glucose concentrations over an observation period of 21 days. However, complete reduction to normoglycemic values has not yet been documented. Streptozotocin-induced diabetic rats when kept on fenugreek diet have shown reduction in blood sugar and cholesterol concentrations. The plant has been found to act as an insulin secretagogue in non-insulin dependent diabetes mellitus (NIDDM) patients. But in insulin dependent diabetes mellitus (IDDM) subjects, not
quite convincing results are yet available. Some glycosidic extracts in fenugreek seeds and leaves have been found to produce early liver degeneration in experimental mice models. So some amount of cautions should better be practised while consuming high doses of the plant extracts (Acharya et al. 2007). Hence, it becomes quite clear that apparently a bit more research into the anti-hyperglycemic activity of fenugreek can someday solve the problem of buying expensive drugs for controlling diabetes (Acharya et al. 2007).

1.4.1.4 Hypocholesterolemic Effect
Rats have demonstrated lowering of blood LDL and VLDL levels when they were kept on a fatty diet supplemented with 15% to 20% fenugreek extracts. Even triglyceride levels have shown a significant decline. Human NIDDM subjects too have shown a positive response along with a slight increase in blood high-density lipoprotein (HDL) levels. All these results point towards the potential antiatherosclerotic activity of fenugreek seeds and hence, a possible future therapy for ischemic heart disease (IHD) patients (Al-Habori and Raman 2002).

1.4.1.5 Neuroprotective Effect
The antioxidant action of fenugreek possibly has a role to play in protecting neurons from free radical–induced toxicities. Therefore, these plants can become a possible source of prevention and treatment of certain neurodegenerative disorders like Alzheimer’s disease, Huntington’s disease and Parkinson’s disease (Acharya et al. 2007).

1.4.1.6 Anticarcinogenic Effect
The anticarcinogenic potential of fenugreek has been shown in experiments conducted on mouse skin papilloma models where the tumourigenesis has been induced by exposing the animals to certain mutagenic chemicals. The mice that underwent therapy with fenugreek seed extracts throughout the induction period showed maximum resistance to tumour development as was evident from the reduced frequency of micronuclei and chromosomal aberrations in their cells (Chatterjee et al. 2013).

However, quite a few adverse effects have been reported from consumption of fenugreek seed extracts (Acharya et al. 2007). People with hypersensitivity to fenugreek seed chemicals developed rhinorrhea, wheezing and angioedema upon its administration (Al-Habori and Raman 2002). Few others were reported to be suffering from dyspepsia, diarrhoea and dizziness (Acharya et al. 2007). Presence of anticoagulant property in fenugreek seeds poses a serious threat to patients undergoing warfarin therapy with the possibility of occurrence of intracranial haemorrhage and followed by a massive catastrophe to follow (Konkle 2012).

1.5 Coloured Potatoes as Functional Food
Cultivation of coloured potatoes (Solanum tuberosum L.) began with the purpose of harvesting potato cultivars with appealing colours (Figure 1.1) and excellent taste for use in different cuisines. Naturally obtained colouring agents are always acceptable than synthetic dyes to avoid significant health hazards. Moreover, potato finds use in a wide variety of dishes all around the world as an indispensable part of most food cultures.
The chemical responsible for imparting colour to these potatoes is called anthocyanin which, if acylated, provides increased durability and stability of the pigment during the time of processing and storage of potatoes. The most studied variety among the coloured potatoes is the red-fleshed potato where the major anthocyanin pigment has been found to be pelargonidin-3-rutinoside-5-glucoside acylated with $p$-coumaric acid (Rodriguez-Saona et al. 1998).

Phenolic compounds are one of the groups of secondary metabolites of plant. They are the source of various plant-derived nutraceuticals (Wildman 2001). The popular nutraceutical families under this large umbrella are lignin, tannins, coumarins, flavonols, flavonones, isoflavones and anthocyanins. The same author pointed that the diversity of phenolic compounds is based on hydroxyl group or phenol structure on an aromatic ring (Wildman 2001). Interesting and larger molecules are formed from phenol structure such as lignin, tannins, coumarins, flavonols, flavonones, isoflavones and anthocyanins. For plants, these molecules perform many functions, including attracting pollinators, absorbing light, defending against pathogens and herbivores, promoting symbiotic association with nitrogen-fixing bacteria and reducing the development of competitive plant. The predominant biosynthetic pathways that form phenolic compounds are the malonic and shikimic acid pathways. The more significant is shikimic acid pathway in higher plants (Wildman 2001). In lower plants, such as bacteria and fungi, the predominant source of secondary metabolites is the malonic acid pathway. In plants, flavonoids are

Figure 1.1 Advanced clones of potato (*Solanum tuberosum* L.) with coloured tubers with potential for use as nutraceutical and as functional food and value-added food products grown near Kunming, Yunnan province, P. R. China. (a). Normal/Standard Coloured Flesh-Yunshu 502 (Whole Tubers); (b). Purple Coloured Flesh-Purple Yun-1 (Whole Tubers); (c). Red Coloured Flesh (Whole and Sliced Tubers); (d). Pink Coloured Flesh (Whole and Sliced Tubers); (e). Yellow Coloured Flesh (Whole and Sliced Tubers) and (f). Purple Coloured Flesh (Whole and Sliced Tubers). Photo courtesy: (a).-(e). Xianping Li and Yanshan Li. (See color plate section for the color representation of this figure.)
one of the major classes of phenolic compounds. Glycosides are actually naturally occurring flavonoids. They promote the symbiotic association with nitrogen-fixing bacteria and roots of plants. Hesperidin in citrus fruit is most ubiquitous flavonoids (Wildman and Kelley 2007). They also pinpointed quercetin as a common flavonoid (Wildman and Kelley 2007). Further, they found that plants produced anthocyanidins and anthocyanins and their functions mainly acted as colouring pigments. They were thus responsible for the violet, blue, pink and red colouring of many vegetables and fruits, including strawberries, raspberries, radishes, plums, peaches, plums, peaches, oranges, grapes, cherries, red cabbage, coloured potatoes, apples and blueberries (Wildman and Kelley 2007). These colouring pigment molecules help to captivate animals for seed dispersal and pollination. Only 16 anthocyanidins in plants have been identified and include petunidin, malvidin, peonidin, delphinidin, cyaniding and pelargonidin (Wildman and Kelley 2007). Anthocyanidins and anthocyanins are responsible for the violet, blue, pink, and red colouring of many vegetables and fruits, including strawberries, raspberries, radishes, plums, peaches, plums, peaches, oranges, grapes, cherries, red cabbage, coloured potatoes, apples and blueberries (Wildman and Kelley 2007).

However, these anthocyanidin and anthocyanin pigments later proved to be a major source of antioxidants in the potatoes (Nayak et al. 2011). Antioxidant action is necessary in the human body to fight against malignant cells and also protect the retinal cells from being damaged by exposure to UV rays (Burmeister et al. 2011). Therefore, enhancing anthocyanin pigment concentrations along with carotenoids and polyphenols in the potatoes can possibly boost the antioxidant activities in human body cells upon consumption of these coloured vegetables in everyday diet (Nayak et al. 2011). The concentration of these chemicals varies in the different cultivars viz. red, purple, yellow and white coloured potatoes (Burmeister et al. 2011). So selection of the variety with the maximum tolerable limit of anthocyanin is essential to ensure a healthy body (Burmeister et al. 2011).

The red potato extracts have prevented D-galactosamine–induced hepatotoxicity in experimental rats (Han et al. 2006, Nayak et al. 2011). The purple potatoes have resulted in enhanced gene expression for SOD and glutathione peroxidase in liver cells of the experimental animal models (Nayak et al. 2011). This protection against hepatocellular injury was evident from prevention of linoleic acid oxidation (Hashimoto et al. 2010). In addition to the afore-mentioned anthocyanin pigment of red potatoes, purple-coloured potatoes also possess chemicals like acylated glycosides of malvidin, petunidin, peonidin and delphinidin (Lachman et al. 2009). The four main cultivars of coloured potato show significant variations in the concentration of the anthocyanin pigments (Burmeister et al. 2011). These variations are because of interaction between the cultivating environment and its influence on the genetic framework of the plants (Basu et al. 2007). This phenomenon is termed Genotype X Environment interaction (Acharya et al. 2010).

Studies conducted on the concentration of anthocyanin pigments in red, yellow, purple and white potatoes revealed that purple variety retained its colour in dry potato flakes after undergoing steam-blanching procedure (Nayak et al. 2011). Since dry potato flakes are an important source of chips and fried potato products, therefore coloured potatoes can become an important source of value-added products as well (Nayak et al. 2011).
1.6 Red Wine as Functional Food

Red wine had been an important component of Chinese and French cuisines since time immemorial. Studies have revealed that consumption of red wine in moderate amount confers to significant protection against coronary artery disease (CAD). The percentage of alcohol in the drink is only 10% to 15%; and hence, moderate amount of drinks raises the serum HDL level and lowers the serum low-density lipoprotein (LDL) level to prevent atherosclerotic changes in vessels. The process of atherosclerosis is brought about by oxidation of LDL molecules. Therefore, red wine exerts an antioxidant action due to presence of polyphenols in it. These results have been obtained not only from animal experiments but also from studies conducted on human volunteers (Yoo et al. 2010).

Of all the polyphenols present in red wine, the most important member found to exert maximum antioxidant effect is known as resveratrol. It mediates its action through generation of nitric oxide in the vessels. Other chemicals like catechin and quercetin also downregulate cell adhesion molecules expressed on surface of vascular endothelium, thereby reducing the rate of coronary artery thrombosis. Red wine confers neuroprotective action as is evident from animal studies. Reports of improved cognitive function have been obtained in patients of Alzheimer’s disease fed with red wine. The possible mechanism of action is red wine induced non-amyloidogenic processing of amyloid precursor proteins in the neurons leading to less generation of β-amyloid protein plaques in the brain (Yoo et al. 2010).

Red wine has been found to accelerate metabolism of certain cytotoxic chemicals such as malondialdehyde (MDA). When the serum MDA levels were measured in subjects fed with turkey cutlets followed by red wine consumption, the chemical was almost completely absent from the blood indicating effective metabolism of the cytotoxic agent. But the concentration of these chemicals in the berries varies from one place to the other because of the interaction between the genotype and environment under the influence of genotype × environment interaction. It has been seen that resveratrol concentration in grapes is significantly increased in altitudes higher than 1,500 m due to high UV-B levels. Hence, proper control of the environment can help in yielding plants with high levels of polyphenols. However, this is much easier said than done. So many alternative approaches have been devised to obtain better concentration of phenolic compounds like yeast selection, longer skin fermentation and maceration times, raising temperature during fermentation and so on. But more sophisticated techniques are exposure to UV-C rays and providing short-term anoxic treatments to the berries in post-harvest condition. All these procedures point towards growth of the use of red wine as a functional food. But the most important concern in this field is the presence of alcohol in the drink and its proved potential to cause few of the most dreaded disorders in the human body. So further research in this area need to be undertaken to standardise the maximum tolerable dose of alcohol in red wine and its safest limit of consumption by human beings (Acharya et al. 2007, Yoo et al. 2010).

1.7 Tea as Functional Food

Tea [Camelia sinensis (L.) Kuntze] being the most popular beverage in the world is no longer just a refreshing drink for people. Rigorous studies into health benefits of tea
have unfolded an impressive list of chemicals with their concentrations varying in dif-
ferent types of tea (green, white, black, red and oolong tea). These varieties are prepared
by different fermentation techniques that affect the phytochemical levels in the plant.
The highest concentration of polyphenols is detected in the white tea. Polyphenols are
powerful antioxidants. It has been recorded that the levels of polyphenols decreases
with increased duration of fermentation. This knowledge is important for tea manufac-
turers so that significant amount of the phytonutrients is not lost during the course of
fermentation to ensure bringing health benefits of tea to the consumers (Acharya
et al. 2007).

The major catechins present in tea are (−)-epigallocatechin-3-gallate (EGCG),
(−)-epigallocatechin (EGC), (−)-epicatechin-3-gallate (ECG) and (−)-epicatechin (EC).
Flavonoids present in tea may provide benefits in patients with CAD, hypertension,
diabetes and hypercholesterolemia. Green tea has been found to exert anticancer action
in several studies, thereby increasing popularity of the drink worldwide. This particular
effect was obtained by study on U937, a human leukemic cell line and cells of untreated
patients of chronic myeloid leukaemia (CML) or ALL. The anti-hyperglycemic role of
tea was evident from attenuation of serum glucose levels and rise in liver glycogen con-
tent in alloxan- and streptozotocin-treated laboratory mice. An anti-obesity role is also
played by tea via reduction of appetite and delayed gastric emptying.

1.8 Cereals as Nutraceuticals

Historically, plants have been used as an important source of phytomedicinal agents
for treatment and prevention of animals and human diseases. Cereal grains (such as
wheat, maize, rice, millets, etc.) are first most foremost important source of food in
the world.

Historically, grains have been produced and consumed and produced as staple foods.
The word cereal implies a functional meaning relatively than taxonomic, with cereals
being the key members of species of grass. Cereal grains are taxonomically classified in
the family Poaceae and are monocotyledons. Breakfast cereals, porridge, bread and
several other food forms made from cereals are readily available around the globe
(Figures 1.2 and 1.3). Cereal grains are used as binders, thickening agents and fillers; it
is also found in drinks (malted milk), processed meat products, baked goods, other
processed foods and confectionery items (Wildman 2001).

Cereals contain a wide range of components that are absolutely essential for the
human health. The macronutrients, fats, proteins and carbohydrates serve as a massive
energy source and contain various important nutrients such as fatty acids, vitamins and
amino acids. In recent years, however, it has been found that some minor components
also play important roles with respect to nutritional requirements. Certain phytonutri-
ents and dietary fibres can be important to reduction in disease risk and health mainte-
nance. Intake of phytonutrients and dietary fibres has been associated with reduced
cancer risk, chronic ailments, neural degeneration, diabetes, cardiovascular diseases
and chronic inflammation. Therefore, as ingredients, these bioactive compounds are
good potential candidates for functional food and nutraceuticals. An intact grain kernel
contains three main parts: seed coat/bran, cotyledon/endosperm and embryo/germ. Most of the nutrients including polyphenols and dietary fibres are found in the bran and
germ; therefore food products made from intact grains have the maximum health benefits (Moore and Hao 2012).

Wheat (*Triticum aestivum* L.) is the major staple food for nearly one-third of the global population. Wheat is an excellent source of nutrients. Wheat grain or caryopsis consists of true seed and pericarp. About 72% of protein is stored in the seed endosperm which forms 8% to 15% of entire grain weight (Adams *et al.* 2002, Shewry 2009). Wheat grains are rich in sugars, riboflavin, minerals and pantothenic acid. Wheat flour is an important source of amino acids, proteins, carbohydrates and a wide diversity of B-group vitamins, dietary fibres, minerals, fatty acids and fats (Shewry 2007). The environmental factors can influence nutritional content of wheat grains.

Wheat flour is used to make confectionary products, bread, noodles, biscuits and essential wheat seitan/gluten. It is also used as feed stock, wheat straw composites and ethanol production; and also in the preparation of for cosmetics and brewing of wheat beer, preparation of wheat straw composites, protein in meat substitutes and for ethanol production (Shewry 2007, Shewry 2009). Wheat bran and germ can be a basis of dietary fibre for treatment and prevention of digestive disorders (Shewry 2007, Shewry 2009). The key characteristic is the unique property of dough which has given it a lead over other temperate crops. Wheat flour can be processed into a variety of products such as pastries, baked products, noodles, pasta and a wide range of breads and other processed foods. These features rely on the interactions and structure of grain storage proteins. Grain storage proteins collectively form protein fraction called ‘gluten.’ Zeaxanthin and lutein are important for eyes and skin and also help in prohibiting both cancer and cardiovascular diseases (Alan *et al.* 2000).

**Figure 1.2** Potential rice (*Oryza sativa* L.) functional food and value-added food products. (a). Rice Noodle/Vermicelli; (b). Broken Rice; (c). Puffed Rice; and (d). Flattened Rice. Photo courtesy: (a). Ratnabali Sengupta; and (b), (c), and (d). Saikat Kumar Basu.
The whole grains seem to provide protection against diabetes, heart disease and also contain antioxidant with reduced risk for various types of cancer. The cracked wheat, wheat grouts and wheat bran offer a good fibre source (Kumar et al. 2011). Research indicates that wheat contains considerable levels of natural antioxidants which are concentrated in wheat bran fraction of the grain (Moore & Hao 2012). These include phenolic acids, lignans, tocopherols and carotenoids. Wheat antioxidants form chelating complexes as catalysts with transition metals for free radical generation to reduce their availability.
1.9 Nutraceutical Properties of Wheat Bran and Germ

Wheat has sedative, antipyretic, stomachic, antibilious, anticancer, antivinous and antihydrotic properties (Cartera et al. 2006). The young stems of wheat are used in the intoxication and healing of biliousness. Moreover, it is used in the as a cure of for cough, thirst, constipation, malaise, abdominal coldness, sore throat, irritability and pain (Drankham et al. 2003).

In wheat gluten and starch supply energy and heat; the outer layer of bran helps easy bowel movement; the inner coats provide minerals and phosphates; the wheat germ is rich in vitamins E and B; and the wheat protein helps repair and build muscular tissue. Whole wheat provides shield against diabetes, cardiovascular diseases, obesity, constipation, appendicitis and so on (Hadjivassiliou et al. 2003). The gluten protein has been stated to be the source of an inhibitor of angiotensin 1-converting enzyme (Motoi and Kodama 2003) and exorphins or opioid peptide (Yoshikawa et al. 2003).

The main health concern regarding gluten of wheat is the significant association between gluten and celiac disease. Celiac disease, also called the gluten-associated enteropathy, occurs among people hypersensitive to gliadin in the gluten. Detection of anti-endomysial antibodies from the biopsy specimen of celiac disease patients has revealed the pathogenesis of the disease. It is due to production of antibodies against tissue transglutaminase enzyme that causes deamination of the gliadin. This leads to villous atrophy in the small gut and malabsorption syndrome (Binder 2012).

1.9.1 Wheat Bran

Wheat bran represents 14.5% of the kernel weight and is an important dietary source of protein and it also contains trace minerals, vitamins, calcium, fibre, phosphorus, magnesium and calcium. The nutrients essential to human diet are stored in wheat kernel. About 83% of kernel weight is endosperm. It contains maximum protein share in the whole kernel along with iron, many B-complex vitamins as well as essential carbohydrates (Blechi et al. 2007, Drankham et al. 2003, Shewry and Jones 2005, Stevenson et al. 2012, Uauy et al. 2006). Wheat bran assists in controlling constipation-related complication by increasing bowel frequency and stool output. The outer bran layer provides fibre that regulates nutrients excretion and absorption from the body and gives bulk (Kumar et al. 2011). Bran is used as supplementary resource of dietary fibre for prohibit to alleviate gastric cancer, preventing colon diseases, reducing the risk of type 2 diabetes, breast cancer, hernia, gall bladder diseases, hypercholesterolemia, and haemorrhoids and treating irritable bowel syndrome (Garvin et al. 2006; Hadjivassiliou et al. 2003; Reddy et al. 2000).

Wheat bran contains various constituents that have anticancer (anti colon) activity. Whole grains have considerable amount of orthophenolics (antioxidant class) that have the capability to scavenge chelate metals and free radicals. Increased phenolics consumption has been related with a reduced menace of various types of cancer (Andreasen et al. 2001, Duthie and Crozier 2000). Wheat bran and whole wheat have large quantities of the phenolic diferulic acid and other phenolics, including chlorogenic, caffeic and ferulic acids and are reported to demonstrate antioxidant properties (Bors and Michel 2002, Stevenson et al. 2012).
1.9.2 Wheat Germ

Wheat germ is the embryo of kernel of wheat kernel. It is relatively rich in B-vitamins, fat and protein (Adams et al. 2002). The aleurone and outer endosperm contain an elevated concentration of phytic acid, proteins and vitamins than the inner layers of the endosperm. The inner layer contains protein and starch. Wheat germ is dense in nutrients, cholesterol and sodium free, rich in zinc, copper, magnesium, phosphorus, vitamin E, niacin, thiamin, pantothenic acid, para-aminobenzoic acid and ubiquinone coenzymes and also high in fibre. The latter helps to reduce constipation and lowers the risk for diabetes, cardiovascular and colon diseases (Shewry 2007, Shewry 2009). Germ oil is a rich source of fatty acids vitamins D, A and E. It also has elevated levels of lecithin and proteins. Wheat germ oil is used widely for external applications. It aids a big deal in getting in relieving relief from skin irritation. Germ oil constitutes 3% of wheat grain weight and contains about 25% of minerals, protein and vitamins and also has important antioxidant properties. When oil is applied on the skin, it helps to renovate and restore the skin cells damaged by the sizzling heat of sun and also improves the blood circulation (Kumar et al. 2011).

1.10 Barley and Oat as Nutraceuticals

These two crops are a rich source of β-glycans which help in lowering serum cholesterol levels and provide a better control of the post-prandial blood sugar levels. Its role in preventing CAD has also been recognised by the Food and Drug Administration (FDA). The amount of β-glycans present in wild barley (*Hordeum spontaneum* L.) is quite significant and its extraction can be enhanced by use of dry or wet processing or their combination. But not the mere presence of these chemicals can account for the health effects of oat and barley. Factors such as molecular size, ratio of β-(1→4)/β-(1→3) linkages, presence/absence and the quantity of long cellulose-like fragments, and cellotri-syl/cellotetraosyl ratio determine the function of the chemicals in these plants. Depolymerization events occurring during extraction process and temperature changes affect the molecular size of these chemicals. Genotype × environment interaction phenomenon is present for in these plants too. Therefore, further research is needed in the field of devising more sophisticated technologies to extract the β-glycan fractions from the barley without disturbing its physical properties (Lazaridou et al. 2007).

Application of β-glycan rich barley flour has widened in the last few years. Oatmeals have emerged as an important dish for breakfast in almost every house. Muffins made of 100% barley flour possess higher mineral and protein content but low in calorie count. Pastas are prepared from mixtures of barley fractions and semolina. Recent studies conducted in experimental mice models have pointed towards role of barley fractions in preventing chemotherapy induced secondary tumourigenesis (Lazaridou et al. 2007).

1.11 Value-Added Products

Value-added product is a recent introduction in global food market in an attempt to improve the nature and quality of food consumed by people through enrichment, even if not a part of their daily diet. For example, French fries are a common dish in several
houses during lunch and dinner and are relished quite favourite for by most children. But eating too much of such fried food products is extremely detrimental to health. It adds to the calories and increases risk of obesity and cardiovascular diseases. However, if these French fries are prepared from coloured potatoes containing significant amount of antioxidants then such delicacies can certainly prove beneficial to human health. This is how a normal food product can be transformed into a superman food. This is the basic principle of a value-added product.

Therefore, any food product can be labelled as value added if it is originally grown by the farmers, but the value of it gets enhanced by means of labour and creativity. This ensures that the farmers earn steadily throughout the year. And the crop growers too are satisfied upon knowing that they are a part of a healthy food production. But for this production to go on unhindered, the farmers must be flexible and inventive innovative all the time (Vince Ellert, personal communication).

Some of the common examples of value-added products include sweet corn, cut herbs, dried peppers and braided garlic. One of the most rapidly growing value-added product markets in the United States for the last 30 years is freshly cut and dehydrated fruits and vegetables, sold ready made. However, there are strict guidelines imposed upon manufacturer, processing and sale of these products. The food items that are related to health face more stringent regulations than non-food crops before they find their place in the market. So two possible measures have been proposed to enhance the consumer acceptance of these products and hence, widening of the market. They are agri-tourism and agri-entertainment. In this way, crop growers can provide consumers with face-to-face information regarding the process of manufacturing value-added products and also justify the prices assigned to these (University of Kentucky Cooperative Extension Service 2011).

Another brilliant success of value-added product industry is the cultivation of crops and growth of fisheries in the south of Alberta’s Badlands, one of the world’s driest places where the average annual rainfall is less than that in Ethiopia. This miracle has been made possible by the efforts of Dr. Nicholas Savidov in his self-created ecosystem. Dr. Savidov has cultured several hundreds of tilapia fish (Tilapia sp) in a large tank and the wastewater is drained into another small pond containing local aquaponic plants. These plants thrive on the fish excreta and then the filtered water is brought back to the tank containing fishes, clean and oxygenated. This is how Dr. Savidov has transformed an almost barren wasteland into a productive land (Libin 2009).

Hemp hearts are another example of value-added products. They are many times superior to energy bars in terms of calories. The digestibility of proteins is far better than egg or meat proteins. They even lack the anti-nutritional factors present in soy-bean (Lee et al. 2008). This makes hemp heart a better choice for body builders and even babies and mothers. Studies conducted till date have not been able to detect any hypersensitivity reaction to these products and hence, these products may be acceptable to people who are not able to tolerate nuts or milk sugar. It is one of the best sources of balanced levels of Ω-3 and Ω-6 fatty acids (Acharya et al. 2007). All these excellent nutritional qualities may allow hemp hearts to be an alternative therapeutic means for hypercholesterolemia, hypertension, CAD, diabetic gangrene of feet and also boost up the immune system of the body. So hemp hearts can be incorporated in the pastas, salads, energy bars, chocolate bars and different regular sandwiches to help people avail the health benefits of these products (Rocky Mountain Grain Products 2015).
Nevertheless, some controversies still remain unsettled regarding these value-added products. The question that haunts the manufacturers is ‘Are these healthy?’ Several studies have been conducted to find the definite answer to this decades-old question. Some have reported these to be healthy, while some others reported them as hazardous. So it seems that deeper, more serious and independent studies into the health benefits of these food products need to be undertaken before hoping for a wider market for such superman foods (Benbrook et al. 2008).

1.12 Conclusion

So from the above discussion it becomes quite clear that the natural products are slowly gaining popularity worldwide and have the potential to replace synthetic health products, including medicines in the distant future. However, not every product has yet been properly standardised with respect to nutritional constituents in terms of both quality and quantity nor are all of them practically affordable or acceptable to people currently across the globe. High cost of production, unpalatability and some distressing adverse effects are limiting their use in the world market. In addition, wide fluctuations are also observed with respect to genotype × environment interactions and hence the same species show wide variations in the available active constituents and phytonutrients grown under different environmental conditions and habitats. This warrants a need for developing locally adapted cultivars of different species for optimal yield under specific micro-climatic condition. Hence, further studies must be done to eliminate such hurdles and expand the potentials of such healthy foods and/or products in different regional, national and international markets. Only then can we hope for a breakthrough success in the industry of nutraceuticals and functional foods to build a better and promising tomorrow. However, it is worth mentioning that plant-based nutraceuticals, functional foods and value-added products do have huge potential in the not-so-distant future. The current trend also indicates towards the growing interest of the consumers to such health-specific food products and could certainly mean opportunities for the concerned industry.

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References

Aberoumand, A 2012, ‘Screening of phytochemical compounds and toxic proteinaceous protease inhibitor in some lesser-known food based plants and their effects and


1 Important Plant-Based Phytonutrients


Chung, MS, Kim, NC, Long, L, Shamon, L, Ahmad, WY, Sagrero-Nieves, L, Kardono, LBS, Kennelly, EJ, Pezzuto, JM, Soejarto, DD, & Kinghorn, AD 1997, ‘Dereplication of

Cuevas, B 1913, ‘Plantas medicinales de Yucatán, guía médica práctica doméstica’, Mérida Imprenta de la Lotería del Estado de Yucatán, Mérida, Yucatán, Mexico.


Gan, LS, Zhan, ZJ, Yang, SP, & Yue, JM 2006, ’Two new terpenoid glucosides from *Aster flaccidus*, *Journal of Asian Natural Products Research*, vol. 8, pp. 589–94.


1 Important Plant-Based Phytonutrients


capitata) and broccoli (Brassica oleracea L. var. Italica Planch.), Journal of Medicinal Plants Research, vol. 6, pp. 4796–803.


Oguntona, T 1998, ‘Green leafy vegetables’, in AU Osagie & OU Eka (ed.), *Nutritional Quality of Plant Foods*, pp. 120–133. Post Harvest Research Unit, Department of Biochemistry, University of Benin, Benin.


Onocha, PA, Oloyede, GK, & Olasukanmi, GS 2011a, ‘Chemical composition, brine shrimp toxicity and free-radical scavenging activity of leaf essential oil of Acalypha Ornata (Hochst)’, *Advances in Environmental Biology*, vol. 5, no. 1, pp. 188–93.


Pirbalouti, AG 2009, ‘Medicinal plants used in Chaharmahal and Bakhtyari districts of Iran,’ Herba Polonica, vol. 55, pp. 69–75.


Polanco, NG 2004, ‘Conocimiento, uso y manejo de plantas medicinales en el poblado de Hocabá, Yucatán, México’ Bachelor thesis, Universidad Autónoma de Yucatán, Mérida, Yucatán, Mexico.


Pulido Salas, MT, & Serralta Peraza, L 1993, Lista anotada de las plantas medicinales de uso actual en el estado de Quintana Roo, México, Centro de Investigaciones de Quintana Roo (Research Centre of Quintana Roo), Chetumal, Quintana Roo.


Sanabria, OL 1986, Etnoflora yucatanense; el uso y el manejo forestal en la comunidad Xul en el sur de Yucatán, Fascículo No 2, Etnoflora Yucatanense, Instituto Nacional de Investigaciones sobre Recursos Bióticos (National Institute for Research on Biotic Resources), Xalapa, Veracruz, Mexico.


Sharopov, FS, Sulaimonova, VA, & Setzer, WN 2012b, ‘Composition of the essential oil of Artemisia absinthium from Tajikistan,’ Records of Natural Products, vol. 6, pp. 127–34.


1 Important Plant-Based Phytonutrients

University of Kentucky Cooperative Extension Service 2011, Adding value to plant production—an introduction to policies and regulations for Kentucky producers, viewed 12 July 2015, http://www.uky.edu/Ag/CDBREC/varegs.pdf


Yanli, G 2006, ‘Chromatography-Mass Spectrometry analysis on the chemical constituents of several herbs,’ Masters thesis, Chengdu Institute of Biology CAAS.


