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Multiple Beneficial Applications and Modes of Action of Herbs in Poultry Health and Production-A Review

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ABSTRACT
Herbal medicine or herbalism is a time-honored practice of natural medicine that is older than mankind itself. The practice of using traditional herbal medicine based therapy is nowadays gaining more attention worldwide in both human and animal health care systems. Among the livestock sectors, poultry production systems are the most intensively reared with developments especially in the areas of nutrition, disease control, genetic improvement, management and organization of dietary requirements along with the pressure of increasing demand for poultry products as well as threats of emerging pathogens. So this sector is badly in need of sustainable therapeutic and production aids especially based on herbs because of the advantages like, low cost, easy availability, no residual effect, free from the threat of antibiotic resistance etc. Many herbs have been recorded to be fruitfully used by veterinarians to treat a variety of disease conditions in animals. The present study discusses the various useful and practical applications of the rich heritage of herbal wealth for safeguarding poultry health in general, combating infectious as well as non-infectious diseases caused by microbes and parasites (both ecto-and endo parasites) along with immunomodulatory actions for countering immunosuppressive diseases. Moreover, highlighting herb-based poultry growth promoters for increasing production performances use of herbs as antioxidants and their role in organic egg and meat production is a special attraction of the review that will draw the attention of the poultry specialists as well as farming community. The information will be useful to increase poultry production and protect the health of birds in a better way from traditional ways towards modern perspectives and also would promote and popularize usage of herbs amongst poultry producers.

Key words: Herbs, poultry, immunomodulation, growth promoters, antioxidants, antimicrobial, antiviral, production, health

INTRODUCTION

Due to the emergence of drug resistance microorganisms, side effects of antimicrobials and the harmful residual toxicity effects of drugs observed in the food chain, there is an increasing trend towards the use of alternative or complementary medicines for the general health maintenance, immunomodulation and therapeutic purposes for treating various diseases and disorders including cancers. Particularly, the utilization of the plants, herbs, fruits and vegetables, nutritional immunomodulators, panchgavya element of cow urine (cowpathy) are becoming popular due to their low toxicity, fewer side effects, being cost-effective and other beneficial advantages for safeguarding health of humans and their companion animals including poultry (Mahima *et al*., 2012, 2013; Dhama *et al*., 2013a, b; Tiwari *et al*., 2013a, b; Rahal *et al*., 2014a). Apart from these, novel and emerging immunomodulatory as well as therapeutic modalities like bacteriophages, probiotics, cytokines and others are also being explored (Tiwari *et al*., 2011; Dhama *et al*., 2011, 2013c, 2013d; Karthik *et al*., 2014).

Ethno-medicinal plants, the valuable sources of medicines are currently in increasing demand and popularity on which about 80% of people in developing countries still rely for their primary health care. Since antiquity herbal medicines have been used extensively in traditional medical practices as the major remedy and these practices continue today because of several merits like great contribution towards maintaining the health of human and animal, biomedical benefits as well as place in cultural beliefs and also due to the toxicity and side effects of allopathic medicines (Agarwal, 2005; Verma and Singh, 2008; Mahima *et al*., 2012). Herbal medicines are widespread throughout the world and have been used by all cultures for centuries with the best known practices being Ayurvedic medicine from the Indian sub-continent, traditional Chinese medicine, medicinal herbs from African tradition, native North American herbal lore and western herbal medicine, derived from Europe and the Arabic culture. India, possessing one of the richest treasures of herbalism in the world, accounts around 20,000 medicinal plant species where about 800 plant species have been used by different medicinal communities for curing different diseases (Kamboj, 2000; Hashemi and Davoodi, 2012; Mahima *et al*., 2012).

Herbs, traditional/indigenous plants and ethno-veterinary medicines, having multiple beneficial advantages, have been used since long for strengthening body and its immune system and to keep away or fight against diseases (Rios and Recio, 2005; Mirzaei-Aghsaghali, 2012). Ethno-veterinary medicine deals with knowledge, expertise, methods, performs and beliefs of the people 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 one generation to another (Toyang *et al*., 2007). People around the world are now aware of the limitations of synthetic drugs and chemicals in terms of higher cost, anticipated toxicity and adverse effects (Okitoi *et al*., 2007; Adu *et al*., 2009). On the other hand, the natural medicines are more suitable for animal and human health care with the benefits of low cost and total safety. Some of them are studied scientifically by *in vitro* and *in vivo* studies but most of them are yet to be scientifically validated. In this era of food safety concern, emerging antibiotic resistance and residual effects in food products, these can play wonderful role for safeguarding health of humans and animals. But unfortunately, these medical traditions are being mislaid mostly as they are communicated only orally from generation to generation and are largely undocumented (Okitoi *et al*., 2007; Adu *et al*., 2009; Hashemi and Davoodi, 2012; Mahima *et al*., 2012). Herbal therapy needs to be practiced in poultry industry as growth promoters and also for fighting against various infections. The shortcomings are that they are bulky substances which cannot be used as such, most of the herbs have poor bioavailability and hence needs a good carrier. Nanotechnology has revolutionized the world and this technology can also be applied safely for the delivery of herbal drugs (Patel *et al*., 2013). Various types like dendrimers, quantum dots, magnetic nanoparticles, colloidal micelles, polymeric micelles, etc are available (Ansari *et al*., 2012a). Herbal drugs are already available as nano drugs in market like NanoCurc™ (Mathur and Vyas, 2013).

Nature has always had its own medicine for animals as well as birds and herbs have been the medicine and food since their life emerged. Animals as well as birds are instinctively able to self-medicate with herbs, known as the zoo pharmacognosy and early man would almost certainly have been just as capable, later refining it to the ancient art that still have today (Patwardhan and Gautam, 2005; Adu *et al*., 2009). Having originated in the same environment as plants, it is not surprising that animals have an inherent instinct for herbal medication of their health problems, whether horses, dogs, cats, cattle, rabbits, birds or other species. Herbal medicines are being practiced in the form of therapy for livestock among resource poor smallholder farmers worldwide and in a therapeutic aspect; many herbs are being used by veterinarians fruitfully to treat a variety of conditions of animals. Improvements have been shown or reported with those suffering from flu, allergies, colds, rheumatoid arthritis, bacterial/viral infections, hepatitis, heart disease, asthma, chemical intoxication etc. and even effective in treating cancers (Mills and Bone, 2000; Umashanker and Shruti, 2011). Apart from infectious and systemic diseases, topical botanical/herbal application is also effective for specific conditions like ageing, skin infections, ear infections, wounds, burns and skin irritations (Patwardhan *et al*., 2004; Mirzaei-Aghsaghali, 2012).

India is a rich source of medicinal plants and a number of plant extracts are being used against diseases in various systems of medicine such as Ayurveda, Siddha and Unani. Ayurveda is the traditional Indian system of medicine from ancient times, mostly using herbal preparations, to prevent or cure various tumors. The first written records on the medicinal uses of plants appeared in about 2600 BC from the Sumerians and Akkadians. The best known Egyptian pharmaceutical record, "Ebers Papyrus" recorded more than 700 drugs, represents the history of Egyptian medicine dated from 1500 BC. Thousands of herbal and traditional compounds are being screened worldwide to validate their use and several of them find their application in poultry production as well

(Liu *et al*., 1998; Wynn, 2001; Diwanay *et al*., 2004; Premalatha and Sachdanandam, 1999; Rehman *et al*., 2011; Khan *et al*., 2012a).

The present study discusses the multiple beneficial applications of herbs for protecting poultry health in general, countering infectious as well as non-infectious diseases, immunomodulatory effects, increasing production performances, potential to be used as growth promoters, antioxidant usage and their role in organic egg and meat production. The valuable and updated information in the review paper regarding herbs and their various beneficial applications in poultry will be helpful to increase production and safeguard the health of birds in a better way from traditional ways towards modern perspectives and also would promote and popularize usage of herbs amongst poultry producers.

BENEFICIAL APPLICATIONS OF HERBS IN POULTRY

Among all other classes of livestock, poultry industry has been growing persistently over years around the globe with more developments in the last fifty years by providing globally important sources of animal proteins (Byarugaba, 2007). Globally, production of the primary poultry products (meat and eggs) has been rising rapidly. Over a 10 year period between 1995 and 2005, consumption and hence production, has increased globally with the following percentage increases for chicken meat (53%), turkey meat (13%), duck meat (67%), goose meat (53%), chicken eggs (39%) and other eggs (27%) (Scanes, 2007). They are amongst the most intensively reared of all livestock species with the developments especially in the areas of nutrition, disease control, genetic improvement, management and organization of dietary requirements (in precise terms of energy, amino acids, minerals and vitamins), selection and cross-breeding techniques, along with large scale poultry production and vertical integration (Smith, 1990; Adu, 1997; Mirzaei-Aghsaghali, 2012). But, the intensity of husbandry can only be done by controlling many infectious diseases and growth and production disturbances that would otherwise inflict severe losses or even thwart intensive poultry sector. The emergence of new pathogens or one variant of an old pathogen has the potential to spread rapidly and devastate the entire flocks (Byarugaba, 2007; Scanes, 2007).

Since time immemorial, plants and plant parts have been serving as an indispensable source of medicine for indigenous poultry production systems. Conventional disease prevention methods are geared towards birds in confinement and not free range in an indigenous poultry production system. However, the existing indigenous technical knowledge inherited from past generations has sustained the local poultry production system (Hashemi and Davoodi, 2012; Mirzaei-Aghsaghali, 2012). This knowledge is passed on verbally and is hardly documented. Due to high cost of conventional medicines and vaccines coupled with the lack of knowledge on their use, these drugs are usually out of reach of the small-scale farmers. There is, therefore, need for cheap, easy to use and sustainable local poultry disease control programs (Okitoi *et al*., 2007; Adu *et al*., 2009; Mahima *et al*., 2012). The inherent utility and practical applications of indigenous medicinal herbs/plant extracts (garlic, cinnamon, tulsi, ginger, turmeric, lemon, neem, yucca, thyme, rosemary, etc.) are being explored for improving poultry health as well as production with fruitful results (Sudarshan *et al*., 2010; Umashanker and Shruti, 2011; Mahima *et al*., 2012; Khan *et al*., 2012a-c; Sridhar *et al*., 2014).

Herbal medicines as antimicrobials for poultry: The practice of pharmacological treatment of disease conditions began with the use of herbs (Tyler, 2000) and most of the drugs in vogue to treat bacterial and other infections were first isolated from ethno-medicinal plants and other natural sources (Coe and Anderson, 1996). Antimicrobials based on herbal origin represent a vast untapped source of medicines with tremendous therapeutic potential (Cowan, 1999). The indiscriminate use of conventional antimicrobials has led to a steady increase in the drug resistance and the low-income countries, home to the majority of the world's population are particularly affected by this phenomenon (Radyowijati and Haak, 2003). Antibiotic resistant strains of bacteria are an increasing threat to animal and human health with resistance mechanisms having been identified and described for all known antimicrobials in vogue (McDermott *et al*., 2002). This, therefore, necessitates a newer alternative for antimicrobial substances and many plants have been shown to possess antimicrobial traits which are chiefly synthesized during secondary metabolism of the plant (Kokoska *et al*., 2002; Radyowijati and Haak, 2003; Rusenova and Parvanov, 2009).

Neem (*Azadirachta indica*) is one of the most prominent herbal medicines with different biologically active principles like azadirachtin, nimbin, salanin, meliacin etc. and many other derivatives of these principles which belong to natural products called triterpenoids (NRC., 1992; Ansari *et al*., 2012b). The *A. indica* leaf exhibits potent antimicrobial action as it has proven its, anti-bacterial, anti-viral, anti-malarial, anti-fungal and anti-oxidant properties in various experimental studies in poultry (Chakraborty *et al*., 1989; Subapriya and Nagini, 2005; Ansari *et al*., 2012a). Neem oil selectively activates the cell mediated immune response by activating macrophages and lymphocytes have been reported effective as a potent bio-insecticide. Apart from this, it exhibits a wide range of other pharmacological activities viz., anti-inflammatory, anti-hyperglycaemic, anti-ulcer, anti-mutagenic, anti-carcinogenic, immunomodulatory and various other properties without showing any adverse effects (Ganju *et al*., 2003; Chauhan, 2010; Chakraborty and Pal, 2012).

Essential oils derived from plants have provided enough evidences to suggest as a tool in defending bacterial diseases in poultry (Dorman and Deans, 2000; Rota *et al*., 2004; Gopi *et al*., 2014). They consist of complex mixtures of secondary plant metabolites like phenylpropenes and terpenes, they are particularly associated with characteristic plant fragrances and essences. Essential oils can be applied as potential feed additives for the prophylactic action against microbial infections (Mourey and Canillac, 2002; Cabuk *et al*., 2006; Brenes and Roura, 2010). Among the various essential oils, thyme, oregano and garlic have shown to be the most

pronounced antimicrobial activity (Williams and Losa, 2001; Iten *et al*., 2009; Khan *et al*., 2012b). Thyme oil and its components (thymol and carvacrol) demonstrated high antimicrobial activity against most of the poultry pathogens that include *Staphylococcus aureus*, *S. epidermidis*, *Pseudomonas aeruginosa*, *Bacillus cereus*, *Escherichia coli*, *Salmonella enteritidis*, *S. typhimurium* etc. (Smith-Palmer *et al*., 1998; Al-Bayati, 2008; Bolukbasi *et al*., 2008; Sokovic *et al*., 2010; Levic *et al*., 2011). The essential oil from *Origanum vulgare* which is obtained by steam-distillation of its leaves and flowers is well known for its antimicrobial activity along with potent antifungal, antioxidant and insecticidal activities (Florou-Paneri *et al*., 2005; Marcincak *et al*., 2008; Bozkurt *et al*., 2012a). Oregano has shown to be an excellent alternative for ionophore antibiotics thereby providing protection against *E. tenella* infection in birds (Giannenas *et al*., 2004). A study conducted in live birds showed that certain primary components namely curcumin, piperin, thymol and eugenol of the *Curcuma longa* (turmeric), *Piper nigrum* (black pepper), *Thymus vulgaris* (thyme) and *Syzygium aromaticum* (clove), respectively are effective in the control of *Clostridium perfringens,* an important enteropathogenic bacteria (Mitsch *et al*., 2004). Garlic (*Allium sativum*) possesses excellent antimicrobial properties which have been proven by various researchers (Rajendhran *et al*., 1998; Kim *et al*., 2009; Jacob and Pescatore, 2011; Rehman *et al*., 2011). The aqueous extract of garlic has been shown to inhibit *E. coli* and *Salmonella* Typhimurium *in vitro* (Singh and Shukla, 1984; Kumer and Berwal, 1998). *In vitro* antimicrobial activity against *E. coli* has been shown by cinnamon oil that necessitates further *in vivo* studies for possible benefits in poultry production (Friedman *et al*., 2004; Griggs and Jacob, 2005). A variety of other plant based remedies have been proven to possess antimicrobial effect and an important one among them is the aqueous extract of the seeds of *Carica papaya* which lyse bacteria using the enzyme papain (Fajimi and Taiwo, 2005; Pushpangadan, 2006; Adu *et al*., 2009).

Herbs as antiviral agents for poultry: Herbal preparations are gaining more importance in the search for anti-viral agents because of their wide spread availability and easy incorporation in the diet (Kitazato *et al*., 2007). Deva-5 is a herb formulation composed of five herbs namely *Momordica cochinchinensis* L., *Gentiana decumbens* L., *Polygonum bistorta* L., *Hypecoum erectum* L. and *Terminalia chebula* Retz showed *in vitro* antiviral activity against avian influenza A virus subtype H3N8 (Rajasekaran *et al*., 2013; Oyuntsetseg *et al*., 2014). Makau *et al*. (2013) reported that *Alchemilla mollis* extract showed potent anti-influenza activity against influenza A virus subtypes namely H1N1 and H5N1 by inhibiting influenza virus replication. *A. mollis* extract synergistically potentiates the anti influenza effect of zanamivir. Many phyto-chemicals such as pentagalloyl glucose (PGG) and oligonol a low molecular weight polyphenol derived from lychee fruit extract showed strong anti-influenza activity by inhibiting virus entry into host cells, inhibits reactive oxygen species-dependent ERK phosphorylation, blocking the extracellular signal-regulated kinase phosphorylation results in inactivation of the virus (Gangehei *et al*., 2010; Liu *et al*., 2011). Watanabe *et al*. (2011) demonstrated that valtrate from *Valerianae radix* and 1'-acetoxychavicol acetate from *Alpina galangal* showed anti-influenza activity by preventing the nuclear export of viral ribonucleoprotein results in inhibition of virus replication.

Ou *et al*. (2013) investigated the therapeutic effects of the combined extracts of Rhizoma *Dryopteridis Crassirhizomatis* and *Fructus Mume* (RDCFM) against Infectious Bursal Disease Virus (IBDV) infection. They reported that the herbal extracts increased the survival rate, antibody levels and relative body gain and significantly decreased the virus loads in bursa of Fabricius. The active substances namely proto catechuic acid and 4-hydroxycinnamic acid isolated from Fructus Mume (FM) were established as effective against infectious bursal disease virus by enhancing the protection and increasing the immune response for chickens (Ou *et al*., 2011, 2012; Okwor *et al*., 2012). Liu *et al*. (2009) reported that sweet wormwood (*Artemisia annual* L.) extracts inhibited the Newcastle Disease Virus (NDV) proliferation in chicken embryos without causing side effects. Most of the herbal preparations contain various bioactive molecules namely flavonoids, polyphenols, lignans and alkaloids which shows many pharmacological activities such as anti-bacterial, anti-inflammatory, anti-fungal, anti-oxidant and analgesic properties. Sood *et al*. (2012) reported that *Eugenia jambolana* extracts showed 100% virucidal activity against highly pathogenic avian influenza (H5N1) virus in chicken embryonated eggs (ECE) inoculated *in-ovo* and in tissue culture. Eucalyptol, menthol and ormosinine showed anti-influenza activity due to its potent interactions with the viral HA protein (Gangopadhyay *et al*., 2011). Essential oils derived from peppermint and eucalyptus showed protective action in broilers against multiple respiratory pathogens mainly *Mycoplasma gallisepticum* and H9N2 influenza virus infections (Barbour *et al*., 2006, 2011). Lee *et al*. (2012a) reported that supplementation of lyophilized green tea by-product extract namely, catechins in feed or drinking water decreases replication and excretion of H9N2 virus from chickens in a dose-dependent manner. The anti-influenza activity of catechins is mainly due to direct interaction with viral HA and inhibition of viral RNA synthesis (Song *et al*., 2005). Zhai *et al*. (2011) and Jiang *et al*. (2012) reported that oral administration of *ginseng* stem and leaf saponins and *Hypericum perforatum* L. in feed or drinking water significantly increased the serum antibody response to Newcastle disease, inactivated H5N1 and H9N2 vaccines in chickens.

Major disadvantages of herbal therapy are some herbal derivatives namely ginseng saponins need 4-6 years to purify and is very costly in the market (Zhai *et al*., 2011). Methods of the extraction and preparation of the crude extracts and its purity greatly influence the inhibition activity of some herbs against infectious organisms. Extensive works are needed to explore the herb-drug interactions, potential toxicity and methods for identifying the active components.

Herbal medicines as anti-coccidiosis in poultry: Due to vast usage of sulphanilamide, ionophorous antibiotics, amprolium

or synthetic chemical compounds for the treatment of coccidiosis in poultry results in emergence of drug-resistant strains and antibiotic residues in poultry meat posing serious problems to the meat consumers. To overcome this major threat, safe alternative anti-coccidial herbs preparations are required for the treatment and control of avian coccidiosis. Several herbs possess anti-coccidial effects namely *Sophora flavescens* Aiton, *Ulmus macrocarpa*, *Bupleurum chinese* DC, *Sinomenium acutum*, *Artemisia asiatica*, *Pulsatilla koreana*, *Artemisia annua* Linne, *Quisqualis indica*, *Foeniculum vulgare*, *Torilis japonica* and Galla Rhois powder increases survival rates and body weight gains of birds, reduces bloody diarrhea symptoms and oocyst excretions from birds infected by *Eimeria tenella* (Youn and Noh, 2001; Lee *et al*., 2012b; Zhang *et al*., 2012; Dragan *et al*., 2014). Chandrakesan *et al*. (2009) and Arczewska-Wlosek and Swiatkiewicz (2012) evaluated the anti-coccidial activity of some herbal extracts blend containing *Salvia officinalis* (sage), *Solanum nigram*, *Allium sativum* (garlic), *Moringa indica*, *Thymus vulgaris* (thyme), *Echinacea purpurea* (echinacea), *Aloe vera*, *Mentha arvensis* and *Origanum vulgare* (oregano) against *E. tenella*, *Eimeria acervulina*, *E. necatrix* and *E. maxima*. The extract known as febrifugine contains a quinazolinone alkaloid, halofuginone derived from *Dichroa febrifuga* has been reported to possess anti-coccidial and anti-malarial activity (Youn and Noh, 2001). Three plant extracts namely *Tulbaghia violacea* (35 mg kg^{-1}), *Artemisia afra* (150 mg kg^{-1}) and *Vitis vinifera* (75 mg kg^{-1}) showed anti-coccidial action due to its antioxidant activity. *T. violacea* significantly reduced the oocysts production in birds; it can be used as prophylactic or therapeutic anticoccidial agent (Naidoo *et al*., 2008). Therefore, the search of herbal drugs for anti-coccidial treatment gains promise as an alternate in the control of coccidiosis.

The ethnoveterinary usage of herbs in managerial practices for countering common disease conditions of chickens is presented in Table 1.

Herbal medicines against Ecto-and Endo-parasites in poultry: Throughout the world arthropods have been found to inflict immense loss to the poultry industry. Birds are often affected by ecto-parasites which may be continuous or temporary. Continuous external parasites are those that spend all of their adult life on the host and that commonly include sticktight fleas, chicken body lice, scaly leg mites and northern fowl mites. Temporary external parasites are those which feed on the hosts but do not live on them. Common temporary external parasites of poultry include fowl ticks (also known as blue bugs), bed bugs and chicken mites (also known as red mites or roost mites). The use of chemicals viz., hydrocarbons, organophosphorus, carbamates and pyrethroids are found not to be free from adverse effects of toxicity to human, added up drug resistance by target parasites and high cost of drugs, paving the way for herbal alternatives. Commercial phytomedicinal preparation like Pestoban is found to be effective against wide variety of poultry lice viz. *Cuclotogaster heterographa*; *Lipeurus caponis*; *Menopon gallinae* and *Menocanthus apamineus*; *Goniocotes gallinae* (Das *et al*., 1993; ICAR., 2002; Fajimi and Taiwo, 2005; Adu *et al*., 2009). For controlling lice infestation in poultry, the stem and leaf extract of tobacco (*Nicotiana tabacum*) also showed a 100% efficacy by the 2nd day of application on skin (Fajimi *et al*., 2001). Pawpaw leaves when burnt into ashes can be used as a topical agent to control lice in poultry (Nwude and Ibrahim, 1980). Lice can also be controlled by powdered seeds of *Annona squamosa* and *Tephrosia vogelli*. Topical application of 10% aqueous extract of garlic is shown to be an effective way to decrease mite infestation in birds (Jacob and Pescatore, 2011). Cinnamon oil has shown anti-parasitic activity against *Trichomonas*, *Histomonas meleagridis* and head lice in chicken (Zenner *et al*., 2003). *Allium cepa* (onion) has proven pronounced anti-parasitic activity against many helminthes and protozoa such as, *Trichinella spiralis* and *Leishmania* sp. For preventing lice in ducks, drop the bulb in the bird's drinking water and for chickens green leaves (spring onions) can be used to be picked by the birds (Gefu *et al*., 2000).

Among the internal parasitic diseases in poultry, avian coccidiosis is the most wide-spread disease which is mainly controlled by the use of chemotherapeutic agents. Now the emergence of drug-resistant strains demands the need for an alternative and potential control strategy mainly based on herbal remedies. Most widely used and proven herbal anticoccidials include *Aloe vera, Aloe spicata*, *Allium sativum*, *Azadirachta indica*, *Ficus burkei*, *Lannea stullmanni*, *Myrothamnus flabellifoilius*, *Capsicum annum* etc. (Elbanna *et al*., 2012; Kanakaraju *et al*., 2013). Neem extract contains the chemical Azadirachtin which has a significant efficiency on pests, deformental effect on viruses, mites, fungal pathogens, plant parasitic nematodes, intestinal worms, bacteria, mollusks and protozoan parasites such as coccidian species (NRC., 1992; Biu *et al*., 2006). Dietary incorporation of *Azadirachta indica* (neem) and *Artemisia annua* at levels of 10 and 5%, respectively was shown to affect the broiler performances and possess anticoccidial potency against *Eimeria tenella* (Hady and Zaki, 2012). It has been proven that the latex of *Carica papaya* has reasonable pharmaco therapeutic properties against intestinal nematodes of poultry especially, Ascaridia galli, Heterakis gallinanum, *Capillaria* spp., etc. and a dose rate of 1200 mg papaya latex per bird is formulated as an effective anthelminthic preparation (Fajimi *et al*., 2001). Also the aqueous extract of the seeds of *Carica papaya* has shown 90% efficacy towards other helminthes like *Oesophagostomum*, *Trichuris* and *Trichostrongylus*, because of the action of papain on them (Fajimi and Taiwo, 2005; Adu *et al*., 2009). *Citrus aurantifolia* (lime) can prevent worm infestation when its juice is mixed with drinking water (Fajimi *et al*., 2001). *Amaranthus spinosus* is a vermifuge through its ethanolic extract against *Strongylus* sp. and *Trichuris* sp. (Assiak *et al*., 2001). Regular addition of garlic into the drinking water is an effective control measure for intestinal worms and coccidiosisin poultry (Jacob and Pescatore, 2011). Chopped seeds of pumpkin (*Cucurbita moschata*) are shown to be good for the control of tapeworms in laying hens (Jacob and Pescatore, 2011). Herbal immunomodulators that contain holy basil (*Ocimum sanctum*); mango (*Mangifera indica*); Indian gooseberry (*Phyllanthus emblica*); ginseng (*Withania somnifera*) and Shilajit

Table 1: Common diseases of native chickens and their ethnoveterinary managerial practices

Diseases	Herbal remedy	References
Newcastle disease	One litre of water, 8 seeds of *Capsicum annum* (red pepper) and one tablespoon of ash for 9 birds for 3 days	Mwale *et al*. (2005), Okitoi *et al*. (2007), Jafari *et al*. (2008), Lagu and Kayanja (2010), Moreki (2012), Eevuri and Putturu (2013)
	One leaf of *Aloe vera,* one litre of water, 8 seeds of *Capsicum annum* (red pepper) and one tablespoon of ash for 9 birds for 3 days	
	One leaf of *Aloe vera* crushed and added in 1 litre of water	
	Two tablespoon of ground raw garlic mixed with vinegar-2 times daily in 1/2 tablespoon doses	
Infectious bronchitis	*Aloe vera* and *Capsicum annum*	Badubi *et al*. (2006), Deeba (2009)
Fowl pox	*Capsicum annum* and Ash	Badubi *et al*. (2006), Deeba (2009)
Infectious laryngotracheitis	Very high doses of garlic and drops of honey	Lagu and Kayanja (2010)
Infectious coryza	Plenty of garlic and strong sage tea with finely chopped spruce shoots in bran with molasses and *Croton megalocarpus*	Okitoi *et al*. (2007)
Paratyphoid	Fast birds then feed garlic, 1/2 teaspoon of lemon juice diluted with sage tea 2 times daily. Also add finely chopped rue and/or sage to a bran/molasses mash	Lagu and Kayanja (2010)
	Cannabis sativa and *Aloe vera*	
	Root bark extractsof *Erythrina abyssinica* crushed and added in water	
	Nicotiana tabacum tobacco leaves	Singh (2003), Charlton (2004),
	A course of garlic for ten days (1 clove/hen/day) and add to the diet bramble leaves, elder leaves, wormwood, wormseed, cotton-lavender, rue and hyssop	Mwale *et al*. (2005), Wanzala *et al*. (2005), Balakrishnan *et al*. (2009), Lagu and Kayanja (2010)
Helminthosis	Powdered cayenne or senna after a fast	
	Tapeworms - 1/2 teaspoon of grated male fern root mixed with bran, castor oil and molasses daily.	
	Garlic, wormwood (Artemisia spp.), wild ginger, snakeroot, goosefoot, conifers (pine, spruce, firs), fennel seeds, or pyrethrum all preceded by a fast and followed by a laxative period.	
Coccidiosis	Fast for 1 day on warm water then give drops of senna brew (1 ½ pods soaked in 1 dessertspoon of water with a few grains of powdered ginger	Lagu and Kayanja (2010), Eevuri and Putturu (2013)
	Dried leaves of *Artemisia annua* as an in-feed supplement	
Thrush/Candidiasis/ sour crop/crop mycosis	Feed garlic at 2-5% in feed	Mwale *et al*. (2005), Moreki (2012)
Crop impaction	Make of brew of ½ teaspoon of powdered gentian root in a small cupful of water; add milk, 2 teaspoon of olive oil-twice a day	Mwale *et al*. (2005), Moreki (2012)
Egg bound	A pinch of ginger in one teaspoon of castor oil	Deeba (2009), Moreki (2012)
Molt/Feathering/molting	Dill, anise, fennel, seaweed, kelp, bladderwrack, dulse, maidenhair fern, nettle, cleavers, onion, or garlic	Deeba (2009), Moreki (2012)
Feather picking/vent picking/ cannibalism	Feed comfrey	Okitoi *et al*. (2007), Deeba (2009)
Diarrhea/dysentery/scouring	For hens-warm milk with powdered slippery elm bark and honey-3 times daily	Mwale *et al*. (2005), Lagu and Kayanja (2010), Moreki (2012)

(*Asphaltum puniabiunum*) when used experimentally, have shown to fight caecal coccidiosis in poultry (Pangasa, 2005). Regano, a natural extract of a specially selected cultivar of *Oreganum vulgare* gave effective protection against the coccidiosis challenge. The level of protection achieved by the Regano was similar to the protection provided by Salinomycin at 55 g/MT (Saini *et al*., 2003).

Pasture management is considered as one of the best practices to prevent parasitic infestation and pasture rotation will break the life cycle of worms. Some of the pasture plants that can be planted are: Wormwood, Peppermint, lemon grass (Citronella) etc. By planting these plants around the coop area, birds will eat and walk on the leaves assisting with internal and external parasite eradication. Also they form large clumps of aromatic long leaves keeping flies, fleas and mites away from the coop area. Birds eat the tips and brush against the bushes when planted close by around the poultry shed to control parasites.

Immunomodulatory herbs for poultry: Over the past few decades, vigorous emphasis has been made for enhancing the growth and production performances in the poultry industry which badly resulted in an adverse effect on the immunological parameters of poultry, thereby damaging the natural defensive mechanism against various microorganisms including viruses, bacteria, pathogenic fungi, ecto and endo-parasites and various toxins etc. Due to development of antibiotic resistance by the bacteria and pathogenic microbes researchers are now thinking towards immunomodulation. Nowadays, immune-based therapies are gaining more importance than monovalent approaches which are having limited benefits (Hashemi and Davoodi, 2012). 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 with immunomodulatory effects like histamine release, modulation of cytokine and immunoglobulin secretion, class switching, cellular co-receptor expression, lymphocyte expression, phagocytosis etc. (Spelman *et al*., 2006; Mahima *et al*., 2012).

Modulation of immune response to alleviate diseases has since long been of great interest to researchers (Sharma, 1983; Spelman *et al*., 2006; Ozek *et al*., 2011; Mahima *et al*., 2012). Indian medicinal plants are a rich source of substances which

are claimed to induce immunity, thereby stimulating the non-specific immunomodulation, essentially granulocytes, macrophages, natural killer cells and complement functions (Hashemi and Davoodi, 2012; Mirzaei-Aghsaghali, 2012). Immunomodulation using medicinal plants provides an alternative to conventional chemotherapy for several diseases, especially when suppression of inflammation is desired (Mahima *et al*., 2012). Herbal medicine relies on active plant chemicals with biological properties. Many conventional medicines are synthetic compounds designed to mimic the action of plant chemicals. Recently, there has been progress on the ethno-medicinal 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 molecules having influence on immune system and few have been tested as herbal formulations (Ahmed and Bassuony, 2009; Akerreta *et al*., 2010).

There are various natural adjuvants and synthetic agents which have been used as immune stimulants (Levamisole, Thalidomide etc.) but they are proven to possess various side effects. On the other hand, the conventional plant immunomodulators are safer, cheaper and much more effective. So herbal medicines are being used as immunomodulators and have alternative potential for the conventional chemotherapy against a variety of diseases especially in relation to host defense mechanisms. Several plant extracts, compounds and formulations have also been patented and this include various polysaccharides, lectins, peptides, flavonoids and tannins which are used in various *in vitro* models to assess their immune responses (Cherng *et al*., 2008). In literature, many plants have been listed; having immunomodulatory effects and some of them have been proven using modern scientific methodologies (Barnes *et al*., 2007).

Ashwagandha (*Withania somnifera*) is one of the well-known medicinal plants which has been used amply for centuries in Ayurvedic medicine to increase longevity and vitality (Choudhari *et al*., 2006; Winters, 2006). Several bioactive compounds have been isolated from this plant, among which the important one is the steroidal lactone called Withanolides, having antibacterial, antiviral, antitumor and immunomodulatory activities (Elsakka *et al*., 1990; Jayaprakasam *et al*., 2003; Shisodiya *et al*., 2008; Shirin *et al*., 2009). From the study conducted by Bani *et al*. (2006), it has shown that the oral administration of *W. somnifera* extract selectively skewed the immune response towards Th1 response cells rather than Th2 cells by increased IFN gamma and IL-2 versus IL-4 cytokines levels. Besides increasing the expression of T-helper1 (Th1) cytokines, it modulates the immune response by augmenting the CD4 and CD8 counts and Natural killer (NK) cell activity (Davis and Kuttan, 2002; Khan *et al*., 2006). This indicates its unique immunomodulatory profile which suggests that it is having stimulatory effect on T lymphocytes, its subsets and B-lymphocytes involved in antibody synthesis (Benacerraf, 1978; Dean *et al*., 1979; Luster *et al*., 1982; Bani *et al*., 2006). Bhardwaj *et al*. (2012) showed that the supplementation of Ashwagandha root powder at the inclusion rate of 1 percent in poultry diets is found optimum for significant effect on body weight, Feed Conversion Efficiency (FCE), haematological parameters and improving the general health status of birds. Its hydro-alcoholic root extract has shown antiviral activity against IBD Virus replication (Pant *et al*., 2012). Administration of *W. somnifera* extract to broiler chick diets resulted in an increase in Hb, PCV, TLC and antibody titre against viral diseases like IB and IBD, suggesting the improvement in hematological profile and immunological status of the birds (Mushtaq *et al*., 2012; Pant *et al*., 2012). Mice treated with *W. somnifera* and radiation showed a 143.6% increase in bone marrow cellularity and maintained the levels of normochromic and polychromic erythrocytes compared to mice being treated with radiation therapy alone (Devi *et al*., 1996; Kuttan, 1996; Ganasoundari *et al*., 1997; Winters, 2006).

The herb *Tinospora cordifolia* (Family, Menispermaceae) belongs to a group of medicinal plants that grows in the tropical and subtropical regions of India (Sengupta *et al*., 2011). It is a large glabrous climber with succulent corky stem, sub deltoid cordate leaves, branches sending down and pendulous fleshy roots. Guduchi is also well known for its immunomodulatory, antioxidant, antibacterial and antiviral properties, activates macrophages and cytokine production and its extract has been found to have wide use in the Indian System of Medicine for a variety of diseases (Kapil and Sharma, 1997; Prince and Menon, 2003; Srinivasan *et al*., 2008). It can act as an immune prophylactic agent and induces disease resistance properties by boosting general immunity to fight against diseases, prevents oxidative damage, help recruitment of macrophages in response to tumor growth, increases leukocyte counts and reduces cyclophosphamide induced neutropenia (Bishayi *et al*., 2002; Chakraborty *et al*., 2010). Activation of the immune system by the novel (1,4)-alpha-D-glucan from *Tinospora cordifolia* occurs via the activation of macrophages that occurs through TLR6 signaling and NF kappa B translocation along with cytokine responses (Rege *et al*., 1999; Nair *et al*., 2006). The water soluble fraction of *T. cordifolia* leaf fraction is found as an immunoprophylactic agent due to its immunostimulatory and disease resistance properties (Alexander *et al*., 2010). Guduchi can be used as a good alternative to costly allopathic medicine in boosting the immune functions in intoxicated conditions and can effectively complement allopathic medicines in diseased state (Sengupta *et al*., 2011; Bhalerao *et al*., 2012). Crude extract of *Tinospora cordifolia* contains a polyclonal B cell mitogen which enhanced immune response in mice (Alamgir and Uddin, 2010). It also prevents oxidative damage, induced by peroxy nitrite, wherein the action was similar to selective inhibitors of Reactive Oxygen Species (ROS) like mannitol, superoxide dismutase, sodium azide and antioxidants, GSH and vitamin C (Desai *et al*., 2002;

Prince *et al*., 2004; Mirzaei-Aghsaghali, 2012). Moreover, *T. cordifolia* increases the leukocyte counts and reduces the neutropenia induced by single and multiple doses of cyclophosphamide (Thatte *et al*., 1987; Singh *et al*., 2006). It was reported that *T. cordifolia* can stimulate production of cytokines like IL-1 and TNF (Dahanukar *et al*., 2000) which are having important role in hematopoiesis (Mochizuki *et al*., 1987; Guilbert *et al*., 1993; Singh *et al*., 2006; Upadhyaya *et al*., 2011; Kumar *et al*., 2013a).

Neem (*Azadirachta indica*) is another immunomodulatory herb, that has shown marked influence on the haematological parameters in birds like haemoglobin, PCV and RBC indices (Khan and Zafar, 2005; Ansari *et al*., 2012b). It may be due to hepato-stimulatory and hepato-protective effects of neem leaves resulting in the synthesis of more haemoglobin (Hb) in the bone marrow (by erythropoietic factors released by hepatic cells), there is much more increase in the Hb concentration (Talebi *et al*., 2005). It has been proven to be beneficial in immunosuppressed conditions like Infectious Bursal Disease (IBD), in poultry. Feeding of powdered dry leaves of *A. indica* was found to be effective on humoral and cell mediated immune responses, in a flock of broilers which had survived an outbreak of IBD. Renu *et al*. (2003) has shown that the administration of Neem leaf extract enhanced cell mediated immune response (as observed by DTH in term of increased skin thickness to 2,4-dinitro-chlorobenzene in skin contact sensitivity test) and improved humoral immune response against NDV antigen (as detected by indirect ELISA), indicating its immune potentiating effect (Haq *et al*., 1999; Ansari *et al*., 2012a). Studies conducted on the immunomodulatory potential of the above three herbs (*W. somnifera*, *T. cordifolia* and *A. indica*) against chicken infectious anaemia, an immunosuppressive viral disease of young chicks, revealed that these herbs have excellent capacity in stimulating both the cellular and humoral immune responses in chicks against the causative virus and also ameliorating effects on viral pathogenesis were observed (Lateef *et al*., 2013; Latheef *et al*., 2013). On assessing the viral load in target organs, using the real time PCR technique, it was found that the viral load in herbal treated birds reduced almost up to 50% compared to the control group, thereby resisting viral multiplication in those organs (Latheef, 2013).

Wild mint (*Mentha longifolia*) has been found to enhance immunity especially in broiler chicks in addition to the improvement in growth performance, feed conversion ratio and gross return. The active virtues of this particular herb depend on the abundance of volatile oil containing thymol (hydrocarbon) in addition to higher oxygenated compounds. The polysaccharides obtained from four Chinese plants (Astragalus root, Isatis root, Achyranthes root and Chinese Yam) significantly improved antibody titres in vaccinated chicken. Due to the presence of low molecular weight polysaccharides like acyranthan (ACH) and astragalan (APS), they can be used as feed additives to improve immunity of broiler birds (Alzorekya and Nakahara, 2003; Chen *et al*., 2003; Durrani *et al*., 2008; Khaligh *et al*., 2011; Okokon *et al*., 2012). In another study, herbal formulation containing extracts of *Asparagus racemosus* was proven effective to be recommended for use as a positive immunomodulator in normal and immuno-compromised broiler chicks (Kumari *et al*., 2012).

Herbs and spices rich in flavonoids, vitamin C and carotenoids generally have more beneficial effects on immune system. Those plants containing these molecules of immunostimulatory properties are *Echinacea* sp., *Glycyrrhiza glabra* (Liquorice), *Allium sativum* (garlic) and *Uncaria tomentosa* (Cat's claw) and they can improve the functions of lymphocytes, macrophages and NK cells a s well as increase phagocytosis and stimulate the interferon synthesis (Frankic *et al*., 2009). Echinacea stimulates macrophages, cytokine production, Natural Killer (NK) cells, neutrophil and B-lymphocyte activity. Liquid preparations have been shown to have immune-stimulating property and enhance several white blood cells and phagocytosis (Burton Goldberg Group, 1999) and production of specific IgG in birds. Liquorice is also a potent immunomodulatory with anti complimentary and antioxidant activity (Ablise *et al*., 2004). Glabridin, one of its active principles, prevents LDL oxidation (Belinky *et al*., 1998). 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). Cat's claw (*Uncaria tomentosa*) induces p ositive 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-KB activation and suppression of TNF-α synthesis (Sandoval-Chacon *et al*., 1998; Sandoval *et al*., 2000). Other actions like modulation of apoptosis, tumor cell proliferation and DNA repair, lead to cyto-protective effect (Sheng *et al*., 1998) and selectively induce apoptosis, leading to antitumor activity (Sheng *et al*., 2000). Researchers reported that broilers fed with oxidized fat showed a significantly increased concentration of tocopherols, beta-carotene, lutein and retinol in plasma and tissue. Also, essential oils extracted from medicinal plants improve the immune response and also are able to cause changes of the duodenal mucosa with beneficial effects for the animal (Stef *et al*., 2009).

Conflicting reports are available regarding the efficacy of herbs producing immunomodulating effects on poultry. The reason may be attributed to the mechanism of action of plant extracts, the desirable effects of these extracts mainly depend upon the structure and level used in addition to the metabolism (Barreto *et al*., 2008). Second, it is difficult to precisely determine the required active ingredients for exerting the positive effect due to unknown dose required to elicit a response (Khan *et al*., 2012d). Third, the chemical composition of the plant extracts vary with different parts of the plants as well as environmental conditions, climate, soil and harvesting time (Khan *et al*., 2012a-d). Rajput *et al*. (2007) reported that the combination of an inactivated H5N1 vaccine and *Cochinchina momordica* seed extract as adjuvant significantly increased the daily body weight gain and immune response in broiler chickens.

Antimicrobial and immunomodulatory properties of two herbs viz., Ashwagandha (*Withania somnifera*) and Neem (*Azadirachta indica*) are depicted in Fig. 1 and 2, respectively.

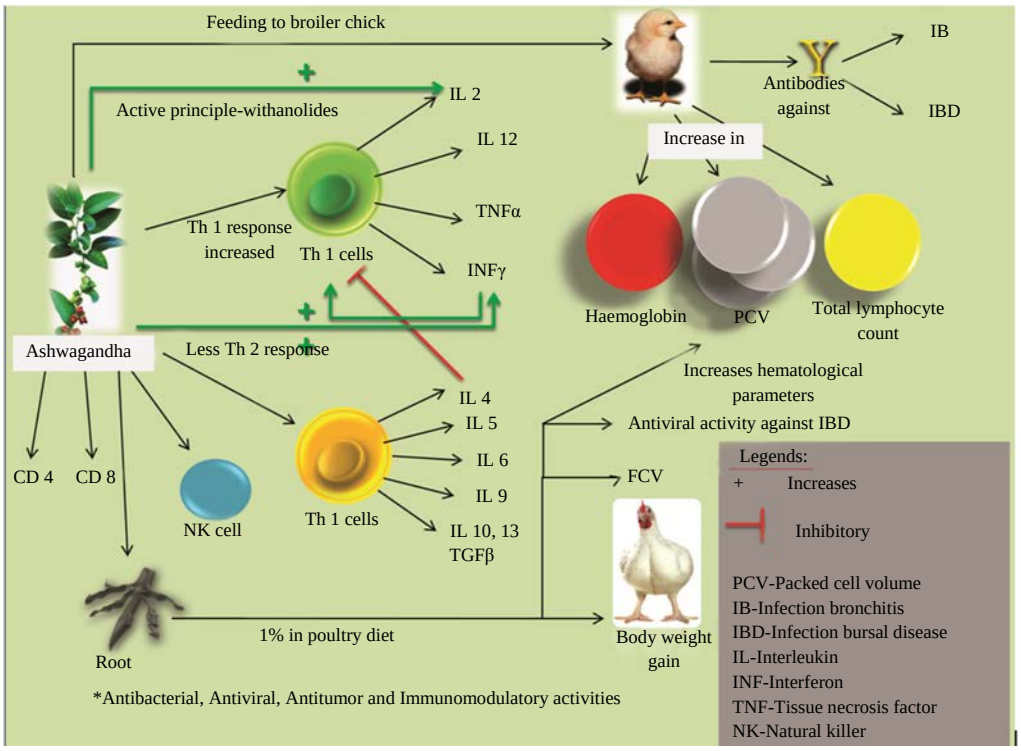

Fig. 1: Antimicrobial and immunomodulatory properties of Ashwagandha (*Withania somnifera*)

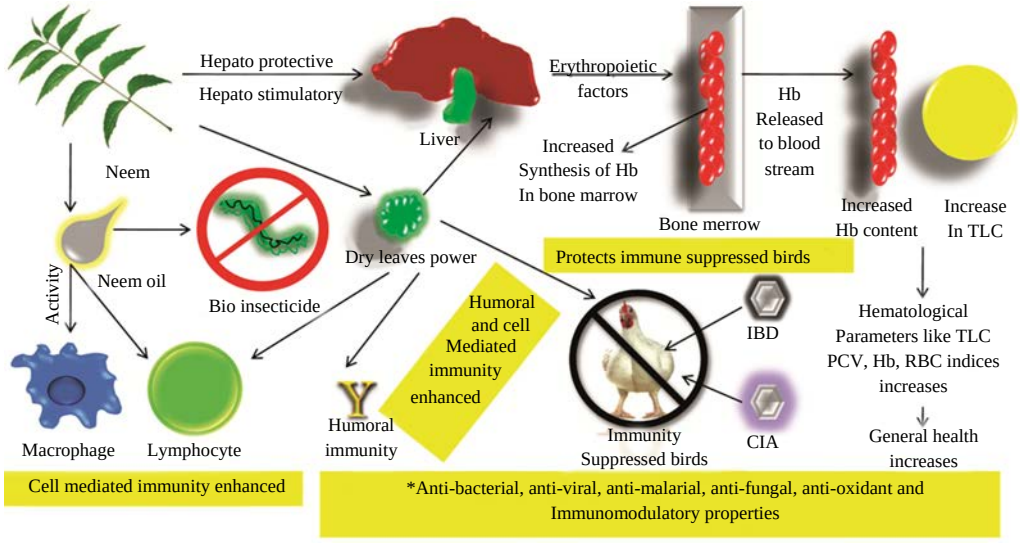

Fig. 2: Antimicrobial and immunomodulatory properties of Neem (*Azadirachta indica*)

HERB-BASED POULTRY GROWTH PROMOTERS

Among the major aspects of food production and safety in nowadays, reduction in the use of antibiotics and other medicinal products in the poultry production is a major concern, especially due to over bacterial resistance and possible transmission of these antibiotic residues into the human food chain (Panda *et al*., 2008; Sanjyal and Sapkota, 2011). Consequently, the poultry feed industry is facing

increased consumer pressure to reduce the use of those antibiotic growth promoters (AGPs) in poultry diets. In broiler diets, the beneficial effects of medicinal plants and their various products including plant extracts and essential oils as phytogenic feed additives are proven (Bolukbasi and Erhan, 2007; Windisch *et al*., 2008; Dalkilic and Guler, 2009; Bozkurt *et al*., 2012b). Plant extracts and various phytobiotics that originate from leaves, roots, tubers or fruits of herbs, spices and other plants have shown to be excellent growth enhancers in poultry industry (Steiner, 2009; Wallace *et al*., 2010. This effect may be due to the synergistic action of various active molecules in them and the greater efficiency in the utilization of feed, resulting in enhanced growth and production (Hashemi and Davoodi, 2010). The basic strategies of including these herbs in poultry diets are to impact the metabolism by combating stress and microbial activity and there are scientific evidences to prove that herbal extracts stimulate the growth of beneficial bacteria and curtail pathogenic bacterial activity in the gastrointestinal tract of poultry. Prevention of the colonization of the pathogens and improvement of the production and activities of digestive enzymes are the essential functions of such phytogenic components (Langhout, 2000; Wenk, 2000; Lee *et al*., 2003, 2004; Tekeli *et al*., 2006; Sanjyal and Sapkota, 2011). Several strategies have been postulated to understand the growth promoting effects of herbs in poultry. First, the improved performance has been linked with increased secretion of digestive enzymes through the production of lipase, amylase, trypsin and chymotrypsin and enhanced nutrient utilization in the liver (Langhout, 2000; Khan *et al*., 2012d). Second, the antibacterial action of essential components of these herbs may suppress the growth of pathogenic bacteria on one hand and promote the growth of probiotic (bacillus, lactobacillus and acidophilus etc.) bacteria in the gut. No doubt literature is full of the beneficial effects of herbs in improved poultry production; however, there are many reports which negate the beneficial effects of herbs. The reason may be due to the difference in experimental protocol, environmental conditions, reduced antimicrobial effect of any plant extract through altering the substrate and unavailability of bio-ingredients which are usually absent in pure conditions (Langhout, 2000; Lee *et al*., 2003; Barreto *et al*., 2008). According to some author, the improved performance may be attributed to the essential components which have antimicrobial, antioxidant and antifungal effects (Khan *et al*., 2012a). Another hypothesis suggests that commercial products of a herb may exert different effects. For example, raw garlic (allicin rich) and processed garlic (non-allicin rich) differ in term of active ingredients which may potentially elicit different response in the host (Khan *et al*., 2012b).

Herbs which are proven as excellent growth promoters in poultry includes *Withania somnifera*, *Ocimum sanctum*, *Emblica officinalis*, *Aloe vera*, *Thymus vulgaris*, *Curcuma longa*, *Origanum vulgare*, *Allium sativum*, horseradish, cyenne pepper, ginger, anis, onions, fenugreek, cumin etc. Herbs like alfa alfa (*Medicago sativa*), senna (*Alexandrian senna*), corn flower (*Centaurea cyanus*) and absinthe (*Artemisia absinthium*) when used as feed additives in broilers can also act as efficient as well as safe growth enhancers and thereby meet the demand of the poultry industry (Dharma and Tomar, 2007; Soltan *et al*., 2008; Khaligh *et al*., 2011; Mirzaei-Aghsaghali, 2012; Kumar *et al*., 2013b). Most of these herbs initiate activity in the feed as flavor enhancers, stimulators of digestive secretions and total feed intake etc. They enhance the digestion and absorption of lipids through the synthesis of bile in the liver. They also accelerate the digestion and reduce the time of rate of passage through the digestive tract. Herbal growth promoters also include spices like cinnamon, cardamom, cloves, laurel, mint etc. (Frankic *et al*., 2009; Alsaht *et al*., 2014). These are well-known for their appetite stimulant effect, especially through the stimulation of pancreatic and other digestive enzymes but different herbs affect digestion processes differently, due to the wide variety of active components present in them (Frankic *et al*., 2009; Mirzaei-Aghsaghali, 2012). Herbs can act as alternative to Antibiotic Growth Promoters (AGPs) because they exhibit antimicrobial properties and thus can form integral part of poultry nutrition (Gbenga *et al*., 2009). Broad antimicrobial activity is possessed by many herbs and their bio-active constituents. There exists scientific evidence that herbs and plant extracts can work by stimulating growth of microbiota and minimizing the activity of pathogens in the poultry gastro intestinal tract. In comparison to other type of dietary treatments herb like garlic (*Allium sativum*) when supplemented with antibiotic and thyme in broiler chick diet causes significant increase in the length of the small intestine. Significant lower concentration of *E. coli* is also achieved by supplementation of such combination from herbal extracts in the diet (Kamel, 2001; Tucker, 2002; Cross *et al*., 2003; Lewis *et al*., 2003; Sarica *et al*., 2005). A study on Aloe vera gel has shown to improve the feed efficiency, increase gizzard weight, gastro-intestinal weight as well as length by increasing the size of digestive tract and also it has been found to reduce the total count of aerobic bacteria in the gastro intestinal tract in broilers (Sinurat *et al*., 2003).

EFFECT OF HERBAL PREPARATIONS ON GENERAL PERFORMANCE OF POULTRY

Herbs and herbal products are easily available, low cost, abundance and incorporated in poultry feeds to enhance the body weight gain and to increase the feed efficiency. Allinson *et al*. (2013) reported that herbal extracts enhances the performance in poultry and increases the feed: gain and weight gain ratio by significantly decreasing the bacterial and oocsyt count. Feeding Garlic Powder (GP) to broilers enhances the performance, improves digestibility, digestive organs,

Crude Protein (CP), Dry Matter (DM) and Ether Extract (EE) digestibility (Issa and Abo Omar, 2012). Tollba and Hassan (2003) demonstrated that natural feed additives such as black cumin (*Niglla sativa*) and garlic (*Allium sativum*) improves the physiological and productive performance of broiler chicks, growth rate, Feed Conversion Ratio (FCR) and decreased mortality rate under high temperature conditions. Thyme (*Thymus vulgaris*) and oregano (*Origanum vulgare*) supplementation at 15 or 20 g kg^{-1} diet can increase the feed conversion ratio, body weight gain, feed intake and performance of broilers due to its active principle known as carvacrol and thymol (Abdel-Wareth *et al*., 2012). Incorporation of essential oils from herbs in poultry diets showed various beneficial effects, enhancing performance traits, reducing pathogenic bacteria and decreasing antibiotic residues in meat and egg products (Hertrampf, 2001). Demir *et al*. (2003) and Elagib *et al*. (2013) reported that incorporation of growth promoter such as 3% of garlic (*Allium sativum*) powder (250 g) causes significant increase in feed intake, body weight gain, higher feed conversion ratio, highest breast weight and growth performance. Supplementation of feed with *Curcuma longa* rhizome powder at the rate of 0.75-1 g kg^{-1} results in increased feed consumption in broilers (Al-Kassie *et al*., 2011). Initial body weight, final body weight, egg weight and egg yolk index, egg shell thickness, egg yolk weight, plasma glucose and triglyceride were not statistically affected by dietary garlic powder supplementation (1, 2 or 4%) in laying quails for 14 weeks (Canogullari *et al*., 2010). On the contrary, plasma and yolk cholesterol concentrations were decreased with increasing garlic powder supplementation but the level of HDL in blood was augmented with garlic supplementation compared to the control diet. In the previous studies it was found that rabbits fed diet supplemented with *Yucca schidigera* extract did not affect growth performance in general but improved the immunity function, moreover, rabbits fed diet supplemented with yucca extract had lower ammonia in serum, lipid peroxidation in liver and increased hepatic antioxidant activities.

HERBS AS ANTIOXIDANTS FOR POULTRY

Nowadays, there has been an increase in demand for natural antioxidants in food due to its health benefits against oxidative stress and several diseases. Plant derived antioxidants are gaining more demand in poultry nutrition because their meat has high content of polyunsaturated fatty acids and susceptible to lipid oxidation (Christaki, 2012). Many plants have been identified as excellent poultry antioxidants; important among which are rosemary (*Rosmarinus officinalis*), Olive leaves (*Olea europea* L.) garden thyme (*Thymus vulgaris*), marjoram (*Origanum majorana*), sage (*Salvia officinalis*), oregano (*Origanum vulgare*) and so forth (Madsen and Bertelsen, 1995; Botsoglou *et al*., 2002, 2005, 2013; Rahal *et al*., 2014b). Among these, Rosemary and rosemary extracts are some of the most studied natural antioxidants in poultry products and these studies have demonstrated the ability of rosemary products to act as natural antioxidants in various poultry products (Rojas and Brewer, 2007; Karre *et al*., 2013). Apart from these, fruits like plum, grape seed extract, cranberry, pomegranate, bearberry, pine bark extract etc. provide good alternatives to synthetic antioxidants due to the high phenolic compound in them (Brannan, 2008; Karre *et al*., 2013). Spices like cinnamon, cloves, marjoram, wild marjoram, caraway, peppermint, nutmeg etc., have been shown to have antioxidant properties as they contain the compounds such as polyphenolics, lignans, flavonoids and terpenoids (Craig, 1999; Botsoglou *et al*., 2013). Among the herbal plants, tulsi (*Ocimum sanctum*) and Ashwagandha (*Withania somnifera*) have been proven as an excellent adaptogen and antistress agent. It has proven to reverse the Cadmium-induced oxidative stress in chicken (Bharavi *et al*., 2010). Studies showed that active ingredients of plants have strong antioxidant effects including neutralization of superoxide, hydrogen peroxide and nitric oxide either by scavenging radicals or by increasing the production of catalase (CAT), superoxide dismutase (SOD) and glutathtion peroxidase (GPx) (Ali *et al*., 2006; Yarru *et al*., 2009). Turmeric has been shown to increase the expression of SOD gene and protects the mitochondria against premature damage (Reddy and Lokesh, 1994; Miquel *et al*., 2006). The beneficial antioxidant effect of turmeric has been due to the presence of tetrahydro curcumin, cinnamic acid, curlone and niacin (Khan *et al*., 2012a). Ginger contains some important metabolites and alkaloids like gingerol, shogaol, gingerdione, shogaols and other phenolic compounds which have antioxidant properties (Zhang *et al*., 2009; Zhao *et al*., 2011). In thyme, important alkaloids isolated include carvacrol, thymol, caffeic acid, p-cymene-2, 3-diol and biphenylic (Schwarz *et al*., 1996; Bolukbasi *et al*., 2006). Regarding the mechanism of action of thymol, Lee *et al*. (2004) concluded that phenolic OH group of thymol acts as hydrogen donor to neutralize the peroxyl radicals which is produced during the initial step of lipid peroxidation.

EFFECT OF HERBAL PREPARATION ON ENZYMES OF POULTRY

Deshpande (2006) reported that dietary supplementation of tulsi leaf powder (*Ocimum sanctum*) causes significant increase in serum cholesterol and HDL levels in laying hens. However, turmeric (*Curcuma longa*) as nutraceutical to improve broiler performance had no significant effect on cholesterol concentration (Namagirilakshmi, 2005). Supplementation of turmeric rhizome powder to broilers considerably reduced the liver enzymes such as ALT and ALP (Emadi and Kermanshahi, 2007) and tulsi leaf powder

ameliorates the lead induced toxicity in cockerels by reducing the liver enzymes (Prakash *et al*., 2009). Feeding of tulsi leaf powder to broilers, neutralises the toxic effects of aflatoxins by significantly reducing the enzyme activities of AST, ALT and ALP (Sapcota and Upadhyaya, 2009). Lanjewar *et al.* (2008) reported that supplementation of tulsi leaf powder to broilers causes significant reduction in serum LDL cholesterol, total cholesterol and triglycerides. However, Gupta and Charan (2007) reported that tulsi supplementation reduces serum SGOT levels in broilers, whereas it has no significant effect on SGPT, creatinine and uric acid. Supplementation of herbal growth promoters such as amla to broilers causes reduced cholesterol, increased SAP and SGPT levels and no effect on SGOT (Vidyarthi *et al*., 2008). Reddy *et al.* (2007) reported that feeding of broilers with tulsi leaf powder (0.5%) and selenium (0.3 ppm) significantly decreased the lipid peroxidation levels and increased the plasma GSH levels. Feeding of broilers with combination of *Aloe vera* and *Curcuma longa* had no significant effect on serum glucose, HDL, LDL, total cholesterol and triglyceride levels. Furthermore, Reddy (2010) observed that supplementation of amla, tulsi and turmeric powder in different combinations had no significant change on serum SGOT, SGPT and cholesterol levels.

Multiple beneficial applications and overview of the usage of herbs along with their modes of actions for protecting health of poultry and increasing production performances are presented in Table 2 and Fig. 3.

Table 2: Some of the popular herbal remedies for poultry

Herbs	Activity	References
Withania somnifera (Ashwagandha)	Antimicrobial, Immunostimulant, Adaptogen and vitalizer	Shirin *et al*. (2010), Ansari *et al*. (2013)
Azadirachta indica (Neem)	Antimicrobial, Anthelminthic, Ectoparasiticidal, Immunostimulant-stimulate phagocytosis	Talebi *et al*. (2005), Hady and Zaki (2012)
Aloe vera (Aloe)	Growth enhancer, anticoccidial and anti-inflammatory property-inhibits cyclooxygenase pathway, enhance wound healing (mannose-6-PO4),	Sinurat *et al*. (2003), Elbanna *et al*. (2012)
Ocimum sanctum (Tulsi)	Queen of plants. Adaptogen, Antistress, Analgesic, growth promoter	Bharavi *et al*. (2010)
Tinospora cordifolia (Guduchi)	Hepatoprotectant, Immunostimulant, adaptogen	Aghsaghali (2012)
Allium sativum (Garlic)	Growth enhancer, feed additive, antioxidant Endectoparasiticide, Immunostimulant- augment NK cell and T cells, growth perormance and egg production, Hypocholesterolemic	Ao *et al*. (2010, 2011), Toghyani *et al*. (2011), Yan *et al*. (2011), Dey *et al*. (2012) Khan *et al*. (2012b), Dieumou *et al*. (2013)
Emblica officinalis (Amla)	Anti-inflammatory, Anti-pyretic, Enhance growth	Ganju *et al*. (2003)
Curcuma longa (Turmeric)	Active ingredient – curcumin- growth performance, Immunomodulator, feed additives, Anti-inflammatory, antiseptic, reducing the mortality due to ascites, hypoglycemic, hypolipidemic and antioxidant	Hussain (2002), Cousins *et al*. (2007), Daneshyar *et al*. (2012), Khan *et al*. (2012a)
Zingiber officinale (Ginger)	Effective in diarrhoea, eye diseases, haematuria, improve stamina, indigestion, tympany, dysentery, stomach-ache and skin diseases, growth performance, egg production, yolk cholesterol, antioxidant, feed additives	Ali *et al*. (2008), Incharoen *et al*. (2009), Moorthy *et al*. (2009) Akbarian *et al*. (2011), Khan *et al*. (2012c)
Allium cepa (Onion)	Anthelminthic, for diarrhoea, skin infections, antioxidant	Gefu *et al*. (2000) Karre *et al*. (2013)
Carica papaya (Papaya)	Endectoparasiticide (seeds)	Pushpangadan (2006), Adu *et al*. (2009)
Echinacea spp.	For upper respiratory tract infections and gut infections, immunostimulant	Frankic *et al*. (2009), Mahima *et al*. (2012)
Andrographis paniculata (Kirayat, Kalmegh)	Stimulation of antibody and DTH response Stimulate macrophage migration, phagocytosis of 14C-leucine labeled *E. coli*, and in-vitro proliferation of splenic lymphocytes	Kumar *et al*. (2004)
Asparagus racemosus (Satawar, Shatavari)	Immunomodulator, Prevent leucopeni, Inhibits carcinogen ochratoxin A induced suppression of chemotactic activity and production of IL-1 and TNF-α by macrophages	Kumari *et al*. (2012)
Nyctanthes arbor-tristis (Harsinghar)	Hepatoprotective, antileishmanial, antiviral and antifungal activities	Kannan *et al*. (2007)
Thymus vulgaris (Thyme)	Growth promoting, antioxidant, immunomodulator and antimicrobial, antilipidimic	Mansoub (2011), Shahryar *et al*. (2011), Khan *et al*. (2012d)
Yucca schidigera (Yucca)	Antioxidant activity, growth enhancer, active ingredient, reducing NH3 and ammonia emission Stimulation of spermatogenesis	Chepete *et al*. (2012), Chrenková *et al*. (2012), Baláži *et al*. (2013), Ashour *et al*. (2014)
Rosmarinus officinalis (Rosemary)	Feed additives, antioxidant, growth promoters, active ingredient	Cullen *et al*. (2005), Botsoglou *et al*. (2005)
Origanum vulgare (Oregano)	Feed additives, antimicrobial and growth promoters	Aligiannis *et al*. (2001), Cross *et al*. (2007), Kirkpinar *et al*. (2011)
Cinnamomum cassia (Cinnamon)	Immunomodulator, growth promoters, natural antibiotics, chemopreventive effect, antioxidant and antimicrobial	Singh *et al*. (2007a), Chen *et al*. (2008), Toghyani *et al*. (2011)

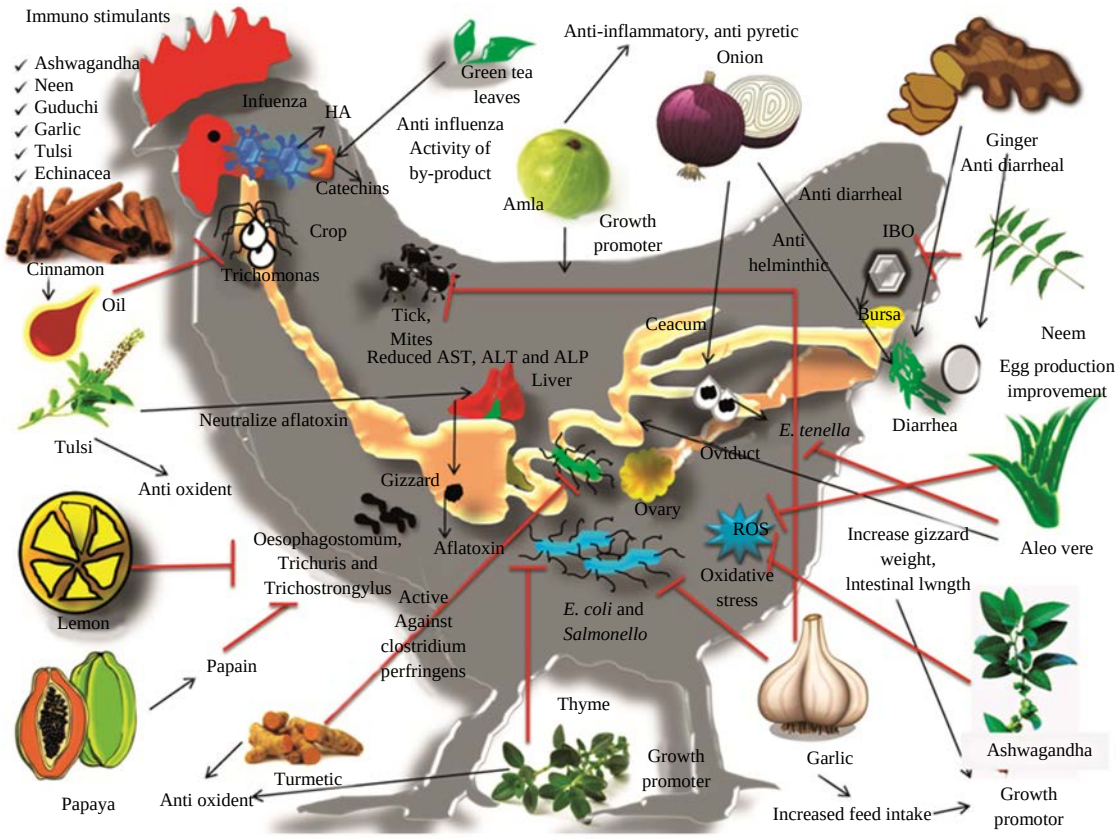

Fig. 3: An overview of the beneficial application of herbs in poultry health and production

ROLE OF HERBS IN ORGANIC EGG PRODUCTION IN POULTRY

Recently, organic egg production is gaining more importance and needs access to forage material such as pasture/crop in the hen yard or supplemented with roughage in the form of silages and vegetables in addition to the basal diet (The Council of the European Union, 2007). Hammershoj and Steenfeldt (2012) studied the effect of feeding kale (*Brassica oleracea* ssp. *acephala*), thyme (*Thymus vulgaris*) and basil (*Ocimum basilicum*) as a forage material on various egg quality parameters and egg production. They reported no significant difference in forage intake and laying rate between treatment groups but kale treatment significantly increased egg weight, higher egg shell strength; lutein, β-carotene and violaxanthin content. Several studies have emphasized on the importance of forage material (whole wheat, *Phacelia tanacetifolia*, *Fagopyrum esculentum* and *Linum usitatissimum*) on egg production, calcium supplements to laying hens, carotenoids in egg yolk, various egg quality parameters, conversion of oil rich forage material into specific fatty acids to the egg yolk and supply of vitamins, essential amino acids and minerals (Horsted *et al*., 2006; Hammershoj and Steenfeldt, 2009; Woods and Fearon, 2009; Hammershoj *et al*., 2010). Moreover, different aromatic herbs, vegetables and forage material can directly transfer flavours to the egg (Tserveni-Gousi, 2001) and as a result of altered microflora composition of the intestine due to change in forage material, thereby causing new flavours to the egg (Richter *et al*., 2002).

ROLE OF HERBS IN ORGANIC MEAT PRODUCTION IN POULTRY

Incorporation of turmeric (*Curcuma longa*) root powder and mannan oligosaccharides in broiler ration as a feed supplement results in decrease in the fat percentage up to 1% (Al-Sultan, 2003) and 1.2% (Samarasinghe *et al*., 2003) levels over body weights. Emadi and Kermanshahi (2006) reported that supplementation of turmeric rhizome powder (0.75%) in broiler rations leads to improved carcass quality, lean meat and significant decrease in abdominal fat pad up to 57% level and heart weights to live body weight. Furthermore, turmeric powder supplementation in broiler feed causes higher dressing percent up to 57% level, increased the liver weight, spleen weight and whole giblets weight (Kurkure *et al*., 2002;

Al-Sultan, 2003; Durrani *et al*., 2006). Shyama Tulsi (*Ocimum sanctum*) leaf preparation as a broiler feed supplementation for its growth promoter activity causes no significant change in the weights of the bursa, liver and spleen (Gupta and Charan, 2007). Singh *et al.* (2007b) reported that supplementation of the amla and turmeric combined powder at the rate of 5g kg^{-1} in broiler feed results in enhanced dressing percentage and decreased mortality in broiler chicks. Mehala and Moorthy (2008) demonstrated that combination of *Curcuma longa* (Turmeric) and *Aloe vera* at different concentrations showed no significant change in the abdominal fat and breast muscle weights. A combination of tulsi, amla and turmeric at the rate of 0.5% has not shown significant difference in ready to cook yield percentage and giblet weights (Reddy, 2010).

CONCLUSION

It has been vivid that the potential of medicinal herbs as the valuable source of therapeutics aids has attained a global significant place in the health system all over the world not only for humans but also for animals as well as birds. Herbs can be used as a good alternative therapeutic aid to costly allopathic medicines/chemotherapy and boosting immune functions in intoxicated conditions and can also effectively complement allopathic medicines in diseased state. Globally, the poultry industry is going through a crucial era of increasing demand for the products at the same time, experiencing production and health problems. So the sustainable present and future of poultry sector necessitates the optimum and accurate implementation of herbal remedies which overcome the demerits of extensive allopathic drugs. The tremendous potentials of traditional, herbal, botanical and medicinal plants could be made practical with the adjunct of the recent advances in science and technologies including of molecular, biotechnological and nanotechnology. Also, there is a great need to strengthen Research and Developmental facilities for integration of these modern and novel scientific advances with herbal usages. A thorough re-evaluation and scientific validation of these valuable ancient medicines need to be redirected from current perspectives and future prospects which are in great demand in the developed world as they are able to cure many infectious diseases. These need to be much promoted to combat a variety of poultry diseases, particularly the immunosuppressive ones, safeguard poultry health and boost the productive performance of birds.

Research works and project formulations should be carried out for studying and assessing the potentials of useful medicinal properties, discovering beneficial active components, revealing mechanism of actions of individual herbs in particular, herbal metabolites and standardization of doses, purification and extracting procedures, so as to authenticate, strengthen and widen the beneficial usages of these traditional medicines. Advances in biotechnological and molecular approaches being exploited for allopathic drugs and other medicines need to be explored to their full potentials for scientific validation and promoting fruitful applications of herbs. Nanotechnology based 'smart' drug delivery systems and nanomedicines would facilitate drug delivery in an efficient way and targeted manner which would reduce the drug doses to be administered as well as drug toxicity/side effects thereby rendering safer products. Species identification, cultivation and efforts for conserving precious herbal species also need to be taken on priority. Apart from this, strict quality control and regulatory measures need to be implemented so as to have a check on the standards and avoid adulteration of these various traditional medicines/products available. All these approaches would help to prove the medicinal and health values of herbs and their products which would make them promoted and popularized as well as accepted by mass community with dimension and practical applications for animal and human health benefits as well as poultry industry. These will all together improve prospects of this traditional wealth towards modern medicines, drugs and health care products derived from their origin to improve the market potential and commercialization aspects at global level.

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