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Immunomodulatory and Therapeutic Potentials of Herbal, Traditional/Indigenous and Ethnoveterinary Medicines

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Abstract: Herbs/Botanical plants are considered as God's gift to human beings in the form of natural medicines, like the one well known "Sanjeevani booti" described in Hindu Mythology. The traditional and ethno-veterinary practices have been in use for centuries, transferring the knowledge from generation to generation and they are accessible, easy to prepare and administer, with little or no cost at all. Even though the modern developments in therapeutic field brought about a rapid decline in traditional medicine, the plant-based remedies are still having a crucial role as potential source of therapeutic aids in health systems all over the world for both humans and animals. Among the 21,000 medicinal plants listed by the World Health Organization (WHO), 2500 species are native to India, which stands first in the production of medicinal herbs. This innumerable treasure of medicinal herbs brings India the distinction of 'the botanical garden of the world'. Nowadays immune-based therapies are gaining more importance than monovalent approaches which are having limited benefits. Apart from the actions like treating diseases, control of ecto- and endo-parasites, fertility enhancement, bone setting and poor mothering management, an array of herbal medicines have been reported which are having immunomodulatory effects like modulation of cytokine secretion, histamine release, immunoglobulin secretion, class switching, cellular co-receptor expression, lymphocyte expression, phagocytosis and so on. The present article describes in brief few of these important ones viz., ashwagandha, anila, tulsi, arjuna, aloe vera, garlic, turmeric, ginger, shatavari, neem, guduchi, kiwifruit, tut, kamala, palashlata, kokilaksha etc. being used for human and animal health benefits.

Key words: Herbs, ethnoveterinary medicine, immunomodulation, therapy, disease, health

INTRODUCTION

In 21st century, world is facing the problem of population growth, increase in the incidences of the disease, unemployment and change in ethical values (Mahima *et al.*, 2012a). Due to development of antibiotic resistance by the bacteria (Verma *et al.*, 2007; Lambey *et al.*, 2009; Kumar *et al.*, 2011, 2012a, b) and

antiviral resistance (Verma *et al.*, 2012) by the viruses, the researchers are now thinking towards immunomodulation. The term immunomodulation is generally used to describe the pharmacological manipulation of the state of activity of the immune system. Immunomodulators either make an increase or decrease in the magnitude of immune response. The augmentation of immune response is known as immunostimulation/immunopotential while

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suppression of immune responsiveness is termed as immunosuppression (Chauhan, 2010). From a therapeutic point of view, immunomodulation refers to a process and a course of action in which an immune response is altered to a desired level (Archana *et al.*, 2011). The development of science and biotechnology particularly in field of nutrition leads to the formation of designer milk (Mahima *et al.*, 2012b) and designer eggs (Mahima *et al.*, 2012c) that can also be used for enhancing the immunity (Mahima *et al.*, 2012d). The uses of herbal plants as health promoters are gaining increasing attention in both consumer and scientific circle (Upadhyay *et al.*, 2011; Hashemi and Davoodi, 2012). Various physiological products, microbial products, synthetic chemicals, cow therapy (panchgavya) (Verma, 2005) and herbal products have immunomodulation property. Among these, the herbs exhibit an array of diverse biological activity such as antistress, adaptogenic, anti-ageing and immunomodulatory activity. Many herbs are being used by veterinarians fruitfully to treat a variety of conditions of animals as well as in birds (Dhama *et al.*, 2012). Herbs provide potent anti-inflammatory, antibacterial, antiviral and antifungal benefits. Improvements have been shown or reported with those suffering from flu, allergies, colds, rheumatoid arthritis, bacterial/viral infections, hepatitis, heart disease, asthma, skin infections, ageing, chemical intoxication etc. and effective in treating cancers (Mathew *et al.*, 2010; Umashanker and Shruti, 2011). Apart from infectious and systemic diseases, topical botanical/herbal application is also effective for specific conditions like ear infections, wounds, burns and skin irritations (Mizaei-Aghsaghali, 2012).

Herbs, traditional/indigenous plants and ethnoveterinary medicines, having multiple beneficial advantages, have been used since long for strengthening of body and its immune system and to keep away or fight against diseases. 'Nakul Samhita', an Indian ancient literature, describes the treatment of animals with many herbs, written about 5000 B.C. Our Ayurveda system of medicine, an ancient medicinal system, is a good knowledge store for herbs and minerals having medicinal properties. Several medicinal plants used in Indian traditional medicine called Rasayanas which increases the resistance of the body against a variety of infections have attracted the attention of many scientists. It is one among the eight branches of Ayurveda which has been meant for nourishing and rejuvenating drugs with multiple applications for longevity, memory enhancement, immunomodulation and adaptogenic (Patwardhan and Gautam, 2005). Herbal therapy is also popularly called as "Rasayana Chikitsa". In our country the ancient medicinal

system of Ayurveda is a vast repository of knowledge in herbals and minerals of medicinal properties. The rasayana drugs are endowed with multiple properties like delaying ageing, improving mental functions and preventing diseases (Sharma, 1983). Burgeoning interest in medicinal herbs has increased scientific scrutiny of their therapeutic potential and safety, thereby providing practitioners with data to help farmers make wise decision about their use (O'Hara *et al.*, 1998).

Ethnoveterinary medicine deals with people's knowledge, skills, methods, practices and beliefs about the care of their animals and to keep them healthy, which are acquired through practical experience and has traditionally been passed down orally from generation to generation (Toyang *et al.*, 2007). Since centuries before the introduction of western and allopathic medicines, all livestock keepers relied on these traditional practices. According to the World Health Organization, at the moment, at least 80% of people in developing countries depend largely on these practices for the control and treatment of various diseases. Limitations of synthetic drugs and chemicals in terms of higher cost, anticipated toxicity and adverse effects are becoming known to the people. On the other hand, the natural medicines are more suitable for animal and human health care with the advantages of low cost and total safety (Rahal and Kumar, 2009a). Some of them are studied scientifically by *in vitro* and *in vivo* studies but most of them are yet to be scientifically validated. In the era of emerging antibiotic resistance and residual effects in food products, food safety concern, these can play wonderful role for safeguarding health of humans and animals.

In the last few years there has been an exponential growth in the field of herbal medicine and these drugs are gaining popularity both in developing and developed countries because of their natural origin and less side effects. Many traditional medicines in use are derived from medicinal plants, minerals and organic matter. The World Health Organization (WHO) has listed 21,000 plants, which are used for medicinal purposes around the world. Among these 2500 species are in India, out of which 150 species are used commercially on a fairly large scale. India is the largest producer of medicinal herbs and is called as botanical garden of the world (Umashanker and Shruti, 2011). The country has one of the richest plants medical traditions in the world. There are estimated to be around 25,000 effective plant-based formulations, used in folk medicine and known to rural communities in India. There are over 1.5 million practitioners of traditional medicinal system using medicinal plants in preventive, promotional and curative

applications. It is estimated that there are over 7800 medicinal drug-manufacturing units in India, which consume about 2000 tonnes of herbs annually (Verma and Singh, 2008).

In literature many plants have been listed having immunomodulatory effect and some of them have been proved by using modern scientific methodologies. In this paper, few important herbs are discussed with their immunomodulatory action/properties either on laboratory animals, domestic animals or human beings.

IMMUNOMODULATORY AND MEDICINAL PROPERTIES OF HERBAL AND TRADITIONAL/INDIGENOUS DRUGS

- Possess potent anti-inflammatory, antibacterial, antiviral and antifungal benefits (Rios and Recios, 2005; Mizaei-Aghsaghali, 2012)
- Alleviate, reduces and/or helpful in preventing suffering from infectious and systemic diseases (flu, allergies, colds, rheumatoid arthritis, bacterial/viral infections, hepatitis, heart disease, asthma, skin infections, ageing, chemical intoxication etc.)
- Multiple immunomodulatory actions including modulation of cytokine secretion, histamine release, immunoglobulin production, immunoglobulin class switching, cellular co-receptor expression, lymphocyte proliferation and phagocytosis promotion (Spelman *et al.*, 2006)
- Topical application gives relief from ear infections, wounds, burns and skin irritations
- Effective in treating and fighting the deadly malady of cancers (Kamiyama *et al.*, 2005)
- Helpful in delaying the process of ageing.
- Exhibit beneficial biological activity-antistress, adaptogenic and cytoprotective (Patwardhan and Gautam, 2005)
- Improving mental functions and preventing diseases
- Enhances vaccine responses (Ragupathi *et al.*, 2008)
- Being natural medicines, they are safer
- Easily accessible, easy to prepare and administer
- Part of own traditional culture
- Environment friendly
- No perceived danger of evolving drug resistance
- Are cost effective
- Apart from their wide use in human health, many are also being used by veterinarians to fruitfully treat a variety of conditions of animals, as described below. (Blecha, 2001)

Benefits of herbal medicine over conventional therapies:

- Conventional medicine usually addresses symptoms while herbal therapies can often improve or even reverse a condition by identifying and treating the root cause. Therefore, are also effective in chronic conditions, such as asthma, allergies, recurring skin conditions and cancers
- Works soothingly and are generally well tolerated by most animals
- Being nature's medicine, are effective for many different conditions
- With fewer harmful side effects pose less risk than many pharmaceutical drugs
- Easier to administer: Many herbal medicines are dispensed as a tincture or tea that can be mixed with food or water thus can be much easier than a pill/bolus
- Less adverse reactions
- Higher efficacy over time
- Do not show drug-resistance and serious environmental effects (Patwardhan *et al.*, 2004)

Documented systems of medicinal herbs include Chinese medicine, Japanese Kampo, Tibetan herbs, Indian Ayurveda and African healing herbs. The promotive, preventive, corrective and curative approach in health care and the medicinal plants possessing such properties are indeed the strength of the Indian Systems of Medicine (ISM). The ancient masters of Ayurveda and Siddha organized, codified and synthesized the medicinal wisdom with sophisticated theoretical foundation and philosophical explanations. They adopted the fundamental doctrines of *Darshana* philosophy, particularly the *Nyaya*, *Sankhya* and *Vaisesika*, which encompassed all sciences-physical, chemical, biological and spiritual. Nevertheless, the holistic approach of ISM, more particularly of Ayurveda, which internalize all aspects of health and diseases, is perhaps the greatest contribution of Indian medicine (Pushpangadan, 2006). Indian medicinal plants provide a rich source for antioxidants that are known to prevent/delay different disease conditions. The medicinal plants also contain other beneficial compounds like ingredients for functional foods. Hence, the global knowledge about Ayurveda and Indian herbals are hopefully be enhanced by information on the evidence-base of these plants. This ultimately helps in yielding rich dividends (Vaidya and Devasagayam, 2007).

Modulation of immune response to alleviate diseases has long since been of interest. Herbal medicines have always been a form of therapy for livestock among resource poor smallholder farmers (Mizaei-Aghsaghali, 2012). Recently, there has been progress on the ethnomedicinal plants as immunomodulatory agents because of the fact that plant extracts have been widely investigated during last few decades in different parts of the world for their possible immunomodulatory properties. In due course, several studies have demonstrated the isolation of potential bioactive molecule and few have been tested as herbal formulations. Several plant extracts, compounds and formulations have also been patented.

Herbal medicines for infectious diseases: The use of herbs and botanical extracts for antimicrobial property and immune enhancement has been practiced from very old days in nearly every culture across the globe (Ahmad *et al.*, 2006; Roxas and Jurenka, 2007). A number of plants, plant extracts and constituents have been identified as having anti-microbial, antiviral or antifungal activities and are often considered as immune enhancing (Rios and Recios, 2005). Spices such as onion, garlic, mustard, red chilli, turmeric, clove, cinnamon, saffron, curry leaf, fenugreek and ginger are some medicinal plants and dietary constituents having antimicrobial, immunostimulating and antioxidant property (Rajendhran *et al.*, 1998; Tilak and Devasagayam, 2006).

Herbal medicines for non-infectious diseases and disorders: Herbal medicines have a complex mode of action on various organs and systems due to active ingredients present in them. They are supposed to have greater impact on different factors that promote growth and health, by improving physiological and immunological functions of body. Thus, they can be considered as more sustained and long term solutions. Special contribution of these products has been proved on microsomal system against liver dysfunctions and thereby is shown to be as efficient liver protectants. Interestingly, it has been found that *Nelumbo lucifera* Gaertn (Nymphaeaceae) is a well-known aquatic plant which has been used for the treatment of several disorders including skin disease, cough, inflammation, fever etc (Mukherjee *et al.*, 2010).

Anti-cancer: Several herbal preparations are proved to boost up the immune system and make the body to defend against future or existing cancer. Some of the Indian herbs with anti-tumor property are echinacea, *Aloe vera*, tulsi, turmeric, satavar, garlic, aqueous extracts of

black pepper and cardamom etc. Aromatherapy encompassing the use of essential oils derived from different types of plant materials or parts that are claimed to possess therapeutic properties is proven as an effective anticancer therapy (Boehm *et al.*, 2012). Another unique anticancer herb is green tea or black tea which contains tumor growth inhibiting factors as well as other polyphenols, vitamin C, carotene, fluoride, zinc, selenium (Mahima *et al.*, 2012e), manganese, potassium, niacin and folic acid. The black tea contains theaflavins, which inhibits the chymotrypsin-like activity of the proteasome and proliferation of human multiple myeloma cells (Mujtaba and Dou, 2012). Chinese medicine also reveals various anticancerous herbal preparations which are gaining attention nowadays (Efferth *et al.*, 2007). Moreover, in Chinese medicine, the anti-cancer activity of a mushroom called Ling Zhi which contains triterpene as the active ingredient has been evaluated by researchers. The cytotoxicity exerted by triterpene is due to alteration of proteins involved in cell proliferation and or cell death, carcinogenesis, oxidative stress, calcium signaling and ER stress (Majdalawieh and Carr, 2010; Yue *et al.*, 2010).

Immune enhancing activities: Several botanicals are found to have immune enhancing activity, demonstrated by especially Chinese workers from time to time. The immunostimulating activities of many of these components have been most widely studied in mouse, chicken and human cell lines. Emerging evidence indicates that herbal plants exert their beneficial effects on animal immune system mostly by plant secondary metabolites. For example, *Coriolus versicolor* extracts has unique potency for using as an adjuvant since it contains glucans containing (1,4) backbone with (1,3) and (1,6) glucocytic linkages (Ng, 1998). Ginseng with its steroidal saponine, has immune-stimulating properties including cytokine production (IL-2, IL-6, TNF- α and IFN- γ), macrophage activation and lymphocyte activity. Saponins have ability to stimulate the cell-mediated immune system, as well as to enhance the antibody production. Saponins reportedly induce the production of cytokines such as interleukins and interferons. Meyer saponins, Quillaja saponins and the butanol extract of *Lonicera japonica* and de-acetylated saponin-1 administered on the nasal mucosa all stimulate the immune response *in vivo*. Herbal plant polysaccharides, also has been extensively studied for immunomodulatory effects. The polysaccharides obtained from four Chinese herbs, Astragalus root, Isatis root, Achyranthes root and Chinese Yam, considerably improves the antibody titre in vaccinated chicken (Hashemi and Davoodi, 2012). Commercial preparations of immunomodulatory herbs is shown in Table 1.

Table 1: Commercial preparations of immunomodulatory herbs

Preparation	Description
Immuplus R	It is made up of four herbs (<i>Withania somnifera</i> , <i>Tinospora cordifolia</i> , <i>Ocimum sanctum</i> and <i>Embilica officinalis</i>) and these herbal preparations are widely studied for immunomodulatory effects in treatment of domestic animals and birds
Immu 21	It is a polyherbal immunomodulator. It increase phagocytic activity of peritoneal macrophages. It has been found that immu 21 effectively enhanced the immune status of animals treated with cytotoxic and immunosuppressive agents like cyclophosphamide and azathioprine
Hi-immuplus	It is a natural health product with ingredients that have many healing properties. Its function has been assigned as immune and anti-Fatigue. The ingredients are <i>Ganoderma lucidium</i> and <i>Antrodia camphorate</i>
Echinacea liquid	It is an easy to take liquid form of Echinacea which has been used to relieve symptoms of mild upper respiratory tract infections such as colds and flu. It helps to shorten the duration and decrease the severity of cold symptoms and may decrease the incidence of colds. It supports healthy function of the immune system. The ingredient is <i>Echinacea purpurea</i> dry root and <i>Echinacea purpurea</i> dry flowering herb
Immusarc	It is an herbal preparation which helps to achieve optimum immune effectiveness. It contains <i>Withania somnifera</i> and <i>Embilica officinalis</i>
Septilin	It is a herbal preparation from the Himalaya drug company which mainly contains Balsamodendron mukul, along with <i>Tinospora cordifolia</i> , <i>Rubia cordifolia</i> , <i>Glycyrrhiza glabra</i> and <i>Embilica officinalis</i> . It possess immunomodulatory and anti-inflammatory properties which facilitates non-specific immune responses of the body. It stimulates phagocytosis by macrophages, and polymorphonuclear cells, there by prevent infection. It also stimulates humoral immunity and increases antibody production
Rumalaya	It is an analgesic and antipyretic remedy which contains Mahagograj guggul, shemkha bhasma, shilajit, latakasturi, swarnamakshika bhasma, maharasnadi quath, manjishtha, shigres, gokshura, guduchi
Rosehip (Rosa canina)	It is the fruit of the rose plant that typically is red-to-orange. Its preparation can be used for treating rheumatoid arthritis due to its anti-inflammatory and anti-oxidant effects. It contains high amount of vitamin C with which it supports body's natural defence system

IMPORTANT HERBAL AND TRADITIONAL MEDICINES

Neem (*Azadirachta indica*)

- **Family:** Meliaceae
- **Common names:** Nimba/holy tree/vembu
- **Active principle/compound:** Azadirachtin, nimbin, gedunin, gallic acid, catechin, NB-II peptidoglycan

Neem tree is known as the tree of the 21st century (United Nations Declaration). It is regarded as a highly exploited medicinal plant of Indian origin, with its every part (namely root, bark, wood, twig, leaf, flower, fruit, seed, kernel and oil) having medicinal use. Neem plant extract stimulates phagocytic activity and antigen presenting ability of macrophages. It stimulates cytokines and thereby the immune system (Thatte and Dhanukar, 1997). It enhances mitogenic response of splenocytes to concanavalin-A (Con-A). It stimulates production of IL-1, IFN γ and TNF- α reflecting activation of Th1 type of response. Also enhances antibody titres against Newcastle's disease antigen in broiler chickens (Renu *et al.*, 2003). It is an effective antiseptic for the treatment of small pox. Aqueous extract of neem possess anti-complement activity. The plant extracts are effective against allergic disorders and limiting anaphylactic reactions. Feeding of neem leaves increases immunity in immunosuppressed condition like IBD; antiviral activity against duck plague virus in poultry (Xu *et al.*, 2012) and increase the survival rate in Asian seabass Lates calcarifer fingerlings against *Vibrio harveyi* infection (Talpur and Ikhwanuddin, 2013). It prevents leukocyte apoptosis

mediated by cisplatin and 5-fluorouracil in mice. Neem oil selectively activates the cell mediated immune response by activating macrophages and lymphocytes. As a bioinsecticide, neem has been reported effective in the control of 400 insect species, including flies, spiders and nematodes. It enhances DTH in psoriasis patients and has anti-leprotic action (Chauhan, 2010).

Giloy (*Tinospora cardifolia*)

- **Family:** Menispermaceae
- **Common names:** Guduchi/giloy/amrita
- **Active principle/compound:** Tinosporone, tinosporic acid, berberine, giloin. Alkaloids, diterpenoids, flavonoids and lignins

Guduchi means to rejuvenate dead cells. It is widely used in veterinary folk medicine and has also been claimed to be beneficial according to 'Ayurveda' for the cure of jaundice, skin diseases, diabetes, anemia, emaciations and various infections for its anti-spasmodic, anti-inflammatory, anti-arthritis and anti-allergic properties (Chopra, 1982). It has immunopotentiating activities and is anti-bacterial, anti-allergic, anti-diabetic, analgesic and diuretic. It stimulates reticuloendothelial system, bone marrow cellularity and proliferation of stem cells and enhances the haemopoietic growth factor and IL-3. It enhances GSH and Vitamin C and so function as an effective antioxidant (Prince *et al.*, 2004). The aqueous extract of this plant is capable of increasing leukocyte count in mice and it is also proven to have hepatoprotective effect (Ganguly and Prasad, 2011). This plant extracts showed anti-neoplastic activity in cultured HeLa

cells. The Cordifolioside A and syringing present in the plant extract have immunomodulatory activity (Sharma *et al.*, 2012). It has anti-complementary activity and is a potent hepatoprotectant so effective in preventing hepatotoxicity. Immunomodulatory proteins in its stem increase the number of macrophages and its phagocytic activity (Rege *et al.*, 1999; Aranha *et al.*, 2012). It has been shown that mice pre-treated with G1-4A exhibited protection against mortality due to lipopolysaccharide (Desai *et al.*, 2007). It is also helpful in prevention of cyclophosphamide induced immunosuppression in mice. It has synergistic effect with cyclophosphamide in reducing animal tumours. Also, the alcoholic extract of *Tinospora cordifolia* has shown to activate tumor associated macrophages and showed antitumor effect on the spontaneous T-cell lymphoma and may have some clinical implications (Singh *et al.*, 2004). It is being used as an immunostimulant in HIV patients and also has action against avian influenza viruses. Inhibition of ochratoxin A induced suppression of chemotactic activity and production of IL-1 and TNF- α by mouse macrophages has been reported. Polyclonal B cell mitogen (G1-4A) found in its stem extract enhanced immune response in mice. By the activation of macrophages, it increases the granulocyte-macrophage colony-stimulating factor (GM-CSF), leading to leukocytosis and improved neutrophil function. It is having effect on classical complement pathway by inhibiting C3-convertase (Thatte *et al.*, 1994). Immunosuppression due to cholestasis (obstructive jaundice) can be overcome by the use Giloy (Thatte and Dahanukar, 1989).

Astragalus (*Astragalus membranaceus*)

- **Family:** Fabaceae
- **Active components:** Triterpenoid saponins (Astragalosides), flavonoids

Astragalus membranaceus root has a long tradition in Chinese medicine. It is generally considered to have immunomodulatory, anti-inflammatory and adaptogenic (stress-relieving) properties. Research shows that *Astragalus* root stimulates the immune system in many ways. It increases the number of stem cells in bone marrow and lymph tissue and encourages their development into active immune cells.

It also enhances the body's production of immunoglobulin and stimulates macrophages and can activate T-cells and Natural Killer (NK) cells. *Astragalus* stimulated NK-cell activity of human peripheral blood

lymphocytes and restored steroid-inhibited NK-cell activity (Mills and Bone, 2000). Its traditional and modern usage is primarily for immune-related complaints (frequent infections) or malignancies. *Astragalus* extracts and constituents have been shown to enhance the activity of NK cells and lymphocyte activated killing of tumors, as well as stimulate the activity of other immune cells such as macrophages and B-cells. Much of the research on this herb is published in Chinese and its usage is most often combined with several other herbal preparations making specific dosing recommendations difficult. *Astragalus* is generally considered safe with few reported adverse events (Cho and Leung, 2007).

Ashwagandha (*Withania somnifera*)

- **Family:** Solanaceae
- **Common names:** Winter cherry/Indian ginseng
- **Active principle/compound:** Steroidal alkaloids and lactones (Withanolides, Withaferins)

Ashwagandha is a potent adaptogen or vitalizer, with immunomodulatory (Kushwaha *et al.*, 2012), antitumor and cytoprotective properties (Mishra *et al.*, 2000). It possess both immunostimulatory and immunosuppressive properties. It prevents myelosuppression induced by cyclophosphamide, azathioprin and prednisolone. It has the property of mobilization and activation of macrophages (phagocytosis), increases activity of lysosomal enzymes and antistress activity in mice and rat. These pharmacological activities are attributed to the presence of several alkaloids and withanolides. Extracts of *Ashwagandha* has antioxidant (Blecha, 2001) and detoxifying properties and reduces tumor incidence in mice and increases serum T3 and T4 in mice. Anti-carcinogenic effects in animal and cell cultures are due to decreasing the expression of nuclear factor-kappa B, suppressing intercellular tumor necrosis factor and potentiating apoptotic signalling in cancerous cell lines. It has been shown to be immunoprotective against *Bordetella pertussis* infection in animals and possess better efficacy in inhibiting growth of breast and colon cancer cell lines in compare to doxorubicin. It induces inhibition of delayed hypersensitivities. *Ashwagandha* has been proven to prevent stress induced changes in adrenal function and enhance protein synthesis. Milk fortified with it increases total proteins and body weight. Bharavi *et al.* (2010) has proven that *Withania somnifera* root powder can prevent Cadmium-induced oxidative stress in chicken.

Amla (*Emblica officinalis*)

- **Family:** Phyllanthaceae
- **Common names:** Indian gooseberry/amla
- **Active principle/compound:** Flavonoids, Kaempferol, ellagic acid and gallic acid

Amla is well known for its anti-oxidant and detoxification properties along with tonifying and antiaging effect (Saini *et al.*, 2008). As an adaptogen, amla improves immunity and augments both cell mediated and humoral response. It enhances IL-2 and gamma-IFN production and inhibits apoptosis. It enhances NK cell activity and Antibody Dependent Cellular Cytotoxicity (ADCC). It acts as an immunomodulator in repeated respiratory infections in human beings. Amla possess anti-inflammatory and antipyretic properties. It is a potent immunosuppressant as that of dexamethasone and can be used in arthritis (Ganju *et al.*, 2003). It helps to reduce inflammation and oedema (Baliga and Dsouza, 2011). As a tonic, it is prescribed for rejuvenation, recuperation and vitality. It inhibits immunosuppressive effects of Chromium on lymphocyte proliferation. A high amount of Ascorbic acid is present in the fruits of amla. It is useful for anaemia, jaundice and dyspepsia in combination with iron (Sai Ram *et al.*, 2002). It can also be used to treat and prevent cancer (Baliga and Dsouza, 2011).

Tulsi (*Ocimum sanctum*)

- **Family:** Lamiaceae
- **Common names:** Tulasi/holy basil
- **Active principle/compound:** Oleanolic acid, ursolic acid, rosmarinic acid, carvacrol, eugenol, β -caryophyllene

Tulsi is regarded as the “Queen of plants”/“The mother medicine of nature”. It is an analgesic, anticancer, adaptogen or antistress agent and also having antidiabetic property (Hussain *et al.*, 2001; Rahal and Kumar, 2009b). Its anti-oxidative property and inhibition of lipid peroxidation are due to the presence of eugenol (Gupta *et al.*, 2002). Immunostimulant potential of Tulsi is helpful in treatment of immunosuppression. It shows its immunomodulatory effect by increase in IFN- γ , IL-4, T helper cells, NK cells (Mondal *et al.*, 2011) thus reducing total bacterial count, increasing neutrophil and lymphocyte count and enhancing phagocytic activity and phagocytic index. Oil from Tulsi seed can mediate GABAergic pathways and by this it can modulate both

humoral and cell-mediated immunity (Mediratta *et al.*, 2002). Aqueous extract showed immunotherapeutic potential in bovine sub-clinical mastitis. It inhibits mast cell degranulation and histamine release in presence of allergen. It is useful in constipation and wounds. Tulsi plant has shown to enhance the production of RBC, WBC and haemoglobin in rats. It is more potent than dexamethasone in the treatment of acute viral encephalitis. Tulsi is suggested to shorten the course of illness, clinical symptoms in patients suffering from viral hepatitis and also enhances survival of viral encephalitis patients. It is also useful in allergic and inflammatory disorders due to the action of its oil and has shown to decrease significantly the symptoms of arthritis and edema (Reghunandan *et al.*, 1995; Singh *et al.*, 2010). It has been proven as a herbal adaptogen in reversing the Cadmium-induced oxidative stress in chicken (Bharavi *et al.*, 2010).

Pipali (*Piper longum*)

- **Family:** Piperaceae
- **Common names:** Pippali/Indian long pepper
- **Active principle/compound:** Alkaloid-Piperine

It has immunomodulatory and anti-inflammatory activities by suppressing the proinflammatory cytokines. It can also act as a bio-enhancer and anti-tumor agent (Patwardhan and Gautam, 2005). Its alkaloid piperine has a variety of pharmacological activities like nerve depressant, antagonistic effect on electroshock and chemo-shock seizures as well as muscular incoordination. Piperine increases bone marrow cellularity in mice and rats. It helps in prevention and control of Giardiasis in human beings. The root and fruit decoction are used in acute and chronic bronchitis and cough.

Arjuna (*Terminalis arjuna*)

- **Family:** Combretaceae
- **Common names:** Arjun tree/neermarunthu/arjuna/koha/kahu/arjan, white marudah
- **Active principle/compound:** Arjunic acid, arjunantin, β -stilbesterol, tannins

It is used for wound/fracture healing with immunopotential. The extract from stem bark of this plant has the property of inhibition of HIV-protease. It is used in fracture and wound treatment of animals for its immunopotential properties. It is a cardiac tonic herbal

medicine for man. It is an antineoplastic agent due to the cancer cell growth inhibitory constituents residing in its bark, stem and leaves (gallic acid, ethyl gallate and the flavone luteolin) (Pettit *et al.*, 1996).

Aloe vera

- **Family:** Aloaceae
- **Common names:** Guarpatha/ghrita kumari/star cactus/ barbados/katraazhai
- **Active principle/compound:** Polysaccharides (Glucomannan, acemannan, mannose derivatives, hemicellulose, carboxypeptidase and salicylate), aloin, p -coumaric acid, aldopentose, calcium oxalate (Bensky and Gamble, 1993)

It promotes wound healing by stimulating macrophage and fibroblast activity. The active principle 'Acemannan' induces apoptosis in cancer cells, stimulate leukocyte and lymphocyte and cause the release of IL-1, IL-6 and TNF- α . It can modulate immune response by augmenting secondary humoral immunity in rats (Halder *et al.*, 2012). Mucilaginous leaf-gel (Acemannan) has anti-inflammatory property. It prevents ultraviolet induced suppression of DTH by reducing keratinocyte derived immuno-suppressive cytokines. It can selectively stimulates cytokines and activates lymphocytes (Egger *et al.*, 1996). Its isolates have shown to exert inhibitory properties against Staphylococcal infections (Lorenzetti *et al.*, 1964) and Candidiasis (Stuart *et al.*, 1997). It also shows some beneficial effect in antiretroviral therapy (Awodele *et al.*, 2012).

Garlic (*Allium sativum*)

- **Family:** Liliaceae
- **Common names:** Lasun/dasuan/vellai poondu
- **Active principle/compound:** Allin, allicin, allyl sulfides

It is having antiseptic property which was first demonstrated by Louis Pasteur (Tyler, 1994). Allyl sulfides are known for antitumor, anticarcinogenic and antistress action. Organosulfur compounds of garlic-inhibit growth of tumors in animals and modulate activity of diverse chemical carcinogens. It increases NK cells production and activation and helps in maintaining homeostasis of immune function. Garlic is having effect on multiple cytokines like reduction of proinflammatory cytokines (IL1, IL6, IL8 and TNF) and stimulation of IL10 (Spelman *et al.*, 2006). It enhances production of IL-2,

augment macrophage (oxidative burst) and T lymphocyte (blastogenesis) functions. Due to its ability to influence multiple proinflammatory cytokines, it is having hypoglycaemic action and protection against inflammatory bowel disease (Ebadi, 2002). Garlic is useful in food poisoning, tympany, sterility, FMD, skin infection, contact hypersensitivity, stomach-ache, arthritis, internal parasites and rheumatism. Garlic boosts IL-10 and IL-4 and is useful in treating psoriasis (O'Hara *et al.*, 1998). It possess antioxidant property also (Tilak *et al.*, 2005). Researchers are focusing on an extract of *A. sativum* called ajoene, which appears to protect CD⁺ cells from attack by HIV early in the viral life cycle. At low concentrations, the drug appears to have little toxicity and its anti-HIV activity is 45 times more powerful than the drug dextran sulfate. Ajoene is found only in fresh *A. sativum* and is not readily procurable. Recent investigations reveal that *A. sativum* impairs the activity of the liver enzymes that process protease inhibitors and raises the protease inhibitor levels. The *in vitro* antiviral activity of *A. sativum* extract (GE) on human cytomegalovirus (HCMV) has also been evaluated in tissue cultures, plaque reduction and early antigen assay. A dose-dependent inhibitory effect of GE is evident when GE was applied simultaneously with HCMV (Guo *et al.*, 1993). Allicin can protect against plasmodium infection by enhancing the host's innate as well as adaptive immunity (Feng *et al.*, 2012).

Turmeric (*Curcuma longa*)

- **Family:** Zingiberaceae
- **Common names:** Haldi/Indian saffron/yellow ginger
- **Active principle/compound:** Zingiberene, curcumin, α and β -turmerone

It is used as a general tonic, immunostimulant and blood purifier. It possesses anti-inflammatory activity and antioxidant activity (Devasagayam *et al.*, 2001). Curcumin inhibits growth of ovarian cancer cells and induce apoptosis in lung cancer cell lines. Anti-cancer effects are also observed in various cancer cell types including skin, colon, duodenal and ovary in the laboratory animals. Anti-cancer properties of curcumin may be mediated, at least in part by inhibition of inducible form of NO synthase. It increase intestinal IgA in animals fed a high fat diet. It is useful in mouth blisters, sprains, internal parasites, skin disease, constipation, internal injury, eye diseases, wounds, galactagogue, external parasites, sprains, mastitis, cough, cold, bone fracture, heatstroke, wounds, FMD, haematuria, broken horn and

stomach-ache. Anti-inflammatory effect gives relief from rheumatoid arthritis and osteoarthritis. It is also an anti-Alzheimer's agent. It also acts as HIV-1 and HIV-2 protease inhibitor, hepatoprotective, hypoglycemic and hypolipidemic agent (Jain *et al.*, 2007; Goyal *et al.*, 2010).

Ginger/Adarak (*Zingiber officinale*)

- **Family:** Zingiberaceae
- **Active principle/compound:** Citral, curcumin (sesquiterpene) and dehydrozingerone

Ginger which is called "The Great Medicament" in Ayurveda, is effective against a variety of ailments. It is useful in constipation, food poisoning, diarrhoea, eye diseases and haematuria. It is also useful in conditions like indigestion, tympany, dysentery, stomach-ache and skin diseases. The most effective principle in exerting antimicrobial activity is citral, along with Curcumene, a sesquiterpene, which is found to inhibit *Rhizoctonia solani* (Agrawal *et al.*, 2001). The ethanol extract of ginger is also bactericidal, especially against gram positive bacteria (Alzoreky and Nakahara, 2003). It also has antioxidant and anti-inflammatory property (Chang *et al.*, 2012; Park *et al.*, 2012).

Ginseng (*Panax ginseng*)

- **Family:** Araliaceae
- **Active principles/compounds:** Ginsenosides, saponins (panaxadiol, Panaxatriols) and ginsan (acidic polysaccharide)

Ginseng has been in use for centuries in reducing stress and boosting energy and it has been shown to stimulate every aspect of the immune system in vertebrates (Bensky and Gamble, 1993). It is used to regenerate liver cells after toxicity or injury, even in cases of chronic disease. It is being used as anti-stress factors for very long years in human and animal medicines with proven results (Blecha, 2001). The saponins from its root stimulate lymphocytes and cytokines (Cho *et al.*, 2002) and those cytokines include IL-1, IL-12, TNF α and INF γ (Song *et al.*, 2002). It is used as a restorative tonic and known as an adaptogen. Panax enhances NK cell activity and increase immune cell phagocytosis. It has protective role in cancer and also possess anti-inflammatory activity. Ginseng is often used to treat feline leukemia and secondary conditions in animals arising from cancer, such as rapid weight loss cachexia and blood infections. It improves endocrine and liver function in dogs (Kwon *et al.*, 2003) and in horses increases antibody response against Equine herpesvirus 1 when given for a few weeks prior to being vaccinated (Pearson *et al.*, 2007).

Sitaphal (*Annona squamosa*)

- **Family:** Annonaceae
- **Common names:** Custard apple/sugar-apple
- **Active principle/compound:** Squamosamide, acetogenin

It has anti-inflammatory properties and contains high content of vitamins which helps in healing and enhances immunity. High content of Tannin is present in its leaves. It modifies the expression of Th1 and Th2 cytokines. It up-regulates CD4+, CD8+ and CD19+ cell population and increases splenic T and B cellular proliferation. It has shown analgesic, anti-inflammatory and significant anti-tumor property against human hepatoma cells. It is also having anti-cancer property (Sun *et al.*, 2012).

Echinacea/Cone flower (*Echinacea purpurea*)

- **Family:** Asteraceae
- **Common names:** Indian head/Indian comb, purple coneflower
- **Active principle/compound:** Alkamides, echinacoside, arabinogalactan, caffeic acid, chicoric acid

It has anti-inflammatory action and stimulates macrophage cytokine production and Natural Killer (NK) cells. It can stimulate neutrophil and B-lymphocyte activity. Liquid preparations have been shown to have immune-stimulating property (Ulusik and Keskin, 2012) and enhance several white blood cell types as well as phagocytes (Burton Goldberg Group, 1999). It enhances production of specific IgG in mice. It is well known among humans as a first line of defense against the common cold and flu (Blumenthal, 2004). Extracts of *Echinacea* enhance phagocytosis and protect the gut from harmful microorganisms. The herb may inhibit the growth of some tumors. It is very effective in treating canine seasonal and chronic upper respiratory infections, including kennel cough (Reichling *et al.*, 2003). The juice from the aerial portion of *E. purpurea* and aqueous and alcohol extracts of the roots have viral inhibition properties in cell culture (Wacker and Hilbig, 1978).

Saunf (*Foeniculum vulgare*)

- **Family:** Apiaceae
- **Common names:** Fennel/finocchio/saunf
- **Active principle/compound:** Phenylpropene-anethole

It has anti-carcinogenic, anti-inflammatory and antioxidant property. Immunostimulatory action has been

shown by murine peritoneal macrophages in vitro and boosting immune system of humans (Naeini *et al.*, 2009). It is useful in diarrhoea, stomach-ache, dysentery, FMD and paraplegia (Cherng *et al.*, 2008).

Makoy (*Solanum nigrum*)

- **Family:** Solanaceae
- **Common names:** Black nightshade/wonderberry/manathakali
- **Active principle/compound:** Glyco-alkaloids-solasodine

The water-extractable and the alkali-extractable polysaccharides from *Solanum nigrum* have been proven to possess potent antitumour activity (Li *et al.*, 2009) which may be associated with their potent immunostimulating effect (Ding *et al.*, 2012). It causes significant increase in IFN- α , IL-2 and IFN- γ production and decrease in IL-10 expression. Its antitumor activity is reflected in activation of different immune responses in mice rather than by directly attacking cancer cells (Li *et al.*, 2009).

Bach (*Acorus calamus*)

- **Family:** Acoraceae
- **Common names:** Sweet flag/calamus/vasambu
- **Active principle/compound:** Beta-asarone, eugenol

Ethanol extract of *A. calamus* rhizome is having immunosuppressant action which inhibited proliferation of mitogen (phytohaemagglutinin) and antigen (purified protein derivative) stimulated human Peripheral Blood Mononuclear Cells (PBMCs). It also inhibited production of Nitric Oxide (NO), interleukin-2 (IL-2) and tumor necrosis factor- α (Mehrotra *et al.*, 2003). It inhibits the production of proinflammatory cytokines, possesses anti-inflammatory activity and has applicability against IgE mediated disorder. It has anti-obesity property, inhibits adipogenesis in 3T3-L1 cells and reduces lipid accumulation in fat cells. It is also effective against cattle ticks. Belska *et al.* (2010) demonstrated that the pectic polysaccharide from *A. calamus* L. in low concentrations was able to stimulate in vitro IL-12 and nitric oxide production by murine macrophages (Belska *et al.*, 2010).

Clove (*Syzygium aromaticum*)

- **Family:** Myrtaceae
- **Common names:** Caryophyllus/kiraambu
- **Active principle/compound:** Eugenol, eugenol acetate, α and β -caryophyllene

Anti-inflammatory action of plant is exhibited by eugenol due to the suppression of the nuclear factor- κ B pathway. It is also found that eugenol in noncytotoxic concentrations exert immunomodulatory/anti-inflammatory action on cytokine production by murine macrophages (Bachiega *et al.*, 2012). In a study by Halder *et al.* (2011) it was found that clove oil can modulate the immune response by augmenting humoral immunity and decreasing cell mediated immunity (Halder *et al.*, 2011).

Liquorice (*Glycyrrhiza glabra*)

- **Family:** Fabaceae
- **Active principle:** Glycyrrhizic acid, glabridin, sterine etc.

It has hepatoprotective property, modulatory effect on the complement system and inhibits replication of Severe Acute Respiratory Syndrome (SARS)-associated virus. It causes an increase in the resistance to herpes simplex virus-1 infection and *Candida albicans* by IFN and Th2 cytokines secretion. Glycyrrhizic acid and its aglycone have actions like modulation of NF- κ B and IL-10 production which explains reduction of inflammation in liver (Yoshikawa *et al.*, 1997). It is a popular remedy for throat infections. Glycyrrhizin inhibits ROS generated by neutrophils and acts as an anti-inflammatory agent at the site of inflammation. It also possesses anti-viral activity against HIV (Akamatsu *et al.*, 1991). Its anti-inflammatory action is based on its weak deoxycortisone-like and ACTH action. It is also a potent immunomodulatory (Borsuk *et al.*, 2011) with anticomplementary and antioxidant activity (Ablise *et al.*, 2004). Glabridin from it prevents LDL oxidation (Belinky *et al.*, 1998). Its anti-infective property is due to its effect on the production of INF and Th2 cytokines (Patwardhan and Gautam, 2005). The components of its root can modulate Bcl-2/Bax (the family of apoptotic regulatory factors) which attributes for their cytoprotective activity (Jo *et al.*, 2004).

Cats claw (*Uncaria tomentosa*)

- **Active principles:** Pentacyclic and tetracyclic oxindoles

It is effective for immunological and digestive disorders. It induces positive influence on IL-1, IL-6 and IFN- γ production and found to exhibit immune adjuvant activity with pneumococcal vaccine (Winkler *et al.*, 2004). Its anti-inflammatory effects are due to negation of NF- κ B activation and suppression of TNF- α synthesis (Sandoval-Chacoan *et al.*, 1998; Sandoval *et al.*, 2000).

Other actions like modulation of apoptosis, tumor cell proliferation and DNA repair lead to cytoprotective effect (Sheng *et al.*, 1998) and induce apoptosis selectively, leading to antitumor activity (Sheng *et al.*, 2000). Quinic Acid (QA), active ingredient of *Uncaria tomentosa*, enhances the DNA repair and immunity and able to generate neuroprotective effects in neurons (Zhang *et al.*, 2012).

Harsinghar (*Nyctanthes arbor-tristis*)

- **Family:** Oleaceae

Nyctanthes arbor-tristis is a biopesticidal plant and its aqueous extract has been found to have potent immunomodulative, hepatoprotective, antileishmanial, antiviral and antifungal activities (Puri *et al.*, 1994). It contains tertiary and quaternary alkaloids which increases immunobioactivities. In a study by Kannan *et al.* (2007) an ethanolic extract of *N.arbor-tristis* when fed orally enhanced the circulating antibody while its chronic administration of increased the total counts of White Blood Cells (WBC) and potentiated the Delayed-type Hypersensitivity (DTH) reactions (Kannan *et al.*, 2007).

Kirayat (*Andrographis paniculata*)

- **Family:** Acanthaceae
- **Common names:** Charita/kalmegh
- **Active principle/compound:** Diterpene lactones (andrographolide, deoxy andrographolide)

It has the ability to enhance immune function (Naik and Hule, 2009). Ethanol extract of Kirayat stimulates antibody production in mice and enhances production of IFN-gamma and TNF- α . It has been found to stimulate macrophage migration, phagocytosis of *E. coli* and *in vitro* proliferation of splenic lymphocytes (Puri *et al.*, 1993). The dichloromethane fraction of its methanolic extract was proven to possess the anticancer and immunomodulatory activity (Kumar *et al.*, 2004). This plant showed hepatoprotective activity in mice and anti-malarial activity in dogs. It enhances IgG antibody level against *S. typhimurium* in mice.

Kiwifruit (*Actinidia macrosperma*)

- **Family:** Actinidiaceae
- **Active principle/compound:** Polysaccharides, alkaloids, saponins and organic acid

It is distributed throughout the world, especially in East Asia. Traditionally, it has been used to treat different

cancers, including those of the digestive system and mammary gland (Lu *et al.*, 2007). There is a renewed interest in its chemical composition and biological activities. It has been extensively employed to treat various ailments such as leprosy, abscess, rheumatism, arthritis inflammation, jaundice, abnormal leucorrhoea and so on (Lai and Zhang, 2002). Moreover, it is also useful for the treatment of cancers, especially those of lung, liver and digestive system.

Satavar (*Asparagus racemosus*)

- **Family:** Asparagaceae
- **Common names:** Satavar/shatavari/shatamull

Asparagus is used in transplantation immunology. It has been employed for preventing leucopenia produced by cyclophosphamide. A steroidal sapogenin acid from the roots of *Asparagus racemosus* is having potent immunomodulating property (Sharma and Varmal, 2011). Its immunomodulatory action is by significant increase of CD3+ and CD4/CD8+ % T cell activation and immunoadjuvant action is by significant up-regulation of Th1 (IL-2) and Th2 (IL-4) cytokines (Guatam *et al.*, 2004). It is considered as a good candidate for evaluation in patients receiving cytotoxic drugs. It inhibits the carcinogen ochratoxin A induced suppression of chemotactic activity and production of IL-1 and TNF- α by mouse macrophages. It contains an anticancer agent asparagin which is useful against leukaemia. It also contains active antioxytotic saponins which have got antispasmodic effect and specific action on uterine musculature (Syamala, 1997; Gautam *et al.*, 2009).

Kutakai (*Picrorhiza kurroa*)

- **Family:** Scrophulariaceae
- **Common name:** Kutki and kuru
- **Active principle/compound:** Kutkin, picroside, vanillic acid, D-mannitol androsin and apocynin

It boosts the immune system by increasing both the cell mediated and humoral immunity. It has protection property against the worm *Leishmania donovani* which causes leishmaniasis and can be used as adjunct to antileishmanial chemotherapy (Sane *et al.*, 2011). The biopolymeric fraction RLJ-NE-205 from it improves the immune system and considered as a biological response modifier (Gupta *et al.*, 2006). It possess hepatoprotective activity, anti-inflammatory activity and is used in the management of bronchial asthma. It has role in enhancing DTH response, antibody production, macrophage

migration, phagocytic activity and skin graft rejection. It inhibits ochratoxin-induced suppression of chemotactic activity and production of IL-1 and TNF- α . It also Increases haemagglutinating antibody titer, plaque-forming cells and DTH response to SRBC.

Onion (*Allium cepa*)

- **Family:** Liliaceae
- **Common name:** Pyaj

It is a very useful medicine in food poisoning, internal parasites, diarrhoea, FMD, dysentery and loss of appetite. It is also found to be effective in skin diseases and hoof diseases. It has lipid lowering effects and shown to inhibit oxidation of low-density lipoproteins (Ahmed *et al.*, 2009). It is having profound antibacterial effect which is mentioned even in the Egyptian Papyrus Ebers. The aqueous extract of the plant has shown to increase the CD4 and total WBC counts in a dose dependent manner, revealing its immune boosting capabilities (Mirabeau and Samson, 2012). Every part of the plant is having one or another medicinal properties like, leaf juice extract is administered ophthalmically to treat jaundice, dried shoot is taken orally as a cicatrizing agent and to treat insect bites, root is taken orally to facilitate expulsion of the placenta, essential oil from fresh bulb is administered by inhalation to treat cold etc. (Ross, 2001).

Mustard (*Brassica campestris*)

- **Common name:** Sarsaun
- **Active principles/compounds:** Glucosinolates and sterols

It is useful in constipation, food poisoning, stomach-ache, fever, indigestion, dysentery, external parasites, mastitis, mouth blisters and burn. It exerts action against hoof diseases and other skin diseases like eczema. Mustard is rich in calcium and iron and helps to restore bacterial balance in the intestines. The mustard's greens are rich in vitamin A, iron and zinc and are best when eaten raw or steamed. White mustard has been used throughout the world to relieve pain and as a diuretic and an antibiotic. Mustard flour is an antiseptic and can also be used as a deodorizer. The mustard's oil can be used for pain relief of arthritic conditions and chilblains. Mustard is also an excellent expectorant and a very powerful natural emetic. Due to its chemical components, seeds can be widely employed in cancer, non-genetic diabetes, hyperglycemia, hyperlipidemia and hypercholesterolemia (Szollosi, 2011).

Coriander (*Coriander sativum*)

- **Family:** Umbelliferae
- **Common name:** Dhanyiya, dhumia, kothimbir

Traditionally it has been found useful in tympany, diarrhoea, food poisoning, constipation, haematuria, fever, indigestion and loss of appetite (Wagensteen *et al.*, 2004). Its methanol derived stem extract is having antibacterial property, due to its ferrous sequestering activity (Wong and Kitts, 2006). The aqueous crude extract has shown to stimulate the peripheral blood mononuclear cells and increases INF- γ secretion (Cherng *et al.*, 2008).

Asafoetida (*Ferula asafoetida*)

- **Family:** Apiaceae
- **Common name:** Heeng
- **Active principle/compound:** Resin (asaresinoternol), ferulic acid, umbelliferone, sugars, sesquiterpene coumarins and polysulfides

It possess antifungal, antiviral, anti-diabetic, anti-inflammatory and anti-mutagenic activities. Recent studies have shown new promising antiviral sesquiterpene coumarins from this herb. It is also shown to be a remedy of great value as a carminative in flatulence and colic. The essential oil is eliminated through the lungs and is excellent for asthmatic bronchitis and whooping cough. It also exerts a significant anthelmintic action against roundworms and pinworms. It has been found useful in treating neck sore, paralysis, stomach-ache and indigestion (Iranshahy and Iranshahi, 2011).

Banana (*Musa paradisiacal*)

- **Common name:** Kela

Banana is the best natural source of vitamin B6. This vitamin is required for the production of antibody for having a healthy immune system. The presence of high quantity of vitamin B6 in banana also makes it a food item that helps human boy in making hemoglobin. Beneficial in galactagogue, tympany, diarrhea, haematuria, prolapse of uterus, heat-stroke, sterility, dysentery, loss of appetite, indigestion, mastitis, food poisoning and post partum complaints. Banana is rich in potassium, an agent that helps in keeping the nervous system and heart healthy. The presence of high amount of potassium in banana makes it a beneficial fruit for the bones and kidneys.

Antifungal and antibiotic principles are found in the peel and pulp of fully ripe bananas (Sampath Kumar *et al.*, 2012).

Punarnava (*Boerhaavia diffusa*)

- **Family:** Nyctaginaceae

It possess immunomodulatory effects due to the immunosuppressive action (Sen *et al.*, 2002). Ethanolic extract of *Boerhaavia diffusa* was shown to inhibit the cell proliferation significantly (Mungantiwar *et al.*, 1999). Extracts of *B. diffusa* roots inhibited human NK cell cytotoxicity in vitro, production of nitric oxide in mouse macrophage cells, interleukin-2 and tumor necrosis factor- α (TNF- α), in human PBMCs, demonstrating its immunosuppressive potential effect (Mehrotra *et al.*, 2002). It also exhibits antidiabetic, anti-metastatic, antioxidant, antiproliferative and antiestrogenic, analgesic, anti-inflammatory, antibacterial activity.

Datura (*Datura metel*)

- **Family:** Solanaceae
- **Common names:** San, dhustura Hin., kaladhatura Ben, dhatura mal, ummam Kan; dattura tam, vellummattai Tel, tellavummetta
- **Active principles:** Hyoscyamine, hyoscine and meteloidine

It is having anticancerous and anthelmintic actions. Inhalation with its leaves and seeds is found useful in whooping cough, asthma and other respiratory diseases. Root, leaf and seed are febrifuge, antidiarrhoeal, anticatarrhal and are effective in insanity, cerebral complications and skin ailments. Leaf can be used as antitumour, antirheumatic and vermicide agent. Its warm leaf smeared with an oil is used as a bandage or as a poultice for treating rheumatic swellings of joints.

Periwinkle (*Catharanthus roseus*)

- **Family:** Apocynaceae
- **Common names:** Nityakalyani, Sadabahar, Baramassi, Ushamalari
- **Active principle/compound:** Vinblastine, vincristine, raubasine, reserpine and serpentine

The alkaloids present in the leaves are effective antimicrobial (Dhankhar *et al.*, 2012) and anticancerous drugs. Vinblastine is used in combination with other anticancer agents for the treatment of lymphocytic

lymphoma, Hodgkin's disease, testicular carcinoma and choriocarcinoma (Narayana and Dimri, 1990).

Tut (*Morus alba*)

- **Family:** Moraceae
- **Common name:** Mulberry

The roots are considered as an anthelmintic and vermifuge, whereas root bark and stem bark of this plant are reported to act as vermifuge and purgative (Akhtar *et al.*, 2000). It increases both humoral as well as cellular immune response (Bharani *et al.*, 2010). Its fruit contains Pyrrole alkaloids, which activate the macrophages and enhance the immune response (Kim *et al.*, 2013).

Kamala (*Mallotus philippinensis*)

- **Family:** Euphorbiaceae

The fruit has been used as an anthelmintic, cathartic, aphrodisiac, lithotropic and styptic. It has also been used in external applications for the control of parasitic infections of the skin, as an antiseptic for ears and systemically for urinary disorders (Sharma and Varmal, 2011); antituberculous drug (Hong *et al.*, 2010); against keratinocyte hyper-proliferative disorders (Valacchi *et al.*, 2009).

Kokilaksha (*Asteracantha longifolia*)

- **Family:** Acanthaceae

It is commonly used in traditional ayurvedic and unani medicine as aphrodisiac, tonic, sedative and blood diseases etc (Pawar *et al.*, 2010). Methanol extracts of this plant has got in-vitro antimicrobial activity against bovine mastitis pathogens like *S. aureus* and *E. coli* (Mubarack *et al.*, 2011).

CONCLUSION AND FUTURE PERSPECTIVES

Herbal and traditional botanical products ideally have multiple effects and are helpful in a variety of disease conditions, for beneficial effects on human health as well as their companion/domestic animals. When considering on a global basis, the use of plant products as immunostimulants has a traditional history not only in India but also in almost all ancient civilizations including Chinese, Arab and American. These are good alternatives to conventional chemotherapy. Same immunomodulatory herbs at a glance are shown in Fig. 1.



Fig. 1: Immunomodulatory herbs at a glance

As India is having a rich biodiversity of herbs and medicinal plants, efforts should be made in their identification and testing/validation for their immunomodulatory properties and to prepare prophylactic and therapeutic formulations for safeguarding animal health and production, as well as for human health. Research and development (R and D) programs should be encouraged for their scientific validation. By quality control approach, adulterations of these precious preparations with pesticide, heavy metal residues or other drugs could be avoided. Integrated and holistic monitoring of biological process is necessary to achieve clinical success (Multiple immunomodulating approaches). Historical knowledge from the great traditions like Ayurveda and others will have an important role in bioprospecting-drug discovery utilizing traditional knowledge of herbs, medicinal plants and indigenously well known drugs being used since ancient times. Integration of modern medicine, traditional knowledge and use of science and technologies with a systems biology approach can be most suitable in this regard. Herbal and

traditional/indigenous preparations need to be popularized for their wide application and acceptance, for which promotional approaches need attention so that their full potential can be utilized for safeguarding health and production in livestock, pet and domestic animals, poultry and laboratory animals apart from numerous human health benefits.

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