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A review on herbal feed additives in livestock

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Abstract

Phytogenic feed additives are plant-derived products used in livestock nutrition to improve the performance of farm animals. The ban on nutritive antibiotic use in Europe and the increased awareness of the consumers triggered a need for natural and safe feed additives to achieve better production results of farm animals. Phytogenic feed additives comprise a wide variety of herbs, spices, and products derived thereof, and are mainly essential oils. Plant extracts are used in animal nutrition as appetite and digestion stimulants, stimulants of physiological functions, for prevention and treatment of certain pathological conditions, as colorants and antioxidants. This article is a review of present literature data on the commonly available herbs in India and usage of their medicinal properties including improve digestibility, antimicrobial, anti-inflammatory, anti-oxidant and immunostimulant in animal's diet.

Introduction

Keeping farm animals healthy is necessary to obtain healthy animal products. Only quality feed together with proper hygiene, potable water and management can ensure the production of nutritious animal products with desired organoleptic properties (Saxena, 2008). A ban of antibiotics as feed additives in animal nutrition is realized since 1986 in Sweden and later on to various countries. A general ban is foreseen in some years from now, because of the increased occurrence of pathogens resistant against therapeutical antibiotics used in animals and humans. With the restricted use or ban of dietary antimicrobial agents we must explore new ways to improve and protect the health status of farm animals (Wenk, 2003). In this aspect, herbs and spices are not just appetite and digestion stimulants, but can, with impact on other physiological functions, help to ensure good health and welfare of the animals, what can positively affect their performance.

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. During the last two decade the use of additives of natural origin in animal and human nutrition has been encouraged.

Feed additives are commonly described as non-nutrient substances that accelerate growth, efficiency of feed utilization and are beneficial for health or metabolism of the farm animals (Church and Pond, 1988). Beside the feed enzymes, probiotics, prebiotics (oligosaccharides), organic acids, the herbs and botanicals can be used as feed additives. A definition of various herbal feed additives can be derived from 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, flavour, scent, or the like.

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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 odour and other characteristic properties of the plant, used chiefly in the manufacture of perfumes, flavours and pharmaceuticals.

Active Principles in Herbs

To gain advantageous effects of herbs and spices, they can be added to feed as dried plants or parts of plants and as extracts. The composition of extracts from the same plant depends on the method of extraction and the properties of the extraction solvent used. Depending on the chemical characteristics of extraction solvents we can extract only certain molecules. Unpurified extracts contain a number of different molecules extracted with certain solvent, which can affect the action of each other, while purified extracts contain only one active component. Plants mainly contain one or some predominant active molecules (secondary metabolites), which are responsible for certain biological effects. The amount of these molecules varies depending on the variety of plant, growing conditions, harvest time etc. Generally these compounds enable the plants to interact with the environment and may act in a defence system against physiological and environmental stress as well as predators or pathogens (Wenk, 2003). Beside compounds with toxic properties, several of these secondary plant metabolites have been reported to show beneficial effects in food products and also in mammalian metabolism. They are of main relevance in herbs and are specifically enriched and eventually standardized in botanicals. The effect of active components from herbs and spices depends largely on the dosage used . No effect whatever can be observed at small doses; on the other hand, large amounts can be even toxic.

Modes of Action of Herbs And Botanicals

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 inhibition or - particularly - antioxidant properties. 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 in vivo as well as in food (Wenk, 2003). Often used plants, its active components and functions are presented in Table 1(Frankic, 2009).

Table 1: Often used plants, its active components and functions (Frankic, 2009)

Sr. No.	Plant	Used parts	Major active Component	Function
			Aromatic Species	
1.	Nutmeg	Seed	Sabinene	Digestion stimulant, antidiarrhoeic
2.	Cinnamon	Bark	Cimetaldehyde	Appetite and digestion stimulant, antiseptic
3.	Cloves	Cloves	Eugenol	Appetite and digestion stimulant, antiseptic
4.	Cardamom	Seed	Cineol	Appetite and digestion stimulant
5.	Coriander	Leaves, Seed	Linalol	Digestion stimulant
6.	Cumin	Seed	Cuminaldehyde	Digestive,Carminative, Galactagogue
7	Anise	Fruit	Anethol	Digestion Stimulant, Galactagogue
8	Celery	Fruit, Leaves	Phtalides	Appetite and digestion stimulant
9.	Parsley	Leaves	Apiol	Appetite and digestion stimulant, antiseptic
10.	Fenugreek	Seed	Trigonelline	Appetite stimulant
			Pungent spices	
11.	Capsicum	Fruit	Capsaicin	Digestion stimulant
12.	Pepperr	Fruit	Piperine	Digestion stimulant
13.	Horsradish	Root	Allylizotiocianat	Appetite stimulant
14.	Mustard	Seed	Allylizotiocianat	Digestion stimulant
15.	Ginger	Rizome	Zingerone	Gastric stimulant
16	Garlic	Bulb	Allicin	Digestion stimulant, antiseptic
			Herbs	
17	Rosemary	Leaves	Cineol	Digestion stimulant, antiseptic, antioxidant
18	Thyme	Whole plant	Thymol	Digestion stimulant, antiseptic, antioxidant
19	Sage	Leaves	Cineol	Digestion stimulant, antiseptic, carminatif
20	Laurel	Leaves	Cineol	Appetite and digestion stimulant, antiseptic
21	Mint	Leaves	Menthol	Appetite and digestion stimulant, antiseptic

Herbs develop their initial activity in the feed of farm animals as flavour and can therefore, influence the eating pattern, secretion of digestive fluids and total feed intake. Herbs or the phytochemicals can influence selectively the micro-organisms by an anti-microbial activity or by a favourable stimulation of the eubiosis of the microflora. The consequence can be a better nutrient utilization and absorption or the stimulation of the immune system. Finally herbs can contribute to the nutrient requirements of the animals and stimulate the endocrine system and intermediate nutrient metabolism.

Often the desired activity of herbs is not constant. Conflicting results may arise from the natural variability of the composition of plant secondary metabolites. 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 results of in vivo experiments. For example, rosemary and sage from different geographical locations and types of processing (dried herbs and essential oils) or from different suppliers (Wenk, 2003) showed significant differences in antioxidative capacity. Furthermore, several secondary plant metabolites are showing strong flavours, which may affect sensory characteristics of the feed and, therefore, feed intake. Additionally, antibacterial properties and probably concentration dependent effects on feed intake and on digestion of nutrients can be expected and should be taken into consideration when conducting in vivo experiments with phytochemicals using farm animals.

Common Herbs Found in India

Turmeric (Curcuma Longa)

Turmeric is commonly called "Haridra" in Sanskrit, "haldar" in Gujarati, Haldi in Hindi "Pasupu" in Telugu, Kaha in Sinhala, Manjal in Tamil and "Arisina" in Kannada, (Eevuri and Putturu, 2012). Turmeric is a rhizomatous herbaceous perennial plant of the family Zingiberaceae, with medicinal properties known to possess antimicrobial and anti-oxidant properties. Rhizome is the segment of medicinal importance and is usually boiled, cleaned, dried and powdered before usage.

Composition

Dried turmeric contains 6.3% protein, 5.1% fat, 3.5% minerals, 69.4% carbohydrates and 13.1% moisture. It contains up to 5% essential oils and up to 5% curcumin (polyphenol). Curcumin is the active substance of turmeric which is known as C.I. 75300, or Natural Yellow 3. The active ingredients of turmeric are tetrahydro curcuminoids, curcumin, dimethoxy curcumin and bismethoxy curcumin (HMPC, 2009).

Uses: The continuing research indicates that turmeric and its active compound "Curcumin" is unique anti-oxidants, antimutagenic, antitumorigenic, anticarcino-genic, anti-inflammatory, antiarthritis, antimicrobial and hypocholesterolemic properties (Gowda et al., 2009). Therapeutic properties of turmeric include anti-oxidant, anti-diabetic, antibacterial, antifungal, antiprotozoal, antiviral and hypocholesteremic activities (Abbas et al., 2010; Ahmadi, 2010).

Turmeric and curcumin have been shown to protect liver against a variety of toxicants including carbon tetrachloride, aflatoxin B_1 and cyclophospha-mide in mouse, rat and duckling (Soudamini and Kuttan, 1992). The curcuminoids present in turmeric powder have shown protective effect against aflatoxin B_1 (Gowda et al., 2008). The traditionally turmeric is used in various conditions like biliary disorders, anorexia, cough, diabetes, wounds, hepatic disorders, rheumatism and sinusitis.

Tulsi (*Ocimum Tenuiflorum*)

Tulsi or *tulasi* (Holy Basil) is an aromatic plant in the family Lamiaceae, which is native throughout the Old World tropics and widespread as a cultivated plant and an escaped weed. The two main morphotypes cultivated in India and Nepal are green-leaved (Sri or Lakshmi *Tulsi*) and purple-leaved (Krishna *Tulsi*) .

Composition

Tulsi contains eugenol (1-hydroxy 2-methoxy 4 allyl benzene) a phenolic compound and ursolic acid having pharmacological effects. Other chemical constituents of *Tulsi* are: oleanolic acid, rosmarinic acid, carvacrol, linalool, β-caryo-phyllene, β-elemene, β-caryophyllene and germacrene-D (Prakash and Gupta 2005).

Uses

Tulsi is an effective treatment for reducing blood glucose levels and total cholesterol levels (Suanarunsawat et al., 2011). It is a well known therapeutic agent for several pathological conditions possess antistress and antioxidant properties and also possess remarkable biological activities like

antimicrobial, immunomodulatory, anti-cancerous, anti-oxidant, anti-inflammatory, hepatoprotective and cardioprotective etc. It also shows some promise for protection from radiation poisoning and cataracts. Experimental studies indicated that an alcoholic extract of *Tulsi* modulates immunity, thus promoting immune system function (Mondal et al, 2011). Marked by its strong aroma and astringent taste, it is regarded in Ayurveda as a kind of "elixir of life" and believed to promote longevity. *Tulsi* extracts are used in ayurvedic remedies for common colds, headaches, stomach disorders, inflammation, heart disease, various forms of poisoning, and malaria. Traditionally, *tulsi* is taken in many forms: as herbal tea, dried powder, fresh leaf, or mixed with *ghee*. Essential oil extracted from Karpoora *Tulsi* is mostly used in skin preparations due to its antibacterial activity.

Amla

Phyllanthus emblica (syn. *Emblica officinalis*), the Indian gooseberry, or *aamla*, is a deciduous tree of the Phyllanthaceae family and is known for its edible fruit. Common name of this tree include Usiri (in Telugu), Nellikai (in Tamil and Kannada).

Composition

Amla powder contains 5.05 to 6.78 per cent moisture, 0.23 to 0.59 per cent fat and minerals like Calcium 79.6mg, Phosphorous 12.38mg and Iron 88.03mg/100g (Mishra et al., 2009). Amla is one of the richest sources of Vit-C. Several active tannoid principles (Emblicanin-A, Emblicanin-B, Punigluconin and pedunculagin) have been identified for their health benefits. The fruit also contains other polyphenols: flavonoids, kaempferol, ellagic acid and gallic acid (Rehman et. al., 2007).

Uses: Medical studies conducted on Amla fruit suggest that it has antiviral, anti-bacterial and anti-fungal propertiest. Amla has been particularly indicated for anemia, asthma, bleeding gums, diabetes, chronic lung disease, hyperlipidaemia, yeast infections, scurvy and cancer. Amla has been known in Ayurvedic medicine for its tonifying, anti-ageing and immune enhancing properties (Eevuri and Putturu, 2012). Animals fed on amla powder showed better ability for uptake and killing of bacteria, which might be due to the presence of tannins which stimulates phagocytic cells.

Indian gooseberry has undergone preliminary research, demonstrating *in vitro* antiviral and antimicrobial properties. There is preliminary evidence *in vitro* that its extracts induce apoptosis and modify gene expression in osteoclasts involved in rheumatoid arthritis and osteoporosis (Pennolazzi et al, 2008). It also promoted the spontaneous repair and regeneration process of the pancreas occurring after an acute attack (Sidhu et al., 2011). Experimental preparations of leaves, bark or fruit have shown potential efficacy against laboratory models of disease, such as for inflammation, cancer, age-related renal disease, and diabetes. It has antioxidant property eventhough it has high density of tannins.

All parts of Amla tree are used in ayurveda / unani medicines. It may be used as a herbal *rasayana* called *Chyawanprash* (rejuvenative) to promote longevity, and traditionally to enhance digestion, treat constipation, reduce fever, purify the blood, reduce cough, alleviate asthma, strengthen the heart, benefit the eyes, stimulate hair growth, enliven the body, and enhance intellect (Rehman et. al., 2007).

Aloe Vera (*Aloe barbadensis*)

Aloe vera belongs to *Asphodelaceae* (*Liliaceae*) family, and is shrubby, perennial, xerophytic, succulent, pea-green color plant. It has fleshy, long triangular leaves that have spikes along the edges. The fresh parenchymal gel from the centre of the leaf is clear and dried to form concentrate and juice products. The sticky latex liquid is derived from the yellowish green pericyclic tubules that line the leaf (rind): this is the part that yields laxative anthraquinones (Eevuri and Putturu, 2012).

Composition

Dried aloe contains 73.07% carbohydrates, 4.73% protein, 0.27% fat and trace amounts of tannins (0.155%g/100g), oxalate (0.68g/100g) and Phytate (0.54g/100g). It contains phyto-chemicals like saponins (5.651g/100g), flavanoids (3.246g/100g), alkaloids (2.471g/100g) and phenols (0.232g/100g) phenols, which is an indicative of cosmetic and medicinal value. It is also rich in minerals like Na, K, P, and Mg (Adesuyi et al., 2012).

Uses

Aloe vera promotes the rate of wound healing and effective in treatment of wounds. Topical application is effective for genital herpes and psoriasis. Aloe vera extracts may be useful in the treatment of diabetes and elevated blood lipids in humans (Boudreau and Beland, 2006) which is due to the presence of compounds such as mannans, anthraquinones and lectins.

Aloe vera extracts have been used as immunostimulant that aids in fighting cancers in cats and dogs (King et al., 1995). Extracts of aloe vera might have anti-bacterial and anti-fungal activities which possibly could help to treat minor skin infections such as boils, benign skin cysts and may inhibit growth of fungi causing tinea. Juice from the pulp is useful for treating jaundice, menstrual disorders, scalp disorders, skin diseases, burns and haemorrhoids. Moghadassi and Verma (2011) has reviewed that it is useful for skin damaged from X-rays. On other hand concentration of glucose in gelatin results in high osmotic pressure that protects skin from live bacteria.

Ginger (*Zingiber officinale*)

Ginger is a rhizomatous plant grown throughout South Eastern Asia, China and parts of Japan, Austria Latin America, Jamaica and Africa. It has been used as spice and medicine in India and China since ancient times (Sasidharan and Nirmala, 2010).

Composition

Dried ginger contains 7.8% protein, crude fibre 6.2%, Ether extract 11.0% and ash 9.0% (Aletor, 2014). It contains phyto-chemicals like Gingerol, Ginderdiol, Gingerdione, dehydroshogaol, Curcumene, Gingerone, Zingiberene, Camphene, and Paradol (Agarwal et al., 2001; Gupta and Ravi Shankar, 2005; Ali et al 2008).

Uses

Ginger is used as growth promoter, antimicrobial and antioxidant agent, hypolipidemic or anti hyperlipidemic, hupocholesterolomic, meat and carcass quality improver (Agarwal et al., 2001; Ademola, 2009; Zhang et al., 2009).

Garlic (*Allium sativum*)

Garlic is spice / herb well known for its medicinal uses and its origin assumed to be in Central Asia. It is a medicinal plant of Alliceae family. Garlic is used in various food products and herbal products and Indian garlic is famous for its aroma with sweetness.

Composition

Dried garlic contains 27.4% crude protein, crude fibre 1.0%, Ether extract 2.5% and ash 1.5% (Aletor, 2014). Garlic contains at least 33 sulphur compounds, which are responsible both for garlic pungent odour and many of its medicinal effects like lowering cholesterol level. It contains phyto-chemicals like Allicin, Diallyl Sulphide, Diallyl Trisulphide and Ajone (Chang and Cheong, 2008; Kim et al 2009; Choi et al 2010).

Uses

A variety of herbal supplement including garlic have been widely used to maintain and improve health of human. It has been long being considered that garlic has several beneficial effects for human and animals, exhibiting antimicrobial and antioxidant, antiviral antifungal anti parasitic properties (Ankri and Mirelman, 1999).

Possible Use of Herbs and Spices

Herbs and Spices as Appetite and Digestion Stimulants

There is evidence to suggest that herbs, spices and various plant extracts have appetite and digestion-stimulating properties (Afshar, 2012). When considering supplementing the feed with herbs and spices or their extracts to stimulate the appetite, we have to know the taste preferences of different animal species. The spices known for their appetite stimulant effect are cinnamon, cloves, cardamom, laurel and mint. Janz *et al.* (2007) found that pigs preferred the feed supplemented with garlic or rosemary over the feed supplemented with oregano or ginger.

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 (Afshar, 2012).. 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 (Srinivasan, 2005). 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 (Suresh and Srinivasan, 2007).

Influence of Herbs or Botanicals on Feed Intake

A large number of herbs are used as feed additives to replace the antibiotics for livestock production. Wenk (2003) reported that 0.25% Turmeric in feed of laying hens improved feed intake but at higher levels up to 1% feed intake returned to the control treatment without supplementation. In has been concluded that in both species (piglet and broiler) a slight increase in

feed intake could be observed at least partly at low levels and then a dramatic decrease at higher levels of a particular herb.

Antimicrobial Action of Herbs and Spices

Feed supplements with growth promoting activity increase stability of feed and beneficially influence the gastrointestinal ecosystem mostly through growth inhibition of pathogenic microorganism's growth. Due to improved health status of digestive system, animals are less exposed to the toxins of microbiological origin. Consequently herbs and spices help to increase the resistance of the animals exposed to different stress situations and increase the absorption of essential nutrients, thus improving the growth of the animals (Windisch et al., 2008).

Numerous secondary metabolites formed by plants serve as defence agents against physiological and environmental stressors, predators and pathogenic microorganisms. Several *in vitro* studies showed strong antimicrobial activity of certain plant extracts against Gram" and Gram positive bacteria. Pasqua et al. (2006) found a change in long chain fatty acid profile in the membranes of *E. coli* grown in the presence of limonene or cinnamaldehyde. Similar observations were made with *Salomonella enterice* grown in the presence of carvacrol or eugenol and with *Bronchotrix thermosphacta* grown in the presence of limonene, cinnamaldehyde, carvacrol or eugenol. The changes in fatty acid composition can affect surviving ability of microorganisms. The studies measuring hydrophobicity of *E. coli* (test for measuring the ability of microbial attachment) showed a large increase of hydrophobicity of *E. coli* grown in the presence of Chinese cinnamon and a moderate increase when medium was supplemented with thyme or Ceylon cinnamon (Wenk, 2003). 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).

The exact antimicrobial action of herbs and spices in *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. Castillo et al. (2006) reported that the mixture of cinnamaldehyde, capsicum oleoresin and carvacrol enhances the growth of lactobacilli, and so increases the ratio of lactobacilli to enterobacteria. So herbs and spices do not posses only the antimicrobial activity, but also modulate the composition of microbial population by prebiotic activity.

Anti -Inflammatory Action

Extracts of curcuma, red pepper, black pepper, cumin, cloves, nutmeg, cinnamon, mint and ginger showed anti-inflammatory effect in the studies on rats (Srinivasan, 2005). The major active molecules with anti-inflammatory action are terpenoids and flavonoids and suppress the metabolism of inflammatory prostaglandins.

Antioxidative Action

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 peroxidise and glutathione reductase. Main molecules responsible for the antioxidative properties of herbs and spices are phenolic substances (flavonoids, hydrolysable tannins, proanthocianidins, phenolic acids, phenolic terpenes) and some vitamins (E, C and A). Often used herbs rich in phenolics are: rosemary, thyme, garlic, oregano, sage, green tea, chamomile, ginko, dandelion and marigold.

The health promoting effect of antioxidants from plant is thought to arise from their protective effects by counteracting reactive oxygen species. 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 (Aghsaghali, 2012). Herbs and spices can protect the feed against oxidative deterioration during storage.

The herb commonly used for feed/food preservation is rosemary (*Rosmarinus officinalis*) and it can be used individually or in combination with tocopherols or synthetic antioxidants (Jacobsen et al., 2008).

Immunostimulant Function

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 interpheron synthesis (Craig, 1999).

Conclusion

With the trend towards more "natural" animal production systems, anti-microbial agents are being replaced by herbal feed additives. These are not just appetite and digestion stimulants, but can, with impact on other physiological functions, help to sustain good health and welfare of the animals and improve their performance. They can regulate feed intake and stimulate digestive secretions and finally an optimized digestion capacity with reduced risk of digestive disorders. Several phytochemicals like essential oils or dietary fibre can contribute to a balanced microflora (eubiosis), an optimal precondition for an effective protection against pathogenic micro-organisms and an intact immune system. The common herbs found in India are Turmeric, Tulsi, Amla, Aloe vera, Neem, Garlic, Ginger and other various types of spices. Possible use of herbs can be summarised as appetite and digestion stimulants, increased feed intake, antimicrobial action, anti-inflammatory, Antioxidative and Immuno-stimulant function. Current studies show promising results regarding the use of phytochemicals as growth and production promoters. There is still a need to clarify the phytochemical composition and the mechanisms of action for many herbs, spices and their extracts and furthermore, to assess the appropriate dose that should be safely used in specific circumstances and animal species.

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