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**Review Article**

# Application of herbs and phytogenic feed additives in poultry production-A Review

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**ABSTRACT**

During the last decade, herbs and phytogenic compounds have attracted a lot of attention for their potential role as alternatives to antibiotic growth promoters (AGPs) in monogastric animals. AGPs have been an integral part of the poultry feed industry for more than fifty years. However, AGPs alternatives have been searched since antibiotics prolonged use has precipitated the development of resistant strains within groups of primary pathogenic or opportunistic bacteria and the breakdown of the symbiosis between animals and desirable flora. Many non-therapeutic substitutes (prebiotics, probiotics and symbiotics), especially plants extracts from a wide variety of herbs, spices and derivatives, have already been used since the antiquity. They were appreciated for their specific aroma and various medicinal properties. Recent studies on these compounds have shown some positive effects (antimicrobial, antioxidant and regulator of the gut flora) in poultry production. This indicates that plant extracts can be considered as growth promoters; however evaluation procedures of their therapeutic/beneficial effects, their toxicity and interactions with prescription drugs have to be improved.

**Keywords:** growth promoters, herbs, phytogenics, poultry production.



## INTRODUCTION

The industrialization of poultry husbandry and the improvement of feed nutritional efficiency have accelerated the introduction of feed additives which became widely used in animal feed for many decades. The objective outlined by scientists, is to increase production (eggs, meat) while maintaining animals in good health. The use of antibiotics in poultry feed as a growth promoter is beneficial in improvement of production parameters and diseases prevention. However this large utilization has led to the increasing resistance of pathogens to antibiotics and the accumulation of antibiotic residues in animal products and in the environment. This situation requires the world to restrict using AGPs in animal feed (Nisha, 2008).

The nutritional value of raw materials available to livestock is closely linked to the quality and size of the microbial flora especially in the host animal digestive tract and its environment. Unlike ruminants, poultry do not have a natural bacterial flora capable of degrading all nutrients. These animals are characterized by a resistor and a limited immunity against infection due to colonization by pathogenic microorganisms. This is why, the use of AGPs for the inhibition of pathogenic bacteria has been recommended in order to improve production performance and animal health. Nevertheless, this is no longer possible after the observation made by the WHO on antimicrobial resistance in both animals and humans. From 2006, the European Union banned systematically the use of AGPs in animal feed (http://www.efsa.europa.eu/en/topics/topic/amr.htm).

The removal of AGPs from animal feed may affect their productions performance and foster the resurgence of pathogens causing illness and economic losses in farms.

In this context, herbs and plant extracts are searched to be incorporated in poultry feed as growth promoters such as probiotics and prebiotics (Alloui, 2013).

Herbs and plant extracts represent a new class of additives in poultry feed. Their uses are still limited in relation to their mode of action and aspects of application. In addition, complications may be encountered due to various changes in botanical origins, transformations and compositions of plants and their extracts. Most of the investigations have studied the interactions of various active compounds and their physiological impacts and effects on production performance (Figueiredo *et al*., 2008)

The hypothesis that phytogenic compounds could improve the food palatability has not been demonstrated. Furthermore, it is believed that the phytogenic compounds can improve the digestive enzyme activity and nutrient absorption.

Many studies have demonstrated their antioxidant and antimicrobial activity in vitro but in vivo these results are limited.

In addition, other effects such as anti-inflammatory, anti-fungal, anti-infectious and anti-toxigenic have been confirmed in some researches (Giannenas *et al*., 2003; 2004; Lopez - Bote, 2004; Burt, 2004; Lee *et al*., 2004; Walace, 2005; Naidoo *et al*., 2008; Ayachi *et al*., 2009; Arczewska-Wlosek and Swiatkiewicz , 2012; Ahmed *et al*., 2013; Khan, 2014 ).

All these assumptions are being addressed by the project ‘’REPLACE’’ in the EU programs framework. The objective of this project is to examine the possibility of using plants and their extracts as natural alternatives to antimicrobials in animal feed (http://www.replace-eu.com).

The aim of this work is to provide a synthesis of current knowledge in the scientific literature demonstrating the efficiency of plants or their extracts, to replace AGPs in poultry feed.

**Definition and regulation of phytogenics feed additives (PFA)**

Herbs and plant extracts used in animal feed, called today phytogenics feed additives (PFA), are defined as compounds of plant origin incorporated into animal feed to enhance livestock productivity through the improvement of digestibility, nutrient absorption and elimination of pathogens residents in the animal gut ( Kamel, 2001; Balunas and Kinghorn, 2005; Athanasiadou *et al*., 2007) .

The large variety of plant compounds used as PFA are assembled according to their origin and treatment, such as herbs and spices (eg: garlic, anise, cinnamon, coriander, oregano, chili, pepper, rosemary and thyme) but also essential oils or oleoresins (Kamel, 2000). Another category of compounds are extracted exclusively from fruits. They are represented by water soluble polyphenols (flavonoids) which can also be used in animal feed (Lopez –Bote, 2004).

The content of active substances in these products can vary greatly depending on what part of the plant is used (grains, leaves, roots, bark, flowers, or buds), the harvest season and geographical origin. The technique of treatment (cold, steam distillation, extraction or maceration with non-aqueous solvents…) also changes the active substances and related compounds in the final product (Windisch *et al*., 2008).

The use of feed additives is generally subjected to regulatory restrictions. In general, they are considered as products applied by the farmer to healthy animals for nutritional purposes on a permanent basis, in contrast with veterinary drugs which are applied for the prophylaxis and treatment of diagnosed diseases under veterinary supervision for a limited time followed by a waiting period.

In the EU, these feed additives must demonstrate the identity and traceability of the entire commercial product, the claimed nutritional effects in addition to proofs of absence of interaction with other compounds. They must be tolerated by the animals, the users (farmers, manufacturers of animal feed) and the environment (European Commission, 2003).

Problems using these plant extracts in animal feed may occur and cause physiological disturbances in animals, in relation with biochemical interactions within the animal organism. This is why the study of their use in diets will focus not only on their antioxidant, antimicrobial activities and their beneficial effects on palatability and intestinal functions, but also on their effectiveness to promote animal growth as AGPs.

**Antioxidant action of PFA**

The antioxidant properties of herbs and spices have been largely described by Craig (1999), Nakatani (2000) , Lambert *et al*., (2001) ; Ruberto *et al*., (2002) ; Wei and Shibamoto (2007). Among the varieties of plants with antioxidant constituents, plants of the *Labiatae* families (like mint) have attracted a great interest. Their antioxidative activities are due to phenolic terpenes (Cuppett and Hall, 1998). Other herbs species with antioxidative properties such as thyme and oregano contain large amounts of monoterpenes, thymol and carvacrol (Ruberto *et al*., 2002; Rahim *et al*., 2011). Plants rich with flavonoids such as green tea and other Chinese herbs have been described as natural antioxidant (Nakatani, 2000; Piao *et al*., 2006; 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.

The antioxidant properties of several PFA can contribute to dietary lipids protection from oxidation. This aspect has not been described in poultry feed; however *Labiatae* plants used as antioxidants in feed diet of small animals is very encouraging (Cuppett and Hall, 1998).

The activity of *Labiatae* phenolic compounds in improving the stability of animal products has been demonstrated in broiler chickens by several authors (Botsoglou *et al*., 2002a; Botsoglou *et al*., 2003; Basmacioglu *et al*., 2004; Giannenas *et al*., 2005; Florou - Paneri *et al*., 2006). The oxidative stability was also demonstrated with other PFA (Botsoglou *et al*., 2004; Govaris *et al*., 2004; Schiavone *et al*., 2007). However, it is uncertain whether these phytogenics antioxidants can replace commonly used antioxidants in feeds (α - tocopherol) in common feeding practices.

The use of PFA as an antioxidant is not only important for the poultry health, but also for the oxidative stability of their products (meat). Supplementation of turkey feed with 200 mg extract of oregano / kg feed significantly decreases lipid per-oxidation during refrigerated storage of fresh and cooked meat (Botsoglou *et al*., 2003).

The use of PFA instead of antioxidants is costly. However, this economic impact can be reduced by intensifying systemic needed plants and developing new technological processes of extraction.

**Actions on palatability and digestion of FPA**

Some PFA were sometimes seen as having a role to improve the taste and feed palatability. This implies an improvement in poultry production performance. The number of studies that tested the effect of plant extracts on palatability is very limited in this specie.

In general, an increase in feed intake in chickens is much more due to additives such as organic acids, probiotics and prebiotics (Catala - Gregori *et al*., 2007). Thus, the assumption that herbs, spices and extracts improve the feed palatability does not seem to be justified in general (Windisch *et al*., 2008).

A wide range of PFA is known to exert beneficial actions on the gastrointestinal tract, such as spasmolytic, laxative or against flatulence (Chrubasik *et al*., 2005). In Chinese medicine, cinnamon (*Cinnamonum cassia zeylanicum*) was used against diarrhea and reduced appetite. Smith-Palmer *et al*., (1998) found cinnamon extract, thyme and clove to be efficient against several bacteria. Furthermore, stimulation of the digestive secretions of bile, mucus, saliva and improvement of enzymes activities are of great nutritional interest (Platel and Srinivasan, 2004).

Other researchers have shown that essential oils used in chickens have positively influenced the activity of trypsin and amylase (Lee *et al*., 2003; Jang *et al*., 2004; Jamroz *et al*., 2005). It was also found that the phytogenic additives have a stimulatory effect on intestinal mucus in chickens. This effect is assumed to influence the adhesion of pathogens and in consequence help to stabilize the microbial equilibrium in the chicken gut (Jamroz *et al*., 2006).

These improvements could also be due to morphological changes induced in the gut such as villi and crypts size modifications in the jejunum and colon of PFA ingesting chickens (Jamroz *et al*., 2006).

Srivastava *et al*., (1995); Kumar and Berwal, (1998) showed that the use of garlic oil (*Allium sativum*) have anti-tumoral and anti-oxidative properties. Similarly, a British study showed a positive effect of garlic on growth and feed intake in chickens (Lewis *et al*., 2003). These authors concluded that garlic may have a positive effect on the gut flora by reducing pathogenic bacteria explaining the improved chicken performances.

All these observations encourage the assumption that these additives may favorably affect the gut functions, but the number of in vivo studies in poultry is still limited.

**Antimicrobial and immune actions of FPA**

PFA are well known for their antimicrobial effects in vitro against important pathogens but also against fungi (Allen *et al*., 1997; Smith -Palmer *et al*., 1998; Cosentino *et al*., 1999; Waldenstedt, 1998, 2003; Giannenas and Kyriazakis, 2009).

Most studies show a greater sensitivity of Gram + bacteria compared to Gram- (Shelef, 1983; Zaika, 1988; Smith -Palmer *et al*., 1998; Ceylan and Fung, 2004). This does not mean that the plant extracts are not active on Gram - bacteria, but the dosage should be higher. In addition, the antimicrobial activity is dependent on the physico-chemical characteristics of plant compounds and bacterial strains used (Sari *et al*., 2006). Burt and Reindeers (2003) observed an antibacterial effect of essential oils of oregano and thyme against *E. coli* (Gram -) at a dose of 0.6 ml / L.

Ayachi *et al*., (2009) studied the in vitro effect of some extracts of berries, dates and thyme to fight against *E. coli* and *Salmonella* isolates from chicken. These authors concluded that only the thyme would be effective against *Salmonella*.

Thyme would work with the most active compounds (thymol and carvacrol) against fungi such as *Candida albicans* (Cosentino *et al*., 1999). Other investigations have demonstrated the effectiveness of walnut leaves (*Juglandaceae*) to reduce the proliferation of *Clostridium perfrengens* in chickens but also to enhance the growth of these birds (Lovland and Kaldhusdal, 2001 ; Engberg *et al*., 2007; Mathis *et al*., 2007). Clove frequently used as a spice is very rich in eugenol. It is used as an antibacterial in human and veterinary medicine (Nascimento *et al*., 2000; Rhayour *et al*., 2003).

The essential oil of oregano contains about 60% carvacrol and 10% thymol with a demonstrated effectiveness against some strains of salmonella (Koscova *et al*., 2006) located in the digestive tract of chicken. However, to have a good efficacy against several types of

microorganisms, it is interesting to combine several extracts devoid of chemical incompatibility. The same way as antibiotics, antibacterials from plants do not distinguish between commensal and pathogenic bacteria. It is worth-noting that, as other bacteria, the lactobacilli and bifidobacteria are less sensitive to plant extracts, which is reassuring, because they are used as probiotics.

PFA are an interesting solution to clean the digestive tract of birds which is very useful in diseases prevention in poultry (Shelef, 1983). Additionally, some plant extracts have demonstrated an activity against some chicken parasites, especially coccidia (*Eimeria spp*) (Giannenas *et al*., 2003, 2004; Christakis *et al*., 2004; Naidoo *et al*., 2008; Rczewska-Wlosek and Swiatkiewicz, 2012).

Betaine is a byproduct of the sugar beet industry; it has recently been a subject of several studies in the USA and Sweden. It seems to have a positive impact in fighting coccidiosis. In Sweden, Waldenstedt *et al*., (1999) showed that the addition of betaine in the poultry feed, reduced weight loss during coccidial infection by different *Eimeria* species in poultry. 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.

Turmeric is a spice coming from the rhizome of *Curcuma longa*. It is used as a food coloring, but also for medicinal purposes. The active component is curcumin, a phenolic compound at concentrations of about 1 to 5%. It has antioxidant, anti-inflammatory and anti-tumoral activities. In infected chicken with *Eimeria maxima*, supplementation of feed with 1% turmeric spice improves weight gain, reduces intestinal lesions and oocyst excretion. Curcumin exerts its anticoccidial effect through its antioxidant action on the immune system (Allen *et al*., 1998). Soltan *et al*., (2008) found that the supplementation of poultry feed with anise grains, improved blood parameters and increased the phagocytic activity and lymphocyte counts. Cinnamon has also an immuno-stimulating effect that can be attributed to its anti-oxidant property.

In addition to all these antimicrobial implications, phytogenics improve the microbial carcass hygiene and the preservation quality, in relation with their antimicrobial and antioxidant properties (Botsoglu *et al*., 2002b; Ruberto *et al*., 2002; Aksit *et al*., 2006).

According to the European Food Safety Authority (EFSA), this alternative should be considered as one of the most effective ways to reduce the microbial contamination of food and to control the spread of foodborne diseases within the human population through the food chain. Addition of plants extracts in foods and / or systems used on carcass surfaces decreases the bacterial contamination of poultry products (Gülmez *et al*., 2006). In the improvement of microbial carcass hygiene, oils extracted from plants (such as oregano, rosemary, sage) have a positive effect (Young *et al*., 2003; Govaris *et al*., 2007). However, it is too early to conclude that these decontamination methods are entirely effective and reliable.

**Effects of FPA on production performances**

The effects of FPA on production performance have shown promising results. Cabuk *et al*., (2006) measured production parameters in chickens grown on feed supplemented with a mixture of essential oils of oregano, bay leaf, sage, anise and citrus. This mixture has significantly improved feed conversion resulting of high nutrients availability due to changes in the intestinal ecosystem.

Lippens *et al*., (2005) have attempted to assess the effectiveness of a mixture composed of cinnamon, oregano, thyme, cayenne pepper, citrus extracts and of another mixture of plant extracts and organic acids in comparison with the avilamicine in chicken feed. The supplemented with plant extracts group of animals reached a much larger body weight than the other groups. Apparently, the increase in body weight was due to the increase of feed intake. This was attested by a reduced feed conversion in animals of the plant extracts group (0.4% lower than avilamicine group and 2.9% lower than the organic acids group).

Fenugreek (*Trigonella foenum-graecum*), is an annual legume, cultivated all over the world, it is one of the herbs with multi-functional characteristics. It is a good source of dietary proteins for humans and animals. Fenugreek seeds supplementation improved significantly feed conversion ratio of broiler chickens which might be related to morphological changes in the gastrointestinal tissues (Srinivasan, 2006; Alloui *et al*., 2012; Mamoun *et al*., 2014).

The inclusion of anise seeds at a level of 0.5-0.75/kg corn-soybean-meal diet administered to broilers during 6 weeks, improved their body weight gain, performance index and relative growth rate. In contrast, a higher inclusion level of anise seeds (1.5 g/kg diet) reduced growth performance (Soltan *et al*., 2008).

Garlic (*Allium sativum*), thyme (*Thymus vulgarus*) and conflower (*Echinacea purpurea*) as feed supplements have recently been reported to exert a wide range of beneficial effects on the production performance (weight gain, feed conversion, egg production and quality) of broilers and laying hens (Aji *et al*., 2011; Rahimi *et al*., 2011; Khan *et al*., 2012).

Bolukbasi and Erhan, (2007) studied the effect of dietary supplementation with thyme on performance of laying hens and *E. coli* concentrations in their feces. Thyme addition to basal diet at the level of 0.1-0.5% have given an improvement in feed conversion and egg production associated to a decline of *E.coli* concentration in feces.

Effect of PFA on egg quality traits, such as yolk composition, shell thickness or Haugh Unit rating, were reported in a few studies only, whereas the majority of reports did not identify substantial effects (Nichol and Steiner, 2008; Singh, 2009; Navid *et al*., 2013 ).

## CONCLUSION

PFAs are good alternatives to replace AGPs. They can be combined with other compounds such as prebiotics or probiotics to promote the performance of poultry production. Phytogenics have been used since a very long time, but empirically. General mechanisms of action were little known in humans and animals. Nowadays, much progress has been made to evaluate their effects on the poultry organism. For this, it is the responsibility of additive-manufacturers to promote and control these products taking into consideration all legislative requirements governing the production and marketing of these products. The identification, composition, effectiveness, toxicity and residues analysis, traceability and the risk of manipulation are the main factors to control during the manufacturing process. The industry of animal feeds and especially the poultry one must bring to market an effective, cheap diet of high quality.

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