How do plant extracts work?

Dr. Edgar O. Oviedo-Rondón, DVM, PhD, Dip. ACPV.
Associate Professor/Extension Specialist

Prestage Department of Poultry Science
North Carolina State University, Raleigh, NC 27695, USA

Herbs, spices, plant extracts and essential oils (EO) have been used for centuries to preserve food for humans and to make it more appetizing. These products are well recognized for their health benefits in many societies around the world. It is difficult to distinguish between the different EO available, as each EO is a mixture of fragrant and volatile compounds. They are named after the aromatic characteristics of the plants from which they are extracted. Each EO is a very complex mixture of compounds with variable chemical compositions and concentrations. Factors that influence EO production include organ specific production and the plants developmental phase, which are both in turn affected by ecological factors and climatic conditions. Plant cultivation, processing and EO isolation methods also affect the type and concentration of the product obtained. Because of the large variation in composition and concentration, their mechanism of action and their final biological effects are also very variable.
For this reason, more stable and very specific blends have been designed to be used as feed additives in animal production.
Each specific blend of EO available on the market for livestock and poultry production can have specific and distinct properties related to the composition and concentration of its individual chemical compounds. These activities may include; 1) antimicrobial (antibacterial, antifungal, antiviral, antiparasitic) or modulators of gut microflora, 2) antioxidants, 3) anti-inflammatory or immunity stimulants, 3) regulators of gastrointestinal function and mucus production, 4) palatability enhancers (mainly for swine) and 5) detoxifying agents. Due to their ability to act as microbial modulators they are able to alter bacterial fermentation in the ceca, the colon and the rumen. It has been shown that these changes are generally positive for the animal. Gut microbiota modulation may ultimately alter protein degradation, volatile fatty acid and methane production, thereby reducing any negative effects of microbes on the animal. As a result of these outcomes, either individually or combined EO blends may work as growth promoters or act as performance enhancing products. However, it is almost impossible that two EO blends can work in the same way and give the same results in experiments when tested under the same conditions.

EO have long been recognized for their anti-microbial activity, and they have gained much attention for their potential as alternatives to antibiotics (Lee *et al.*, 2004; Máthé, 2009; Windisch *et al.*, 2009). A wide range of *in-vitro* and *in-vivo* anti-microbial activities of different purified EO or blends (e.g. derived from cinnamon, thyme and oregano etc.) have been published. The exact anti-microbial mechanism of EO is still not fully understood, and may be associated with their lipophilic properties and their chemical structure (Lee *et al.*, 2004; Máthé, 2009).
EO are made up of alcohols, aldehydes, esters, ethers, ketones, phenols and terpenes. Most EO are synthesized from isoprene, which is the building block of terpenoids. Some EO compounds can either alter microbial membrane permeability, or interact with membrane proteins whilst others can interact directly with cytoplasmic components. EO can accumulate in the lipid bilayer of the bacterial plasma membrane where they disrupt the ion gradient, thereby reducing bacterial growth or causing cell death. Therefore, it is believed that these plant-based compounds have an antimicrobial effect similar to antibiotic compounds produced by fungi. However, to be effective as growth promoters, these herbal antimicrobial compounds must be supplemented to the feed in a concentrated form.
In the same way that microbes can become resistant to antibiotics, it has been proven by *in-vitro* experiments that animals may generate resistance to EO compounds as well. The chemical components of the EO, not only affect gut microbiota, but can also influence the amount and type of mucines produced by the intestinal mucosa, altering physical and chemical properties of the intestinal environment. Therefore, their effect on gut microbial modulation could also be indirect, in contrast to the effects observed when using antibiotics as growth promoters.

EO supplementation has been tested in numerous studies with poultry, swine and ruminants with varying responses, depending upon the basal diet used, field or induced disease challenges, and other stress factors. Results also varied depending on the specific EO blend used. The most consistent positive response to EO blends in poultry has been observed under coccidia challenges with compounds such as *Artemesia annua, Sophora flavescens,* Oregano, and *Astragulus membranaceus* (Lee *et al.*, 2004; Giannenas and Kyriazakis, 2009). In piglets, several compounds have been used against enteropathogenic *E. coli* to reduce the severity of diarrhea and improve immune-competency. In ruminants, the scientific evaluations published are considerably less than in other species, even though it has been proven *in vitro* that they reduce methane production.
In poultry, it is interesting that specific EO blends, based mainly on carvacrol and thymol can modulate the microflora under coccidia challenges, maintaining similar microbiota to those seen in non-infected animals. The drastic changes in microbial populations normally caused by *Eimeria* infections were not found (Hume *et al.*, 2006, 2011; Oviedo *et al.*, 2006b). This was reflected by better broiler performance compared to that in infected chickens (Oviedo *et al.*, 2006a). Not only do microbiota remain similar to those seen in the healthy, non-infected broilers, but its diversity is conserved even more than when antibiotic growth promoters are used (Martynova *et al.*, 2012).

The dietary addition of EO improves the storage stability of egg yolks, due to their antioxidant properties, and similar effect has been shown in a few studies for stored broiler meat. Some plant extracts such as garlic may reduce egg yolk cholesterol content. EO evaluated in layer hens reduce feed intake and generally improved feed conversion, egg production and egg weight.

In contrast, in lactating sows, EO tend to enhance the animals feed intake and consequently less weight is lost during lactation. As a consequence, lower annual sow mortality and culling rates are observed together with increased farrowing rates. Additionally, there is evidence that plant-extracted EO improve lactation in sows. Piglets from sows supplemented with EO have higher weights at weaning either due to direct influence of the EO on milk composition or due to the higher production of milk observed especially after the second week of lactation, as a result of higher feed intake.

Scientific reports have indicated that EO work as effective feed additives for animals with beneficial effects on intestinal health, general immunity and as antioxidants for meat and eggs. Possible variation in the results obtained between studies or commercial experiences of EO utilization may be due to difficulties associated with obtaining specific EO blends for testing.

References:

Giannenas, I. and I. Kyriazakis. 2009. Phytobased products for the control of intestinal diseases in chickens in the post antibiotic era. Pages 61-86 In Phytogenics in Animal Nutrition. Steiner, T. (ed). Nottingham University Press, Nottingham, UK.

Hume, M.E., Barbosa, N.A., Dowd, S.E., Sakomura, N.K., Nalian, A.G., Van Kley, A.M. and E.O. Oviedo-Rondón. 2011. Use of pyrosequencing and denaturing gradient gel electrophoresis to examine the effects of probiotics and essential oil blends on digestive microflora in broilers under mixed *Eimeria* infection. Food Borne Pathogens and Disease 8(11):1159-1167.

Hume, M.E., Clemente-Hernández, S. and E.O. Oviedo-Rondón. 2006. Effects of feed additives and mixed Eimeria species infection on intestinal microbial ecology of broilers. Poultry Science 85:2106-211.

Lee, K.W., Everts, H., Beynen, A.C., Williams, P. and R. Losa. 2002. Essential blending essential oils in broiler nutrition. International Journal of Poultry Science 3:738-752.

Martynova-Van Kley, A., E.O. Oviedo-Rondón, S. Dowd and N. Armen. 2012. Effect of Eimeria infection on cecal microbiome of broilers fed essential oils. International Journal of Poultry Science 11:747-755.

Máthé, A. 2009. Essential oils: Biochemistry, Production and Utilisation. Pages 1-18 In Phytogenics in Animal Nutrition. Steiner, T. (ed). Nottingham University Press, Nottingham, UK.

Oviedo-Rondón, E.O., Clemente-Hernández, S., Salvador, F., Williams, P. and R. Losa. 2006a. Essential oils on mixed coccidia vaccination and infection in broilers. International Journal of Poultry Science 5 (8): 723-730.

Oviedo-Rondón, E.O., Hume, M.E., Hernández, C. and S. Clemente-Hernández. 2006b. Intestinal microbial ecology of broilers vaccinated and challenged with mixed Eimeria species, and supplemented with essential oil blends. Poultry Science 85:854–860.

Windisch, W., E. Rohrer and K. Schedle. 2009. Phytogenic feed additives to young piglets and poultry: Mechanisms and application. Pages 19-38 In Phytogenics in Animal Nutrition. Steiner, T. (ed). Nottingham University Press, Nottingham, UK.