Medicinal Plants of India

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Introduction

Crude extracts of fruits, herbs, vegetables, cereals and other plant materials rich in phenolics and antioxidant activity are of prime interest to the food industry because of their ability to retard oxidative degradation of lipids and hence improve the quality and nutritional value of functional food. Concomitantly, the importance of antioxidant constituents of plant materials in the maintenance of health and protection from coronary heart disease and cancer is also raising interest among scientists, food manufacturers and consumers as part of the current trend towards the use of herbal medicine. In addition, the use of complementary alternative medicine (CAM) by patients suffering from chronic disorders, such as cancers, heart, stroke and immune disorders has been well documented. CAMs are either used on their own (alternative treatments) or in addition to conventional medicine (complementary treatments). CAMs can be grouped into herbal medicines derived from medicinal plants, food supplements that include vitamin preparations, trace elements and other substances such as omega-3 fatty acids (Zimmerman and Thompson, 2002).

Prior to undertaking an introduction to Indian medicinal plants, it is essential to mention that both Ayurveda, the traditional Indian medicine, and traditional Chinese medicine (TCM) have remained by far the most ancient surviving traditions that are not only pragmatic in its approach but at the same token philosophically sound (Patwardhan et al., 2005). The essence of the Ayurveda system (from “ayus” or life, and “veda” or knowledge, and thus meaning the “science of life”) lies in the Atharva-Veda (Fernando...
Ayurveda has been categorized into eight branches (Astanga) and addresses many aspects of medicine and the art of healing (Jadhav and Bhutani 2005). Charaka Samhita, is the first recorded book on Ayurvedic medicine, which was written sometime in 900 BC and the other Sushruta Samhita equally important written in 600 BC (Mukerjee and Wahile, 2005; Schuppan et al., 1999). Ayurvedic literature comments on the three body-control systems referred to as the Tridoshas; that comprise the nervous system (Vata or air/wind), the venous system (Pitta or bile), and the arterial system (Kapha or phlegm), and a continuous mutual interaction between the three has been attributed as the hallmark of well-being and health (Balachandran and Govindarajan, 2005). The characteristic of a dosha pertaining to a health or a disease state, have also been associated with a particular therapeutic value of a substance that may be either a plant or a mineral (Chopra and Doiphode, 2002). Besides the three doshas, the other two fundamental elements of Ayurvedic medicine comprise the seven dhatus or basic tissues, and the three waste products (malas) viz. stool, urine and sweat (Dash 1999). Mukherjee and Wahile (2006) noted that Ayurveda is essentially a holistic system formulated on the premise, that the human body is a matrix of seven basic tissues (‘Rasa’, ‘Rakta’, ‘Mansa’, ‘Meda’, ‘Asthi’, ‘Majja’, ‘Shukra’), with the waste products, such as faeces, urine and sweat (malas) being derived from the five basic elements, ether, air, fire, water and earth (pancha dhatu), which are in turn related to the three basic energy types or functional principles known as “vata, pitta and kapha” as mentioned above. Thus any imbalance in these basic principles is the ultimate cause of disease. In ancient Indian medicine, there is also the mention of Rasayana in the Ayurvedic system; a group of herbal formulations that are used to improve the well-being of the body (Gaddipati et al., 2004). The word Rasayana, derived from “rasa” which denotes essence, water, and “ayana” meaning going, essentially refers to nutrition and its acquisition, sustenance of movement, circulation and perfusion in the body tissues (Scartezzini and Speroni, 2000; Singh, 1992).

Ayurvedic literature encompasses numerous plants of medicinal value that have been used as a part of traditional medicine and herbal preparations for thousands of years. Weragoda (1980) noted that amongst the four systems of traditional medicine that has been adopted in Sri Lanka, viz. Ayurveda, Siddha, Unani and Deshiya Chikitsa, both the Ayurveda and the Deshiya Chikitsa systems mainly use plant and herbal preparations for the treatment of various diseases. In the former, about 2000 species of different plants is used whilst the latter comments on the uses of about 500 species (Weragoda, 1980). In this review, we have made an attempt to describe the distribution and uses of some of the most important plants that are commonly used in traditional Indian medicine.

Indian Medicinal Plants

Andrographis paniculata Nees (Kalamegha) is a medicinal herb belonging to the family Acanthaceae and is popular as a rich source of numerous bioactive compounds. It is widely distributed in the plains of India, Sri Lanka, Mainland China and Taiwan (Gamble, 1956). It is an erect branched plant that grows to a height about 0.3–0.9 m. The branches are quadrangular in shape and winged in the upper part. The leaves are lanceolate, acute, undulate with a pale undersurface. The flowers are usually small and occur at solitary distant whilst the seeds are numerous, rugosely pitted and yellowish brown hued (Oudhia, 2002). The stems and leaves are the main sources of active phytochemicals (Kumar et al., 2004). The aerial part of the plant has a very bitter taste and it is mostly
the leaves and roots that are used for medicinal purposes. Andrographolide and other diterpenoids such as dehydroandrographolide, neoandrographolide, andrographiside form the bitter constituents that are believed to contribute towards immune stimulation, anti-inflammatory, fertility decreasing, liver protective and bile secretion-stimulatory actions of the herb (Akowuah et al., 2006; Chen et al., 2007; Pholphana et al., 2004; Zhao et al., 2002). Many other diterpenoids (Matsuda et al., 1994), such as glucosides (Chan et al., 2001) and flavone derivatives (Kuroyanagi et al., 1987) have been isolated from the plant and tested for various biological activities. Andrographis paniculata is widely used as a traditional medicine in China and Southeast Asia (Kuroyanagi et al., 1987). The plant is used as a traditional remedy for fever, and for the treatment of infectious fever-causing diseases. This herb is reputed to possess antidiabetic (Zhang and Tan, 2000), antithrombotic (Zhao and Frang 1991), and antioxidant and antiinflammatory (Sheeja et al. 2006) properties. In Malaysia, decoction from the aerial parts is used to treat cold, hypertension, diabetes, cancer, malaria and snake bite (Perry 1980). It is also considered to be a latent-heat clearing, antipyretic, detoxicant, anti-inflammatory, detumescent, febrifugal, antiphlogistic and analgesic agent for the treatment of acute infections of the gastrointestinal tract, respiratory organs and urinary system (Nazimudeen et al., 1978; Choudhury and Poddar 1985). Recent investigations show Andrographis paniculata contains Andrographolide which is a diterpenoid lactone, and therefore endowed with antitumour activities against in vitro and in vivo breast cancer models (Jada et al., 2007).

Azadirachta indica A. Juss (Neem) is a highly versatile medicinal plant having widespread traditional uses in the treatment of various human diseases (Kirtikar and Basu, 1935; Kirtikar and Basu, 1975; Chopra et al., 1956, Chopra et al., 1958, Sengupta et al., 1960, Mitra, 1963, Verma, 1976, Thakur et al., 1981, Vander Nat et al., 1987, Champagne et al., 1992; Singh and Singh, 2002: Biswas et al., 2002). The plant belonging to the family Meliaceae is a broad leaved evergreen tree is native to Asia, but is also distributed throughout northern, southern and south-eastern Africa (Hördegen et al., 2006). Neem is found to thrive mainly in the arid zones of tropical regions because of its susceptibility to excessive frost (Prakash and Srivastava, 2005). The Indian Neem tree grows to about 20 – 30 m in height with a trunk girth of about 2.5 m (Mukherjee et al., 2005). In contrast to the Indian Neem tree, the Siamese varieties are less branching, the fruits are comparatively large, possess longer and thicker leaflets and exhibits a more dense infloroscence (Sombatsiri et al., 1995). Extracts prepared from the Neem plant has been successfully used to reduce tumors by herbalists throughout Southeast Asia. Researchers in India, Europe and Japan have also revealed that the presence of polysaccharides and limonoids in the barks of Neem trees, leaves and seed oil retain the capacity to reduce tumors and cancers and are also effective against lymphocytic leukemia (Arivazhagan et al., 2000; Akudugu et al., 2001; Subapriya and Nagini, 2003). Hypoglycemic potentials of extracts prepared from neem leaves have been documented by Mukherjee et al. (1995).

Antihyperglycemic/hypoglycemic activity of neem leaves (Murty and Rao, 1978) and neem seed oil (Dixit et al., 1986) has been reported. Intravaginal application of neem oil, (NIM- 76- a refined product from neem oil) can act as a novel contraceptive because Neem seed oil is reported to have spermicidal activity (Sinha et al., 1984). Although Neem oil from the leaves, seed and bark are known to possess a wide spectrum of antibacterial action against both Gram-negative and Gram-positive microorganisms, however studies carried out by Sairam et al. (2000) showed that NIM-76 has by far more stronger antimicrobial activity in comparison to the whole Neem oil. The same study also revealed the antifungal (against Candida albicans) and the antiviral (against Polio virus)
properties of NIM-76. The extract from bark, leaves, fruits, oil and root have been used to control leprosy, intestinal helminthiasis and respiratory disorders in children (Kirtikar and Basu, 1935; Kirtikar and Basu, 1975; Chopra et al., 1956, Chopra et al., 1958). The bark extract is also used as a tonic, an astringent and is useful in relieving fever, thirst, nausea, vomiting and skin diseases (Sengupta et al., 1960). The immunomodulatory activity of the bark extract has also been reported (Vander Nat et al., 1987).

Centella asiatica L. urban (Gotukola, Brahmi, Mandukaparni) is known as Gotukola or Indian pennywort. It is a perennial herbaceous creeper belonging to the Apiaceae (Umbelliferae) family (Cheng et al., 2004). It is native to both tropical and subtropical countries including Australia, the Pacific Islands, New Guinea, Melanesia and Asia. The plant is found to grow in damp, moist and shady habitats through the production of stolons that are characterized by long internodes and nodes, on which reniform-cordate leaves and sessile flowers in simple umbels occur (Mathur et al., 2007). The infl oroscence is 1–7 cm long with secondary umbels of 2–4 flowers bearing purple pinkish petals (Stone 1970). In the Ayurveda system of medicine, the plant is regarded as one of the Rasayanas for its high medicinal properties (Jayashree et al., 2003; Jayaweera, 1982). Centella asiatica, is morphologically close to Hydrocotyle asiatica and both Hydrocotyle asiatica and Centella asiatica are known to produce essential oils characteristic to the species Hydrocotyle and Centella (Yoshinori et al., 1982) and extracts prepared from these plants include various types of flavonoids (Nakoki and Morita, 1960). The herb is effective in lowering blood pressure (antihypertensive agent), is used as a tonic to purify blood through removal of toxins as well as a diuretic, for treating indigestion and nervousness, as a cure for skin disorders, and as a remedy against asthma, leprosy, anemia and inflammations (Jayatilake and MacLeod, 1987; Ramaswamy et al., 1970). Numerous clinical reports verify the ulcer-preventive (Huriez, 1972) and antidepressive-sedative (Sakina and Dandiya, 1990) effects of the herb. Centella asiatica is also regarded as a psychoactive medicinal plant that has existed as a part of ancient Ayurvedic medicine to alleviate symptoms of anxiety and in inducing deep state of relaxation and mental calmness during meditation practices, for thousands of years (Wijeweera et al., 2006). Studies by Bradwejn et al. (2000) confirmed that Centella asiatica does indeed possess anxiolytic activity thereby serving as a minor tranquilizer and the property was attributed to the presence of asiaticoside — a triterpene glycoside. Centella asiatica has also been shown to improve memory (Mukharji, 1953) and the general mental ability of mentally retarded children (Rao and Rao, 1973; Kuppurajan et al., 1978) and can be used as a brain tonic because it improves memory and strengthens the CNS (Sharma and Sharma, 2002) and is also popular for its cognitive-enhancing property (Kumar and Gupta, 2002). In pharmacological studies, the plant extract has been shown to have central nervous system depressant activity (Chatterjee et al., 1992) and also to improve the maze learning in rats (Rao et al., 1999). Documented studies reveal that the plant is endowed with wound healing (Suguna et al., 1996), anticancer (Babu et al., 1995), antioxidant (Zainol et al., 2003) and antileprotic (Sahu et al., 1989) properties.

The ground rhizome of Curcuma longa (Haridra in Sanskrit and turmeric in English) (Singh et al., 1995) and belonging to the family Zingiberaceae, is well known for its natural medicinal properties. The plant is a perennial herb and can attain a height of 100 cm – 1 m (Scartezzini and Speroni, 2000; Kapoor, 1990), it has a short stem and large sheathing leaves, the flowers are yellow flowers and are gathered into a 10 –15 cm long spike (Scartezzini and Speroni, 2000). The parts that are used for medicinal purposes include the rhizome, which is ovate, oblong, cylindrical or pyriform and is usually short-branched (Eigner and Scholz, 1999). The rhizome is usually dried and ground to yield a yellow powder known as turmeric. Turmeric owes its characteristic yellow
colour to the three major pigments viz. curcumin (50–60%), demethoxy curcumin (20–30%) and bis demethoxy curcumin (7–20%) (Govindarajan, 1980; Khurana and Ho, 1988). The curcuminoids are known to possess antioxidant activities (Toda et al., 1985). It is grown in India, particularly in Bombay, Madras and Bengal, but is also distributed in Pakistan, China and in many countries in South-east Asia (Kapoor, 1990; Kirtikar and Basu, 1993; Nandkarni, 1993). Although the origin of *Curcuma longa* is in the Indian peninsula, it is also found in South America (Braga et al., 2006). The use of *Curcuma longa* has been a part of traditional Chinese medicine and Ayurveda for thousands of years (Xia et al., 2007). It is used as an analgesic in the treatment of menstrual disorders, rheumatism, and traumatic diseases because it contains a number of monoterpenoids, sesquiterpenoids, and curcuminoids (Lee, 2006; Tang and Eisenbrand, 1992). The compounds belonging to the two important groups of natural products, the diarylheptanoids and sesquiterpenoids, are believed to impart many of the important biological and medicinal activities of turmeric (Nishiyama et al., 2005). *Curcuma longa* has also been documented as a source of an easily digested starch (similar to arrowroot) and has been utilized in the industry for the preparation of foods for invalids and children (Iyothi et al., 2003). Turmeric powder protects the gastric mucosa against irritants (Scartezzini and Speroni, 2000) and prevents flatulence (Ammon and Wahl, 1991). According to Xia et al. (2007) the clinical condition of depression Traditional Chinese Medicine (TCM) has been attributed to liver “qi” stagnation (qi is somewhat equivalent to prana of the Indian medicinal tradition), the symptoms of which can manifest as mental stress, hypochondriac distensive pain, or lumps in the breasts, hernial pain and irregular menstruation. *Curcuma longa* serves as the main ingredient in many traditional prescriptions known to invigorate qi (Xia et al., 2007). Various studies have also been carried out on the antioxidant and related anticancer activities of compounds derived from turmeric rhizomes such as the curcuminoids (curcumin (1,7-bis(4-hydroxy-3-methoxyfenil)-1,6-heptadiene-3,5-dione), demethoxy-curcumin, and bis-demethoxy-curcumin) which are considered as the major antioxidative compounds of turmeric (Cousins et al., 2007). Curcumin and its sodium salt have been shown to have a strong anti-inflammatory activity in carragenin- and caoline-induced edema, formaline-induced arthritis with a corticosteroid-like and a strong antioxidant activity (Scartezzini and Speroni, 2000). The chemopreventive properties of curcumin have been extensively investigated and well documented (Conney et al., 1997; Nagabhushan and Bhide, 1992; Surh, 1999; Surh et al., 2001). There are numerous documented studies that provide evidence that curcumin contributes to the inhibition of both tumour formation and promotion of cancer initiation (Duvoix et al., 2005). Azuine and Bhide (1992a; 1992b) described the anti-tumor potential of curcumin induced by benz(a)pyren, 7,12-dimethylbenzaanthracen or phorbol esters, while Ikezaki et al. (2001) demonstrated the chemopreventive effects of curcumin on glandular stomach carcinogenesis induced by N-methyl-N’-nitro-N-nitrosoguanidine (MNNG) and sodium chloride in rats. Besides curcuminoids, other compounds from *Curcuma longa* possessing antioxidant capabilities include erpinene, ascorbic acid, beta-carotene, beta-sitosterol, caffeic acid, campestrol, camphene, dehydrocurdione, eugenol, p-coumaric acid, protocatechuic acid, stigmasterol, syringic acid, turmerin, turmeronol-a, turmeronol-b and vanillic acid (Duke, 2004). The wound healing properties of *Curcuma longa* has also been investigated for e.g. Sidhu et al. (1998) evaluated the in vivo effects of curcumin (difeurloylmethane), from the rhizomes of *Curcuma longa* on wound healing in rats and guinea pigs and observed that Curcumin treated wounds resulted in enhanced fibronectin (FN) and collagen expression. Transforming growth factor (TGF-β1) plays an important role in wound healing by stimulating the expression of fibronectin (FN) and collagen by fibroblasts and increases the rate of formation of granulation tissue in vivo (Quaglino et
The genus *Datura* comprises of 15 species that are distributed throughout the warmer parts of the world, and about ten species are found in India, of which *Datura innoxia*, *Datura metel*, *Datura alba* and *Datura stramonium* are important drug plants whilst others are ornamental species (Shanmuga Priya et al., 2002). *Datura* is a perennial plant belonging to the family *Solanaceae* and most of its species are herbaceous (Drake et al., 1996; Vaillant et al., 2005). Sasthri (1952) found generally the *Datura* plant is bushy and attains a height of 2–3 feet. *Datura* also known as Jimsonweed, Thorn apple, Devil’s trumpet has been used extensively in traditional medicine as an anaesthetic for setting bones, treating bruises and wounds, skin ulcers, hemorrhoids, asthma, rheumatism, whooping cough, muscle spasm, sciatica, and for the treatment of painful menstruation (Satyavati et al., 1976). Studies on the antibacterial activity of *Datura innoxia* and *Datura stramonium* by Eftekhar et al. (2005) revealed that methanol extracts prepared from *Datura innoxia* possess antibacterial activity against *Bacillus subtilis*, *Enterococcus faecalis* and *Staphylococcus aureus* however the antibacterial activity of *Datura stramonium* was low and mostly directed towards gram positive bacteria in comparison to *Datura innoxia*. However, both plants exhibited no activity against *E. coli* as well as against *Pseudomonas aeruginosa*. The analgesic effects of extracts prepared from *Datura fastuosa* leaves and seed extracts have been reported by Abena et al. (2003) and decoction prepared from the leaves of this plant is used as a treatment for hepatopathy, cardiac palpitation, mental diseases and tooth pain. In the Ayurveda system of medicine the bark, leaves, and seeds of *Datura metel* are for the treatment of many illnesses (Krishnamurthi et al., 2004) although the whole plant is considered as narcotic, anodyne and antispasmodic (Lindley 1985). According to Ayurveda, the seeds of *Datura metel* have proved useful in the treatment of leucoderma, skin disorders, ulcers, bronchitis, jaundice, piles and diabetes (Agharkar, 1991). The leaves possess the property to relieve asthma whilst the powdered seeds are mixed with butter and administered internally for impotence (Lewis, 1971; Lewis and Elvin-Lewis, 1977). A study carried out by Krishnamurthi et al. (2004) showed that the powder prepared from the seeds of *Datura metel* (suspended in 1% sodium CMC) possess hypoglycemic potential — both normal and alloxan-induced diabetic rats administered with graded doses exhibited significant reduction in blood glucose.

*eclipta alba* (Linn.) Hassk. (Bhringaraja) is distributed in the moist tropical regions of the world (Tabassum and Agrawal, 2004). *Eclipta alba* Hassk., syn. *Eclipta prostrata* belonging to the family *Asteraceae* is a small profusely-branched annual herb with white flower heads, which is found to occupy moist niches throughout India and are found to occur at an altitude of about 600 meters (Zafar and Sagar, 1999). The herb exists in three forms: the white, yellow and black fruiting variants (Patnaik, 1993). The plant has been mentioned in ancient texts as a nervine tonic (Uniyal et al., 1998; Satyavati et al., 1976; Vaidya, 1997) as well as being endowed with hepatoprotective, hair growth promoting and anti-aging properties (Thakur and Mengi, 2005). The plant is used in India for the preparation of hair-oil and hence the Sanskrit synonym *Kesharaja*. The plant is reported to contain the phytoconstituents eclalbatin, alpha-amyrin, ursolic acid, oleanolic acid (Upadhyay et al., 2001), ecliptasaponin, daucosterol, stigmasterol-3-O-
glucoside (Zhang and Chen, 1996) and coumestans as main active principles (Wagner et al., 1986). Since the plant contains coumestans, such as wedelolactone (W) and demethylwedelolactone (DMW) (Zafar and Sagar, 1999), it has been extensively studied for its hepatoprotective activity and is used for treatment of catarrh and jaundice (mixed with honey) and viral hepatitis (Wagner et al., 1986; Saraf et al., 1991; Singh et al., 1993, Saxena et al., 1993 and Singh et al., 2001). The aqueous and alcoholic extracts of the plant confer protection against the myotoxic effects of snake venom (Mors et al., 1989). Moreover, it is also reported to possess antinociceptive, anti-inflammatory and bronchodilator activities (Leal et al., 2000). Tabassum and Agrawal (2004) noted that the plant has been used as an anthelmintic, expectorant and an antipyretic, as well as a substitute for Taraxacum — a popular liver tonic.

Emblica officinalis Gaertn (Amalaki, Dhatriphala, Amritaphala) is a medium to large deciduous tree belonging to a small subgenus of trees of the Euphorbiaceae and is mostly distributed in India, Sri Lanka, Pakistan, Uzbekistan, South East Asia, and China (Scartezzini et al., 2006). It is regarded as an important plant of the Ayurveda system of medicine and serves as one of the major ingredients of Chyavanprash, which is widely consumed in India as a health tonic as a control against aging and to mitigate age-related ailments (Ojha, 1988). Scartezzini et al. (2006) found that Charak Samhita and Sushrut Samhita, the two classic texts of Ayurveda, eulogize Amalaki as “the best among the rasayanas (rejuvenative) herbs,” “useful in relieving cough and skin disease”, and “the best amongst the sour fruits”. The genus name Emblica originates from the “corruption” of the Sanskrit name “Amlika,” although some authors attributes the source of “corruption” to the Arabic word “Embelgi” generally used by Arabic physicians to name the fruit of the plant (Scartezzini et al., 2006). Practically all parts of the plant are used for medicinal purposes (Vasudevan and Parle 2007). The therapeutic value of the fruits has been attributed to its high ascorbic acid content, which is about 1 g Vitamin C per 100 mL of fresh juice (Kapoor 1990). However, in this aspect, Ghosal et al. (1996) has contradicted that Emblica fruits do not contain ascorbic acid, neither in the free or in the conjugated form, but on the contrary contain two new hydrolysable tannins of low molecular weight, viz. emblicanin A (2,3-di-O-galloyl-4,6-(S)-hexahydroxydiphenoyl-2-keto-glucono-δ-lactone) and emblicanin B (2,3,4,6-bis-(S)-hexahydroxydiphenoyl-2-keto-glucono-δ-lactone), as well as other tannins, such as punigluconin (2,3-di-O-galloyl-4,6-(S)-hexahydroxydiphenoylgluconic acid) and pedunclagin (2,3,4,6-bis-(S)-hexahydroxydiphenoyl-d-glucose). Both emblicanin A and emblicanin B is known to possess very strong antioxidant properties and also retains the capacity to improve the efficacy of Vitamin C in the reduction of dehydroascorbic acid to ascorbic acid (Bhattacharya et al., 2000; Ghosal et al., 1996). Moreover studies pertaining to the tannins present in Emblica officinalis have been shown to protect erythrocytes against oxidative stress caused by asbestos (Ghosal et al., 1996), exhibit antioxidant activity against ischemia reperfusion indicating a cardioprotective property (Bhattacharya et al., 2002), antiulcerogenic effects (Sairam et al., 2002) and anticataractogenic effects in vitro (Suryanarayana et al., 2004). The fruits of the plant is highly valued in both Ayurvedic and Unani (Graeco-Arab) systems of medicine because of its therapeutic properties which include inhibition of micronuclei formation, sister chromatid exchanges, clastogenicity (chromatid breaks) and mutagenicity induced by metals such as lead, aluminum, cadmium, nickel, and caesium, and the provision of protection against radiation (Scartezzini and Speroni, 2000). The ability of the plant to inhibit in vivo clastogenicity caused by benzopyrene and cyclophosphamide has been duly reported by Sharma et al. (2000) and Haque et al. (2001). The fruit is known to possess antidiabetic activity (Sabu and Kuttan 2002) and is also used for the treatment
of various gastric ailments including dyspepsia (Chawla et al., 1982; Kapoor, 1990). In some rural parts of Malaysia, the plant is used for the treatment of headaches, fever, hypertension and to treat inflammation of the eyes; the hypotensive and anti-inflammatory activities of the plant have been studied by Asmawi (1990). Stress is known to play a crucial role in aetiopathogenesis of gastric ulcers (Miller 1987) and many rasayanas have been reported to have antiulcerogenic activity (De, et al., 1997; Rao et al., 2000; 2001; Sairam et al., 2001), with *Emblica officinalis* being one of them (Rege et al., 1999). In the Ayurveda system of medicine, rasayanas are regarded as a class of plant-derived drugs with a reputation of promoting health and longevity by strengthening the immune system, acting as an antiaging agent and though rejuvenating the body during debilitated condition (Udupa and Singh 1995). *Emblica officinalis* is referred to as one of the ‘tridoshic rasayana’ in the Charaka Samhita because of its rejuvenating effect on the ailing body by imparting homeostasis of the ‘tridoshas’ — vata, pitta and kapha (Jagetia et al., 2002).

*Momordica charantia* Linn (Ambuvallika) is also referred to as bitter gourd or karela in India, is a member of the Cucurbitaceae family and is cultivated throughout the tropics, particularly in India, China, East Africa and South America (Ilhan et al., 2000). The plant is an annual with a long, angled and grooved stem, the fruits are oblong or ovate, 5–15 cm long, pendulous, orange-coloured when mature, green or whitish when unripe, and the post-dehiscence pulp exhibits a blood-red or scarlet hue (Scartezzini and Speroni, 2000). *Momordica charantia* is commonly used as a traditional remedy for diabetes in India, Asia, Africa and South America (Virdi et al., 2005) and as a folk remedy for various other ailments (Ilhan et al., 2000). In Turkey, the matured fruits are applied externally for the rapid healing of wounds and internally for the treatment of peptic ulcers (Baytop, 1984). The unripe fruits of the bitter gourd plant have been shown to produce a hypoglycemic effect in experimental models following oral administration (Akhtar et al; 1981; Day et al., 1990; Pugazhenthi et al., 1995; Sharma et al., 1960; Srivastava et al., 1987). Several constituents including charantin (mixture of sterol glucosides), vicine (pyrimidine nucleoside) and p-insulin (polypeptide) are reported as the active ingredients for the hypoglycemic activity (Oliver-Bever, 1986; Raman and Lau, 1996). *Momordica charantia* is known to improve glucose metabolism (Welihindu et al., 1986) not only via a direct hypoglycemic effect but also through improvement of lipid metabolism (Virdi et al., 2003). Although insulin was first isolated from mammalian pancreas, Ng et al. (1986) have reported the presence of insulin-like molecules in the seeds of *Momordica charantia*. Besides diabetes, the fruit, leaves, seeds and roots of *Momordica charantia* have been used in the Indian system of medicine to treat a number of diseases (Virdi et al., 2005). In Ayurvedic medicine, *Momordica charantia* is prescribed as a stimulant, blood purifier, laxative and antihelminthic whilst the powdered fruit is claimed to be useful in healing wounds, and leprous and malignant ulcers (Raman and Lau, 1996). It is used for the treatment of stomach aches, colds and fevers, rheumatism, gout, and the induction of abortion in Turkey (Ilhan et al., 2000). Bittergourd fruit have been also reported to possess antiviral and antitumor activities (Bourinbaiar et al., 1996; Raza et al., 1996). Protein extracted from the seeds, MAP-30, has been found to inhibit HIV-1 infection and replication in vitro (Bourinbaiar and Lee-Huang, 1995). Sreejayan (1991) revealed the fruit juice to be a strong scavenger of superoxide and hydroxyl radicals, even after boiling for 45 min with acid or alkali treatment. The management of diabetes without any side effects is still a challenge to the medical arena and has lead to an increased demand for complementary and alternative medicine with antidiabetic activity and less side effects (El Batran et al., 2006). It is most likely that the humble bitter gourd may offer such an opportunity. Post-translational glycosylation or covalent attachment of carbohydrates to proteins is crucial for the biosynthesis of glycoproteins (Fatima and
Husain, 2007). Today, glycoproteins have assumed a high degree of popularity in the area of biotechnology because of their immense therapeutic potential (Lis and Sharon 1993) for e.g. glycosylated proteins from plants have been administered as oral vaccines (Rogan and Babiuk, 2005). A number of peroxidases such as horseradish peroxidase, soybean peroxidase and lupin extensin peroxidase are known to be glycosylated (Price et al., 2003). It is appropriate to report here, that the role of carbohydrate moieties in the stabilization of proteins using bitter gourd peroxidase as a model system has been investigated by Fatima and Husain (2007).

Ocimum sanctum Linn (Tulasi) is an annual erect herb that grows to a height of 1-2 m and belongs to the family Labiatae (Lamiaceae) (Sembulingam et al., 2005). According to Pushpangadan and Bradu (1995), there are more than 150 species in the genus. The leaves are toothed, purple or pale green in hue and are slightly hairy (Juntachote and Berghöfer, 2005). However the shape and colour of the leaves in O. basilicum is highly variable and may vary from small and liniform to large and round while the colour of the leaves could range from yellow-green to grey-green, to red or almost black (Graye et al., 2002). The plant is found to grow throughout India, up to an altitude of 1,800 m. in the Himalayas and is cultivated in temples and gardens (Grover et al., 2002). The plant is sacred to the Hindus and is aptly referred to as “Holy basil” in English. The Hindus however designate the green one as Lakshmi or Sri Tulsi and the purple plant as Krishna Tulsi (Kothari et al., 2004). Ocimum sanctum has been used extensively in Indian traditional systems of medicine as an anthelmintic, expectorant, antipyretic, insecticidal and as a treatment for a variety of skin diseases (Asha et al., 2001). The leaves of Ocimum tenuiflorum L. (syn. Ocimum sanctum) contain essential oil, the constituents of which have been found to be eugenol, eugenal, carvacrol, methyl-chavicol, limatrol and caryophylline (Rai et al., 2004). Essential oils from Ocimum sanctum are also used in the development of skincare products, preparation of perfumes and for aromatherapy purposes (Lertsatitthanakorn et al., 2006). Dhar et al. (1968) reported on the hypoglycemic effect of ethanolic extract (50%) of leaves. Studies using 70% ethanol extract of Ocimum sanctum leaves have exhibited significant reduction of blood glucose level in normal, glucose fed hyperglycemic and STZ (50 mg/kg IP) induced diabetic rats (Grover et al., 2002). Documented studies in which the plant has exhibited both antioxidant properties (Kelm et al., 2000) and hypolipidemic effects (Sarkar et al., 1994) exist. Javanmardi et al. (2003) reported that Iranian basils possess valuable antioxidant properties for culinary and possible medicinal use. However Javanmardi et al. (2003) reported that the amount of total phenolics varied in different accessions and ranged from 22.9 to 65.5 mg GAE/g of dry material. The content of the total phenolics are important because the antioxidant potential of a herb or spice is attributed to the redox properties of phenolic compounds which allow them to act as either as reducing agents or as hydrogen donators and singlet oxygen quenchers (Caragay 1992; Rice-Evans et al., 1997). The aqueous and alcoholic extract from the leaves of this plant have been investigated extensively for various pharmacological properties including their activity against cancer (Bhargava and Singh, 1981; Chattopadhyay, 1993; Prashar and Kumar 1995; Ganasoundari et al., 1997). The seeds of this plant are reported to possess hypoglycemic, hypourearemic and uricosuric, anti-inflammatory and analgesic activities (Sarkar and Pant 1989; Sarkar et al., 1990; Singh et al., 1996). Oil from Ocimum sanctum usually contain five fatty acids viz. palmitic (11.69%), stearic (3.19%), oleic (13.82%), linoleic (52.23%) and linolenic (16.63%) (Singh et al., 1996) and linolenic acid (a dual inhibitor of arachidonate metabolism), and these fatty acids have deemed responsible for imparting the antiinflammatory activity of the oil (Singh and Majumdar, 1997).
Piper longum Linn (Pippali) belongs to the family Piperaceae and is a slender aromatic climber with perennial woody roots that grow in the hotter parts of India (Pullela et al., 2006). The family Piperaceae has over 700 species that are distributed both in the southern and the northern hemisphere (Parmar et al., 1997). The fruits are commonly known as “pippali” and are used both as a spice as well as a preservative in pickles (Pullela et al., 2006). Piper longum is regarded as an important traditional medicinal plant, amongst the people of Asia, especially those of the Indian subcontinent, and also among the people of the Pacific (Guido et al., 1998). The fruits of Piper longum are used for the treatment of diseases associated with the respiratory tract, infections such as coughs, bronchitis, asthma, malarial fever, diarrhea and jaundice (Krishnamurthi, 1969).

Piper longum forms an important component of those medicines that have been reported as beneficial for the treatment of gonorrhea, menstrual pain, tuberculosis, sleeping problems, respiratory tract infections, chronic gut related pain, and arthritic conditions (Singh, 1992). Fruits from Piper longum mixed with roots from Piper sarmentosum Roxb. and Quercus infectoria (nut gall) are routinely used to cure bloody diarrhea in Thai traditional medical practice because of their antiaemobic activity in vivo (Sawangjaroen et al., 2004). Other beneficial effects of Piper longum include analgesic effects, relaxation of muscle tension, and alleviation of anxiety (Singh and Blue Menthal, 1997). The first amide to be isolated from the piper species was piperine, which has been reported to induce central nervous system depression and display both antipyretic and anti-inflammatory activities (Parmar et al., 1997). Besides Piper longum, piperine is also the major alkaloidal component of black and long peppers and has been attributed with the enhancement of structurally and therapeutically different drug bioavailability (Annamalai and Manavalan, 1990; Atal et al., 1985; Bano et al., 1987; Bano et al., 1991; Zutshi et al., 1985). Investigations related to the immunomodulatory and antitumor effects of piperine from Piper longum have been conducted by Sunila and Kuttan (2004) using alcoholic extracts. Besides piperine, other compounds isolated from Piper longum include the alkaloid amide piplartine from the stem bark, piperlongumine and piperlonguminine from the roots of the plant (Chatterjee and Dutta, 1967).

The genus Terminalia, comprises of about 250 species and is widely distributed mostly in the tropical areas of the world (Fabry et al., 1998). Terminalia chebula Retz (Harad, Haritaki) is an important medicinal tree belonging to the family Combretaceae and is found to grow throughout India especially in the deciduous forests and areas of light rainfall (Naik et al., 2004). The tree is abundant in the Northern part of India and in the southern part of India it is found to occur in the Deccan tablelands and the tree is usually found to grow at elevations of 6000 feet (Thakur et al., 1988). The plant indigenous to Pakistan and India but is distributed in many Asian and African countries where it seves as a popular folk medicine because of its homeostatic, antitussive, laxative, diuretic and cardiotonic properties (Barthakur and Arnold, 1991; Singh, 1990). The dried fruits (Chebulae fructus) are commonly known as black Myroblans in English and Harad in Hindi (Saleem et al., 2002) and are included in the Indian pharmacopoeia under the category astringent (Naik et al., 2004) — the cause of astringency being the presence of chebulinic acid, besides this acid, the fruits also contain tannic acid (20 – 40 %), gallic acid, resins etc. (Thakur et al., 1988). Gallic acid which is the product of tannin hydrolysis is not only important in the pharmaceutical industry but also finds

Special Feature
application in the preparation of dyes as well as in the leather and chemical industries (Hadi et al., 1994; Mukharjee and Banerjee, 2003). The dried fruits are also popular as a folk medicine in China (locally referred to as Xi-Qin-Ge or Zhang-Qin-Ge) and applied as a carminative, deobstruent, astringent and expectorant agent as well as a remedy for salivating and heartburn (Gao et al., 2007). Terminalia chebula has proved beneficial in the treatment of various diseases of the mouth such as dental caries, spongy and bleeding gums, gingivitis and stomatitis (Date and Kulkarni, 1995). From a study conducted by Jagtap and Karkera (1999), the antibacterial activity of extracts prepared from Terminalia chebula was apparent and thus they concluded that the plant could serve as an effective agent in the treatment of carious teeth, owing to its ability to inhibit the growth and accumulation of Streptococcus mutans on the surface of the tooth. About 20–40 % of the ripe fruit of Terminalia chebula is tannic acid (Chopra and Handa, 1958) and studies exist that depict the bacteriostatical and bactericidal activity of Terminalia chebula towards some Gram-positive and Gram-negative pathogens (Kau, 1980). The fruits of Terminalia chebula are among one of the components of “Triphala” which is a compound formulation originating from the Ayurveda system of medicine and comprises of three medicinal plants viz. Terminalia chebula, Terminalia bellerica and Emblica officinalis (Jagetia et al., 2002) and has been used extensively as a drug against a number of diseases (Awasthi and Nath, 1968; Reddy et al., 1990). The antidiabetic potential of Triphala was observed in a study carried out by Sabu and Kuttan (2002) in which oral administration of Triphala, reduced alloxan induced diabetes in diabetic rats. The study also showed that the activity of Terminalia bellerica as an antioxidant played a major role in reducing serum glucose level followed by Emblica officinalis and Terminalia chebula. The plant can be used as a laxative (in the form of the fruit pulp), a rejuvenative, a nerve or as an astringent (due to the presence of chebulinic acid), in the preparation of tonics, as an expectorant, anthelmintic and the application may be in the form a decoction, powder, paste, or gargle against the inflammation of mucous membrane of mouth (Prasad et al., 2006). Malekzadeh et al. (2001) found black myrobalan powder is often used in traditional medicine in the southern and central parts of Iran as a remedy for human gastritis and peptic ulcers. Studies pertaining to antibacterial activity of black myrobalan powder by Malekzadeh et al. (2001) against Helicobacter pylori (responsible for chronic gastritis, peptic ulceration and gastric cancer in humans) as well as other pathogenic bacteria revealed that water extracts of the black myrobalan at a concentration of 1.0–2.5 mg/ml inhibited urease activity of Helicobacter pylori. Malekzadeh et al. (2001) concluded that the scientific basis behind the traditional use of black myrobalan powder in the treatment of gastric infections caused by Helicobacter pylori was due to the antibacterial activity of the plant.

Withania somnifera Dunal (syn Physalis flexuosa L) is a member of the Solanaceae family commonly known as Ashwagandha in India (from “asva” meaning ‘horse’, and “gandha” meaning ‘smell’), because the roots of the infected plants emanate a smell similar to that of horse urine (Scartezzini and Speroni, 2000). The shrub is distributed in the western part of India and grows to a height of 1.5m and has ovate leaves and greenish–yellow flowers (Ganzera et al., 2003). The fruits of this plant appear as tiny orange berries and reported to contain saturated and unsaturated fatty acids (Stoller et al., 1974; Monika et al., 1993; 1994). According to Kapoor (1990) and Kirtikar and Basu (1993) the plant is mainly distributed in the dry areas of India, on the Himalayas but limited to an elevation of 1600 m, in Beluchistan, Sri Lanka and the Mediterranean area; it occurs spontaneously in Sicily and Sardinia. The plant is widely used in Ayurvedic medicine (Rasool and Varalakshmi, 2006) as a tonic, aphrodisiac, sedative, for the treatment of geriatric problems such as amnesia (Ghosal et al., 1989; Asthana and Raina, 1989) and as Medharasayana (that which promotes learning and good memory)
The active chemical constituents of *Withania somnifera* has kindled the interest of many researchers because of the obvious absence of any toxic side effects of the drugs prepared from this plant when treating the elderly (Schliebs et al., 1996). The plant is said to possess a potential property of pacifying ‘Vata’ in herbal drugs (Dhuley, 2001; Singh et al., 2001) and is mentioned in the Vedas as a herbal tonic and health food (Ziauddin et al., 1996). *Withania somnifera* is also referred to as the ‘Indian Ginseng’ because both Ginseng and Aswagandha tend to share many therapeutic properties that are common to both (Patwardhan et al., 1991).

For example, *Panax ginseng* is regarded as an adaptogen while *Withania somnifera* is a rasayana and the properties that are ascribed to Ayurvedic rasayanas are said to be remarkably similar to those present in adaptogens and according to Bhattacharya and Muruganandam (2003), both the plants retain the capacity to promote the well being of an individual both physically and mentally by mitigating stress. The roots of *Withania somnifera* is regarded as a rasayana (Bhattacharya and Muruganandam, 2003) and thus attributed with high medicinal value (Capasso et al., 2003; Kapoor 2000; Schulz et al., 2001; Tripathy et al., 1996), however preparations from both roots and leaves have been used in traditional medicine as tonic, hypnotic, sedative and diuretic (Jain and DeFillips, 1991; Nadkarni, 1976). Different studies in *Withania somnifera* have reported on its immunomodulatory effects (Ziauddin et al., 1996) anticonvulsive (Kulkarni et al., 1995), adaptogenic (Bhattacharya and Muruganandam, 2003), anticancer (Christina et al., 2004) and anabolic (Grandhi et al., 1994) activities and also the beneficial effects of the plant in the treatment of arthritis (Rasool and Varalakshmi, 2006) hypertension and rheumatism (Thakur et al., 1989) as well as stress (Grandhi et al., 1994). *Withania somnifera* also exhibits anti-inflammatory (carragenine-induced) activity and has exhibited hepatoprotective effects against alcohol and CCl₄ (MIP-1β) (Sudhir et al., 1986). *Withania somnifera* is a rich source of bioactive compounds and include withaferin A which was isolated from this plant as an antitumor principle (Devi, 1996). Withaferin A has also been associated with anti-inflammatory (Sethi et al., 1970) and immunosuppressive (Shohat et al., 1978) properties. Sitoindosides VII–X as well as withaferin A from the roots of *Withania somnifera* is used in the Indian medicine to attenuate cerebral functional defects including amnesia in geriatric patients (Schliebs et al., 1996). Sitoindosides IX and X are immunostimulatory in their action (Ghosal et al., 1989) while sitoindosides VII and VIII are antioxidants (Bhattacharya et al., 1997; Panda and Kar, 1997). The major chemical constituents reported from *Withania somnifera* are known as withanolides (Jayaprakasam and Nair 2003) — the two withanolides isolated from *Withania somnifera* of Pakistani origin are the 5-dehydroxywithanolide-R and withasomniferin-A (Rahman et al., 1991). Withanolide D has antitumour activity (Leyon and Kuttan, 2004). The other withanolides present in *Withania somnifera* including their glycosylated products are reported to have immunomodulatory and other activities (Zhao et al., 2002). Diwanay et al. (2004) have described the utilization of botanical drugs as a means of immunoprotection in cancer chemotherapy and *Withania somnifera* offers protection against immunosuppression and thus the plant may have a potential use in the development of new anticancer drugs (Senthilnathan et al., 2006). This was also emphasized upon by Jayaprakasam et al. (2003) who observed the effectiveness of the withanolides from *Withania somnifera* leaves in inhibiting the growth of human cancer cell.
Future of Herbal Medicine

There are strengths and limitations in the clinical application of traditional herbal medicines. The strengths include extensive in vivo testing of the effects of herbal preparation. The fact that the majority of plants from which many of the present day drugs have been derived have been sourced not only from ethanobotanical leads but also from the materia medica of the ancient “rishis” and shamanic traditions of tribal “medicine men” that dates back to thousands of years when man roamed the forests as hunter gatherers. Limitations include reproducibility of ethanomedical use confounded by comparison of the effects of mixtures of compounds versus single compound activity, special medical use which is essentially a diagnostic problem due to problems in translation of local disease categories to Western ones and vice versa, dosing determinations (amount and frequency), and placebo versus therapeutic effects. For traditional plant medicines to be adopted in the modern market the active ingredients and the novel bioactive compounds thus isolated will need to perform better than the commercially prepared drugs currently on the market. Although most governments in the Asia Pacific region strongly support the natural product industry but concomitantly the situation warrants for a pragmatic approach that will not only weld the structure-based approaches and classical medicinal chemistry into an integrated whole but will maintain a sustained endeavor in providing the necessary ingredients for the success of natural products in meeting a global market. An alternate solution lies in the integration of natural products in the drug discovery process via pathway analysis that embraces the “omics” technology as a wholistic, rapid and cost effective approach. Natural products are the backbone and the fortitude of the future pharmaceutical industry and it is fervently hoped that this review on the medicinal plants of India will earnestly contribute to the growing global pharmaceutical discovery and drug development industry.

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