Application of Herbal Feed Additives in Animal Nutrition - A Review

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Abstract
Use of herbal feed additive is gaining importance in animal production due to ban on use of certain antibiotics, harmful residual effects and cost effectiveness. A number of feed additives like probiotics, prebiotics, organic acids and plant extracts have been found to have beneficial effects on animal production. Medical herbs properties to improve digestibility, antimicrobial, anti-inflammatory, anti-oxidant and immune-stimulant activity must be exploited in feeding of animals as well as safe food product for human beings. Furthermore, research on standardization of correct dosages of herbal feed additive for particular function need to be studied.

Key words: Antimicrobial, Anti-Oxidant, Immune-Stimulant, Feed Additive, Herb, Spices

Introduction
Firstly, there is growing interest in herbal feed additive in livestock production due to development of microbial resistance to antibiotic drugs and their consequences on human health. The second is a response to consumer pressures to eliminate the use of all non-plant xenobiotic agents from the diets of animals. Herbal feed additives play a significant role in health and nutrition. Herbal feed additives include herb, spices and botanicals which can be defined as (Webster’s Encyclopedic Unabridged Dictionary of the English Language, 1989):

Herb: A flowering plant whose stem above ground does not become woody and persistent. A plant when valued for its medical properties, flavor, scent, or the like.

Spices: Any of a class of pungent or aromatic substances of vegetable origin, as pepper, cinnamon, cloves, and the like, used as seasoning, preservatives etc.

Botanical: A drug made from part of a plant, as from roots, leaves, bark etc. Essential oils are any of a class of volatile oils obtained from plants, possessing the odor and other characteristic properties of the plant, used chiefly in the manufacture of perfumes, flavors and pharmaceuticals.
Table 1: Different herbal feed additives, its active components and functions

<table>
<thead>
<tr>
<th>Plant</th>
<th>Used parts</th>
<th>Active component</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutmeg (Myristica fragrans)</td>
<td>Seed</td>
<td>Sabinene</td>
<td>Digestion stimulant, antidiarrhoeic</td>
</tr>
<tr>
<td>Cinnamon (Cinnamomum zeylanicum)</td>
<td>Bark</td>
<td>Cimetaldehyde</td>
<td>Appetite and digestion stimulant, antiseptic</td>
</tr>
<tr>
<td>Cloves (Syzygium aromaticum)</td>
<td>Cloves</td>
<td>Eugenol</td>
<td>Appetite and digestion stimulant, antiseptic</td>
</tr>
<tr>
<td>Cardmom (Amomum subulatum)</td>
<td>Seed</td>
<td>Cineol</td>
<td>Appetite and digestion stimulant</td>
</tr>
<tr>
<td>Coriander (Coriandrum sativum)</td>
<td>Leaves and seed</td>
<td>Linalol</td>
<td>Digestion stimulant</td>
</tr>
<tr>
<td>Cumin (Cuminum cyminum)</td>
<td>Seed</td>
<td>Cuminaldehyde</td>
<td>Digestive, carminative, galactogogue</td>
</tr>
<tr>
<td>Anise (Pimpinella anisum)</td>
<td>Fruit</td>
<td>Anethol</td>
<td>Digestion stimulant, galactogogue</td>
</tr>
<tr>
<td>Celery (Apium graveolens)</td>
<td>Fruit, leaves</td>
<td>Phtalides</td>
<td>Appetite and digestion stimulant</td>
</tr>
<tr>
<td>Parsley (Petroselinum crispum)</td>
<td>Leaves</td>
<td>Apio</td>
<td>Appetite and digestion stimulant, antiseptic</td>
</tr>
<tr>
<td>Fenugreek (Trigonella foenum-graecum)</td>
<td>Seed</td>
<td>Trigonelline</td>
<td>Appetite stimulant</td>
</tr>
<tr>
<td>Capsicum (Capsicum annuum)</td>
<td>Fruit</td>
<td>Capsaicin</td>
<td>Digestion stimulant</td>
</tr>
<tr>
<td>Pepper (Piper nigrum)</td>
<td>Fruit</td>
<td>Piperine</td>
<td>Digestion stimulant</td>
</tr>
<tr>
<td>Horsradish (Armoracia rusticana)</td>
<td>Root</td>
<td>Allyl izotiociant</td>
<td>Appetite stimulant</td>
</tr>
<tr>
<td>Mustard (Brassica Nigra)</td>
<td>Seed</td>
<td>Allyl izotiociant</td>
<td>Digestion stimulant</td>
</tr>
<tr>
<td>Ginger (Zingiber officinale)</td>
<td>Rizom</td>
<td>Zingerone</td>
<td>Gastric stimulant</td>
</tr>
<tr>
<td>Garlic (Allium sativum)</td>
<td>Bulb</td>
<td>Alkin</td>
<td>Digestion stimulant, antiseptic</td>
</tr>
<tr>
<td>Rosemary Rosmarinus officinalis</td>
<td>Leaves</td>
<td>Cineol</td>
<td>Digestion stimulant, antiseptic</td>
</tr>
<tr>
<td>Thyme (Thymus vulgaris)</td>
<td>Whole plant</td>
<td>Thymol</td>
<td>Digestion stimulant, antiseptic, antioxidant</td>
</tr>
<tr>
<td>Mint (Mentha piperita)</td>
<td>leaves</td>
<td>Menthol</td>
<td>Appetite and digestion stimulant, antiseptic</td>
</tr>
<tr>
<td>Shatavari (Asparagus racemosus)</td>
<td>Root</td>
<td>Sapogenins, flavonoids and saponin</td>
<td>Prevention and treatment of gastric ulcers, dyspepsia and as a galactogogue.</td>
</tr>
<tr>
<td>Jivanti (Leptadenia reticulata)</td>
<td>Leaves and twigs</td>
<td>Stigmasterol, β – itosterol, flavonoids, pregnane glycosides</td>
<td>Galactogogue, antimicrobial and anti-inflammatory activity</td>
</tr>
<tr>
<td>Shatavari (Asparagus racemosus)</td>
<td>Root</td>
<td>Shatavarin-I-IV, quercitin, rutin, hyperoside</td>
<td>Galactogogue</td>
</tr>
</tbody>
</table>

(Source: Mirzaei-Aghsaghali, 2012)

Modes of Action and Beneficial Effects of Herbal Feed Additives
Plants have evolved a wide range of low molecular weight secondary metabolites. Generally these compounds enable the plants to interact with the environment and may act in a defense system against physiological and environmental stress as well as predators or pathogens. Beside compounds with toxic properties, several of these secondary plant metabolites have been reported to show beneficial effects in food products and also animal metabolism. Most of these active secondary plant metabolites belong to the classes of isoprene derivatives, flavonoides and glucosinolates, and a large number of these compounds have been suggested to act as antibiotics or as antioxidants (Rhodes, 1996 or Hirasa and Takemasa, 1998). Herbs develop their initial activity in the feed of farm animals as flavor and can therefore influence the eating pattern, secretion of digestive fluids and total feed intake. Herbs or phytochemicals can influence selectively the microorganisms by an anti-microbial activity or by a favorable stimulation of the eubiosis of the microflora. The mechanism by which the majority of herbal feed additives exert their antibacterial effect is by acting in the bacterial cell wall structure, denaturing and coagulating proteins. The essential oils alter the permeability of the cytoplasmic membrane to H+ and K+ ions. This change leads to the disruption of essential cellular processes such as electron transport, protein translocation, oxidative phosphorylation and other enzyme-dependent reactions, resulting in the loss of chemiosmotic control and, consequently, in bacterial death (Dorman & Deans, 2000). The disruption of the bacterial cytoplasmic membrane is due to the lipophilic nature of essential oils that accumulate in the membranes. Other action may be related to the inhibition of nutrient absorption, enzymatic inhibition, synthesis of DNA, RNA and synthesis of proteins by the bacterial cells. The antioxidant activity of essential oils is related mainly to the presence of phenolic compounds, flavonoids and terpenoids protect food, tissues and cells against the deleterious effect of autoxidation reactions.

Herbal feed additive affects improve nutrient utilization and absorption or the stimulation of the immune system. The possible mechanisms of action of herb in the animal for growth promotion include changes in the intestinal microbiota, increased digestibility and nutrient absorption; enhanced nitrogen absorption, improvement of the immune response morphological and histological modifications of the gastrointestinal tract and antioxidant activity. Finally herbs can contribute to the nutrient requirements of the animals and stimulate the endocrine system and intermediate nutrient metabolism.

Beneficial effects of herbs or botanicals in farm animals may arise from activation of feed intake and secretion of digestive secretions, immune stimulation, anti-bacterial, coccidiostatic, anthelmintic, antiviral or anti-inflammatory activity and antioxidant properties. The herbal feed additives exert their beneficial effects by:

1. **Influence of herbal feed additives on feed intake, digestibility of nutrients and animal performance:** After the ban on antibiotics, more herbs are used as feed additives for a better
growth condition. Due to the wide variety of active components, different herbs and spices affect digestion processes differently. Most of them stimulate the secretion of saliva. Curcuma, cayenne pepper, ginger, anis, mint, onions, fenugreek, and cumin enhance the synthesis of bile acids in the liver and their excretion in bile, what beneficially effects the digestion and absorption of lipids. Most of the prelisted spices stimulate the function of pancreatic enzymes (lipases, amylases and proteases); some also increase the activity of digestive enzymes of gastric mucosa. Besides the effect on bile synthesis and enzyme activity, extracts from herbs and spices accelerate the digestion and shorten the time of feed/food passage through the digestive tract (Frankic et al., 2009). Plant herbs such as garlic (*Allium sativum*), lemongrass (*Cymbopogon citratus*, DC. Stapf.) and peppermint (*Mentha piperita*) are widely used as antibacterial agents and extensively used to maintain the microbial ecosystem of the gastrointestinal tract especially in tropical regions (Shin and Kim, 2004). Garlic as an alternative growth promoter in livestock production reported improved growth rate, digestibility and carcass traits (Kongmun et al., 2011). Lemongrass and peppermint have been reported as feed additives to improve production performance of beef and dairy cattle (Yang et al., 2007). Recently menthol (*Mentha arvensis*) is reported to improved ileal protein and amino acid digestibility thus feed efficiency in weaned piglets (Maenner et al., 2011) and black pepper improved performance in broiler chicken (Tazi et al., 2014)

2. **Herbal feed additives as antimicrobial supplements:** Several studies showed strong antimicrobial activity of certain plant extracts against Gram− and Gram+ bacteria. Plants readily synthesize substances for their defense against insects, herbivores, and microorganisms. Moreover, they may produce secondary antimicrobial metabolites as a part of their normal growth and development or in response to stress. Several researches have studied the antimicrobial effect of oriental herbs including *Allium sativum*, *Angelica dahurica*, *Anguisorba officinalls*, *Artemisia argyi*, *Coptis chinensis*, *Dictamnus dasycarpus*, *Fraxinus rhynchophylla*, *Geranium thunbergii*, *Hydrastis canadensis*, *Phellodenron amurense*, *Polygonum cuspidatum*, *Scutellria baicalensis* and *Sophora flavescens*. These herbs contain major flavonoid components, baicalin, baicalein, limonene, cinnamaldehyde, carvacrol or eugenol which exerts antimicrobial effect along with other supportive herbs. These herbs have antibacterial effect against *Salmonella spp* or *E. coli* and gram positive bacteria *Staphylococcus spp* and *Streptococcus spp*. Active principles in herbal feed additives changes fatty acid composition which can affect surviving ability of microorganisms by increasing hydrophobicity. 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. Plant extracts, known as phytobiotics, have been exploited
for their antimicrobial, anti-inflammatory, anti-oxidative, and anti-parasitic activities. There is a lot of variations in the composition of phytobiotics due to the biological factors (plant species, growing location, and harvest conditions), manufacturing (extraction/distillation and stabilization) and the storage conditions (light, temperature, oxygen tension, and time; Huyghebaert et al., 2011).

3. **Herbal feed additives as anti-inflammatory**: Extracts of curcuma, red pepper, black pepper, cumin, cloves, nutmeg, cinnamon, mint and ginger showed anti-inflammatory effect. The major active molecules with anti-inflammatory action are phenols, terpenoids and flavonoids. These molecules suppress the metabolism of inflammatory prostaglandins. Phenolic compounds of plants are hydroxylated derivatives of benzoic acid and cinnamic acids and have been reported to possess anti-inflammatory effects. Flavonoids have long been recognized to possess anti-inflammatory, anti-allergic, antiviral and antiproliferative activities (Muanda et al., 2011). The most known herbs and spices with anti-inflammatory potential are chamomile, marigold, liquorice and anis (Frankic et al., 2009). Plants of the Labiatae families (like mint) have attracted a great interest. Their antioxidative activities are due to phenolic terpenes (Cuppett and Hall, 1998). Thyme and oregano contain large amounts of monoterpenes, thymol and carvacrol (Rahim et al., 2011). Plants rich with flavonoids such as green tea and other Chinese herbs have been described as natural antioxidant (Wei and Shibamoto, 2007). Black pepper (*Piper nigrum*), red pepper (*Capsicum annuum* L) and chili (*Capsicum fretuscene*) contain also several antioxidative compounds (Nakatani, 1994). But in many of these plants, the parts containing the active substances are of a very fragrant and/or spicy taste leading to restrictions of their use in animal feed. Recently anti-bacterial, anti-viral, anti-fungal, anti-tumor, anti-inflammatory, immunomodulatory, wound-healing, anti-oxidant, and anti-diabetic effects properties of *Aloe vera* have been reviewed for poultry (Babak and Nahashon, 2014).

4. **Herbal feed additives as antioxidants**: Antioxidants are compounds that help delay and inhibit lipid oxidation and when added to foods tend to minimize rancidity, retard the formation of toxic oxidation products, and help maintain the nutritional quality (Muanda et al., 2011). The health-promoting effect of antioxidants from plants is thought to arise from their protective effects by counteracting reactive oxygen species. Several studies suggested that plants rich in antioxidants play a protective role in health and against diseases, and their consumption lowered risk of cancer, heart disease, hypertension and stroke. The antioxidant potential of medicinal plants may be related to the concentration phenolic substances (flavonoids, hydrolysable tannins, proanthocyanidins, phenolic acids, phenolic terpenes) and some vitamins (E, C and A). Garlic and
onion biological action products are ascribed to its sulfur-containing active principle which has been reported to their lipid lowering effects and inhibit oxidation of low-density lipoproteins (Ahmed and Bassuony, 2009). Often used herbs rich in phenolics are: rosemary, thyme, oregano, sage, green tea, chamomile, ginko, dandelion and marigold. Herbs and spices can protect the feed against oxidative deterioration during storage.

5. **Herbal feed additives as immunostimulant:** 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, liquorice, garlic and cat’s claw. These plants can improve the activity of lymphocytes, macrophages and NK cells; they increase phagocytosis or stimulate the interferon synthesis (Frankic et al., 2009). Lavinia et al. (2009) have shown that 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 (Lavinia et al., 2009). Recently effect of β-glucan and cow urine distillate have been highlighted as immunomodulator in broiler chicken (Ganguly, 2013)

6. **Herbal feed additives as coccidiostat:** Some plant extracts have demonstrated an activity against some chicken parasites, especially coccidian (Naidoo et al., 2008; Arczewska-Wlosek and Swiatkiewicz, 2012). Betaine is a byproduct of the sugar beet industry; it has recently been seems to have a positive impact in fighting coccidiosis. It protects against osmotic stress associated with dehydration and permits normal metabolic activity of cells. However, the protective effects of betaine on the intestinal cells are also exerted on parasitic cells. The active component is curcumin; a phenolic compound coming from the rhizome of *Curcuma longa* exerts its anticoccidial effect through its antioxidant action on the immune system (Allen et al., 1998). *Galla rhois* and *Nectaroscordum tripedale* extracts have shown promising result against coccidial infection (Lee et al., 2012; Habibi et al., 2014)

**Advantages of Herbal Feed Additives**

Selection and feeding of herbal feed additives over other feed additives is due to:

1. Natural constituent of feeds.
2. Absence of residual effects.

**Limitations of Herbal Feed Additives**

1. Not easily quantifiable and standardized due to their complex composition.
2. The location, soil type, weather conditions, altitude, season during which the plant is grown, harvesting procedure and storage conditions may affect the composition of plants.

3. Although majority of herbals are stable, there are various constituents which are photo labile, thermo labile thus less stable.

4. Variety and environmental growth conditions, harvesting time and state of maturity, method and duration of conservation and storing, extraction method of the plants, as well as possible synergistic or antagonistic effects, anti-nutritional factors or microbial contamination are factors which may substantially affect the use of herbal feed additives.

Conclusion

Keeping farm animals healthy is necessary to obtain healthy animal products. For the last decade the use of additives of natural origin in animal and human nutrition has been encouraged. Numerous researches focused on the clarification of the biochemical structures and physiological functions of various feed additives like probiotics, prebiotics, organic acids and plant extracts. To gain advantageous effects of herbs and spices, they can be added to feed as dried plants or parts of plants and as extracts. But there need of research on various properties of specific herb for improving digestibility, antimicrobial, anti-inflammatory, anti-oxidant, immunostimulant effect and their effect dosages.

References


