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Phytogenics as New Class of Feed Additive in Poultry Industry

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Abstract: The aim of this study summarizes the experimental knowledge on efficacy, possible modes of activity and aspects of application of phytogenic products as feed additives for poultry. Feed additives are a group of feed ingredients that can cause a desired animal response in a non-nutrient role such as pH shift, growth or metabolic modifier. Many substances found in nature have a wide range of growth promoting, immunostimulatory or antimicrobial activity. Common feed additives used in poultry diets include antimicrobials, antioxidants, pH control agents and enzymes. Phytogenic are a relatively young class of feed additives and in recent years this feed additives have gained considerable attention in the feed industry. They are a wide variety of herbs, spices and products derived thereof and are mainly essential oils. Although, numerous reports have demonstrated antioxidative and antimicrobial and immune stimulation efficacy *in vitro*, respective experimental *in vivo* evidence is still quite limited. A limited number of experimental comparisons of phytogenic feed additives with antibiotics and acidifiers have suggested similar effects on the gut. Gut microflora has significant effects on host nutrition, health and growth performance by interacting with nutrient utilization and the development of gut system of the host. In addition, some phytogenic compounds seem to promote intestinal mucus production. However, a systematic approach toward the efficacy and safety of phytogenic compounds used as feed additives for poultry is still lacking.

Key words: Antimicrobial, botanical, essential oil, feed additive, phytogenic, poultry, broiler

INTRODUCTION

Feed additives are products used in animal nutrition for purposes of improving the quality of feed and the quality of food from animal origin or to improve the animals performance and health. The initial use of antibiotics in diets arose from the discovery in the late 1940's, in the United States that including the fermentation products of *Streptomyces aureofaciens* (a strain of bacteria) in the diets of simple-stomached animals such as pigs and poultry resulted in growth responses (Frost, 1991).

It is important to make a distinction between antibiotics used in the treatment and prevention of disease in farm animals (prescribed therapeutic and prophylactic use) which differs from their use as feed additives to enhance growth (Castanon, 2007). As feed additives, antibiotics are used at low concentrations of 2.5-50 ppm (depending on the compound used). In the next 50 years, the use of antibiotics as feed additives in pig and poultry production became virtually universal. However, the possibility of developing resistant populations of bacteria and the side effects of using antibiotics as growth promoters in farm animals have been led to the European Union and United States ban on the use of antibiotics on farm animals as growth and health promoters.

This will have avoidable consequences for growth performance of birds in the poultry industry. Hence, an intensive search for alternatives such as probiotics, prebiotics, symbiotics, enzymes, toxin binders, organic acids, organic minerals, oligosaccharides and other feed additives has started in the last decade (Fulton *et al*., 2002). Phytogenics are a group of natural growth promoters or non-antibiotic growth promoters, derived from herbs, spices or other plants. In this context, the present research provides an overview of recent knowledge on the use of phytogenic feed additives in poultry diets and possible modes of action and safety implications.

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PLANT SECONDARY METABOLITES (PSM)

The biological or therapeutic activity of a medicinal plant is closely related to the plant chemicals in it. As Plant Secondary Metabolites (PSM) are an extremely large group of compounds, a comprehensive overview of their biochemistry, bioactivity and chemistry is not possible in a relatively short paper. PSM, also known as phytochemicals, represent a diverse group of natural products, some of which may be nutritionally valuable but many of which have no nutritional value or antinutritional properties. Although precise numbers are at best an estimate, of the >100000 different compounds of natural origin that have been described >80000 are derived from plants. These chemicals can be classified into major groups of chemicals such as essential oils, alkaloids, acids, steroids, tannins, saponins and so forth. Each one of these classes of chemicals may have a preferred effective method of extraction.

SAFETY OF PLANTS

Herbal plants and plant derived products are known for herb medicinal values for centuries. They are also extensively used, particularly in many Asian, African and other countries. It is estimated that there are 250,000-500,000 species of plants on earth (Borris, 1996). Relatively small percentages (1-10%) of these are used as foods by both humans and other animal species (Cowan, 1999). Compared with synthetic antibiotics or inorganic chemicals, these plant-derived products have proven to be natural, less toxic, residue free and are thought to be ideal feed additives in food animal production (Hashemi *et al*., 2008).

HERBAL PLANTS CLASSIFICATION

With respect to biological origin, formulation, chemical description and purity, phytobiotics comprise a very wide range of substances and 4 subgroups may be classified) herbs (product from flowering, non-woody and non-persistent plants) botanicals (entire or processed parts of a plant, e.g., root, leaves, bark) essential oils (hydro distilled extracts of volatile plant compounds) and oleoresins (extracts based on non-aqueous solvents) (Windisch and Kroismayr, 2006).

HERBAL PLANTS PROPERTIES

Antimicrobial (Guo *et al*., 2004a), antioxidant (Hashemi *et al*., 2009a), anti-stress (Chattopadhyay *et al*., 2005), gut microflora manipulation (Hashemi *et al*., 2009b), nutrigenomics effect (Franco-Jimenez *et al*., 2007) and immune enhancement (Guo *et al*., 2004b) properties probably are the major mechanisms by which herbal plants exert positive effects on the growth performance and health of animals (Fig. 1).

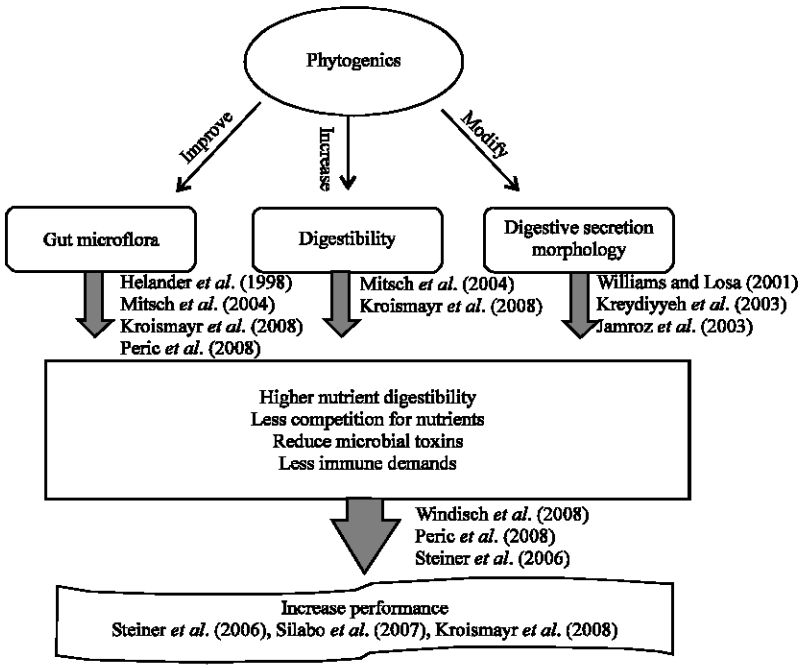

Fig. 1: Main mechanisms of herbal plants exert positive effects on the growth performance and health of animals. Tobias Steiner, BIOMIN GmbH, Herzogenburg, Austria with some modification

ANTIBACTERIAL ACTIVITY OF PHYTOBIOTICS

Herbs and spices are well known to exert antimicrobial actions *in vitro* against important pathogens including fungi (Windisch *et al*., 2008). A common feature of phytobiotics is that they are a very complex mixture of bioactive components. For example, hawthorn fruit, a common growth-enhancing and digestion modifier has been shown to contain >70 kinds of organic chemicals along with some unidentified factors and active bio-active compounds (Wang *et al*., 1998).

Growth enhancement through the use of phytobiotics is probably the result of the synergistic effects among complex active molecules existing in phytobiotics. Phytochemicals in phytobiotics are well known to have antimicrobial ability (Cowan, 1999). Phytochemicals exert their antimicrobial activity through different mechanisms, tannins for example act by iron deprivation, hydrogen bounding or non specific interactions with vital proteins such as enzymes (Scalbert, 1991).

Chung *et al*. (1993) showed that tannic acid inhibits the growth of intestinal bacteria such as *Bacteroides fragilis*, *Clostridium perfringens*, *E. coli* and *Enterobacter cloacae*. Alkaloid is known to be a DNA intercalator and an inhibitor of DNA synthesis through topoisomerase inhibition (Karou *et al*., 2006). The main mechanism by which saponins display an antimicrobial activity is based on their ability to form complexes with sterols present in the membrane of microorganisms.

This causes damages in the membrane and the consequent collapse of cells (Morrissey and Osbourn, 1999). Essential oils have long been recognized for their anti-microbial activity (Lee *et al*., 2004a) 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; Mitsch *et al*., 2004).

The exact anti-microbial mechanism of essential oils is poorly understood. However, it has been suggested that their lipophilic property (Conner, 1993) and chemical structure (Farag *et al*., 1989a, b) 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 (Helander *et al*., 1998). Moreover, structural properties, such as the presence of the functional groups (Farag *et al*., 1989c) and aromaticity (Bowles and Miller, 1993) are also responsible for the antibacterial activity of essential oils.

PHYTOGENICS AS FEED ADDITIVES IN POULTRY

In recent years, phytogenic feed additives have attracted increasing interest as an alternative feeding strategy to replace antibiotic growth promoters. Effect of phytobiotic feed additives on production performance in poultry are shown in Table 1. Hernandez *et al.* (2004) reported that extracts from sage, thyme and rosemary and the blend of carvacrol, cinnamaldehyde and capsaicin improved feed digestibility in broilers. The researchers attributed the positive effects of plant extracts on nutrient digestibility to the appetite and digestion-stimulating properties and antimicrobial effects. Therefore they may exert multiple functions in the animal body. Increased feed intake and digestive secretions are also observed in animals offered phytobiotic-supplemented feed (Windisch and Kroismayr, 2006).

The primary mode of action of phytogenic feed additives arises from beneficially affecting the ecosystem of gastrointestinal microbiota through controlling potential pathogens. Improved digestive capacity in the small intestine may be considered an indirect side effect of phytogenic stabilizing the microbial eubiosis in the gut. Consequently, phytogenic relieve the host animals from immune defense stress during critical situations and increase the intestinal availability of essential nutrients for absorption, thereby helping animals to grow better within the framework of their genetic potential.

Ground thyme has been shown to inhibit the growth of *S. typhimurium* when added to media (Aktug and Karapinar, 1986). The essential oil of the thyme has been shown to inhibit the growth of the *E. coli* in media (Marino *et al*., 1999). However, bird growth responses to essential oil supplementation are still controversial (Table 2). No essential oil effects on growth performance were reported by Botsoglou *et al.* (2002), Zhang *et al.* (2005), Jang *et al.* (2007) whereas improved growth performance were observed at different ages of birds fed certain essential oil supplemented diet(s) by Jamroz *et al.* (2003), Hernandez *et al.* (2004) and Cross *et al.* (2007) (Table 3).

The effect of *hymus vulgaris* (thyme) and *Cinnamomuim zeylanicum* (cinnamon) on the performance of broilers was studied by Al-Kassie *et al.* (2009) who found their effect on the live weight gain and the improvement of the health of poultry in addition to other performance traits, feed conversion ratio and feed intake. Guo indicated that 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. Immuno-

Table 1: Effect of phytobiotic feed additives on production performance in poultry[1]

		Treatment effect, percentage of difference from untreated control				
Phytobiotic feed additive	Dietary dose (g kg^{-1})	FI	BW	ADG	FCR	Reference
Broilers						
Plant extracts						
Oregano	0.150	-6	-	-2	-4	Basmacioglu *et al*., 2004
Oregano	0.300	-3	-	+1	-2	Basmacioglu *et al*., 2004
Rosemary	0.150	0	-	-1	-1	Basmacioglu *et al*., 2004
Rosemary	0.300	-2	-	+1	-4	Basmacioglu *et al*., 2004
Thymol	0.100	+1	-	+1	-1	Lee *et al*., 2003
Cinnamaldehyde	0.100	-2	-	-3	0	Lee *et al*., 2003
Thymol	0.200	-5	-	-3	-3	Lee *et al*., 2003
Carvacol	0.200	+2	-	+2	-1	Lee *et al*., 2003
Yucca extract	2.000	-1	-	+1	-6	Yeo and Kim, 1997
Essential oil blend	0.024	-4	0	-	-4	Cabuk *et al*., 2006
Essential oil blend	0.048	-5	0	-	-6	Cabuk *et al*., 2006
Plant extracts[2]	0.200	-	-2	0	-2	Hernandez *et al*., 2004
Plant extracts[2]	5.000	-	+2	+3	-4	Hernandez *et al*., 2004
Plant extracts[2]	0.500	0	-2	-2	+2	Botsoglou *et al*., 2004a
Plant extracts[2]	1.000	+2	-1	0	+2	Botsoglou *et al*., 2004a
Essential oil blend	0.075	-7	-	-3	-4	Basmacioglu *et al*., 2004
Essential oil blend	0.150	-7	-	-1	-1	Basmacioglu *et al*., 2004
Essential oil blend	0.036	+3	-8	-	-5	Alcicek *et al*., 2004
Essential oil blend	0.048	+2	-8	-	-4	Alcicek *et al*., 2004
Plant extracts[1]	0.100	+1	-	+1	0	Lee *et al*., 2003
Essential oil blend	0.024	-2	0	-	-2	Alcicek *et al*., 2003
Essential oil blend	0.048	0	+14	-	-12	Alcicek *et al*., 2003
Essential oil blend	0.072	-2	+8	-	-9	Alcicek *et al*., 2003
Herbs and spices						
Oregano	5.000	+5	-	+7	-2	Florou-Paneri *et al*., 2006
Thyme	1.000	+1	+2	-	-1	Sarica *et al*., 2005
Garlic	1.000	-5	-5	-	0	Sarica *et al*., 2005
Herb mix	0.250	0	-	+2	-2	Guo *et al*., 2004a
Herb mix	0. 50	+5	-	+2	+3	Guo *et al*., 2004a
Herb mix	1.000	+2	-	+1	+1	Guo *et al*., 2004b
Herb mix	2.000	+1	-	+1	0	Guo *et al*., 2004b
Turkeys						
Herbs and spices						
Oregano	1.250	-5	+2	-	-	Bampidis *et al*., 2005
Oregano	2.500	-6	+1	-	-	Bampidis *et al*., 2005
Oregano	3.750	-9	+1	-	-	Bampidis *et al*., 2005
Quail						
Essential oils						
Thyme	0.060	0	-	+6	-	Denli *et al*., 2004
Black seed	0.060	+1	-	+2	-	Denli *et al*., 2004
Herbs and spices						
Coriander	5.000	+3	-	+1	+1	Guler *et al*., 2005
Coriander	10.000	+3	-	+5	-1	Guler *et al*., 2005
Coriander	20.000	+4	-	+8	-4	Guler *et al*., 2005
Coriander	40.000	+5	-	+4	+1	Guler *et al*., 2005

Windisch *et al*., 2008 [2]Entire product

active polysaccharides derived from two mushrooms, *Tremella fuciformis* and *Lentinus edodes* and the herb *Astragalus membranacea* Radix seem to be potential alternatives for antimicrobial growth and health promoters.

These products were considered to play an important role in strengthening the animals defense system by improving the physical conditions of gut ecosystem and enhancing functions of the immune system of chickens. Lower population of pathogenic bacteria may increase availability of nutrients eliminate sub-clinical infections and reduce production of growth-depressing toxins or metabolites by intestinal microflora.

However, bird growth responses to herbal plants and its derived supplementation are still controversial. While comparing the effects of various herbs and oils on broiler performance, Cross *et al*. (2007) concluded that the quality as well as the quantity of active chemicals in plant extract determines bird response. Some factors may affect

Table 2: Literature review of the effects of specific essential oil blends on live performance, carcass traits and digesta parameters

Essential oil composition	Diet, husbandry and challenge conditions	Effect of EO reference	References
Blend non specified	+20 mg kg^{-1} virginiamycin. Three experiment in cages	No effect on BW and FCR	Vogt, 1990, 1991
Crina® poultry	Floor pens	No effect on BW and FCR	Ristic and Damme, 2001
Oregano (carvacrol-thymol)	Wheat-soybean meal basal diet- floor pens	No effect on BW and FCR	Botsoglou *et al*., 2002
Carvacrol and cinnamaldehyde combination		Negative effects as compared to the two fed individually	Lee *et al*., 2004c
EO blends		Improve antioxidant activity in carcasses	Dorman *et al*., 1995; Saricoban and Ozcan, 2004; Basmacioglu *et al*., 2004
Apacox®		No effect on BW and FCR, retarded lipid oxidation in meat	Botsoglou *et al*., 2004a, b
Genex® (EO+organic acids) 500-1000 ppm		Growth promoting effect compared to flavomycin	Spais *et al*., 2002
Capsaicin, carvacrol,cinnamic aldehyde,150-300 ppm	Wheat-barley diet	Improvement in BW (5.4,8.1%) and feed conversion (3.1 and 7.1%). Reduced *E. coli* and *C. perfringens*	Jamroz *et al*., 2003
Crina® Poultry; or thymol and cinnamaldehyde	Maize-maize starch-soybean meal diet in wire floored cages	No effect of BW and FCR Amilase activity improved in Crina®	Lee *et al*., 2003
Cinnamaldehyde	Diet with carboxymethyl cellulose, rye	Reverse negative effects of high viscosity diets	Lee *et al*., 2004 a, b
Blend from Turkey	Corn-soybean meal diets with wheat and sunflower meal in floor pens	Improved BW, FCR andcarcass yield	Alcicek *et al*., 2003
Crina® poultry and combinations with antibiotics and lactic acid		Improve BW, FCR Combination with antibiotics or lactic acid did not show any effect	Suk *et al*., 2003
EO blend plus lactic acid		Improve BWG and increase digestive enzyme activities of the pancreas and intestinal mucosa	Jang *et al*., 2004
Oregano (carvacrol and thymol)		Reduced feed intake and significantly improve feed efficiency	Halle *et al*., 2004
EO blend		Improve BWG, FCR and carcass yield	Alcicek *et al*., 2004
RepaXol™ (oregano, cinnamon, thyme and capsicum) 100-300 ppm	Corn soybean meal diets in floor pens and cages from 1-42 days	No effect on BWG, FCR or FI. Improvement of final carcass yield and Feed efficiency at 14 days but not over the course of the experiment	Zhang *et al*., 2005
Crina® poultry and Crina® Alternate	Corn soybean meal diets in floor from 1-49 days Cocci-vaccinated birds	Improvement of FCR 13 days but not over the course of the experiment. No effect on cocci-vaccinated birds	Oviedo-Rondon, 2005d
Oregano (carvacrol and thymol)	*Eimeria tenella* infection-cages	Improve responses	Giannenas *et al*., 2003
Oregano (carvacrol and thymol)	Mixed Eimeria vaccination	Improvement in BWG andFI	Waldenstet, 2003
Oregano (carvacrol and thymol)	Mixed Eimeria infection and induced necrotic enteritis	Improve BWG, lesion scores	Saini *et al*., 2003a, b
Thymol, carvacrol, eugenol, curcumin and piperin.	12 field trials to test *Clostridium perfringens* Numbers	Reduced Clostridium perfringens colonization	Mitsch *et al*., 2004
Crina® Poultry and Crina® Alternate	Mixed Eimeria vaccination and infection	Crina Alternate but not Crina Poultry improved BWG, FCR and lesion scores post-infection. No effect on cocci-vaccinated birds	Oviedo-Rondon, 2005a-c

Ferket *et al*., 2005

Table 3: Effects of essential oils on growth performance in broilers

Item	Negative control	Antibiotic control	Essential oil treatment
Garcia *et al*. (2007)			
ADG (g $bird^{-1}$)	68.90	66.50	68.80
FCR (g g^{-1})	1.92	1.54	1.59
Ertase *et al*. (2005)			
ADG (g $bird^{-1}$)	61.30	65.80	71.30
FCR (g g^{-1})	1.61	1.50	1.41
Jamroz *et al*. (2003)			
ADG (g $bird^{-1}$)	48.10	48.90	49.20
FCR (g g^{-1})	1.85	1.81	1.79

Yang *et al*., 2009; ADG: Average Daily Gain. FCR: Feed Conversion Ratio

Table 4: Herbs products for poultry available in market

Products name and composition	Company name and address	Additional information
Aerocid Liquid composition of organic acids and herbs to be nebulized in the stables	Herbavita Bvba, Belgium	Properties • Stress-reducing • Antibacterial action
Anihom Liquid composition of extracts of plants	Herbavita bvba, Belgium	Target groups: Broilers, Layers Properties. Stimulates the immunity system, emollient for the air passages, beneficial for the intestinal tract
Aquacid Composition of organic acids and extracts from herbs	Herbavita bvba, Belgium	Target groups: Broilers, Layers Properties Promotes the appetite, stimulates the enzyme production, beneficial for a healthy digestion and feed conversion
Herban liquid Herbal extracts	KELA nv, Belgium.	Target group: calf, pig, poultry
Herban powder Herbal extracts	KELA nv, Belgium.	Target group: calf, pig, poultry
Artripul Liquid composition of extracts of plants	Herbavita bvba, Belgium	Target groups: Broilers Properties: Beneficial for the muscles, joints and the maintenance of strong bones, maintains the joints and muscles supple, beneficial to maintain strong bones
Phytobiotic growth promoter Blend of phytobiotics from quantified essential oils extracts, plant extracts from Thyme, Origanum, Rosmary, Clove and Cynnamon.	Tav veterinaria, Spain	Target group: swine poultry and calves. Properties: Growth promoter, Prevents coccidial multiplication and reduces its damage effect on the intestinal wall
Bronchimax Liquid composition of extracts of plants.	Herbavita bvba, belgium.	Target groups: Broilers Properties: Emollient for the airways and ensures efficient respiration
Ammofree-premix AmmoFree is a poly herbal formulation capable of binding ammonia and increases the utilization of ammonia nitrogen in GI tract	Indian herbs, India	Ammo Free Premix supports and enhances the intestinal enzyme system, ammo free Premix increases the utilization of ammonia nitrogen in GI tract Ammo Free Premix binds ammonia and prevents its excess release in poultry shed
Animunin	Indian herbs, India	Animunin is a herbal feed supplement which functions like a respiratory antiseptic and helps to maintain normal respiratory functions (Complicated Chronic Respiratory Disease)
Avericox® Plant extracts and additives: appetizing and aromatic substances (essential oils).	Mercordi animal care, Belgium	Avericox® can be used to combat coccidiosis as well as to optimise growth and production in poultry. The essential oils control the coccidial population
Colinex® Echinacea angustifolia Echinacea purpurea Vincetoxicum hirudinaria	Mercordi animal care, Belgium	Colinex® LA is an extremely powerful immune stimulator and can therefore be used succesfully to prevent *E. coli* infections

Survey in Euro Tier-2008

the effectiveness of phytobiotic additives could be include: plant parts and their physical properties, the genetic variation of plant, age of the plant, different dosage used, extraction method, harvest time and compatibility with the other ingredients which may also explain why difference in body weight gain and difference in feed conversion ratio could happen when different kinds of phytobiotics are used in chicken diet (Yang *et al*., 2009).

In addition, the efficacy of dietary phytobiotic can be affected by intrinsic and extrinsic factors such as nutritional status of animals, infection, diet composition and environment (Giannenas *et al*., 2003; Lee *et al*., 2004a, b, c). Herbal products for poultry available in market are shown in Table 4. Although, phytobiotics are a group of natural additives, research into their mechanisms of action, compatibility with diet, toxicity and safety assessment needs to be done before they can be applied more extensively in poultry feed.

CONCLUSION

There are so many advantages of using herbs than antibiotics. phytogenic feed additives may have the potential to promote production performance and productivity and thus add to the set of nonantibiotic growth promoters such as organic acids and probiotics. Even antibiotics can't be used during laying period of chickens due to residual effect in eggs. Now a day few herb products are available in market. Farmers can easily use in their layer, broiler and parent stock without any

residual effect. Even these herbs can be used during the laying period. Farmers also interested to use the herbs for their poultry. But products are not still familiar to the farmers.

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