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Herbs and Herbal Supplements, a Novel Nutritional Approach in Animal Nutrition

Review Article

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ABSTRACT

Livestock are an integral part of the agriculture sector and encompass a great impact on the national economy. An eco-friendly alternative to enhance production, prevent and treat disease conditions of animal is a great challenge for animal nutritionists. Keeping farm animals healthy is necessary to obtain healthy animal products. The use of naturally occurring compounds like herbs, herbal preparations and other botanicals are preferred over chemical compounds for enhancement of overall animal health and to satisfy consumer concerns as well. As herbal feed additives may be used drug (finely divided dry medicinal herbal raw materials), herbal extracts or herbal isolate (e.g. essential oil). Herbal drug is a whole or cut up, dry (occasionally raw) part of a plant, algae, fungi or lichen which is used for its medicinal properties. Herbs enhance and add flavors in animal feed and can therefore influence eating patterns, secretion of digestive fluids and total feed intake. The primary site of activity is the digestive tract. Due to the wide variety of active components, different herbs and spices affect digestion processes differently. Herbs, spices and their mixtures are also recognized as anti-inflammatory agents, and also act as antioxidants. Several in-vitro experiments have proved certain plant extract exhibit strong antimicrobial activity against Gram− and Gram+ bacteria. Herbs and their preparation have an affirmative impact on feed intake, growth, meat, milk and egg production. They also have known to enhance the quality and stability of animal products.

KEY WORDS animal nutrition, digestion, growth, herbal supplements, meat, milk, production.

INTRODUCTION

Livestock are an integral part of the agriculture sector and encompass a great impact on the national economy. Many methods such as feeding of antibiotics, pre and pro biotic, hormones, methane inhibitors and other additives in animal diet, are being exercised from the decade. These practices not only impose an extra financial burden on animal raisers but also leave residues in animal products, which may have a health concern (Sharma *et al.* 2008). Antibiotic as a feed additives have been banned in animal nutrition in many European countries (Anadon, 2006) due to the increased occurrence of pathogens resistant to therapeutic antibiotics used in both animals and humans. With the restricted use or outright ban on feed additives, new strategies of improving and protecting the health status of farm animals must be explored. Additionally, useful additives should ensure optimum animal performance and increase nutrient availability. This goal can be attained by good housing or climate conditions, better feeding strategies by the best possible combination of the pro nutrients available, including pro- or probiotics, organic acids, dietary fiber, highly available nutrients, herbs, spices or botanicals (Rosen, 1996). Feeding of prebiotic and probiotic is a safe practice and being implemented for years. For example, researchers have not reached to final conclusions and have mixed attitudes about this. It is well documented that feeding of yeast whether it is alive or dead has not shown any conclusive evidence that supplementation is beneficial at all times (Yoon and Stern, 1995; Erasmus *et al*. 2005) and most of the research in this section is done under *in-vitro* conditions (Chaucheyras *et al*. 1995; Lynch and Martin, 2002; Lila, *et al*. 2004; Rossi *et al*. 2004).

The world is witnessing a resurgence of interest in natural, traditional and alternate health system. The use of naturally occurring compounds like herbs, herbal preparations and other botanicals are preferred over chemical compounds to satisfy consumer concerns over safety and toxicity, is becoming a new goal in livestock production (Makkar *et al*. 2007). An eco-friendly alternative to enhance production, prevent and treat disease conditions of animal is a great challenge for animal nutritionists. In fact herbs, spices and their extracts were already used thousands of years ago in Mesopotamia, Egypt, India, China and old Greece, where they were appreciated for their specific aroma and various medicinal properties (Greathead, 2003) as they possess a positive impact on physiological functions, help to ensure good health and performance. Traditional herbal medicine, whether Ayurvedic medicine, Indian herbs, Chinese herbs, Western herbs or African herbs are generally holistic in therapy and relies upon the whole plant, roots, seeds or leaves that has been established to be more effective (Alimon, 2009). Herbal drug is a whole or cut up, dry (occasionally raw) part of a plant, algae, fungi or lichen which is used for its medicinal properties. Apart from plant organs (root, rhizome, crust, flower, fruit, seed, etc.), plant exudates are also herbal drugs (tars, gums). Herbal preparations are fat oil, essential oil, plant juices, tinctures and extracts (dry, soft, fluid) (Runjaić-Antić *et al.* 2010) obtained by special procedures such as distillation, extractions, etc. Essential oils are composed of more than 100 individual products (Tassoul and Shaver, 2009), are volatile and aromatic compounds with an oily appearance, which are obtained from plants (Burt, 2004).

According to one estimate there are 250000-500000 species of plants on earth. Relatively small percentages (1-10%) of these are used as foods and other functions by both humans and other animal species (Cowan, 1999). Plant extracts are used in animal nutrition as appetite and digestion stimulants, carminative, galactogogue, colorants and for prevention and treatment of certain pathological conditions. They contribute to the nutrient requirements of the animals; stimulate the endocrine system and intermediate nutrient metabolism (Wenk, 2003). Plant extracts are rich in polyphenols (Salah *et al*. 1995; Bravo, 1998; Bown *et al*. 1997) are good sources of natural antioxidants and have been used for many years to prevent lipid oxidation in food (Madsen and Bertelsen, 1995). Green tea by-product is widely used as feed supplements in animal diets and can be used as a protein source without any detrimental effects on the performance of lactating cows (Kondo *et al*. 2004). Sarsaponin, a naturally occurring steroid saponin contained in *Yacca schidigera* is believed to be a potent natural feed additive (Ryan, *et al*. 1997). The methanol extract of *Sapindus rarak* significantly increased daily weight gain and feed efficiency of rice straw based diet of animals (Thalib, *et al*. 1996).

Herbal preparations help in the digestion process and increase milk quantity as well as quality. Being a component of nature, these preparations are considered safe, cost effective and environment friendly with no side effect. Hence, their inclusion in the diet should be encouraged to enhance animal's performance, improve feed utilization, maintain health and alleviate adverse effect of environmental stress (Bhatt, 2000). Naturally occurring many plant secondary metabolites has shown potential to improve rumen fermentation to increase feed efficiency and live weight gain. Unlike chemical feed additives, these plant feed additives could pass easily many of the regulatory hurdles for use in organic farming. The main objective of the present review was to report the potential effects of medicinal and aromatic herbs and their combinations in the animal production industry and given new practical approach in order to improve the use of natural active substances present in plants.

Mode of action

The mode of action of herbs and plant extracts has not been fully elucidated. However, there are certain potential mechanisms by which they may improve performance. The diverse activities of herbs and other feed additives can have considerable importance during the growth phase of animals. In the very young animal, nutrient digestion and metabolism are not yet fully functional. Furthermore, the immune system and a stable digestive tract microflora (eubiosis) must be established, for which regular feed intake is compulsory. After this critical period, digestive processes can be optimized and adapted to the available feedstuffs. In these later stages of growth, factors related to product quality (feed quality and meat, milk or egg quality) play a major role. Most of the herbs have antibacterial, coccidiostatic, anthelmintic, anti-viral, anti-inflammatory or, particularly, antioxidant properties. Herbs and spices can protect the feed against oxidative deterioration during storage. This is a widely used practice in pet food and human food industry. The commonly used herb for feed/food preservation is rosemary (*Rosmarinus officinalis*). It can be used alone or in combination with tocopherols or synthetic antioxidants (Jacobsen *et al*. 2008). Herbs and their mixture can affect the animal by improved digestive tract function, by anti-inflammatory, anti-oxidative and anti-microbial effects and

Table1 List of commonly used herbs in animal nutrition and their activity (from various sources)

SN	Name	Scientific name	Used part	Active constituent	Activity
1	Amla	*Embellica officinalis*	Fruit	Vitamin C, gallic acid, ellegic acid and tannins	Potant antioxidant
2	Artichoke	*Cynara scolymus*	Leaves	Cynaropicrin a sesquiterpene lactone	Cholagogue, antioxidant and antilipemic action
3	Ashavgandha	*Withania somnifera*	Root, leaves, seeds	Withanolids, glycene, withanine	Immunomodulator, hepatoprotective, analagesic
4	Asparagus	*Asparagus racemosus*	Rhizome	Phytosterols, saponins, polyphenols, flavonoids and ascorbic acid	stimulate the immunity enhancer and galactogogue,
6	Bahera	*Terminalia belerica*	Fruit	Phenols, tannins	reduction in methane emission
7	Cinamone	*Cinnamomum zeylanicum*	Bark and leaves	Eugenol , phenolic and polyphenolic substances	astringent, warming, stimulating, carminative, antiseptic, antifungal, antiviral, blood purifying
8	Clove	*Syzygium aromaticum*	Buds	Eugenol	Appetite and digestion stimulant, antiseptic, antimicrobial choleretic and insecticidal
9	Coriander	*Coriandrum sativum*)	Seeds and leaves	Oil contains carvone, geraniol, limonene, borneol, camphor, elemol, and linalool. flavonoids include quercitin, kaempferol, rhamnetin, and epigenin.	Appetizer, stomachic and carminative
10	Cumin	*Cuminum cyminum*	Seeds	Cuminaldehyde	Digestive, carminative, galactagogue
11	Fennel	*Foeniculum vulgare*)	Seeds and leaves	Fenchone, anethole, limonene and estragole	Stomachic, Carminative, purgative and diuretic
12	Fennal flower	*Nivella sativa*	seeds	oil contains an abundance of conjugated linoleic (18:2) acid, thymoquinone, nigellone melenthin, nigelline, damascenine and tannins	Stomachic and antihistaminic, galactogogoue.
13	Fenugreek	*Trigonella foenum-graecum*	Leaves and seeds	Protodioscin, trigoneoside, diosgenin and vamogenin	antimicrobial properties
14	Garlic	*Allium sativum*,	Bud	γ-glutamyl-S-alk(en)yl-L-cysteines and S-alk(en)yl-L-cysteinesulfoxides, , alliin.	appetizers and stomachic, immunity enhancer and methane inhibitor
15	Green chirayta	*Andrographis paniculata*	Plant and root	Andrographine and andrographolide	Anti-pyretic, liver tonic, hypoglycaemi, Antioxidant and meat preservative
16	Harad	*Terminalia chebula*	Fruit	p-coumaricacids, ferulic acids, cinnamic acids and phloretic acids	reduction in methane emission
17	Jeewanti	*Leptadenia reticulata*	Whole plant	Flavonoids, phenolicCompounds, glycosides, proteins and amino acids,carbohydrates, phenolic compounds, tannins andsaponins	Galactogogue, stomachic, cooling, nutritive, aphrodisiac, stimulant, diuretic, and eyetonic
18	Lemon balm	*Melissa officinalis*	Leaves	Essential oil	Mild sedative, carminative, spasmolytic and antibacterial.
19	Lemon grass	*Cymbopogon citratus*	Leaves and shootes	Citral, myrcene, citronella; citronellol; and geranilol	Antibacterial, antinociceptive
20	Liquorice	*Glycyrrhiza glabra*	Root	Liquiritin and flavonoids	Galactogogue, antioxidant
21	Marsh mellow	*Althea officinalis*	Roots and leaves	mucilage, starch, Pectin, and cane sugar	Used to reduce irritations caused by acute inflammation and in cough remedy
22	Milk Thistle	*Sylibum marianum*	Ripe seeds	Silymarin or silibinin	Stimulates the regenerative capacity of the liver, stabilizes the lipid structures in the hepatocellular membrane and antiperoxidative effects
23	Neem	*Azadirachta indica*	Leaves	Neem oil contains nimbin, nimbidin and nimbinine	Antibacterial, antifungal, antiviral, anthelmintic, stimulate fibre degrading enzymes, defaunating agent
24	Oregano	*Origanum vulgare*	Leaves	Leanolic acids, ursolic acids, and phenolic glycosides	Antioxidant and meat preservative
25	Peppermint	*Mentha piperita*	Leaves and stem	Volatile oil, tannins and bitters	Spasmolytic and antibacterial
26	Rosemary	*Rosmarinus officinalis*,	Leaves	Volatile oil,tannin, bitter substances and resins	Anti inflammatory, antioxidant
27	Shikakai	*Acacia concinna*	Pods	Triterpenoids, steroids, saponins, acacidol, acacic acid and sonumin	Methane inhibiting effect
28	Thyme	*Thymus ulgaris*	Whole plant	Essential oil also contains thymol, p-Cymene, myrcene, borneol, and linalool	Appetite and digestion stimulant, antiseptic, antibacterial and antiviral activity
29	Zinger	*Zingiber officinale*	Rhizome	Camphene ,β-bisabolene and ar-curcumene	Methane reducing capacityGastric stimulant

in addition some will be described as influences to different physiological functions.

Improved digestive tract functions

Herbs enhance and add flavors in animal feed and can therefore influence eating patterns, secretion of digestive fluids and total feed intake. The primary site of activity is the digestive tract. Due to the wide variety of active components, different herbs and spices affect digestion processes differently. Herbs may exert multiple functions in the animal body (Hernandez *et al.* 2004). Most of them act as sialagogues and stimulate the secretion of saliva, which makes swallowing easier. The extracts from *Salvia officinalis, Thymus vulgaris* and *Rosmarinus officinalis* and the blend of carvacrol, cinnamaldehyde and capsaicin improved feed digestibility in broilers (Hernandez *et al.* 2004). They also observed the positive effects of plant extracts on nutrient digestibility to the appetite and digestion-stimulating properties and antimicrobial effects. Increased feed intake and digestive secretions are also observed in animals given phytobiotic-supplemented feed (Windisch *et al.* 2008).

Curcuma longum, *Zingiber officinale*, *Foeniculum vulgare*,*Mentha piperita*, *Allium sepa*, *Trigonella foenum-graecum*, and *Cuminum cyminum*enhance the synthesis of bile acids in the liver and their excretion in bile, which is necessary for the digestion and absorption of lipids. Most of the herbs and spices stimulate the function of pancreatic enzymes (lipases, amylases and proteases); some also increase the activity of digestive enzymes of gastric mucosa (Srinivasan, 2005). Besides the effect on bile synthesis, secretion and enzyme activity, herbs, spices and their combinations accelerate the digestion and shorten the time of feed/food passage through the digestive tract (Patel and Srinivasan, 2001; Bhatt, 2000; Suresh and Srinivasan, 2007). Herbs or the phytochemicals can selectively influence the intestinal microflora by either antimicrobial activity or by favorably promoting eubiosis of the microflora resulting in better nutrient utilization and absorption, or stimulation of the immune system. Lastly, herbs can contribute to nutrient requirements, stimulate the endocrine system and affect intermediate nutrient metabolism. Phytogenic substances from certain herbs, spices, and their extracts have also been shown to have pharmacologic actions within the digestive tract, as evidenced by their relaxant and spasmolytic effects (Camara *et al.* 2003; Madeira *et al.* 2002; Reiter and Brandt, 1985)

Anti-inflammatory effect

Herbs, spices and their mixtures are also recognized as anti-inflammatory agents. The anti-inflammatory effect of extracts of *Curcuma longum*, *Foeniculum vulgare*, *Mentha piperita*, *Cuminum cyminum*,*Cinnamomum zeylanicum* and *Zingiber officinale* were studied on rats (Srinivasan, 2005; Manjunatha and Srinivasan, 2006) and as the major active molecules with anti-inflammatory action are terpenoids and flavonoids were reported. The other plants with high content of terpenoids are *Myristica fragrans, Rosmarinus officinalis*, *Andrographis paniculata*, and *Thymus vulgaris*. The most known herbs and spices with anti-inflammatory potential in animal nutrition are *Matricaria recutitachamomil, Calendula officinalis, Foeniculum vulgare and Glycyrrhiza glabra* (Craig, 2001). One of the most common features of inflammation is increased oxygenation of arachidonic acid, which is metabolized by two enzymic pathways-the cyclooxygenase (CO) and the 5-lipoxygenase (5-LO) leading to the production of prostaglandins and leukotrienes, respectively. Amongst the CO products, PGE2 and amongst the 5-LO products, LTB_4 are considered important mediators of inflammation. Herbs can modulate the biochemical pathways of prostaglandin synthesis through inhibition of cyclooxygenase-1 and cyclooxygenase-2, leukotriene biosynthesis by inhibiting 5-lipoxygenase. It means it works as a dual inhibitor of eicosanoid biosynthesis (Grzanna *et al.* 2005).

Anti-oxidative effects

There is a need to assess the antioxidant status of feed available and antioxidant status of animals to combat different stress contracted by animals in response to get maximum benefit whether in the form of milk, meat or wool. In physiological conditions, mammals constantly produce reactive oxygen species (ROS). Low concentrations of ROS are essential for several physiological processes, including protein phosphorylation, transcription factors activation, cell differentiation, apoptosis, oocyte maturation, steroidogenesis, cell immunity and cellular defense against microorganisms (Miller *et al.* 1993). However the access cellular concentration of ROS whether it is endogenous and nutritional, is to be disposed by the organism. Oxidative stress refers to a lack of balance between production of ROS and the level of antioxidants, which results in oxidative alteration of biological macromolecules such as lipids, proteins and nucleic acids (Favier, 1997). Domestic animals are frequently exposed to oxidative stress, especially in intensive breeding systems (Aurousseau, 2002). Oxidative stress is responsible for numerous disease processes in animals, including sepsis, mastitis, enteritis, pneumonia, respiratory and joint diseases Lykkesfeldt and Svendsen, (2007). Numerous secondary metabolites formed by plants serve as defense agents against physiological and environmental stressors, predators and pathogenic microorganisms. Main molecules responsible for the antioxidative properties of herbs and spices are phenolic substances (flavonoids, hydrolysable tannins, proanthocianidins, phenolic acids, and phenolic terpenes) and some vitamins (A, E and C). Frequently used herbs rich in phenolics are *Rosmarinus officinalis, Thymus vulgaris, Origanum vulgare, Salvia officinalis, Camellia sinensis, Taraxacum officinale,* and *Ginkgo* (Halliwell *et al.* 1995; Craig, 2001; Ćetković *et al.* 2004; Fasseas *et al.* 2008). Many active components of herbs and spices can prevent lipid peroxidation through quenching free radicals or through activation of antioxidant enzymes like superoxide dismutase, catalase, glutathione peroxidase and glutathione reductase. At the cellular level, oxidation of fatty acids (FA) also referred to lipoper oxidation, is a major consequence of oxidative stress and a self-propagating biological reaction initiated by ROS, which remove protons from FA (Niki *et al.* 2005), the most susceptible being polyunsaturated FA of the n−3 family (n−3 PUFA) (Kamal-Eldin and Yanishlieva, 2002). Lipoperoxidation severely alters mammalian cell structure and functions, and may produce toxic metabolites unless ROS are rapidly neutralized by antioxidants. At the organism level, lipoperoxidation has been implicated in the deterioration of physiological functions that include growth and reproduction, as well as immunity leading to a higher susceptibility to infectious diseases (Miller and Brzezinska-Slebodzinska, 1993). These antioxidants function within a synergistic network of antioxidant compounds, both exogenous and endogenous to the body. A surplus of exogenous antioxidants has only a limited capacity to defend the body from deleterious ROSs (Harris 1992). The ultimate goal of any antioxidant supplement should be to up-regulate the entire system which is naturally regulated by a number of pathways, many of which are not well understood (Harnafi and Amrani, 2007). Vitamin E, a synthetic antioxidant is commonly used in animal nutrition, but its bioefficiency is limited when n−3 PUFA intake is increased (Allard *et al.* 1997). Moreover, pro-oxidant action has been reported (Mukai *et al.* 1993) when high doses are ingested, or in the absence of other antioxidants able to recycle the oxidized form of Vitamin E. Therefore, to optimize the antioxidant protection of animals fed n−3 PUFA rich diets, it would be preferable to use other antioxidants, rather than increase vitamin E intake which may be ineffective or even deleterious. Feeding trials conducted with poultry showed that plant extracts obtained from *Origanum vulgare* prevented lipoperoxidation in muscle tissues and may be complementary to Vitamin E (Papageorgiou *et al.* 2000; Young *et al.* 2003; Giannenas *et al.* 2005).However, use of such natural antioxidants in animal nutrition is limited due to the low bioavailability of polyphenols. Indeed, absorption, metabolism and excretion of polyphenols have been extensively studied in laboratory animals (mostly rats), and it was demonstrated that many types of polyphenols can lose part of their antioxidant capacity *in vivo* (Manach *et al.* 2004). Pharmacological studies examining particular antioxidant compounds often fail to correlate with results of whole feed trials (Chaudiere and Ferrari-Iliou, 1999). Chinese herbal mixtures in a corn, corn silage and alfalfa hay based diet increased the digestive enzymes activities in post-ruminal digestive tract and enhanced antioxidant status of serum in a formulation dependent manner (Wang *et al.* 2011).

Anti-microbial effect

The anti-microbial properties of plant-derived substances have been well known for centuries (Newman *et al.* 2000; Cowan, 1999). This property is mainly attributed to the essential oils of the plants. Several *in-vitro* experiments have proved certain plant extract exhibit strong antimicrobial activity against Gram− and Gram+ bacteria. Pasqua *et al.* (2006) found a change in long chain fatty acid profile in the membranes of *Escherichia coli* grown in the presence of limonene or cinnamaldehyde; *Salomonella enterice* grown in the presence of carvacrol or eugenol and Bronchotrix *thermosphacta* grown in the presence of limonene, cinnamaldehyde, carvacrol or eugenol. The changes in fatty acid composition can affect the surviving ability of microorganisms. The study measuring hydrophobicity (test for measuring the ability of microbial attachment) showed a large increase of hydrophobicity of *Escherichia coli* grown in the presence of St. John's wort or Chinese cinnamon and a moderate increase when the medium was supplemented with thyme or Ceylon cinnamon. The differences in hydrophobicity were in good correlation with MIC50 values (minimal inhibitory concentration). This confirms the fact that herbs and spices act as antimicrobial agents by changing the characteristics of cell membranes, and causing ion leakage, thus making microbes less virulent (Windisch *et al.* 2008). *Origanum vulgare* and *Thymus vulgaris* contain the monoterpenes carvacrol and thymol, respectively, and have demonstrated high efficacy in-vitro against several pathogens found in the intestinal tract (Barrarta *et al.* 1998; Burt, 2004; Jugl-Chizzola *et al.* 2006).

Garlic (*Allium sativum* L.) is considered as a good antimicrobial agent. The thiosulfinate compounds of garlic react with biological molecules having free SH groups to influence or inhibit growth of bacteria Small *et al.* (1947). The breakdown products of allicin have the ability to cross cell membranes and combine with sulphur containing molecular groups in amino acids and proteins, including bacterial enzymes, thus, interfering with bacterial cell metabolism (Ahmed, 2010). Animal cells contain glutathione, a sulphur containing amino acid that combines with the allicin derivative and therefore, are not poisoned by allicin derivatives, thus, preventing cell damage (Kyung *et al.* 2002; Davis, 2005).Ahmed *et al.* (2009) reported a lower and non-significant faecal coliform count in the treated group supplemented with natural juice containing garlic in growing buffalo calves than in the controls However, laboratory studies have indicated that garlic extract had significant inhibitory effect on coliform (Leuschner and Zamparini 2002; Nikolic *et al.* 2004).The anti-bacterial properties of *Allium sativum* were confirmed against *Escherichia coli* (Ahmed *et al.* 2009), *Staplylococcus aureus* and Salmonella spp. (Ahmed *et al.* 2009). Meichin *et al.* (2002) reported that *Allium sativum* extract have potential for prevention or control of infections caused by enteric pathogens, such as *Escherichia coli, Enterobacter cloacae, Enterococcus faecalis* and *Citrobacter freundii*. El-Astal (2004) reported high anti-bacterial efficacy of *Allium sativum* extract on certain pathogenic gram-positive bacteria (*Staphylococcus aureus, Staphylococcus saprophyticus, Strepococcus Pneumonia* and *Streptococcus faecalis*) and gram-negative bacteria (*Escherichia coli, Escherichia cloacae, Klebsiella pneumonia, Proteus mirabilis, Pseudomonas aeruginosa* and *Acinetobacter haemolyticus*). *Allium sativum* also contains active substances which suppress the action of fungi and viruses. Volatile oil from thyme (*Thymus vulgaris*) was assessed for antibacterial and antiviral activity as inhibitors of microbial growth (Dorman and Deans, 2000). The mixture of *Thymus vulgaris, Cinnamomum zeylanicum* and *Origanum vulgare* extracts inhibited the growth of coliform bacteria (Namkung *et al.* 2004). Brown algae *Ascophyllum nodosum* could be a good feed supplement with growth promoting activity of pigs infected with *Escherichia coli* (Turner *et al.* 2002).

The exact antimicrobial action of herbs and spices *in-vivo* situations is hard to evaluate, because of the very complex and balanced microbial populations in gastrointestinal tract and the interaction of active components from herbs and spices with other nutrients. Phytogenic feed additives may be suitable replacements of antibiotics to improve animal health and growth performance naturally, particularly during the first few weeks post weaning (Nakmung *et al.* 2004).

However, available research data (Main *et al.* 2001; Muhl *et al.* 2007) appear to be insufficient. In one study Sulabo *et al.* (2007) noted that the addition of a commercial product containing a proprietary blend of phytogenic substances was associated with higher post weaning growth performance in nursery pigs over controls. However, growth performance was better in pigs fed diets containing antibiotics than in those fed the phytogenic test diets. In the evaluation of the effects of oregano oil on nursery pig performance, pigs fed diets supplemented with oregano oil did not perform as well as pigs fed diets containing antibiotics (Windisch *et al.* 2008; Ragland *et al.* 2007).

It is reported that *Mentha piperita* oil exhibits antimicrobial activity (Pattnaik *et al.* 1996; Montes-Belmont and Carvajal, 1998; Imai *et al.* 2001) and inhibitory activity on motility of the gastro-intestinal tract in monogastric animals (Duthie, 1981; Hills and Aaronson, 1991) Clove oil has been demonstrated to have antimicrobial (Dorman and Deans, 2003), choleretic (Yamahara *et al.*1983) and insecticidal (Park and Shin,2005) activities, and a relaxant effect on smooth muscle (Reiter and Brandt, 1985). In lemongrass, antibacterial (Dikshit and Husain, 1984, Valero and Salmeron, 2003), antioxidant (Cheel *et al.* 2005), and antiseptic (Viana *et al.* 2000) activities have been studied. Essential oils have long been recognized for their antimicrobial activity (Lee *et al.* 2004) and they have gained much attention for their potential as alternatives to antibiotics in broiler chickens. Some studies with broilers demonstrated *in vivo* antimicrobial efficacy of essential oils against *Escherichia coli* and *Clostridium perfringens* (Jamroz *et al.* 2003). The exact anti-microbial mechanism of essential oils is poorly understood. However, it has been suggested that their lipophilic property and chemical structure (Farag *et al.* 1989b) can play a role. It was suggested that terpenoids and phenylpropanoids can penetrate the membranes of the bacteria and reach the inner part of the cell because of their lipophilicity.

Effect of herbs and their combinations on specific physiological functions

Plant extracts and spices as single compounds or as mixed preparations can play a role in supporting both performance and health status of the animal (Janssen, 1989; Bakhiet and Adam, 1995; Gill, 2000; Manzanilla *et al.* 2004). They affect the physiological and chemical function of the digestive tract. The mixture of cinnamaldehyde, capsicum oleoresin and carvacrol enhances the growth of lactobacilli, and increases the ratio of lactobacilli to enterobacteria. So herbs and spices do not possess only the antimicrobial activity, but also modulate the composition of microbial population by prebiotic activity (Castillo *et al.* 2006). The stabilizing effect on intestinal microflora may be associated with intermediate nutrient metabolism (Baratta *et al.* 1998, Jamroz *et al.* 2003). The pharmacological action of active plant substances or herbal extracts in humans is well known, but in animal nutrition the number of precise experiments is relatively low. Different herbs and their combinations can affect specific physiological functions in animals such as feed intake and utilization, growth, heat stress, rumen fermentation pattern and methane inhibition.

Feed intake and utilization

Food ingested by ruminants is digested through the microbial process of ruminal fermentation and endogenous enzymatic hydrolysis of intestinal digestion. Numerous techniques have been developed and suggested to improve the

Table 2 Effect of different herbs on the physiological functions of different animals

Herbs	Animal	Effect	Reference
Asparagus recemosus	Lactating cows	Increased dry matter intake and milk production	Bahrain and Singh 2002; Tanwar *et al.* 2008; Mishra *et al.* 2008
	Lactating buffaloes	Increased milk production	Patel and Kanitkar, 1969; Mahantra *et al.* 2003; Somkuwar *et al.* 2005
Ilex paraguarensis	Cattle	Sustained milk production	Celi *et al.* 2010
	Sheep	Improved feed intake and wool growth	Celi and Raadsma 2009
Leptadenia reticulata	Lactating goats	Galactopoitic response	Anjaria *et al.* 1967
Sapindus rarak	Cows	Increased weight and feed efficiency of rice straw based diet	Thalib *et al.* 1996
Origanum vulgare	Sheep	Reduced methane production	Wang *et al.* 2009; Hristov *et al.* 2010
	Lambs	no significant effects on performance, organ weights and blood parameters	Ünal and Kocabağli, 2014
	Nursery pigs	No effect on pigs performance	Windisch *et al.* 2008; Ragland *et al.* 2007
	Poultry	Improved performance	Giannenas *et al.* 2005
Allium sativum	Cows	Improved body weight gain, feed intake and Feed conversion efficiency, reduced methane production and have antibacterial property	Ghose *et al.* 2010; Busquet *et al.* 2005; Patra *et al.* 2006
	Poultry	Improved feed conversion rate	Rahimi *et al.* 2011; Tollba and Hassan 2003
Azadirachta indica	Cows	Improved weight and antiparasitic	Kudke *et al.* 1999
Rosmarinus officinalis	Poultry	Improved antioxidant capacity of products	Lopez-Bote *et al.* 1998
Thymus vulgaris	Poultry	Improved growth and live weight gain	Ocak *et al.* 2008; Rahimi *et al.* 2011; Al-Kassie *et al.* 2009
Sideritis scardica	Poultry	Anticoccidial effect	Florou-Paneri *et al.* 2004
Sophora flavescens	Poultry	Anticoccidial effect	Youn *et al.* 2001
Artemisia annua	Poultry	Anticoccidial effect	Allen *et al.* 1997
Cayenne pepper	Poultry	Enhanced yolk color	Sirri *et al.* 2007
Morus nigra	Poultry	Enhanced yolk color, egg quality, shelf life	Al Kirshi, 2009
Cinnamomum zeylanicum	Poultry	Enhanced antioxidant status	Albercht, 1979; Kende, 1982; Faix *et al.* 2009; Al-Kassie *et al.* 2009
Trichilia connaridodes	Rats	Enhanced antioxidant status	Prassana and Purnima, 2011
		In-vitro studies	
Acacia auriculoformi	*In-vitro*	Antiprotozoal activity	Makkar *et al.* 1998
Sapindus saponaria	*In-vitro*	Antiprotozoal activity, reduced methane production	Kamra *et al.* 2000; Hess *et al.* 2003a,
Quillaja saponaria	*In-vitro*	Antiprotozoal activity	Makkar *et al.* 1998; Hristov *et al.* 2003
Origanum vulgare	*In-vitro*	Methane inhibitor	Evans and Martin, 2000
Azadirachta indica	*In-vitro*	Anthelmintic activity	Al Roffai *et al.* 2012
Allium sativum	*In-vitro*	Methane inhibitor	Bungalvan *et al.* 2010

efficiency of ruminal fermentation and dietary manipulation is regarded as an effective and sustainable method. For example, expansion and heat treatment have been used to protect grain proteins from ruminal degradation (Nakamura *et al.* 1994; Weisbjerg *et al.* 1996; PrestlØkken 1999a) and thereby increasing their protein value by shifting the site of protein digestion from the rumen to the small intestine (PrestlØkken 1999b).

Ilex paraguarensis could be recommended as a natural novel feed supplement with the potential for improving feed intake and wool growth in lambs (Celi and Raadsma 2009). Chinese herbal medicines have been found to improve metabolism, promote growth and development, and enhance secretion and activity of digestive enzymes (Fang *et al.* 2000; Guo *et al.* 2008) and therefore could be used as natural feed additives to manipulate nutrient digestion and metabolism.

Çabuk *et al.* (2006) measured production parameters of broilers which were supplemented by a mixture of *Origanum vulgare*, *Lauras nobilis, Salvia officinalis,Pimpinella anisum*and *citrus* essential oils. The mixture of essential oils significantly improved feed conversion, what can be attributed to the more effective availability of nutrients due to the changes in intestinal ecosystem. Lippens *et al.* (2005) tested the efficacy of a mixture of *Cinnamomum zeylanicum*,*Origanum vulgare*,*Thymus vulgaris*,*Cayenne pepper* and *citrus* extracts and organic acids in comparison to nutritive antibiotic avilamicin in broiler chickens. Chickens supplemented with plant extracts gained significantly higher body weight than the control or avilamicin treated group. Higher body weight was a consequence of increased feed consumption. Feed conversion efficiency of plant extracts supplemented group was 0.4% better than avilamicin treated group and 2.9% better than in the control group. Further, they did not find any synergistic effect between plant extracts and organic acids (Lippens *et al.* 2005).

Growth

Growth is a trait that is affected by the intake of dietary antioxidants (Catoni *et al.* 2008). The high metabolic rate of growing tissues produces large amounts of free radicals (Rollo 2002), and if they are not safely removed by antioxidants, may lead to oxidative stress. Therefore, antioxidant supplementation may help to counteract negative effects of oxidative stress associated with growth. Because growth is extended to numerous tissues, it is likely to be affected by the overall oxidative status of an individual. It is reasonable to speculate that those antioxidants with the highest antioxidant potency and environmental abundance, that is, polyphenols, would play an important role during growth (Catoni *et al.* 2008).

Ocak *et al,* (2008) reported that the feed supplemented with 2% *Thymus vulgaris* could significantly improve the growth of broilers. Use of herbal extracts, especially *Allium sativum* improved feed conversion rate compared to virginiamycin (antibiotic) in broilers. This effect could be attributed to improvement of digestive enzymes secretion (Rahimi *et al.* 2011). Coneflower is not a suitable feed additive alternative for antibiotic as a growth promoter in broilers, though coneflower and garlic were the most effective in immune function enhancement and were able to reduce the serum lipid profile (Rahimi *et al.* 2011). Tollba and Hassan (2003) found that *Allium sativum* as a natural feed additive, improved broiler growth and feed conversion ratio (FCR), and decreased mortality rate. The effect of *Thymus vulgaris* (thyme) and *Cinnamonuim zeylanicum* (cinnamon) on the performance of broilers was studied by Al-Kassie *et al.* (2009), and an improvement on the live weight gain and the health of poultry, feed conversion ratio (FCR) and feed intake were observed. A higher growth rate was also observed in chickens, when the diet was supplemented with Chinese herbal medicines (Guo *et al.* 2008; Chen *et al.* 2009) what had similar growth-promoting effect to that of antibiotic in growing broiler chicken (Ma *et al.* 2004).

Mushroom and herb polysaccharides increased growth of immune organs such as thymus, bursa and spleen weights in both normal or immune-inhibition-treated chickens and rats (Guo *et al.* 2008). Ghalyanchi *et al.* (2008) compared the use of antibiotic, probiotics and two herbal preparations and revealed that the herbal preparations were effective in replacing virginiamycin as a growth promoter in broiler chicks and replacing antibiotic with essential oils is effective in supporting growth performance of broiler chicks (Demir *et al.* 2003).

Gebert *et al.* (1999) studied the influence of dietary supplementation of five single herbs (*Herba epimedit, Rhurbarb, Mangnoliavine fruit, Gold thread, Tibet bitter root*), and two mixtures Phyto starter 004 and Porah herbaW-15 on feed intake and growth performance of weanling pigs. All additives were added at 0.5% of the diet; and performance was compared with an unsupplemented basal diet consisted of barley**,** wheat, oats, corn, soybean meal, potato protein, fish meal, fat, amino acids and a mineral / vitamin premix. The analyzed nutrient content of the basal and experimental diets was almost identical. The daily weight gain of piglets was improved with garlic supplementation (Janz *et al.* 2007). A better growth rate and body weight gains in pigs were obtained in ruchamax (a herbal combination) supplemented group (Jakhar, 1995). Ruchamax increases salivary secretion, optimizes digestive functions, feed assimilation and thus metabolism (Rohilla and Bujarbaruah 1997).

Allium sativum extract can be supplemented to the calves for better performance (Ghosh*et al,* 2010). A significant increase in average body weight gain, feed intake and Feed conversion efficiency and significant decrease in severity of scours as measured by faecal score and faecal coliform count in the treated group was observed by (Ghosh*et al.* 2010), when newborn crossbred (Holstein cross) calves were given 250 mg/kg BW per day per calf *Allium sativum* extract for 2 months (pre-ruminant stage). *Allium sativum*extract supplementation in the calf's diet significantly improved their growth and other performances at their pre-ruminant stage. Therefore, significant lower feed cost per kg BW gain was found in the treatment group (Ghosh *et al,* 2010). Kudke *et al.* (1999) supplemented calves feed with powder of *Azadirachta indica* leavesand observed a higher weight gain than the control ones. They also noted a higher incidence of parasite infections in the control group. Livol a mixture of several herbs was incorporated @ 5-10 ml/d in veal calves; they produced a higher weight gain due to improved digestion, higher enzymatic activity and efficient utilization of nutrients (Kumar and Shah, 1995; Sardar, *et al.* 1997; Wheelar, 1997). In another experiment Bhatt (2000) found a better growth rate and feed conversion efficiency of crossbred heifers over control when supplied with two herbal preparations (Ruchamax and Pachoplus, produced by Dabur Ayurvet, India). A significant difference in the digestibility of dry matter (DM), organic matter (OM) and gross energy (GE) with herbal supplement fed groups was also observed (Bhatt 2000). Studies conducted by Lan *et al.* (2000) and Wang and wangn, (2007) showed that some formulas of Chinese herbal medicines (CHM) containing *Radix Astragali* and *Rhizoma Atractylodis* increased growth of beef cattle. In contrast, Wang *et al.* (2011) did not find any significant differences in average daily gain of crossbred beef cattle supplemented with (CHM).

Rumen fermentation pattern

Ruminants have unique power to degrade and utilize lignocellulosic feeds by microbial fermentation in the rumen. The fermentation end products and their ratio in rumen remain in a balanced form for the further utilization by the animal. Any deviation from this leads to such consequences either beneficial or detrimental. Secondary metabolites, such as phenolic compounds, essential oils, and sarsaponins, produced by certain plants affect the rumen microbial activity (Chesson *et al.* 1982; Wallace *et al.* 1994). Essential oils are able to manipulate rumen fermentation, due to selective pressures exerted on different microbial populations, resulting in different bacterial numbers and activities, in both the liquid and solid milieu of the rumen. Moreover, these effects will differ depending on the chemical composition of the essential oils used; hence more research is required to better understand the effect of essential oils, both singularly and in combination, on rumen microbes and their fermentation (Chesson *et al.* 1982; Wallace *et al.* 1994). Pure and naturally occurring mixtures of essential oils, blends of essential oils (BEO) are available as commercial rumen manipulators. Crina by CRINA SA (Akzo Nobel, Gland, Switzerland) is the best mixture. It is a mixture of natural and nature-identical essential oil compounds that includes thymol, eugenol, vanillin, and limonene as its main components on an organic carrier (Rossi, 1995). BEO has been shown to affect both volatile fatty acids (VFA) production and nitrogen and starch degradation in the rumen. Castillejos *et al.* (2007) found that total VFA production was unaffected at 0 h post feeding of BEO but it increased at 3 h post feeding in sheep. Newbold *et al* (2004) found that 110 mg/d BEO tended to stimulate total VFA production at 6 h after feeding in sheep but not after 2 h post feeding. However, Beauchemin and McGinn (2006) reported no effects of 750 mg/d BEO on total VFA production at 4 h post feeding in cattle. Castillejos *et al.* (2005) suggested that essential oil supplementation might selectively stimulate acetate formation. Cinnamaldehyde and eugenol mixture, anise oil and capsicum oil may be used as modifiers of rumen fermentation in beef production systems reported by Cardozo *et al.* (2006). They also reported that the effect of herbs and spices on ruminal fermentation in beef cattle may differ depending on ruminal pH. At pH 5.5, *Allium sativum*, *Cayenne pepper, yucca schidigera*and cinnamaldehyde altered ruminal fermentation in favor of propionate, which is more energetically efficient. Some studies have attempted to exploit plant secondary metabolites as natural feed additives to improve the efficiency of rumen fermentation such as enhancing protein metabolism, decreasing methane production, reducing nutritional stress such as bloat, and improving animal health and productivity (McIntosh *et al.* 2003; Benchaar *et al.* 2007).

Sarsaponins have been reported to decrease the ammonia nitrogen concentration and can alter the acetate and propionate proportions (Wallace *et al.* 1994; Ryan *et al.* 1997). A non-significantly lower ammonia nitrogen concentration was found by Bhatt *et al.* (2009) in herbal preparation (Ruchmax and Payapro) supplemented groups as compared to controls, and rumen microbes using all the ammonia produced and giving more precipitable nitrogen in herbal supplemented groups. The ammonia produced, together with some small peptides and free amino acids, is utilized by rumen microbes to synthesize microbial protein (Mc Donald, *et al.* 1990). Rumen bacteria are considered good scavengers of ammonia and can grow on the relatively low concentration of ammonia in ruminal fluid (Schaefer *et al.* 1980). In another study Sardar *et al.* (1997) did not find any significant differences in ammonia nitrogen concentrations in the animals feeding various levels of Livol, a herbal preparation. Rumen ammonia concentration has been reflected in the balance of nitrogen and energy supplies into the rumen, which is associated with microbial activity (McDonald *et al.* 2002; Hosoda *et al.* 2005).

Tri chloro acetic acid precipitable nitrogen (TCA-ppt-N) is a relevant index of net microbial synthesis. A statistically significant differences were found in TCA-ppt-N concentration in crossbred milking cows, supplemented with herbal preparation (Ruchmax and Payapro) (Bhatt *et al.* 2009), which could be due to increased population of ruminal fauna and flora and to active degradation and hydrolysis of nitrogenous substances and their readily incorporation in to microbial mass. When the microbial masses are carried through to the abomasums and small intestine their cell proteins are digested, absorbed and utilized by the animal. One more important feature of the formation of microbial protein is that rumen bacteria are capable of synthesizing indispensable as well as dispensable amino acids, thus rendering their host independent of dietary supplies of indispensable amino acids (Mc Donald *et al.* 1990). The efficient synthesis of microbial protein at a high ammonia concentration requires readily fermentable and available source of energy and also readily degradable carbohydrates; which matches the synthetic ability of rumen microbes (Oldham, 1981). It has been suggested that methodologies, which increase N-recycling or the utilization of recycled N may benefit animal performance and the rumen environment (Cole and Todd, 2008).

The proportion of volatile fatty acids in the rumen is affected by the diet composition and pH of rumen fluid. It is generally known that fibrous feed causes a rise in acetate proportion, whereas the addition of concentrates to diet leads to an increase in propionate proportion at the cost of acetate (McDonald *et al.* 2002).The total volatile fatty acids (TVFA) concentrations in the strained rumen liquor (SRL) of various groups differed significantly and the highest values (103.9 mmol/100 ML SRL) were observed in Ruchamax supplemented animals. The higher TVFA values in the same group showed a positive correlation with milk production (r=0.836) (Bhatt *et al.* 2009). It might be due to increased population of rumen microbes as adequate levels of ammonia nitrogen can promote the rumen microbial growth, improving the carbohydrate fermentation and subsequently TVFA production (Jackson, 1971). Higher concentration of TVFA in galactagogue treated groups has been regarded as an indicator of better energy supply for milk production (Singh *et al.* 1991).

Significant difference observed in bacterial and protozoal counts in the herbal combination supplemented groups as compared with controls indicated that herbs and their combination provide a favorable environment for microbial growth (Bhatt *et al.* 2009; Phalphale, 1997; Pradhan *et al.* 1994). Optimization of diet formulation and the utilization of feed additives have been shown to modify the rumen environment and enhance or inhibit the specific microbial population (Calsamiglia *et al.* 2007). Feeding of stomachic and rumenotorics led to increase the number, species, and size of rumen microorganisms (Singh *et al.* 1996; Pradhan *et al.* 1994; Phalhphale 1997).

Methane inhibitors

Methane emission from ruminants reduces the efficiency of nutrient utilization and could have a contribution to global warming. In the recent years immense research has been conducted on herbal supplements and its positive effect on farm animals, but the direct effect of these supplements to decrease methanogenesis in the rumen is scanty. The secondary plant metabolites such as flavonoids and tannins have been found to reduce methane production (Woodward *et al.* 2001). Also saponins have been found to suppress or eliminate protozoa from the rumen and reduce methane and ammonia production (Kamra *et al.* 2000; Sliwinski *et al.* 2002; Lila *et al.* 2003). However, effectiveness of plants or plant extracts having high content of saponins, flavonoids and tannins varied depending upon the source, type and level of secondary metabolite present in it. In one study Hosoda *et al.* (2005) found that the feeding of peppermint to lactating dairy cattle decreased nutrient digestibility, changed energy metabolism, and decreased methane production. Thymol (400 mg/L), from *Thymus vulgaris and Origanum vulgare* plants, was a strong inhibitor of methane in *in-vitro* conditions, but acetate and propionate concentrations also decreased (Evans and Martin, 2000). Busquet *et al.* (2005) observed that garlic oil and diallyl disulfide (300 mg/L of ruminal fluid) reduced methane production by 74 and 69%, respectively, without altering the digestibility of nutrients due to the direct inhibition of rumen methanogenic archaea. The stability of cell membrane of Archaea micro organisms depends on glycerol linked long chain isoprenoid alcohols (De Rosa *et al.* 1986) and the synthesis of these isoprenoid units in methanogenic Archaea is catalysed by HMG CoA (Hydroxy methyl glutaryl CoA) reductase. Organo sulphur compounds in *Allium sativum* are strong inhibitors of this reductase and possibly may inhibiting methanogenesis. Methanol extract of seed pulp of *Terminalia chebula* and methanol, ethanol and water extracts of bulbs of *Allium sativum* reduced methane production significantly in rumen liquor of buffaloes (Patra *et al.* 2006). Hart *et al.* (2006) suggested that allicin a component present in (garlic) *Allium sativum* is responsible for reducing the number of methanogens with no effect on the total bacterial population in fermentor of RUSITEC. The rate and extent of methane production was reduced up to 42 % by addition of *Yucca schidigera* extract in a dose dependent manner (Pen *et al.* 2006). Stated that *Frangula alnus* bark and *Rheum officianale* root resulted in dose dependent linear decrease in methane production. Inclusion of herbal extracts / residues between 30-50 mg, can significantly reduced methane production without adversely affecting the rumen pH and *in vitro* dry matter degradability (Bunglavan *et al.* 2010).

Effect of herbs and herbal preparation on animal products

Feed and feed supplement have a direct positive or negative impact on quality of meat, milk and eggs. Plants produce a huge amount of secondary plant metabolites, some may be harmful to the animals other may not. Many phytochemicals such as saponins, essential oils, tannins and flavonoids from a wide range of plants have been identified, which have potential values for rumen manipulation and enhancing animal productivity as alternatives to chemical feed additives (McIntosh *et al.* 2003; Benchaar *et al.* 2007).

Milk production

Milk production is controlled by interplay of various hormones. Actually milk production is a complex process involving physical and emotional factor and the interaction of multiple hormones, the most important of which is believed to be prolactin. With parturition and expulsion of placenta, progesterone level falls and full milk supply is initiated (Neville *et al.* 2001). Through interaction with hypothalamus and anterior pituitary, dopamine agonists inhibit, and dopamine antagonists increase prolactin secretion and thereby milk production (endocrine control). Thereafter, prolactin level gradually decreases but milk supply is maintained or increased by local feedback mechanism (autocrine control). Therefore, an increase in prolactin level is needed to increase but not maintain milk supply (Lawrence and Lawrence, 1999). Numerous herbs and their mixture are being used for centuries to enhance and sustain milk production in farm animals. *Asparagus recemosus, Leptadenia reticulate, Nigella sativa* are few herbs which are being used as a galactagogues. Galactagogues are believed to assist in the initiation, maintenance, or augmentation of milk production (Gabay, 2002, Abascal and Yarnell, 2008). *Leptadenia reticulata* has been shown to produce significant galactopoitic response in goats, sheeps, cows and buffaloes (Anjaria *et al.* 1967). It has been suggested that Galog, a herbal product, may stimulate milk production (Arora, 1989; Zednik *et al.* 1994). Singhal, (1995) observed 30.1% increase in milk yield from Payapro a herbal combination supplemented cows. Qureshi (1999) observed an increase in milk yield and also an increase in the fat percentage of milk in dairy cows fed with Lectovet (a herbal combination). Galactin, a non-hormonal herbal preparation significantly enhanced milk the production in dairy cows and ultimately improved the dairy economics (Ramesh *et al.* 2000; Kumari and Akbar, 2006). Kolte *et al.* (2008) reported that indigenous herbal preparations effectively restored the altered milk constituents and increased the milk production in cows with sub-clinical mastitis. Ruchamax (a mixture of several herbs) increases the salivary secretions, boosts the populations of friendly bacteria and protozoa, optimizes the digestive functions, and ultimately helps in the assimilation and metabolism of feeds (Pradhan *et al.* 1994; Singh *et al.* 1996; Bhatt *et al*, 2009). Herbal preparation not only increase the milk production, but also arrest decline phase giving a post peak slow but gradual decline that prolonged the lactation period. Overall the percentage monetary gains from animals fed either Ruchamax or Payapro (a combination of more than 10 herbs) was 50.37 % and 23.49%, respectively as compared to control (Bhatt *et al.* 2009). *Ilex paraguarensis* supplementation sustained milk production in dairy cows (Celi *et al.* 2010).Milk flavor can be controlled by the use of herb(s) as a feed supplement for dairy cows. The dried herbs were fed to lactating dairy cows; the characteristic smell of cow milk was suppressed due to the transmission of components peculiar to such herbs into the cows' milk (Ando *et al.* 2001). An increase in milk flavor was observed by Preciado *et al.* (2011) with the supplementation of some herbal galactogogue.

Meat production and quality

Lipid oxidation occurs during processing and storage of meat and meat products is responsible for the loss of quality in meat due to microbiological deterioration. Products of lipid peroxidation adversely affect the color, flavor, texture and nutritive value of meat (Kanatt *et al.* 2007). Quality feed together with proper hygiene, potable water and management can ensure the production of nutritious animal products with desired organoleptic properties (Saxena, 2008).

Free radicals are not only destructive to the living cells but also reduce the quality of animal products through oxidation. Superoxide anion radical, one of the most destructive reactive oxygen species, is a matter of concern for the animal scientists as well as feed manufacturers to ensure the quality of product. Feeding of n−3 PUFA-enriched diets can improve animal fat (Wood *et al.* 2004), but this practice has been associated with an enhancement of lipoperoxidation in plasma (Fuhrmann and Sallmann, 1999; Scislowski *et al.* 2005). Therefore, new bioefficient antioxidants particularly natural antioxidants are a novel approach to respect consumer concerns on safety and toxicity. Plant extracts rich in polyphenols are good candidates, since they are easily obtained from natural sources and they efficiently prevent lipid oxidation in food products.

A study done, demonstrated the bioefficiency of polyphenols in rats fed a PUFA-rich diet with purified polyphenols (*i.e.*, catechin+quercetin). In another investigation with similar experimental conditions (*i.e.*, rats fed a PUFA-rich diet supplemented with 2 g of isoflavone rich powder per kg of diet) was not inducing a reduction of plasma melondialdehyde (MDA) (Kawakami *et al.* 2004). Recent *in vitro* studies using LDL-based models (Deckert *et al.* 2002) or SDS micelles (Zhou *et al*, 2005) demonstrated that polyphenols can maintain a high level of tocopherol in lipid structure either by sparing it or by recycling these oxidized. However, vitamin E kinetic studies demonstrated that tocopherol is rapidly excreted and that the plasma pool is continuously adjusted from the diet or from tissue reserves of tocopherol (Traber *et al.* 1994). The genus Mentha is a rich source of polyphenolic compounds and hence could possess strong antioxidant properties (Ali *et al.* 2002). Mentha characterized by their volatile oils that are of great economic importance, being used by the pharmaceutical, cosmetic, food, confectionery and liquor industries are now cultivated as industrial crops in several countries. Although there are some reports on the antioxidant property of mentha (Dorman, *et al.* 2003; Marinova and Yanishlieva, 1997; Zhang and Wang, 2001), its application in meat production has not been studied.

Supplementation of turkeys with 200 mg/kg of oregano essential oil significantly decreased lipid peroxidation of cooked and fresh meat during refrigerated storage (Botsoglou *et al.* 2003b) and also preserved the quality of chicken meat during frozen storage (Botsoglou *et al.* 2003a). Addition of vitamins C and E with the extracts from herbs and spices more effectively prevent lipid peroxidation in tissues (Papageorgiou *et al.* 2003; Young *et al.* 2003).

Some studies compared the carcass characteristics and meat quality of lambs grazed on low land and mountain pastutures and showed that there were significant differences between the fat content and fatty acid composition, meat color, and meat flavor. Additionally they reported that meat from lambs raised on mountain pastures without any supplementary feeding or treatment is often considered to be of superior quality. This was because lambs on mountain pastures had access to plenty of miraculous herbs and wild shrubs and the meat is often tasty.

Herbs and egg quality

Herbs as a natural colorant are being used for decades in poultry feed. The colorants for increasing yolk color in laying hens or skin color in broilers in intensive production can be of natural (carotenoids) or synthetic origin. Maize and alfalfa are rich in carotenoids and used in poultry feed for energy and as colorant. Besides these, marigold, tagetes and red pepper are also used as natural colorant. The main yellow pigments in tagetes are zeaxantin and lutein, while *Cayenne pepper*(red pepper) contains two important red pigments capsantin and capsorubin. Pigments from natural origin also degrade during the feed storage up to 30% (Sirri *et al.* 2007). Nevertheless, pigments obtained from *Calendula officinalis* and *Cayenne pepper*is very suitable as yolk colorants in organic farming. *Morus nigra*leaves can be a good natural colorant for layer feed. Studies conducted with layers suggested that supplementation of mulberry leaves in layer feed enhanced yolk color, egg quality, shelf life and antioxidant properties of eggs. (Al Kirshi, 2009).

A yellow skin chicken is more in demand than a white skin chicken.The effectiveness of a particular natural source as a pigment for poultry products depends on the level and availability of the xanthophylls in the source as well as the chemical nature of the particular xanthophylls (Delgado-Vargas, 1997). Feeding of purified xanthophylls such as lutein, zeaxanthin, and cryptoxanthin was effective in pigmentation of broiler skin (Quackenbush *et al.* 1965), whereas Kuzmicky *et al.* (1969) reported that neoxanthin and violaxanthin were found to be ineffective. In other studies reported significantly increased skin yellowness in broilers by using saponified marigold concentrates in the diet compared with nonsaponified marigold product.

Stability of animal products

The use of herbs and spices as antioxidants is not important only for the excellent health of the animals, but also for the oxidative stability of their products. The effect of oregano essential oil on oxidative stability of chicken and turkey meat was well studied. Supplementation of turkeys with 200 mg/kg of oregano essential oil significantly decreased lipid peroxidation of cooked and fresh meat during refrigerated storage (Botsoglou *et al.* 2003b). Essential oil of oregano also efficiently preserved the quality of chicken meat during frozen storage (Botsoglou *et al.* 2003a). Extracts from herbs and spices in combination with vitamins C and E even more effectively prevent lipid peroxidation in tissues of chickens and turkeys (Papageorgiou *et al.* 2007; Young *et al.* 2003).

In one study goats feed was supplemented with *Andrographis paniculata*, turmeric and vitamin E to compare their antioxidant contents in meat and it was found that meat from supplemented goats had higher antioxidant activities and better sensory qualities. Jang *et al.* (2009) evaluated the antioxidative potential and quality of the breast meat of broiler chickens, fed a dietary medicinal herb extract mix (MHEM, consisting of *Morus nigra*leaf, Japanese honeysuckle, and goldthread at a ratio of 48.5:48.5:3.0) and observed that MHEM did not affect proximate composition of the breast meat, but the phenols content of the breast meats was twice in supplemented group over the control. The tribarbituric acid (2-TBA) in the treated diets was lower than the control and did not increase during storage.

They concluded that this herbal mixture increased the antioxidative potential and overall preference of breast meat during cold storage. Feeding studies conducted with poultry showed that plant extracts obtained from oregano prevented lipoperoxidation in muscle tissues and may be complementary to vitamin E (Papageorgiou *et al.* 2003; Young *et al.* 2003; Giannenas *et al.* 2005).

Immunostimulation

Several medicinal herbs are used to enhance the immune system or bring it back up to normal levels following an illness. The immune system generally benefits from the herbs and spices rich in flavonoids, vitamin C and carotenoids.

The plants containing molecules which possess immunostimulatory properties are *Echinacea purpurea, Glycyrrhiza glabra, Allium sativum* and *Uacanria tomentosa.* Theseplants can improve the activity of lymphocytes, macrophages and NK cells; they increase phagocytosis or stimulate the interferon synthesis (Craig, 1999). Feix *et al.* (2009) investigated the effects of *Cinnamomum zeylanicum* essential oil on antioxidant status of chickens and reported that it exhibits a significant antioxidant activity in fattening chickens and can be used as a source of antioxidant in dietary supplement. *Cinnamomum zeylanicum* essential oil showed stimulatory effects on macrophages, which play an important role in the initiation and regulation of the immune response (Albercht, 1979; Kende, 1982) and constitute the body's primary line of defense against infections (Van Furt, 1982).

Extracts from herbs and spices help to prevent and alleviate different kinds of health problems without any side effects and leaving harmful residues in animal body. Herbs and spices are effective in treatment of endometritis (inflammation of the endometrium) in cows. Esparza-Borges and Ortiz-Márquez (1996) evaluated the effect of extracts of garlic (*Allium sativum*, *L*), eucalypt (*Eucalyptus globulus*, *Labill.*) and *Gnaphalium onoideum* on acute endometritis of Holstein cows. The most effective of all extracts was the *Allium sativum* extract, however, also eucalypt worked beneficially. Tannins prevent bloat of the rumen (Butter *et al.* 1999) and possess antihelmitic properties (Barry and McNabb, 1999). Asparagus root regulates cholesterol metabolism and improves antioxidant status in hypercholesteremic rats. *Asparagus racemosus* (Shatavari) is recommended in Ayurvedic texts for prevention and treatment of gastric ulcers, dyspepsia and as a galactogogue.

CONCLUSION

Use of herbs and their combinationsis gaining momentum as an alternate practice in animal nutrition for overall excellence of animals. Herbs and spices are not only acting as appetizer and digestion stimulants, but they also attribute positive impact on other physiological functions, help to sustain good health and welfare and improve the performance. Various studies have shown promising results regarding the use of phytochemicals as growth and production promoters. Herbs and herbal extracts are potentially useful as growth promoters in diets and also as therapeutic agents. They can replace antibiotics, have immune enhancers and fight bacterial and viral infections. There is still a need to clarify the phytochemical composition and the mechanisms of action for many herbs, spices and their extracts and furthermore, is required to investigate the effect of herbs and their combination supplementation on productive performance in animals to assess the appropriate dose that should be safely used in specific circumstances and animal species. The antioxidant property of herbs is well documented, so there is a vast scope of animal scientists to have an exhaustive research on use of these notable herbs in feed supplementation to enhance animal produce naturally.

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