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The Perspective of Using Essential Oils in Swine: review

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Abstract: *In animal husbandry, the improper and excessive use of antibiotics has contributed to the emergence of bacterial strains resistant to their action. Over the past decades, the search for alternative strategies to antibiotics has received increasing attention. The antimicrobial properties of essential oils have made them viable alternatives in livestock production. Numerous researchers have investigated these natural compounds as potential substitutes for conventional antibiotics or as preventive measures against diseases in farm animals, including swine. This variability is primarily due to differences in oil composition, purity, dosage, growth phases, and husbandry conditions. Some authors suggest that essential oils such as oregano, thyme, clove, or mint can improve the overall health status of pigs through their anti-inflammatory and antimicrobial properties. This review aims to assess how essential oils are currently used in swine feeding strategies and/or treatment protocols, focusing on their mechanisms of action as demonstrated by existing research.*

• Introduction

In recent years, concerns about antimicrobial resistance and the global push for more sustainable livestock production have intensified the search for effective alternatives to antibiotics. In pig farming, where antibiotics have traditionally been used both therapeutically and as growth promoters, the European Union's ban on antibiotic growth promoters since 2006 has prompted a shift toward natural solutions. Multiple studies have shown that supplementing swine diets with specific EO or EO blends may lead to better feed conversion efficiency, enhanced nutrient absorption, reduced oxidative stress, and stronger immune responses. These effects are particularly relevant during vulnerable stages such as weaning, when piglets are more susceptible to digestive disorders and immune suppression.

• Material and method

This review was conducted based on scientific literature retrieved from international databases including PubMed, Scopus, and ScienceDirect. The search focused on studies published between 2000 and 2024 using combinations of keywords such as "essential oils," "swine," "pigs," "antimicrobial," "growth performance," and "gut microbiota." Only peer-reviewed articles that reported in vitro or in vivo results in swine were included. Exclusion criteria involved studies lacking clear methodology or those unrelated to essential oil application in pigs. The selected articles were analyzed regarding the chemical composition of essential oils, their biological effects, delivery systems, and reported outcomes on pig health and productivity.

• Results and discussions

The most commonly used method for the commercial production of essential oils is steam distillation. Extraction using liquid carbon dioxide at low temperatures and high pressure yields a more natural organoleptic profile but is significantly more expensive. It is well known that essential oils are volatile and therefore must be stored in dark-colored, airtight containers to prevent changes in their chemical composition. Numerous studies have provided information on the composition of various essential oils, with the main components of economic interest described by Bauer et al. (2001). The constituents of essential oils show great diversity, mainly consisting of monoterpenes, sesquiterpenes, benzenoids, and phenylpropanoids. Essential oils act primarily by disrupting the integrity of bacterial cell membranes, causing ion leakage and loss of intracellular content, ultimately leading to cell death. Compounds such as carvacrol and thymol (from oregano and thyme) are known for their ability to alter membrane permeability and inhibit essential bacterial enzymes.

These effects help reduce pathogenic bacteria like *E. coli* and *Salmonella* spp., while promoting beneficial microbes such as *Lactobacillus*, thus contributing to a balanced and healthy intestinal microbiota in pigs (Fig.1). Certain volatile compounds in essential oils can modulate the expression of genes involved in inflammatory responses. Some EO have been shown to reduce the production of pro-inflammatory cytokines such as $\text{TNF-}\alpha$ and IL-6, thereby decreasing intestinal and systemic inflammation. Simultaneously, they enhance the innate immune response by activating macrophages and increasing immunoglobulin levels. This dual role—reducing inflammation while strengthening immune defenses—is especially beneficial during stressful or transitional periods in swine production. By reducing lipid peroxidation and supporting the activity of endogenous antioxidant enzymes (e.g., superoxide dismutase, glutathione peroxidase), EO help preserve intestinal cell integrity and improve metabolic functions. Additionally, some oils can stimulate the secretion of digestive enzymes, leading to better nutrient absorption and improved feed efficiency.

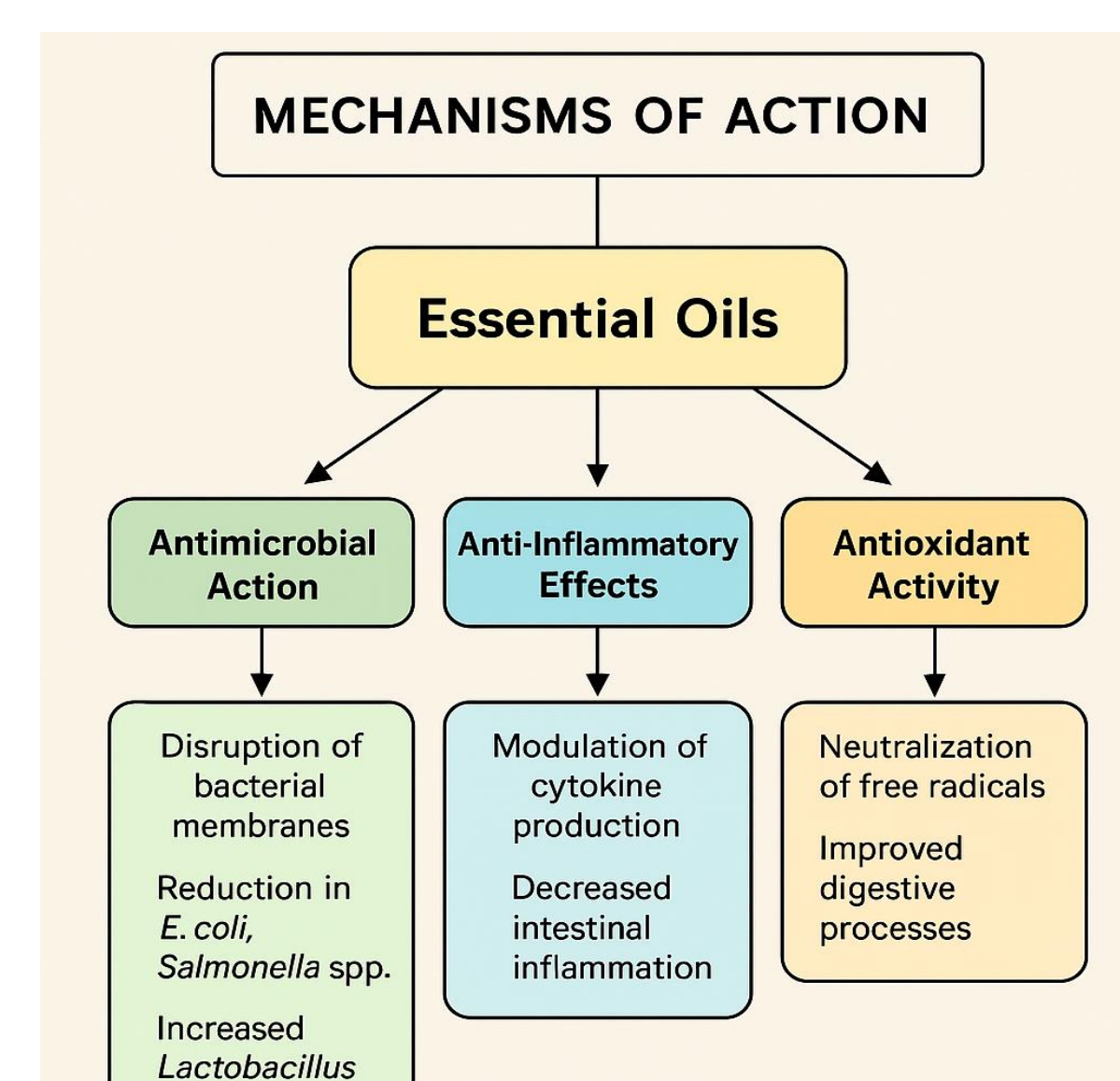


Fig.1 Mechanisms of action of essential oils: antimicrobial, anti-inflammatory, antioxidant.

• Conclusions

Essential oils represent a promising alternative to antibiotics in swine production due to their antimicrobial, antioxidant, and immunomodulatory properties. Their inclusion in pig diets has shown significant benefits, including improved gut health, enhanced feed conversion efficiency, stimulation of the immune system, and reduced prevalence of pathogenic bacteria. Continued research is therefore essential to standardize formulations, deepen our understanding of the individual mechanisms of action, and develop modern delivery technologies (e.g., microencapsulation) that ensure stability and increased efficacy.