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Important Plant-Based Phytonutrients

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List of Abbreviations

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

Phytonutritional Improvement of Crops, First Edition. Edited by Noureddine Benkeblia.

VLDL Very High Density Lipoprotein
SOD Superoxide dismutase

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.

No	Local name	English name	Plant Family	Scientific name	Nutraceutical / Phytochemical	Habit	Part used	Medicinal properties	Tribes using the plant	References
1	Talamong	Blackthorn	Fabaceae	*Acacia mellifera* (Vahl) Benth	30-hydroxylup-20 (29)-en-3-one, 30-hydroxylup-20 (29)-en-3ß-ol, atranorin, methyl-2hyndroxy-4-hydroxy-3, 6 dimethy benzoate, ß-stosterol-3 ß-O-glucoside, linoleic acid, pentacyclic triterpenoids: (20R) 3-oxolupane-30al and (20S) 3-oxolupane-30al, (20*R*)-28-hydroxylupen-30-al-3-one, (20*S*)-3β-hydroxylupan-30-al	Shrub	Stem bark	Treatment of pneumonia, malaria, primary infection of syphilis, sterility and stomach ache, skin diseases, coughs and gastrointestinal ailments	Pokot (Kenya)	Kokwaro (1993), Mutai *et al.* (2007), Mutai *et al.* (2009)
2	Iwongewonge	Indian liquorice, White thorn apple	Solanaceae	*Datura metel* L.	Alkaloids, tripenoid, steroids, flavonoid, triterpenes, phenolic compounds, tannins	Herb	Leaves, seeds	Tuberculosis, asthma, cough, convulsions, antibacterial, insanity, catarrh, diarrhoea, hysteria, rheumatic pains	Sukuma (Tanzania)	Bharathi *et al.* (2010), Kokwaro (1993), Siva Sakthi *et al.* (2011)

3	Acak-acak	Asthma herb, pill bearing spurge	Euphorbiaceae	*Euphorbia hirta* L.	Flavonoids (Quercitrin, Myricitrin), Sterols (Cycloarternol, 24-methylene-cycloarternol, β-sitosterol, euphorbol hexacozonate, 1-hexacosanol, tinyaloxin, campesterol, stigmasterol), tannins (1,2,3,4, 6-penta-O-galloyl-β-D-glucose, 3,4-di-O-galloylquinic acid, gallic acid, 2,4, 6-tri-O-galloyl-D-glucose, euphorbin A,B,E), triterpenoids (α-amyrin, β-amyrin, taraxerone, taxerol, β-amyrin, acetate, taraxerone, 11α, 12α –oxidotaraxero)	Herb	Leaves, latex (whole plant)	Asthma, colic troubles, dysentery, cough, worms and vomiting, antibacterial, molluscicidal activity, anti-diarrhoeal, anti-inflammatory	Acholi (Uganda)	Chen (1991), Chitra *et al.* (2011), Kokwaro (1993), Lee (2011), Shih *et al.* (2010), Shih and Cherng (2012)
4	Magwagwa	Tick berry	Verbenaceae	*Lantana camara* L.	Tannin, catachin, saponin, steroids, alkaloids, phenol, anthroquinone, protein and reducing sugar	Shrub	Leaves, roots, flowers	Coughs, antibacterial, antihypertensive, treatment of malaria, rheumatism, and skin rashes, anti- repellent, antiseptic, anti-inflammatory	Luo (Kenya)	Kokwaro (1993), Mary Kensa (2011), Patel *et al.* (2011)

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Table 1.1 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical / Phytochemical	Habit	Part used	Medicinal properties	Tribes using the plant	References
5	Muvunza hukuma	African mistletoe, Dwarf red hibiscus, Poppy hibiscus	Malvaceae	*Hibiscus micranthus* L. f.	Steroids, flavonoids, carbohydrates, phenols, tannins and few compounds like phenolic acids, flavonoids, β-sitosterol, alkanes, fatty alcohols, acids	Shrub	Roots, stems	Bronchitis, antimicrobial, antiviral, antitumour, antipyretic, anti-inflammatory, haematological effects	Pokomo (Kenya)	Kokwaro (1993), Kumar *et al.* (2010a, 2010b), Kumar *et al.* (2011)
6	Lihululu	Yellow justicia, Sand Paper plant	Acanthaceae	*Justicia flava* (Forssk.) Vahl	Sterols, salicylic acid, lignans helioxanthin[(+)-isolariciresinol, justicinol, decosanoic acid, β-sitosterol- β-D-glucoside], 1-aryl-2,3-naphthalide lignans [Orosunol, 8-demethylorosunol]	Herb	Leaves, root	Diarrhoea, fever, treatment of convulsions and feverish pains, yaws	Luhya (Kenya)	Kokwaro (1993), Johnson (2004), Olaniyi (1982), Olaniyi and Powell (1980),
7	Msalanga	Eastern cape resin tree	Anacardiaceae	*Ozoroa mucronata* (Bernh.) R. Fern. & A. Fern.	Anarcardic acid (LOX inhibition), maronic acid (olean-18-ene keto acid)	Tree	Roots	Dysentery, LOX inhibition, PG synthase inhibition, antimicrobial	Digo (Kenya)	Hostettmann-Kaldas and Nakanishi (1979), Kokwaro (1993), Kubo *et al.* (1987)

8	Mukonda kundi	Mozambique bitter apples	Solanaceae	*Solanum renschii* Vatke	Steroidal alkaloids, steroidal sapogenins	Shrub	Root	Typhoid fever, throat, wounds healing	Kamba (Kenya)	Bussmann (2006), Carle (1981), Heine *et al.* (1988), Kokwaro (1993)
9	Ng'owo	Bush fig, Broom cluster fig, Cape fig	Moraceae	*Ficus capensis* Thunb.	Flavanol, coumarins, steroids and triterpenes, alkaloids, balsams, tannins, resin, carbohydrates, phenolic	Tree	Roots, leaves, stem bark	Constipation, tonic, anti-rheumatic, fever, treatment of tuberculosis, antibacterial	Luo (Kenya)	Adebayo-Tayo and Odeniyi (2012), Dafalla (2005), Kokwaro (1993), Oyeleke *et al.* (2008)
10	Msahala	Alexandrian senna, East Indian senna	Fabaceae	*Cassia senna* L.	Alkaloids, saponins, tannins, phytosterols, naphthalene glycosides, 6-hydroxymusizin glycoside, tinnevellin glycoside, anthranoids (dianthrones, anthrones, anthraquinone)	Shrub	Leaflets, fruits (pods)	Indigestion, foot infections, subcutaneous parasitic infection	Swahili (Kenya)	Kokwaro (1993), Lemli *et al.* (1981), Mengs *et al.* (2004), Viswanathan and Nallamuthu (2012)
11	Segatet	Cape myrtle	Primulaceae	*Myrsine africana* L.	Saponins, tannins, flavonoids, amino acids, steroids and reducing sugar. embelin, rapanone (2,5 dihydroxy benzoquinone)	Shrub	Fruits, stem bark, leaves, root bark	Roundworm, tapeworm, remedy for chest pains and stiff joints	Marakwet (Kenya)	Kokwaro (1993), Midiwo *et al.* (2010), Vasudha *et al.* (2011)

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Table 1.1 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical / Phytochemical	Habit	Part used	Medicinal properties	Tribes using the plant	References
12	Kemagugu	Flame lily, Creeping lily, Climbing lily, Fire lily, Tiger claw, Glory lily	Colchicaceae	*Gloriosa superba* L.	Alkaloids (colchine and colchicoside), glycosides, steroids, terpenoids, tannins, phenols, saponin, flavonoids	Herb	Seeds, tubers	Abortion, antidote for snake bites, antibacterial, treatment of bruises, sprains and colic, wounds, fever	Marakwet (Kenya)	Kokwaro (1993), Rehana banu and Nagarajan (2012), Senthilkumar (2013a, 2013b)
13	Ol-erbat	Babul, Indian gum Arabic tree	Fabaceae	*Acacia nilotica* (L.) Willd. ex Delile	Tannins, saponin, saponin glycosides, volatile oils, phenols, triterpenes, flavonoids and alkaloid, resin, steroids, oleosins, D-glucoronic acid, 1-acetyl beta carboline, hydroxy citronellal, trans decalone, lavandulyl acetate, propionic acid-2-chloro, ethyl ester, 3-picoline-2-nitro	Tree	Whole plant	Gonorrhoea, cough, antibacterial, antimalarial, antifungal, anti-diarrhoea, anticancer, antimutagenic, spasmogenic, vasoconstrictor, anti -pyretic, anti-asthamatic, cytotoxic, anti-diabetic, anti-platelet agregatory, antiplasmodial, molluscicidal	Maasai (Kenya)	Ali *et al.* (2012), Hemamalini *et al.* (2013), Kokwaro (1993), Solomon-Wisdom and Shittu (2010)

14	Iravu	White caper brush, Woolly caper brush	Capparidaceae	*Capparis tomentosa* Lam.	Oxindole (3-Hydroxy-3-methyl-4-methoxyoxindole), glucocapparin, gluconorcappasalin, benzylglucosinolates, rutin, fatty acids, hydrocarbons, sitosterol, β-carotene	Shrub	Roots, fruits, leaves (aerial parts)	Syphilis, skin irritant, antibacterial, spices, cough, infertility, impotence, anti-convulsant	Chagga (Tanzania)	Dekker *et al.* (1987), Kokwaro (1993), Tlili *et al.* (2011)
15	Huhunga	Zambezi false-nettle	Euphorbiaceae	*Acalypha ornata* Hochst. ex A. Rich.	Isopulegly acetate, valenchi, vividiflorene, α-muurolene, 2-hexyne, 6-methyl-α-ionone, γ-elemene, (E)-2-methyl-4-undecene, ledol, cis-3-hexynyl benzoate, 2-methyl-1-octadecene, apiole, oplopanone, γ-endesmol, flavonoids, phenols, resins, sterols, tannins	Shrub	Leaves, roots	Leprosy, antiemetic, relief of postpartum pain, haemorrhoids, leprosy, scabies, antimicrobial	Sukuma (Tanzania)	Ahmed and Onocha (2013), Kokwaro (1993); Onocha *et al.* (2011a, 2011b)

Table 1.2 Medicinal plants from Central and West Asia with potential for use as nutraceutical and functional food.

No	Local name	English name	Plant Family	Scientific name	Nutraceutical	Habit	Part used	Medicinal Properties	References
1	Bumadaran-e-Sabzekoh	Achillea	Asteraceae	*Achillea kellalensis* Bioss. & Hausskn.	Camphor, borneol, α-thujone, cineol, bornyl acetate and camphene	Herb	Flowers	Carminative, indigestion, edema, burns, skin infection gastric ulcer, antibacterial, anti-inflammatory, haemorrhage, dysmenorrhoea, enema, diarrhoea	Pirbalouti *et al.* (2010a), Rustaiyan *et al.* (1999), Zargari (1996)
2	Golnare-e-farsi	Pomegranate	Lythraceae	*Punica granatum* L.	Pomegranatate, ellagic acid,3,3′,4′-tri-O-methylellagic acid, ethyl brevifolincarboxylate, urolic and maslinic acids, daucosterol	Tree	Flowers	Wound healing, antiviral, antibacterial, antifungal, remedy for cut wound, bronchitis, diarrhoea, digestive problems, man sex power reconstituent, dermal infected wounds, diabetes	Pirbalouti *et al.* (2010a, 2010b), Wang *et al.* (2006)
3	Panirak	Common Mallow	Malvaceae	*Malva sylvestris* L.	Phenolics, flavonoids, carotenoids, ascorbic acid	Herb	Flowers, leaves, mature fruits and leafy flowered stems	Treatment of various ailments, including cold, cough and burn, and cut wound-healing	Zargari (1996)

4	Zarrin giah	–	Lamiaceae	*Dracocephalum multicaule* Montbr. & Auch. ex Bentham	Limonene, α-pinene, methyl fgeraniate	Herb	Leaves, flowers (aerial parts)	Foot pain, sedative, analgesia, inflammatory, antibacterial, antiseptic	Mojab *et al.* (2002), Pirbalouti *et al.* (2010a)
5	Khosharizeh	–	Apiaceae	*Echinophora platyloba* DC.	Trans-β-ocimene, 2-furanone, myrcene, linalool and cis-β-ocimene	Shrub	Aerial parts	Antifungal, spice and culinary	Entezari *et al.* (2009), Pirbalouti *et al.* (2010a)
6	Golpar	–	Apiaceae	*Heracleum lasiopetalum* Boiss.	Flavonoids, tannins, saponins	Herb	Fruit	Antiseptic, spice, and condiment	Pirbalouti (2009), Pirbalouti *et al.* (2010a); Rohi Boroujeni *et al.* (2012)
7	Bakhtyari karafs	Wild clery	Apiaceae	*Kelussia odoratissima* Mozaff.	E-ligustilide Phthalide, 3- e - butyldiene phthalide and z-ligustilide	Herb	Leaves	Edible as vegetable, flavouring, indigestion, rheumatism, also used to cure some rheumatism disorders, common cold, cough, blood pressure, blood lipid and stomachache	Pirbalouti *et al.* (2010a, 2010c); Rohi Boroujeni *et al.* (2012), Sedighi *et al.* (2012), Sultana *et al.* (2005)

(Continued)

Table 1.2 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical	Habit	Part used	Medicinal Properties	References
8	Pooneh	Spearmint	Lamiaceae	*Mentha longifolia* (L.) Hudson.	Carvone, cis- piperitone epoxide, piperitenone oxide, menthone, flavonoids: 5,7,4′-trihydroxy-6,2′,3′-trimethoxyflavone	Herb	Leaves, flowers	Edible as vegetable, flavouring, indigestion, cough, anti-inflammatory, carminative, antiemetic, diaphoretic, anti spasmodic, analgesic, stimulant, emmenagogue, and anticatharral activities	Džamić *et al.* (2010), Ghoulami *et al.* (2001), Pirbalouti *et al.* (2010a), Sharopov *et al.* (2012a)
9	Marzeh Koohi	Bakhtiari *savory*	Lamiaceae	*Satureja bachtiarica* Bunge	Thymol, γ-terpinene, p-cymene, β-caryophyllene and borneol	Herb	Leaves, flowers	Edible as vegetable, flavouring, indigestion, cough, antibacterial	Pirbalouti (2009) Pirbalouti *et al.* (2010a, 2010c), Sefidkon and Jamzad (2000)
10	Lolopashmak (Chay-e-kohi)	Betony	Lamiaceae	*Stachys lavandulifolia* Vahl.	α-thujone, α-pinene, myrcene, β-phellandrene, germacrene D, Δ-cadinene, and 1, 4-methano-1 H-indene	Herb	Leaves, flowers	Green tea, antibacterial, skin diseases, menorrhagia, sedative, antispasmodic, diuretic, ulcers, fevers and diarrhoea	Pirbalouti and Mohammadi (2013), Pirbalouti *et al.* (2010a), Rohi Boroujeni *et al.* (2012), Zargari (1996)

11	Avishan	Deanaie thyme	Lamiaceae	*Thymus daenensis* Celak.	Geraniol, geranyl acetate, β-caryophyllene, thymol, p-cymene, methyl carvacrol,	Herb	Leaves, flowers	Green tea, spice, culinary, cough, antibacterial, carminative, anti-inflammatory, expectorant, treatment of colds, antifungal, antiviral, anti-parasites	Nickavar *et al.* (2005), Pirbalouti *et al.* (2010a, 2010c), Pirbalouti *et al.* (2011), Sabahi *et al.* (2013), Zargari (1996)
12	Kakouti	–	Lamiaceae	*Ziziphora tenuior* L.	Pulegone, limonene, piperitenone	Herb	Leaves, flowers	Green tea, spice, culinary, antibacterial, carminative, antiasthmatic	Ebrahimi *et al.* (2012), Meral *et al.* (2002), Pirbalouti *et al.* (2010a), Sezik *et al.* (1991)
13	Khakeshir	Flixweed	Brassicaceae	*Descurainia sophia* (L.) Webb ex Prantl	Cis-β-ocimene, menthol, neoisomenthyl acetate	Herb	Seeds	Laxative, gasteralgia, fever, treatment of some cancers, cough	Li *et al.* (2010), Pirbalouti (2009)
14	Gavzaban-e-koohi	Bugloss	Boraginaceae	*Anchusa italica* Retz.	Saponins, pyrrolizidine alkaloids, γ,α-linoleic acid, stearidonic acid	Herb	Flowers, leaves	Green tea, antidepressant, nerve system relaxant, antianxiety, cold, chest pain, sore throat, antibacterial, asthma, neurasthenia	Mojab *et al.* (2003), Pirbalouti (2009), Safa *et al.* (2012), Zaurov *et al.* (2013)

(Continued)

Table 1.2 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical	Habit	Part used	Medicinal Properties	References
15	Sorya	Ratanjot	Boraginaceae	*Arnebia euchroma* (Royle) I.M. Johnston.	Naphthoquinone red pigments: ethyl 9-(2′,5′-dihydroxyphenyl) nonanoate, octyl ferulate, arnebiabinone and isohexenylnaphthazarins (e.g. acetylshikonin)	Herb	Roots, rhizome	Burn wound, anti-eczema, antimicrobial, anti- inflammatory, anti-viral, anti-tumour, cardiotonic and contraceptive properties	Damianakos *et al.* (2012), Kumar *et al.* (2011), Liu *et al.* (2010), Pirbalouti *et al.* (2010c)
16	Golraye dayhimi	–	Hypericaceae	*Hypericum scabrum* L.	α-pinen, thymol, carvacrol, spathulenol, *p*-Cymene	Herb	Flowers, aerial parts	Green tea, sedative, headache, analgesic, trauma, rheumatism, neuralgia, anti-inflammatory, antiseptic, gastroenteritis, ulcers, hysteria, bedwetting	Baser *et al.* (2002), Pirbalouti *et al.* (2010c)
17	Mort	Myrtle	Myrtaceae	*Myrtus communis* L.	Acylphloroglucinols, phenolic compounds: phenolic acids, flavonol glycosides, volatile components: 1,8-cineole, α-terpineol, methyl eugenol, linalool	Tree	Leaves	Skin discords, digestive discords, astringent, good hair condition, bronchodilatotor, anti- inflammatory	Messaoud *et al.* (2012), Pirbalouti (2009), Pirbalouti *et al.* (2010c)

18	Pesteh Koohi (baneh)	Persian turpentine tree	Anacardiaceae	*Pistacia atlantica* Desf.	Sterols (betasitosterol), triacylglycerol tocopherols (α-tocopherol), phenols (caffeic acid)	Tree	Fruit, resin	Indigestion, tonic, toothache, astringent	Pirbalouti (2009), Pirbalouti *et al.* (2010c), Pirbalouti *et al.* (2012), Saber-Tehrani *et al.* (2013)
19	Gol-e Arooneh, (aruone)	–	Lamiaceae	*Salvia hydrangea* DC. ex Bentham	β-caryophyllene, caryophyllene oxide, spathulenol, 1,8-cineole, α-pinene	Herb	Flowers, leaves	Cough, emollient, sore throat, antibacterial, antispasmodic, carminative and sedative	Barazandeh (2004), Pirbalouti *et al.* (2010c), Rustaiyan *et al.* (1997), Sonboli *et al.* (2009)
20	Zalzalak	Hawthorn	Rosaceae	*Crataegus curvisepala* Lindm. (= *Crataegus oxyacantha* L.)	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	Tree	Fruits, flowers, leaves	Heart discords, edible as wild fruit, hypolipidaemic, anti- inflammatory, antianxiety, antimicrobial	Kashyap *et al.* (2012), Pirbalouti (2009), Verma *et al.* (2007)

(Continued)

Table 1.2 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical	Habit	Part used	Medicinal Properties	References
21	Nakhonak	Southern Milk Vetch	Fabaceae	*Astragalus hamosus* L.	Flavonoids: rhamnocitrin 4′-β-D-galactopyranoside, flavonols hyperoside, isoquercitrin, astragalin, 3-O- gentiobioside, rutin rhamnetin 3-O- glucoside	Shrub	Whole plant	Carminative, astringent, good for ulcers, leucoderma and inflammation, treatment of nervous affections	Bratkov *et al.* (2016), Krasteva *et al.* (2007), Pirbalouti (2009)
22	Mousir	Persian shallot	Alliaceae	*Allium stipitatum* Regel (= *Allium hirtifolium* Boiss.)	Organosulphur, phenolic compounds, allicin, diallyl disulphide diallyl trisulphide, 9-hexadecenoic acid, 11,14-eicosadienoic acid, n-hexadecanoic acid, furostanol and spirostanol saponins, flavonol glycosides	Herb	Bulbs	Edible as vegetable, flavouring, antihypertensive, antibacterial, antioxidant	Barile *et al.* (2005), Ghahremani-Majd *et al.* (2012), Ismail *et al.* (2013), Pirbalouti (2009)
23	Spand	Syrian rue	Nitrariaceae	*Peganum harmala* L.	Alkaloids (β-carboline), reducing compounds, tannins, volatile oils, saponins, flavonoids, sterols (triterpenes), harmine, harmaline, anthraquinone	Shrub	Fruit, seed	Antimicrobial, anti-parasite, asthma, colic, anthelmintic, antiseptic, gastrointestinal, antispasmodic, antiperiodic,	Benbott *et al.* (2013), Dastagir *et al.* (2012), Pirbalouti (2009)

24	Spharzeh	Plantain (psyllium)	Plantaginaceae	*Plantago psyllium* L.	Polyphenolic acid, flavonoids, mucilages (anionic polysaccharide of L-arabinose, D-xylose and D-galactoronic acid), iridoid glycosides	Herb	Seeds	Cough, emollient, cough, sore throat	Naghdi *et al.* (2004), Pirbalouti (2009), Saeedi *et al.* (2010)
25	Rivas	Syrian Rhubarb	Polygonaceae	*Rheum ribes* L.	Chrysophanol, physcion, rhein, aloe-emodin, physcion-8-O-glucoside, aloe-emodin-8-O-glucoside, Sennoside A, rhaponticin, flavonoids	Herb	Leaves, root	edible as vegetable, flavouring, jaundice, indigestion, skin discords, treatment of diabetes, haemorrhoids, ulcer, diarrhoea	Oktay *et al.* (2007), Pirbalouti (2009), Sayyah *et al.* *(2009)*

Table 1.3 Medicinal plants from the Himalayas with potential for use as nutraceutical source and as functional food component.

No	Local name	English name	Plant Family	Scientific name	Nutraceutical/Phytochemical	Habit	Part used	Uses/Medicinal properties	References
1	Bongkar	Aconite	Ranunculaceae	*Aconitum orochryseum* Stapf	Diterpenoid alkaloids [Hetisine-type (orochrine, 2–O–acetylorochrine, 2–O–acetyl–7α–hydroxyorochrine), atisinium chloride and virescenine], flavonoids, flavonol glycosides, diterpenoid, norditerpenoid	Herb	Aerial parts	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	Gajalakshmi *et al.* (2011), Krug and Milliken (2008), Samten (2009), Wangchuk *et al.* (2007), Wangchuk *et al.* (2010)

2	Bongnag, Bikh	Indian Aconite	Ranunculaceae	*Aconitum heterophylloides* (Brühl) Stapf (= *Aconitum laciniatum* (Bruhl) Stapf)	Diterpene alkaloids	Herb	Tubers, leaves, roots, flowers	Anthelmintic, allays bone disease, mumps, gout, chronic infection and leprosy, analgesic, anti-inflammation, used for poison for arrows	Gajalakshmi *et al.* (2011), Krug and Milliken (2008), Samten (2009), Sarkar *et al.* (2012), Wangchuk *et al.* (2013)
3	Lug-mig	Weak violet Aster	Asteraceae	*Aster flaccidus* Bunge	Phenylpropanoids [(7′R, 8S)-9′-lariciresinol-(alpha-methyl)-butanoate, 5,9-dimethoxyl-7-(alpha-methyl)-butanoxyl-phenyl-2E-propenol-(alpha-methyl)-butanoate], 2-oxo-isocostic acid, mussaenoside,kaempferol-3-O-β-Dglucopyranoside,1β,6α-dihydroxyeudesm-4(15)-ene,6β-propionyloxy-1,10-dehydrofuranoeremophil-9-on, indaconitine, lupeol, liquiritigenin, apigenin, tricine, coniferyl aldehyde, friedelin, apigenin, p-hydroxybenzoicacid, 2-O-β-D-glucopyranoside-vicodiol, 10-O-β-D-glucopyranoside-oplopanone	Herb	Whole plant including flowers, roots, aerial part	Useful for treating affliction by evil spirits, antitumour, bronchitis, cramps, common cold and relieves pain	Gan *et al.* (2006), Gangwar *et al.* (2010), Krug and Milliken (2008), Liu *et al.* (2010), Miao *et al.* (2012), Samten (2009)

(Continued)

Table 1.3 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical/Phytochemical	Habit	Part used	Uses/Medicinal properties	References
4	Pangram	Red knotweed or Large leaved knotweed	*Polygonaceae*	*Bistorta macrophylla* (D. Don) Soják	(-)-epicatechin-5-O-beta-D-glucopyranoside, (+)-catechin-7-O-beta-D-glucopyranoside, 1-(3-O-beta-D-glucopyranosyl 4,5-dihydroxy-phenyl)-ethanone (-)-epicatechin, chlorogenic acid, gallic acid, anthraquinone glucoside 1-hydroxy-8-methoxy-3-methyl-6-O-β-D-glucopyranosyl-anthraquinone, 1, 6-dihydroxy- 8-methoxy-3-methyl-anthraquinone, quercitrin, kaempferol-3-O-α-rhamnoside, arborinol , β-sitosterol, β-sitosterol-D-glucoside	Herb	Rhizome, leaves	Allays diarrhoea, stomach pain, dysentery, wound healing	Krug and Milliken (2008), Phondani (2011), Samten (2009), Semwal *et al.* (2010), Wang *et al.* (2004)
5	Yakima	Gold saxifrage	Saxifragaceae	*Chrysosplenium nudicaule* Bunge	Triterpenoids, flavonol glycosides, volatile oil, hexadecanoic acid, ethyl ester, dibutyl phthate, (Z, Z, Z)-9, 12, 15-octadecatrienoic acid, ethyl ester, 2, 6-butylated hydroxytoluene, and 5, 6, 7, 7a-tetrahydro 4, 4, 7a-trimethyl-2(4H)-benzofuranone	Herb	Whole plant including aerial parts	Anti-inflammatory and cholagogue; for headaches, gall bladder problem	Krug and Milliken (2008), Samten (2009), Yanli (2006), Yunshang *et al.* (2004)

6	Bashaka	Primrose, Climbing corydalis	Papaveraceae	*Corydalis crispa* Prain	Isoquinoline alkaloids (protopine, 13-oxoprotopine, 13-oxocryptopine, stylopine, coreximine, rheagenine, ochrobirine, sibiricine, bicuculline)	Herb	Whole plant including roots	Used as tonic, promotes vigour, treatment of infections in the blood, liver and bile, antiplasmodial, antimicrobial, anti-inflammatory	Krug and Milliken (2008), Samten (2009), Wangchuk *et al.* (2012a)
7	Re-skon	Corydalis	Papaveraceae	*Corydalis dubia* Prain	Dubiamine, and isoquinoline alkaloids (cheilanthifoline scolerine, protopine, capnoidine, bicuculline, hydrastine, corydecumbine)	Herb	Whole plant including roots	Impure blood detoxifier and neuralgia, treatment of fever arising from affections of heart, lung, pancreas and kidney, antiplasmodial, antimicrobial, cytotoxicity and antiplasmodial activity	Krug and Milliken (2008), Samten (2009), Wangchuk *et al.* (2011), Wangchuk *et al.* (2012b)
8	Dbang-lag	Early Marsh Orchid	Orchidaceae	*Dactylorhiza hatagirea* (D. Don) Soó	Dactylorhins A-B-C-D-E, dactyloses A and B, lipids, glucoside	Herb	Tubers, roots	General tonic, promotes heat, dysentery, diarrhoea, chronic fever, cough, stomach ache, wounds, cuts, burns, fractures, general weakness, bone fracture,	Krug and Milliken (2008), Kizu *et al.* (1999), Pant and Rinchen (2012), Samten (2009)

(Continued)

Table 1.3 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical/Phytochemical	Habit	Part used	Uses/Medicinal properties	References
9	Bya-rgod-spos	Delphinium glaciale	Ranunculaceae	*Delphinium glaciale* Hook.f. & Thomson	Alkaloids	Herb	Aerial parts	For fever, loss of appetite, headache, dysentery, body swelling of wounds	Churyukanov (1986), Krug and Milliken (2008), Mashkovsky and Samten (2009)
10	Gongthogpa	Tall Wormseed Mustard, Hawkweed-leaved Mustard, Wallflower	Brassicaceae	*Erysimum hieraciifolium* L.f.	Glucosinolates (5-methylthiopentyl, (R)-5-methyl-sulphinylpentyl, 3-hydroxy-5-methylthiopentyl, 3-hydroxy-5-methylsulphinylpentyl,3-hydroxy-5-methylsulphonylpentyl isothiocyanate, 3-hydroxypropyl isothiocyanate, erysinoside, helveticoside	Herb	Aerial parts including fruits, seeds	Useful for meat poisoning, lung problems and in reducing stress and insomnia	Daxenbichler *et al.* (1980), Kjær and Schuster (1970), Krug and Milliken (2008), Samten (2009)

11	Tseka	Fritillaria	Liliaceae	*Fritillaria delavayi* Franch.	Volatile oil, glycosides, sterol, triterpenes, polyoses, saponins, reducing compounds, quinones, flavonic glycosides, coumarins, isosteroidal alkaloids, delavine, delavinone, chuanbeinone, delafrinone, delafrine	Herb	Bulbs	Promotes vigour, counteract accumulation of fluids in joints, treatment of impotence, treatment of different lung diseases (bronchitis, tuberculosis, coughs), treatment of nervous system, antitussive and expectorant activity, anti-inflammatory	Krug and Milliken (2008), Maharjan *et al.* (2011), Saklani *et al.* (2011), Samten (2009)
12	Gangachung	Urn-shaped gentian.	Gentianaceae	*Gentiana urnula* Sm.	Iridoidal glycosides [gentiournosides A-C (*bis*-iridoidal glycosides), gentiournosides D-E (loganin)	Herb	Entire plant including roots	Treat fever, dysentery and poisoning, antipyretic, treatment of thrombus, dysentery and sore throat	Krug and Milliken (2008), Liu *et al.* (1994), Samten (2009)
13	Parpata	Thinfruit Hypecoum	Papaveraceae	*Hypecoum leptocarpum* Hook. f. & Thomson	Alkaloids (leptocarpinine, leptopine, leptopinine, leptopidine, leptopidinine), protopine, isohyperectine, oxohydrastinine (hypecoumine), cryptopine	Herb	Whole plant	Useful in treating common cough and cold, skin diseases, blood pressure and poisonings	Chen and Fang (1985), Krug and Milliken (2008), Samten (2009), Zhou *et al.* (1999)

(Continued)

Table 1.3 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical/Phytochemical	Habit	Part used	Uses/Medicinal properties	References
14	Ud-pel-sngon-po	*Himalayan Blue Poppy*	Papaveraceae	*Meconopsis simplicifolia* (D. Don) Walp.	Alkaloids (berberine, mecambridines)	Herb	Whole aerial part	Treat liver and lung inflammation and fever associated with cough and cold and malaria. heals the blood, liver and the lung infections,	Krug and Milliken (2008), Samten (2009), Tétényi (2005), Wangchuk *et al.* (2011)
15	Pang poe	Spikenard	Caprifoliaceae	*Nardostachys jatamansi* (D. Don) DC. (= *Nardostachys grandiflora* DC.)	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′-dihydropyranocoumarin], susquiterpenes, lignans, neo-lignans, coumarins, terpenoid ester (nardostachysin)	Herb	Whole plant (rhizomes, roots)	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	Chatterjee *et al.* (2000), Chatterjee *et al.* (2005), Krug and Milliken (2008), Mulliken and Crofton (2008), Samten (2009)

16	Tsher-sngon	Prickly Blue poppy	Papaveraceae	*Meconopsis horridula* Hook. f. & Thomson	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-coumaroyltyramine, quercetin, kaempferide, kaempferol, 3-(kaempferol-8-yl)-2,3-epoxyflavanone	Herb	Whole aerial part	Strong analgesic, strengthens bones and joints, treatment of headaches and fractures	Haifeng *et al.* (2009), Krug and Milliken (2008), Liu *et al.* (2014), Ming-Fang *et al.* (2009), Samten (2009)
17	Kutki, putishing	Figwort flower Picrorhiza	Plantaginaceae	*Neopicrorhiza scrophulariiflora* (Pennell) D.Y. Hong	Phenylpropanoid glycosides (scrophulosides A and B), androsin, picroside I, non-glycosidic iridoids, piscrocins (D, E, F, G), iridoid glycosides (piscrosides A and B)	Herb	Stolons, rhizomes, roots	Cold, cough and headache, also for problems related to bile, high blood pressure, sore throat, intestinal pain and conjunctivitis, fever	Kim *et al.* (2006), Krug and Milliken (2008), Rawal *et al.* (2009), Samten (2009), Wang *et al.* (2006)

(Continued)

Table 1.3 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical/Phytochemical	Habit	Part used	Uses/Medicinal properties	References
18	Drimug, muktsi	Tibetan Onosma	Boraginaceae	*Onosma hookeri* C.B. Clarke	Acetylshikonin, β,β-dimethylacrylshikonin, β,β-dimethylacrylalkannin or arnebin-1, shikonin, naphthaquinone pigments	Herb	Roots	To cure lung diseases, purify blood and stop vomiting of blood, also for tuberculosis, anti microbial, anticancer, antithrombotic, anti-inflammatory, wound healing, skin rashes	Krug and Milliken (2008), Ning and Cao (1996), Papageorgiou *et al.* (1999), Samten (2009)
19	Pangchidebo	-	Caprifoliaceae	*Pterocephalus hookeri* (C.B. Clarke) Diels	Loganin, triterpenoid saponins (hookerosides A–D), oleanolic and ursolic acids	Herb	Whole plant (roots)	Antidote, chronic inflammation, cold, cough	Krug and Milliken (2008), Samten (2009), Tian *et al.* (1993), Tan *et al.* (2011), Yang *et al.* (2006)

20	Domnag domthri	-	Plantaginaceae	*Veronica ciliata* Fisch.	Iridoid glycosides, benzoic acid	Herb	Entire plant including roots	Used as a substitute for bile, used to stop bleeding, wound treatment	Krug and Milliken (2008), Kun *et al.* (2003), Samten (2009)
21	A-bhi-sha, Xiao bai he	Dwarf lily	Liliaceae	*Lilium nanum* Klotzsch & Garcke	Not reported	Herb	Whole plant (bulbs as tonic)	Antidote and allays head injuries, heels bone fracture	Chen *et al.* (2000), Krug and Milliken (2008), Samten (2009)
22	Tsepara, lamichop	Bigflower Rhodiola	Crassulaceae	*Rhodiola crenulata* (Hook. f. & Thomson) H. Ohba	Salidroside (rhodioloside), rosavins, 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,	Herb	Fleshy stems (rhizomes), roots	Alleviate depression , stimulation of nervous system, antioxidative	Krug and Milliken (2008), Qu *et al.* (2012), Samten (2009), Wang and Wang (1992)

Table 1.4 Medicinal plants from South Asia with potential for use as nutraceutical source and as functional food component.

No	Local name	English name	Plant Family	Scientific name	Nutraceutical /Phytochemical	Habit	Part used	Medicinal properties	References
1	Laasona	Garlic	Amaryllidaceae	*Allium sativum* L.	Saponins, sterols, tannins, proteins, carbohydrates, cardiac glycosides, sulphur compounds (trisulfide, di-2-propenyl; disulfide, di-2-propenyl; trisulfide, methyl 2-propenyl, diallyl disulide)	Herb	Bulb and oil	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	Douiri *et al.* (2013), Kadam *et al.* (2013), Mikail (2010)
2	Ghee Kunwar, Ghritkumari	Aloe	Xanthorrhoeaceae	*Aloe vera* (L.) Burm. f.	Barbaloin (10-β-D-glucopyranosyl-1,8-dihydroxy-3-(hydroxymethyl)-9(10*H*) - anthracenone), tannins, flavonoids, lectins, terpenoids, carbohydrates, alkaloids, saponin, fatty acids, cholesterol, anthraquinones, chromones, mono and polysaccharides, sterols (lupeol, campesterol, and β-sitosterol), salicylic acid, organic acids, enzymes, saponins, vitamins, minerals, anthrone, aloe emodin, aloetinic acid, choline, choline salicylate, sapogenins	Herb	Leaves, stems	Laxative, anti-helminthic, skin disorders, , anti-inflammatory, cathartic, antiviral, wound healing, burns, antimicrobial, anticancer, antioxidant activity, dysentery, diarrhoea	Basu *et al.* (2007), Joseph and Raj (2010), Patel *et al.* (2012), Raphael (2012)

3	Balsana, Dendhu	St. John's wort	Hypericaceae	*Hypericum perforatum* L.	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)	Herb	Leaves, flowers	Analgesic, anti-viral, anti-censor, antidepressant and antiviral activity, treatment of traumas, burns, scabs and ulcers	Basu *et al.* (2007), Vattikuti and Ciddi (2005),
4	Shimla mirch	hot peppers, chili pepper	Solanaceae	*Capsicum annuum* L.	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	Herb	Fruit	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	Howard *et al.* (2000), Laroche (2007), Sunil *et al.* (2012)

(Continued)

Table 1.4 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical /Phytochemical	Habit	Part used	Medicinal properties	References
5	Kali mirch	Black pepper	Piperaceae	*Piper nigrum* L.	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-octadecanote, ethyl cis-9-octadecanaote, hexadecanoic acid, octadecanoic acid	Herb	Fruit	Helps in digestion, antimicrobial, antiapoptotic, antibacterial, anti-Colon toxin, antidepressant, antifungal, anidiarrhoeal, anti-inflammatory, antimutagenic, anti-metastatic activity, antioxidative, antiriyretic, antispasmodic, antispermatogenic, antitumour, antithyroid, ciprofloxacin potentiator, cold extremities, gastric ailments, hepatoprotective, insecticidal activity, intermittent fever, larvisidal activity	Ahmad *et al.* (2012), Krishnaswamy (2008), Siddiqui *et al.* (2005), Trivedi *et al.* (2011)

6	*Kala-dhatura*	Thorn apple, Downy datura	Solanaceae	*Datura metel* L.	Tropane alkaloids, flavonoids, glycosides, phenols, tannins, sterols saponins	Herb	All parts	In treatment of heart ailments, antibacterial, antifungal, asthma, cough, convulsion, insanity, anaesthetic, antispasmodic, bronchodilator and as hallucinogenic	Akharaiyi (2011), Dahanukar *et al.* (2000), Kiruthika and Sornaraj (2011)
7	Vilayati pudina	peppermint	Lamiaceae	*Mentha* × *piperita* L.	Menthol (Monoterpene), alkaloids, flavonoids, steroids, tannins, phenols	Herb	Leaves	Topical pain reliever & antipyretic, antibacterial, common cold, musculoskeletal pain, to calm pruritus and relieve irritation, anti-inflammation	Galeotti *et al.* (2002), Herro and Jacob (2010), Pramila *et al.* (2012), Sujana *et al.* (2013)
8	-	Scots pine (Pine oil)	Pinaceae	*Pinus sylvestris* L.	Borneol (Monoterpenes: α-pinene, car-3-ene, β-pinene, β-phellandrene, camphene, myrcene, limonene, terpinolene), glycerol, 3′-O-methylcatechin, phenolic compounds	Tree	Needles (leaves)	Disinfectant, antibacterial, antifungal, antiviral, antiseptic (pulmonary, urinary, hepatic), antineuralgic, cholagogue, choleretic, diuretic, expectorant, hypertensive, cough, catarrh	Basu *et al.* (2007), Maciąg *et al.* (2007), Pan and Lundgren (1996)

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Table 1.4 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical /Phytochemical	Habit	Part used	Medicinal properties	References
9	Serpana	Wormwood	Asteraceae	*Artemisia absinthium* L.	Santonin (sesquiterpene), tannins, mucilages, reducing sugars, flavones, volatile oil (1,8-cineole, artemisia ketone, myrcene, (E)-sabinyl acetate, cis-chrysanthenyl acetate, germacrene D, linalool acetate, a dihydrochamazulene isomer, α-phellandrene, linalool, neryl 3-methylbutanoate, neryl 2-methylbutanoate, neryl butyrate, curcumene, carvone, trans-verbenol, trans-epoxyocimene, β-thujone sabinene, chamazulene, α-thujone), resinic acids, carotenoids, coumarins, terpenoids, alkaloids, phenolic compounds (syringic acid, fisetin, isorhamnetin, kaempferol), phytosterols (β-sitosterol, stigmasterol)	Herb	All parts	Photosensitizer, cytotoxic, antihepatotoxic, antibacterial, antifungal, antioxidant, antimalarial	Basu *et al.* (2007), Bora and Sharma (2010), Ivănescu (2010), Orav *et al.* (2006), Sharopov *et al.* (2012b)
10	Karpasa	Cotton	Malvaceae	*Gossypium herbaceum* L.	Gossypol (sesquiterpene), tannin, starch, saponin, calcium, mucilage, carbohydrate, phenolic compounds	Shrub	Seeds, leaves, roots	Contraceptive-for males, wound healing, antimicrobial, menstrual disorders	Basu *et al.* (2007), *Masram et al. (2012)*, Velmurugan *et al.* (2012)

11	Haaliyuna	Asparagus	Asparagaceae	*Asparagus officinalis* L.	Steroidal saponins, vitamins, essential oils, asparagine, arginine, tyrosine, flavonoids (kaempferol, quercetin, rutin), resin, and tannin Shoots constituents: thiophene, thiazole, aldehyde, ketone vanillin, asparagusic acid, methyl and ethyl esters Flowers and mature fruits include: quercetin, rutin, hyperosid. Leaves: diosgenin, quercetin-3-glucuronide	Herb	Tuberous roots, young shoots,	antioxidants, immunostimulants, anti-inflammatory, antihepatotoxic, antibacterial, antioxytocic, dysuria, diabetes, and dysentery, appetiser, antitumour, useful in biliousness, leprosy, epilepsy, and night blindness, disease of kidney and liver, tonic, astringent, vermifuge	Kaur and Kapoor (2002), Negi *et al.* (2010)
12	Pyaja	Red onion	Amaryllidaceae	*Allium cepa* L.	Flavonoid quercetin, carbohydrates, glycosides, cardiac glycosides, proteins, alkaloids, saponins, flavonoids, acid compounds, triterpenic acids, reducing sugars, oils, resin, seed constituents (tianshic acid, N-trans-feruloyl tyramine, β-sitosterol-3 β-glucopyranoside-6′-palmitate, sitosterol, daucosterol, tryptophane, adenine riboside), thiosulfinates (alkane(ene) thial-S-oxide)	Herb	Bulb	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	Benkeblia and Lanzotti (2007), Patwardhan *et al.* (2005), Sampath Kumar *et al.* (2010), Tătărîngă *et al.* (2005), Yuan *et al.* (2008), Begum and Yassen (2015)

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Table 1.4 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical /Phytochemical	Habit	Part used	Medicinal properties	References
13	Hathichak	Glob artichoke	Asteraceae	*Cynara cardunculus var. scolymus* (L.) Fiori	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-caffeoylquinic acid, 1,5-O-dicaffeoylquinic acid, 3-, 4-, and 5-caffeoylquinic acids, 1,3-dicaffeoylquinic acid (cynarin), 1,5-dicaffeoylquinic acid, ferulic acid, cumaric acid, inulin etc.	Herb	Inflorescences, leaves, stalks	Anti cancer, inhibition of UV-induced skin carcinogenesis (anticarcinogenic) and vasomodulating, cardiovascular disease, diuretic and liver protector, antioxidant; antitumour, anti-inflammatory, antimutagenic, anti-proliferative, antiatherosclerotic	Pandino *et al.* (2011), Pandino *et al.* (2012), Velez *et al.* (2012)
14	Anaara	Pomegranate	Lythraceae	*Punica granatum* L.	Carbohydrates, reducing sugars, sterols, glycosides, phenolics, tannins, flavonoids, proteins, saponins, triterpenoids, steroids, alkaloids, vitamin C, punicanyl benzoate, granatumol, punicaflavone, granatumoside	Small tree (shrub)	Root bark, dried fruit, stem bark, leaves, seeds, immature fruits, fruit rind	Blood purifier, treatment of dysentery, diarrhoea, nasal haemorrhage, helminthiasis, acidosis, haemorrhage and respiratory pathologies, antibacterial, antifungal, antiprotozoal, antioxidant, antimicrobial, sore throat, haematuria, haemoptysis, against tapeworms, to relieve conjunctivitis	Ali and Sharma (2006), Bhandary *et al.* (2012), Hegde Chaitra *et al.* (2012)

15	Ghrita-Kumari, Kumari	Strawberry	Rosaceae	*Fragaria* × *ananassa* Duch. ex Rozier	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.]	Herb	Fruit	antioxidant activity, antibacterial, antifungal	Filippone *et al.* (1999), Groyne *et al.* (1999), Panico *et al.* (2009)
16	Haladi, Haridra	Turmeric	Zingiberaceae	*Curcuma longa* L.	Curcuminoids [curcumin (diferuloylmethane), demethoxycurcumin, *bis*-demethoxycurcumin], volatile oils (ar-turmerone turmerone, atlantone, zingiberene, sesquiphellandrene, terpinolene, phellandrene, p-cymene, cineol, caryophyllene, nerolidol, curlone, dehydrozingerone, zerumbone, germacrene, sesquiterpenes etc.), sugars, proteins, resins, tannins, alkaloids, saponins, terpenoids, cardiac glycosides, flavonoids	Herb	Rhizomes	Antimicrobial, anticancer, anti-inflammatory, antiviral and antifungal, reducer of post-surgical inflammation, anti- helicobacter pylori, liver protection (afflictions of the liver), premature ageing, wound healing, muscular disorders, common cold, leprosy, intermittent fevers, indolent ulcer, pyogenic (forming pus) afflictions	Aggarwal *et al.* (2007), Akram *et al.* (2010), Gantait *et al.* (2011), Mazumdar *et al.* (1997), Rajesh *et al.* (2013), Sawant and Godghate (2013)

(Continued)

Table 1.4 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical /Phytochemical	Habit	Part used	Medicinal properties	References
17	Draksha	Grape	Vitaceae	*Vitis vinifera* L.	Triterpenoids, phenolic compounds, saponin, xanthoprotein, flavonoids, reducing sugar, aromatic acid, organic acid, vitamins, carbohydrates, lipids, enzymes, dimers (e-viniferin, balanocarpol, β-glucopyranosyl 8-balanocarpol), resveratrol	Tendril climber	Fruits, leaves, young branch, flowers	Anti-inflammatory, anticancer, anti-convulsant activity, antioxidant, antibacterial, Inhibition of human Tyrosinase activity, skin whitening agents, eye inflammation, treatment of diarrhoea, haem orrhage and varicose vein, antifungical activity, prevention of human cardiovascular diseases	Felicio *et al.* (2001), Park and Boo (2013), Sivakumar and Venkataraman (2010), Spanos and Wrolstad (1990)
18	Muli	Radish	Brassicaceae	*Raphanus sativus* L.	Glucosinolates, isothiocyanates, anthocyanin, alkaloid, tannins, saponins, flavonoids, phytosterols, triterpenoids, phlobatannins, anthraquinones, carbohydrates, reducing sugars, steroids, amino acids, terpenoids, cardiac glycosides and chalcones	Herb	Roots, leaves, seeds	Anticancer, treatment of bronchitis and diarrhoea, antimicrobial, antiviral, treatment of diuretic, urinary troubles, piles and gastrodynia, appetiser, antitumorigenic, antimutagenic, anti-diabetic	Beevi *et al.* (2010), Gutiérrez and Perez (2004), Hanlon and Barnes (2011), Janjua *et al.* (2013), Meera *et al.* (2010), San Juan *et al.* (2012)

19	Jal-indushoor	Watercress	Brassicaceae	*Nasturtium officinale* W.T. Aiton	Phenols, glucosinolate nasturtiin (phenethyl isothiocyanate), flavonoids (quercetin, kaempferol), terpenoids, saponins, glycosides	Herb	Aerial parts (leaves)	Anticancer, anti-inflammation, antioxidant, to cure abdominal pain, treatment of diabetes, bronchitis, diuresis, scurvy, tuberculosis, influenza, asthma	Cartea *et al.* (2011), Mazandarani *et al.* (2012), Özen (2009), Palaniswamy *et al.* (2003), Penecilla and Magno (2011), Sun *et al.* (2002)
20	Hari Phool Gobhi	Broccoli	Brassicaceae	*Brassica oleracea* L.	Sulforaphane (1-isothiocyanato-4-ethylsulfinylbutane), glucosinolates, flavonoids, vitamins, mineral nutrients	Herb	Inflorescences including florets, leaves	Anticancer, antioxidant, skin disease (treatment of warts)	Cartea *et al.* (2011), Jackson and Singletary (2004), Li *et al.* (2012), Moreno *et al.* (2006), Oguntona (1998)
21	Methi	Fenugreek	Fabaceae	*Trigonella foenum-graecum* L.	Coumarin, scopoletin, fenugreekine, trigonelliine, glucosides, acubine type of glucosides, cyanogenic glucosides, phenol, flavanol, amino acids, alkaloids, tannin, steroids, volatile oil, proteins, polysaccarides, saponin, nicotinic acid, sapogenins, phytic acid, fibrs, galactomannans	Herb	Whole plant and seeds	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	Acharya *et al.* (2006), Basch *et al.* (2003), Basu *et al.* (2007), Bukhari *et al.* (2008), Nandagopal *et al.* (2012), Shaikh *et al.* (2013)

(Continued)

Table 1.4 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical /Phytochemical	Habit	Part used	Medicinal properties	References
22	Lodhra, Tilva	Lodh Tree	Symplocaceae	*Symplocos racemosa* Roxb.	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, butulinic acid, acetyloleanolic acid, oleonolic acid, benzoylsalireposide, salireposide, β-amyrin, β-sitosterol, β-sitosterol glycoside, symconoside A, symconoside B	Small tree (shrub)	Bark	Anti-inflammatory, anti oxidant, diarrhoea, dysentery, in dropsy, eye disease, liver complaints, fevers, ulcers, scorption-string, anticancer, antiulcerogenic activity, uterin stimulant	Ahmad *et al.* (2003), Ahmad *et al.* (2005), Gopala Krishna *et al.* (2013), Kambhoja and Keshava Murthy (2004), Krishnaraju *et al.* (2006), Viral (2010)
23	Afeem, Khuskhus	Opium poppy	Papaveraceae	*Papaver somniferum* L.	Alkaloids (morphine, codeine, thebaine, papaverine, noscapine, etc.)	Herb	Capsule, latex, seeds	Antidepressant, painkiller-nowadays especially for cancer patients, anti-cough, muscle relaxant agent, analgesic, CNS, stimulants	Akhtar *et al.* (2013), Basu *et al.* (2007), Dittbrenner *et al.* (2008), Dittbrenner *et al.* (2009), Krishnaraju *et al.* (2006)

24	Gajar	Carrot	Apiaceae	*Daucus carota* L.	Sesquiterpene (daucucarotol), chromones, flavonoids, coumarins, anthocyanins, phenolic, carotenoids (β-carotene, α-carotene), phytosterol, triterpene, polyacetylen (falcarinol, falcarindiol, falcarindiol-3-acetate), isocoumarin (6-methoxymellein), chlorogenic acid, caffeic acid, terpenol, sitosterol glucoside, daucane type sesquiterpenes (trans-dauc-8-ene-4b-ol, trans-dauca-8,11-diene, dau-ca-5,8-diene, acora-4,9-diene, acora-4,10-diene, carotol, daucol, furocoumarins)	Herb	Root and seed	Treatment of ancylostomiasis, dropsy, chronic, kidney disease, bladder afflictions, antibacterial, antifungal, anthelmintic, anticancer hepatoprotective and cytotoxic activities, anti-diarrhoea, anti-infection, anti-high blood cholesterol, anti-inflammation, anti-seizure, antioxidant, anticacinogenic, treatment of swelling	Ahmed *et al.* (2005), Basu *et al.* (2007), Chatatikun and Chiabchalard (2013), Fu *et al.* (2009), Kidmose *et al.* (2002), Sun *et al.* (2009)
25	Santara	Orange	Rutaceae	*Citrus sinensis* (L.) Osbeck	Polymethoxylated flavones, o-glycosylated flavones, c-glycosylated flavones, o-glycosylated flavonols, o-glycosylated flavanones, phenolic acids + their ester derivatives, flavonoid glycoside (hesperidin), β-cryptoxanthin esters, reducing sugar, saponins, cardiac glycosides, carbohydrates, alkaloids, tannins, fixed oils (d-limonene), lipids, proteins, steroids, amino acids, β-carotene	Tree	Fruits	Lowers the cholesterol level, antimicrobial, antioxidants, anticancer	Basu *et al.* (2007), Chede (2012), Dhuique-Mayer *et al.* (2007), Kanaze *et al.* (2009), Osarumwense *et al.* (2011)

(Continued)

Table 1.4 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical /Phytochemical	Habit	Part used	Medicinal properties	References
26	Butter fruit	Avocado	Lauraceae	*Persea americana* Mill.	Peptone, b-galactoside, glycosylated abscisic acid, alkaloids, cellulose, polygalacto urease, polyuronoids, cytochrome P-450, volatile oils, phenolics, saponins, flavonoids, catechins, procyanidins, hydroxybenzoic and hydroxycinnamic acids, zeaxanthin	Tree	Fruits (pulps, peels, seeds), leaves	Protects eye from macular degeneration and cataracts, treatment of various ailments (monorrhagia, hypertension, stomach ache, bronchitis, diarrhoea, diabetes), cardiovascular effects, insecticidal and fungicidal activities, antimicrobial, anti-osteoarthritis, anti hepatotoxicity, anti-inflammation, anticancer	Arukwe *et al.* (2012), Basu *et al.* (2007), Dabas *et al.* (2013), Rodríguez-Carpena *et al.* (2011), Yasir *et al.* (2010)
27	Tamatar	Tomato	Solanaceae	*Lycopersicon esculentum* Mill.	Antioxidants like carotenoids (especially, lycopene, β-carotene), phenolics, ascorbic acid (vitamin C), vitamin E, phytate, glycoside, saponin, tannin, minerals (calcium, phosphorus)	Herb	Fruits	Reduces risk of prostate cancer in males, antioxidant, antibacterial, antifungal, antiviral and anti -carcinogenic, anti-UV rays for skin protection	Basu *et al.* (2007), Oyetayo and Ibitoye (2012), Rai *et al.* (2012)

Table 1.5 Medicinal plants from Latin American with potential for use as nutraceutical and as functional food component.

No	Local name	English name	Plant Family	Scientific name	Nutraceutical	Habit	Part used	Medicinal Properties	References
1	Kabalyáaxnik	Violet wild petunia	Acanthaceae	*Ruellia nudiflora* (Engelm. & A. Gray) Urb.	Flavonoids, apigenin 7-glucuronide, malvidin 3,5-diglucoside	Herb	Roots, leaves	Abdominal pain, diarrhoea, remedy to prevent vomiting	Argueta *et al.* (1994), Bloom (1976), Sanabria (1986)
2	Ox, Ramón	Maya nut	Moraceae	*Brosimum alicastrum* Sw. ssp. *alicastrum*	2 6-dimethoxy-p-benzoquinone, flavonoids, saponins, steroids, tannins, triterpenes	Tree	Leaves	Antidote for snake bites, antitussive, asthma, bronchitis, diabetes, diaphoretic, gynaecological, lactation, menstruation, tuberculosis	Argueta *et al.* (1994), García-Corrales *et al.* (2006), Hausen (1978), Méndez-González *et al.* (2012), Mendieta and Del Amo (1981)
3	Altanisa	Mugwort	Asteraceae	*Artemisia vulgaris* L.	Monoterpenes, polyacetylenes, sesquiterpenes, quiterpenlactones, coumarins, flavonoids, oestrogenic, alkaloids	Herb	Roots, leaves, flowers, seeds	Abdominal pain, anti-parasites, diabetes, diarrhoea, hysterics, remedy to prevent vomiting, rheumatism	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)

(Continued)

Table 1.5 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical	Habit	Part used	Medicinal Properties	References
4	Bakalché	–	Boraginaceae	*Bourreria pulchra* (Millsp.) Milssp.	Benzochromenes (6,6-dimethyl-2-methoxy-6H-benzo[c] chromen-9-yl) methanol, 2-methoxy-6,6-dimethyl-6H-benzo[c] chromen-9-carbaldehyde)	Tree or Shrub	Roots, stem bark, leaves	Antipyretic, fungal infections of the skin, haemorrhaging, herpes simplex, pellagra, tumours	Argueta *et al.* (1994), Erosa-Rejón *et al.* (2010), Mendieta and Del Amo (1981), Méndez-González *et al.* (2012); Sanabria (1986)
5	Kópeché	Black sage	Boraginaceae	*Varronia curasavica* Jacq.	Meroterpenoid naphthoquinones, cordiaquinones J and K, beta-eudesmol, cadina and diene	Shrub	Roots, stem bark	Fever, haemorrhaging, infections of the skin, inflammatory bowel disease	Argueta *et al.* (1994), Hernandez *et al.* (2007), Ioset *et al.* (2000), Méndez-González *et al.* (2012)
6	Kabal muk	–	Celastraceae	*Crossopetalum gaumeri* (Loes.) Lundell	Cardenolides, dichloromethanic (dipertenes, triterpenes)	Shrub	Roots, leaves	Abdominal pain, antidote for snake bites, remedy to prevent vomiting, toothache	Ankli (2000), Méndez-González *et al.* (2012), Pulido Salas and Serralta Peraza (1993)
7	K´ab ché	–	Ebenaceae	*Diospyros anisandra* S. F. Blake	Naphthoquinone plumbagin	Shrub	Roots, stem bark, leaves	Antimicrobial, haemorrhaging, scabies	Ankli (2000); Borges-Argáez *et al.* (2007), Méndez-González *et al.* (2012)

8	Chaya	–	Euphorbicaceae	*Cnidoscolus chayamansa* McVaugh	Cyanogenic glycosides, gallic acid, catechins, protocatechuic acid and rutin, triterpenoids (amyrenone, β-amyrin acetate, α-amyrin acetate) β and α amyrin, alkanes,	Shrub	Leaves, resin	Abdominal pain, cholesterol, diabetes, haemorrhoids, renal calculus, rheumatism	Argueta *et al.* (1994), Escalante-Erosa *et al.* (2004), Kuti and Konoru (2006), Loarca-Piña *et al.* (2010), Méndez-González *et al.* (2012), Narváez (2001)
9	Xikin burro	–	Euphorbiaceae	*Croton chichenensis* Lundell	Dipertenes, clerodane diterpenes, crotofuranensis, 3-acetylaleuritolic acid	Shrub	Roots, leaves	Fungal infections of the skin, remedy to remove warts and pimples, syphilitic lesions, scabies	Ankli (2000), Cuevas (1993), Méndez-González *et al.* (2012), Mex (2005)
10	Pata de Vaca	Bauhinia Orchid Tree	Fabaceae	*Bauhinia divaricata* L.	Dichloromethane-methanol (2:1)	Herb	Roots, leaves	Asthma, anti-inflammatory, anticatharral activities, antibacterial, bronchitis, dysentery, halitosis, renal failure	Ankli *et al.* (2002), Argueta *et al.* (1994), Méndez-González *et al.* (2012), Mendieta and Del Amo (1981), Rodríguez (2009)

(Continued)

Table 1.5 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical	Habit	Part used	Medicinal Properties	References
11	Chaksink'in	Cudjoe wood	Theophrastaceae	*Bonellia macrocarpa* (Cav.) B. Ståhl & Källersjö	Bonediol	Shrub	Roots, leaves, flowers, seeds	Anti-parasites, antitussive, asthma, catarrh, cough, dysentery, toothache, whooping cough	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)
12	Nance blanco	–	Malpighiaceae	*Byrsonima bucidaefolia* Standl.	Methyl gallate, 3-gallate	Shrub	Stem bark	Diarrhoea, dysentery	Castillo-Ávila *et al.* (2009), Méndez-González *et al.* (2012)
13	Analk'ak	Mexican Milkweed	Apocynaceae	*Asclepias curassavica* L.	3,4-seco-triterpenoids, pregnanes and pregnane glycosides, 12b,14b-dihydroxy-3b,19-epoxy-3a-methoxy-5a-card-20(22)-enolide, coroglaucigenin, 12b-hydroxycoroglaucigenin, calotropagenin, uscharidin, asclepin, 16a-acetoxyasclepin, 16a-acetoxycalotropin, 16a-hydroxyasclepin, 12b-hydroxycalotropin	Herb	Leaves, fruit	Anticatharral, asthma, bile, catarrh, cysts, dental caries, gonorrhoea, grippe, headache, rheumatism, skin cancer, tumours	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)

14	Nance	Golden spoon	Malpighiaceae	*Byrsonima crassifolia* (L.) Kunth.	Epicatechin, lupeol, glycolipids, catechin, isoquercitrin, oleanolic acid, quercetin glycoside proanthocyanidins,	Tree or shrub	Stem bark, leaves	Antidote for snake bites, antitussive, bile, constipation, diabetes, diarrhoea, dysentery, scabies	Amarquaye *et al.* (1994), Argueta *et al.* (1994), Geiss *et al.* (1995), Mendieta and Del Amo (1981), Pulido Salas and Serralta Peraza (1993), Rastrelli *et al.* (1997)
15	Malva de monte	Sleepy Morning	Malvacaceae	*Waltheria indica* L.	Flavonoids, 5, 2′, 5′-trihydroxy-3-7-4-trimethoxyflavanone, 5-2′-hydroxy-3,7,4′,5′-tetramethoxyflavone, (-)-epicatechin, quercetin, tiliroside	Herb	Leaves, stems	Amebiasis, diarrhoea, fungal infection on lips, renal insufficiency	Méndez-González *et al.* (2012), Mendieta and Del Amo (1981), Ragasa *et al.* (1997), Rao *et al.* (2005),
16	Guayaba	Guava	Myrtaceae	*Psidium guajava* L.	Amritosid, caryophyllene, ellagic acid, foeniculina, guiajaverin, guajavolide, guavenoic acid, isoquercetin, longicyclen, myricetin, quercetin, tripertene oleanolic	Shrub	Stem bark, Leaves, flowers, fruit, seeds	Anti-inflammatory, anti-parasites, antitussive, diarrhoea, dysentery, haemorrhoids	Ankli (2000), Begum *et al.* (2002), Lutterodt (1989), Mendieta and Del Amo (1981), Narváez (2001), Pulido Salas and Serralta Peraza (1993), Sagrero-Nieves *et al.* (1994), Seetharaman and Manjula (1996)

(Continued)

Table 1.5 (Continued)

No	Local name	English name	Plant Family	Scientific name	Nutraceutical	Habit	Part used	Medicinal Properties	References
17	Puukin	Sierra Nakedwood	Rhamnaceae	*Colubrina greggii* S. Watson var. *Yucatanensis* M. C. Johhst.	Chrysophanol (1,8-dihydroxy-3-methylanthracenedione)	Tree or shrub	Roots, leaves	Abdominal pain, asthma, dysentery, induce labour, kidney diseases, remedy to prevent vomiting, tuberculosis	García-Sosa *et al.* (2006), Méndez-González *et al.* (2012), Mendieta and Del Amo (1981), Polanco (2004), Pulido Salas and Serralta Peraza (1993)
18	Sabak Ché	West Indian snowberry	Rubiaceae	*Chiococca alba* (L.) Hitch.	Oleanolic acid skeleton (3β-hydroxyolean-12,15-dien-28-oic acid), droxyketones, 4-hydroxyheptadecan-7-one, 5-hydroxyoctadecan-11-one, 5,7,4′-trimethoxy-4-phenylcoumarin, exostemin, d-mannitol matairesinol,	Shrub	Root-bark, leaves	Abdominal pain, anti-parasites, diarrhoea, dysentery, infections of the skin, toothache	Argueta *et al.* (1994), Bhattacharyya and Cunha (1992), El-Hafiz *et al.* (1991), Méndez-González *et al.* (2012), Mendieta and Del Amo (1981), Pulido Salas and Serralta Peraza (1993)

19	Sinanché	Prickly yellow	Rutaceae	*Zanthoxylum caribaeum* Lam.	Furoquinoline alkaloids, skimmianine, 5-Methoxycanthin-6-one and N-methylisocorydine	Tree	Stem bark, leaves	Epilepsy, headache, leprosy, rheumatism, scabies	Ankli (2000), Argueta *et al.* (1994), Della Casa and Sojo (1967), Dreyer and Brener (1980), Méndez-González *et al.* (2012), Mendieta and Del Amo (1981), Pulido Salas and Serralta Peraza (1993)
20	Chicozapote	Sapodilla	Sapotaceae	*Manilkara zapota* (L.) P. Royen	Fructose, galactose, glucose, glucuronic acid, myo-inositol, sucrose, flavonoids ampelopsine, catechin, epicatechin, surbose, gallocatechin, myricitrin, quercetrin, chlorogenic acid methyl ester	Tree	Stem bark, leaves, fruits, resin, seeds	Antivenom, cholesterol, diabetes, diarrhoea, dysentery, haemorrhaging, kidney and liver disease	Argueta *et al.* (1994), Chung *et al.* (1997), Ma *et al.* (2003), Mendieta and Del Amo (1981), Méndez-González *et al.* (2012), Narváez (2001), Pulido Salas and Serralta Peraza (1993)

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 oxycoccos* 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. allicin. 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

Centre 2014). 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 chemotherapic 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.

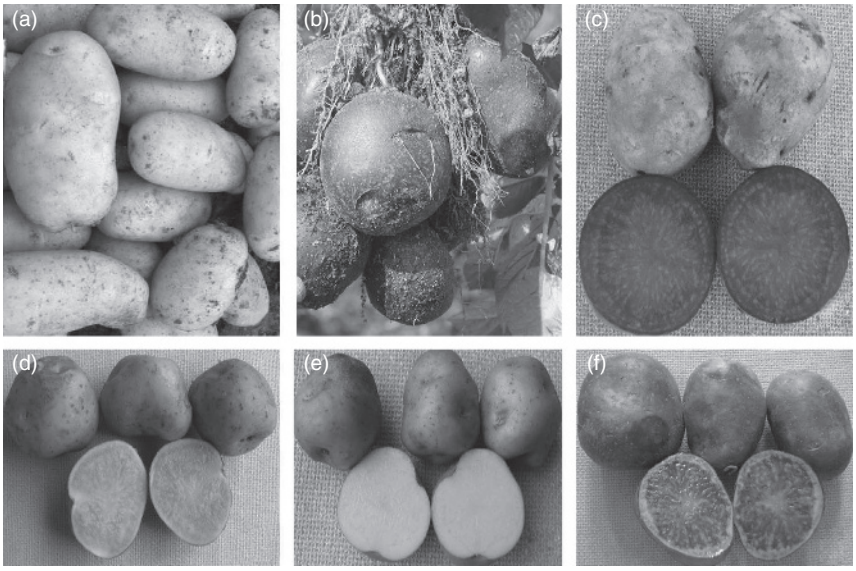

Figure 1.1 Advanced clones of potato (*Solanum tuberosum* L.) with coloured tubers with potential for use as nutraceutical and as functional food and value-added food products grown near Kunming, Yunnan province, P. R. China. (a). Normal/Standard Coloured Flesh-Yunshu 502 (Whole Tubers); (b). Purple 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.*)

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

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 different 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 manufacturers 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 content 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 phytonutrients and dietary fibres can be important to reduction in disease risk and health maintenance. 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

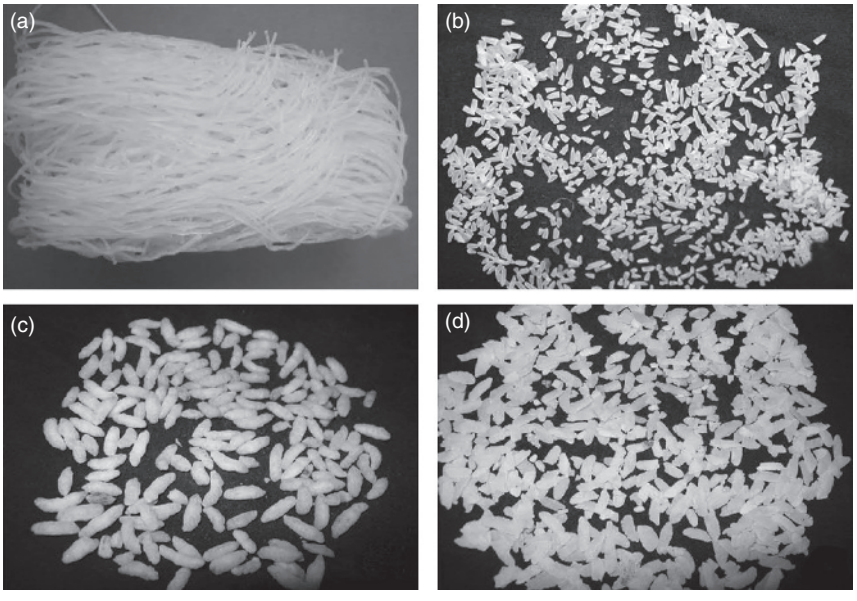

Figure 1.2 Potential rice (*Oryza sativa* L.) functional food and value-added food products. (a). Rice Noodle/Vermicelli; (b). Broken Rice; (c). Puffed Rice; and (d). Flattened Rice. Photo courtesy: (a). Ratnabali Sengupta; and (b)., (c)., and (d). Saikat Kumar Basu.

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 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 pasteries, 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).

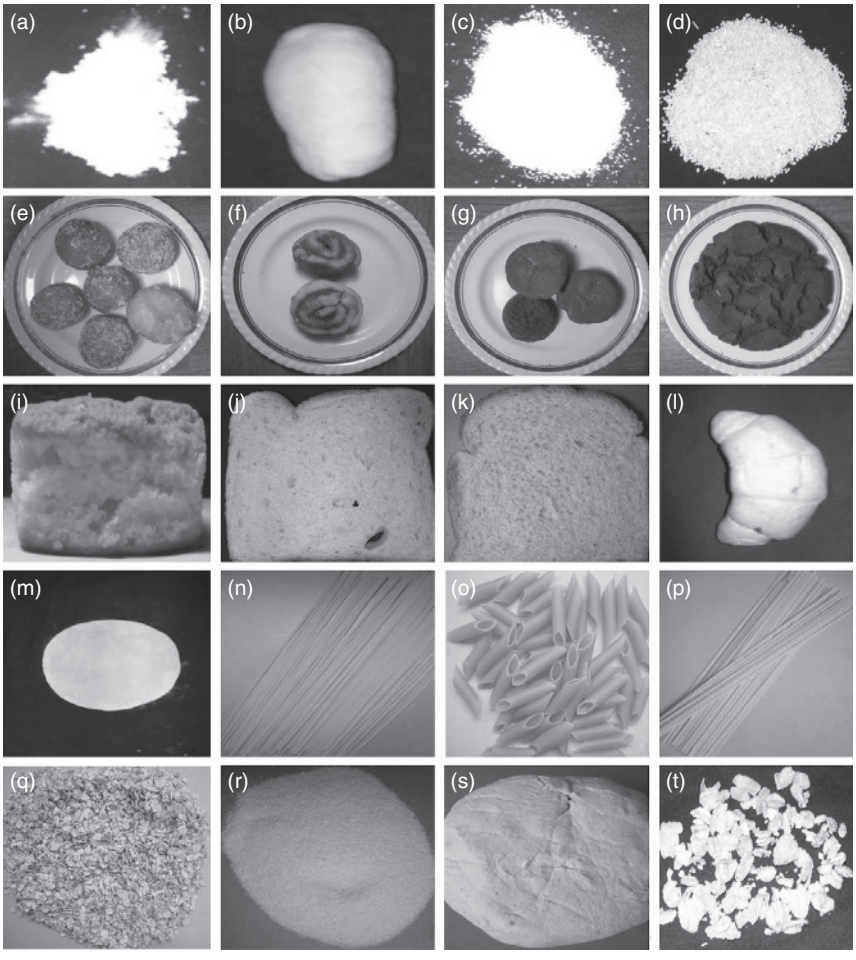

Figure 1.3 Potential cereal-based functional food and value-added food products. I. Wheat (*Triticum aestivum* L.) Products: (a). Wheat Flour; (b). Wheat dough; (c). Refined Wheat Flour; (d). Broken Wheat/ Dalia ; (e). Doughnuts; (f). Cinnamon Buns; (g). Brownies; (h). Cookie; (i). Cheese Cake; (j). Brown Bread Slice; (k). White Bread Slice; (l). Croissant; (m). Flat Bread/Chapati; (n). Spaghetti; (o). Pasta; and (p). Noodles. II. Oats (*Avena sativa* L.) Product: (q). Oatmeal. III. Maize (*Zea mays* L.) Products: (r). Corn Flour; (s). Corn Dough; and (t). Corn Flakes. Photo courtesy: (a).- (t). Saikat Kumar Basu. (*See color plate section for the color representation of this figure.*)

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 gladin 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 for 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 cellotriosyl/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 soybean (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.

Acknowledgements

The authors are deeply indebted to the insights provided by Dr. Sudip Datta Banik, Dr Krishnendu Acharya, Dr. Santanu Paul and Mr. Vince Ellert.

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