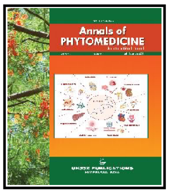
Annals of Phytomedicine 13(2): 75-82, 2024

DOI: http://dx.doi.org/10.54085/ap.2024.13.2.8

Annals of Phytomedicine: An International Journal
http://www.ukaazpublications.com/publications/index.php

Print ISSN : 2278-9839 Online ISSN : 2393-9885



Review Article : Open Access

Essential oils: A promising natural alternative to antibiotics in poultry production

T.J. Sheikh◆, Ranjan Rajeev*, C. M. Modi, Amit Kumar Jha *** and Rajesh Kumar******

Department of Veterinary Pathology, College of Veterinary Science & A.H, Rewa-486001, Madhya Pradesh, India
** Department of Veterinary Pharmacology & Toxicology, College of Veterinary Science & A.H, Rewa-486001, Madhya Pradesh, India*
*** Department of Veterinary Pharmacology & Toxicology, College of Veterinary Science & A.H, Kamdhenu University, Dantiwada-385505, Gujarat, India*
**** Department of Veterinary Animal Genetics & Breeding, College of Veterinary Science & A.H, Rewa-486001, Madhya Pradesh, India*
***** Krishi Vigyan Kendra, Thakurdwara, Moradabad (SVPUA&T), Meerut, Uttar Pradesh, India*

Article Info

Article history
Received 7 July 2024
Revised 27 August 2024
Accepted 28 August 2024
Published Online 30 December 2024

Keywords
Essential oil
Antimicrobial
Antiparasitic
Feed conversion ratio
Poultry

Abstract

Essential oils (EOs) derived from various plants and spices have attracted growing interest as potential substitutes for antibiotic growth promoters in poultry farming. This review consolidates and analyzes recent research findings on the effects of supplementing diets with essential oils on crucial aspects of avian gastrointestinal health and function. Essential oils possess antimicrobial, antiparasitic, antioxidant, anti-inflammatory, and immune-modulating properties that can potentially enhance gut health and poultry performance. They improve nutrient digestibility by enhancing intestinal morphology, enhancing gastric enzyme secretion, and modulating gut microflora. Additionally, essential oils act as appetite stimulants through their aroma and flavor-enhancing effects. Bioactive ingredients like terpenes, phenols, and flavonoids contribute to improved growth performance, intestinal integrity, and antioxidant status in broilers and layers. While the exact mechanisms are not fully elucidated, essential oils influence various physiological processes, including cell membrane permeability, free radical scavenging, and cholesterol metabolism. This review highlights the promise of EOs as natural growth enhancers in poultry diets, emphasizing the need for further research to optimize their effectiveness and unravel their mechanisms.

1. Introduction

It is widely acknowledged that administering antibiotics preventively in poultry nutrition results in enhanced growth, feed intake, feed efficiency, and reduced mortality rates due to clinical diseases. The increasing apprehension regarding the spread and multiplication of antibiotic-resistant organisms through the food chain pose substantial challenges for public health and livestock. In response to concerns about antibiotic resistance, in 2006, the European Union (EU) enacted legislation prohibiting the utilization of antibiotics as growth enhancers for animals (Hong *et al.,* 2012). Currently, researchers are actively exploring alternatives to antibiotics in animal diets, with a particular emphasis on natural additives. In recent years, there has been a growing trend toward utilizing products incorporating essential oils extracted from a variety of spices and botanical sources as supplementary growth promoters in animal nutrition. Essential oils are complex blends of volatile organic compounds derived from plants. These natural substances are extracted through physical methods like pressing or distillation from specific parts of plants with known taxonomic classifications (Franz and Novak, 2009). The name "essential oils" originated from the historical belief that these substances were crucial for life. Humans have utilized essential oils for centuries in cosmetics and medicine.

Corresponding author: Dr. T. J. Sheikh
Assistant Professor, Department of Veterinary Pathology, College of Veterinary Science & A.H, Rewa-486001, Madhya Pradesh, India
E-mail: drsheikh2@yahoo.co.in
Tel.: +91-8770846169

Copyright © 2024Ukaaz Publications. All rights reserved.
Email: ukaaz@yahoo.com; Website: www.ukaazpublications.com

While the development of essential oils was temporarily slowed by the introduction of antibiotics in the mid-1800s, there has been a recent resurgence of interest in these natural compounds. Research indicates that of the approximately 3,000 known essential oils, about 300 have significant commercial value, primarily in the fragrance and flavor industries (van de Braak and Leijten, 1994). Nevertheless, further investigation is needed to optimize their efficacy. These phytogenic additives can operate through diverse mechanisms, including improving feed consumption and taste, triggering the secretion of enzymes, boosting gastric and intestinal movement, activating the endocrine system, and demonstrating antimicrobial properties (Mitsch *et al.,* 2004), acting as antiviral, anthelmintic, and coccidiostat agents (Jamroz *et al.,* 2005), promoting immune system activity, and possessing anti-inflammatory and free radical scavenging properties (Botsoglou *et al.,* 2002). Furthermore, studies have indicated that the antimicrobial properties of the phytochemical constituents found in herbs and their corresponding essential oils have the potential to improve poultry performance and health. Additionally, they can enhance the well-being of birds' digestive systems by reducing the population of pathogenic bacteria (Jamroz *et al.,* 2005). The significance of intestinal health in poultry cannot be overstated, as it directly impacts performance and FCR. Enhancing nutrient assimilation in the gastrointestinal tract involves increasing the size and height of intestinal villi. Dietary constituents have been found to affect the morphology of intestinal villi, with a demonstrated correlation between villi morphology and the dietary preferences of various domesticated animals (Zulkifli *et al.,* 2009). So, numerous botanicals and spices are commonly utilized as food additives. For centuries, garlic, capsicum, and their derivatives like essential oils and oleoresins, alongside compounds such as cinnamic, carvacrol, and piperine from black pepper, have been valued for their ability to enhance flavor. Certain herbs and botanicals can boost growth rates by stimulating feed intake (Wenk, 2006). This review aims to elaborate on recent findings that have examined the impacts of EOs supplementation on critical aspects of avian gastrointestinal health and function. It particularly focuses on its effects on overall growth performance in poultry.

2. Exploring the fundamentals of essential oils

An essential oil is a condensed liquid derived from plants. It contains volatile chemical compounds and is hydrophobic in nature. These oils are alternatively referred to as volatile oils, aetheroleum, or ethereal oils. Paracelsus introduced the term 'essential' in relation to his theory of 'quinta essentia', which described how the essence from plants could be used for medicinal purposes (Oyen and Dung, 1999). On the other hand, the term 'volatile oil' was used in medieval medicine to refer to these plant extracts (Hay and Waterman, 1993). Essential oils (EOs) possess diverse chemical compositions and concentrations, providing beneficial effects on growth and health. The most commonly used essential oils in poultry production with their effect is mentioned in Figure1, which include oregano oil, thyme oil, cinnamon oil, clove oil, eucalyptus oil, peppermint oil, lemon oil, tea tree oil, garlic oil, lavender oil. Though, the usage of EOs may vary based on factors such as the specific health challenges faced by the poultry, formulation preferences, and regulatory considerations. The composition of plant EOs is subject to influence by both environmental and genetic factors inherent to their natural origin. It is important to note that various factors, such as the plant species, its subspecies, the geographic location, harvesting time, the plant part utilized, and the extraction method employed, all play a role in determining the chemical composition of the raw material obtained from the plant. Additionally, there is evidence suggesting that smaller molecules can influence the action of the primary components. Research has demonstrated that essential oils exhibit stronger antibacterial properties compared to just their major individual components combined. This suggests that the minor components present in the EOs play a crucial role, potentially having a synergistic or enhancing effect on the overall antibacterial activity (Gill *et al.,* 2002).

The plant families Apiaceae, Asteraceae, Alliaceae, Lamiaceae, Myrtaceae, Poaceae, and Rutaceae are widely acknowledged for their capacity to generate essential oils, which offer promising prospects for applications in both industry and medicine. Spices are commonly added to food to enhance its flavor and taste, with the belief that they also offer various health benefits. However, the exact mechanisms by which these beneficial chemicals operate in birds have yet to be fully elucidated. To address this gap, we conducted a thorough review of existing avian literature to explore the diverse processes associated with essential oils.

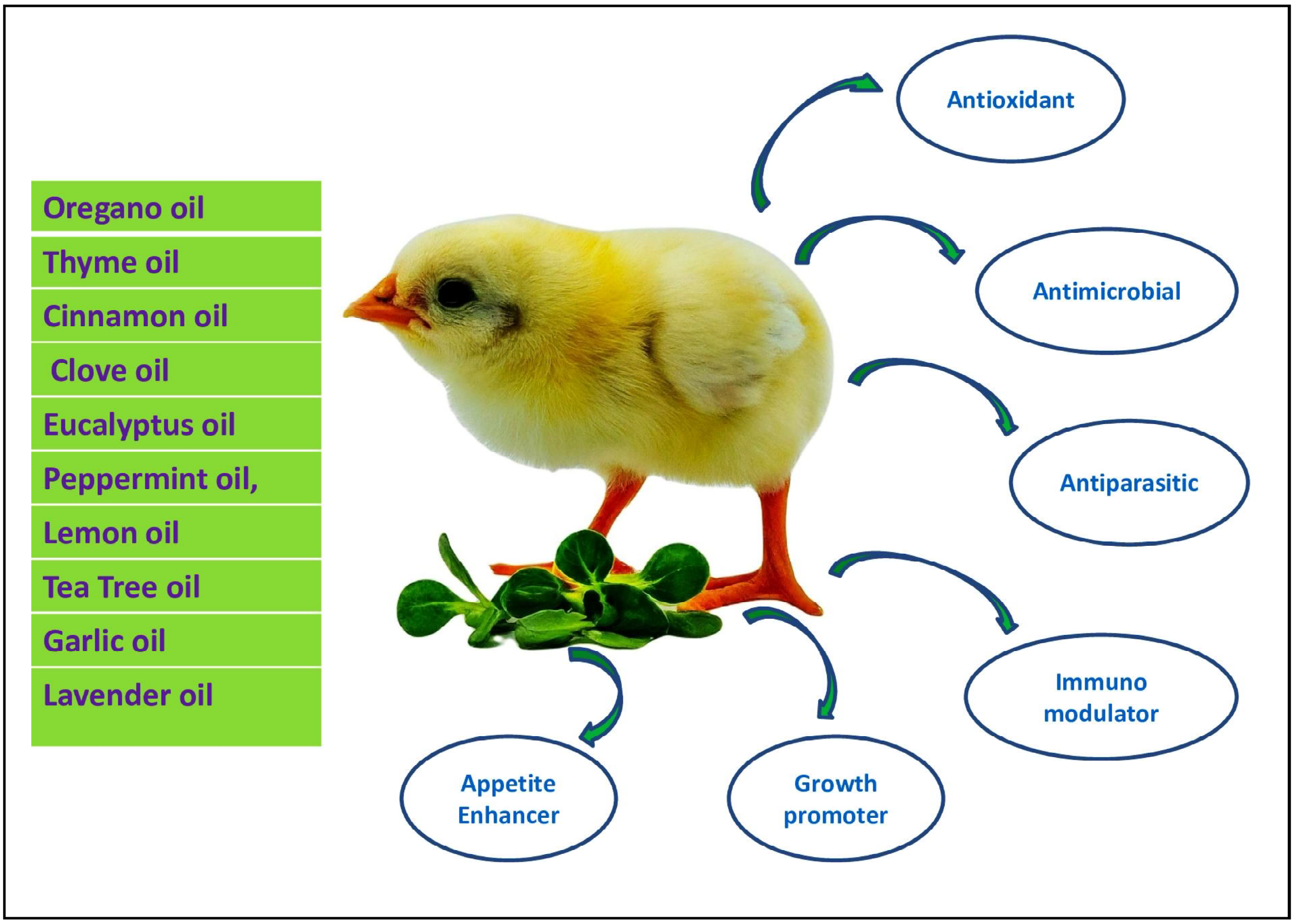


Figure 1: Common essential oils and their effect on poultry.

3. Pharmacological properties of essential oils

3.1 Antibacterial effect

EOs have been revered for their potent antibacterial properties, a fact attested to since ancient times. In contemporary research, their potential as alternatives to antibiotics is being explored due to this characteristic. Multiple research studies have shown that compounds such as thymol, eugenol, and carvacrol, present in EOs, along with essential oils derived from *Thymus hirtus* sp. *algeriensis*, possess strong antimicrobial properties. These substances have proven to be highly effective against aggressive bacteria strains like *Escherichia coli* and *Salmonella typhimurium* (Bouatrous, 2019; Aljuwayd *et al.,* 2023). These bacteria and fungi are notorious for causing enteric infections and are associated with significant health risks. Thymol, eugenol, and carvacrol, sharing structural similarities, have demonstrated enhanced or synergistic antibacterial effects when used together, even at lower concentrations compared to when used individually (Bassole and Juliani, 2012). Research has shown that EOs, whether used individually or in combinations, can effectively suppress the growth of bacteria such as *Clostridium perfringens* and *Escherichia coli* in the hindgut region of the digestive system. These findings suggest that essential oils may have promising applications in controlling the proliferation of these pathogenic microorganisms, thus promoting better gut health (Bassole and Juliani, 2012). Additionally, it has been shown to improve intestinal tract lesions and reduction in body weight loss (Jerzsele *et al.,* 2012). Cinnamaldehyde, derived from cinnamon, exhibits inhibitory effects against various bacteria, including *Clostridium perfringens, Bacteroides fragilis, Bifidobacterium* spp., and *Lactobacillus* spp. (Lee and Ahn, 1998). These findings underscore the potential of cinnamaldehyde as a natural antimicrobial agent, offering insights into its possible applications for promoting gastrointestinal health and combating bacterial infections. Further research into its mechanisms of action and safety profile could elucidate its broader therapeutic implications. This selective inhibition of intestinal pathogenic bacteria can help maintain a healthy microbial balance in the poultry intestine. Microcapsules containing EOs from thyme, summer savory, peppermint, and black pepper seeds exhibited antioxidant and antibacterial characteristics when supplemented in the feed of broiler birds infected with *Salmonella enteritidis*, these microcapsules resulted in enhancements in final body weight, overall feed consumption, FCR (feed conversion ratio), antioxidant status, ileal morphology, intestinal microbial composition, and modulation of antioxidant and inflammatory gene expression in the ileal tissue (Moharreri *et al.,* 2022). A combination of three phenolic compounds naturally occurring in plants - thymol (mainly in thyme), carvacrol (in thyme and oregano), and eugenol (from cinnamon and cloves) - has shown significant antimicrobial activity against bacteria including *Escherichia coli, Salmonella enteritidis, Staphylococcus aureus, and Pseudomonas aeruginosa*. It has been observed in the *in vitro* study that 100% inhibition of mycelia pathogen was observed when EOs, *viz.,* citronella oil, lemongrass oil, and garlic oil were used at 0.5% concentration (Pol *et al.,* 2023). Similarly, antifungal activity was also observed with *Ruta chalepensis* (Hammia and Bouatrous, 2021).

Though the exact mechanism of antibacterial action remains elusive, it may affect primarily target, the cell membrane. These substances are thought to exhibit antibacterial properties by interfering with the bacterial cell membrane's integrity. This interference is believed to disrupt the normal movement of ions, particularly hydrogen (H^+) and potassium (K^+), across the membrane (Deans and Ritchie, 1987). One established mechanism of antibacterial activity is associated with the hydrophobic nature of essential oils, which interfere with cell membrane permeability and cellular homeostasis, leading to cell lysis, influx of extracellular molecules, or cell death (O'Bryan *et al.,* 2015). Essential oils typically have a stronger antimicrobial impact on Gram-positive bacteria compared to Gram-negative species. The increased resistance observed in Gram-negative bacteria is primarily attributed to the presence of hydrophilic components in their outer cell membrane (Seow *et al.,* 2014).

3.2 Antiparasitic properties

A diverse array of botanical species and their corresponding essential oils have undergone thorough examination due to their promising antiparasitic properties. Among these, extensive research has unveiled the remarkable effectiveness of essential oils and seeds derived from garlic, onion, and a variety of mint species (Mentha spp.) in combating gastrointestinal parasitism. These findings highlight the potential of botanical-based interventions as alternative or adjunctive treatments for parasitic infections in the gastrointestinal tract. Coccidiosis, a protozoan disease caused by *Emeria oocyst*, is a common disease in poultry that results in malnutrition and poor performance. The utilization of essential oils against coccidiosis infection has sparked growing interest in recent years. Research studies have illustrated that incorporating essential oils into poultry diets significantly diminishes the excretion of coccidian oocysts and mitigates intestinal lesions in chicks (Barbour *et al.,* 2015). Notably, the main constituents of oregano oil, carvacrol, and thymol, have been found to exhibit significant effectiveness against coccidiosis. Specifically, these compounds show potent activity in combating infections caused by *Eimeria tenella* as well as mixed Eimeria species (Giannenas *et al.,* 2003). Furthermore, studies indicated that phenolic compounds may possess oocyst-killing properties. These studies suggest that such compounds could be effective against *Eimeria tenella*, specifically targeting the oocyst stage of the parasite's life cycle (Williams, 1997). This essential oil blend, including *Punica granatum* (Pomegranate), *Plantago asiatica* (Asian plantain), *Bidens pilosa* (Hairy beggarticks), *Acalypha australis* (Asian copperleaf), *Pteris multifida* (Spider brake fern), *Portulaca oleracea* (Common purslane), *Artemisia argyi* (Common purslane), and *Camellia sinensis* (Tea plant), demonstrates potent anti-coccidial effects, particularly against *Eimeria tennella*, both in laboratory and animal studies (Han *et al.,* 2022). The antiparasitic effect of EOs brought by interference with the developmental stages of parasites and disrupt their life cycles. For example, *Piper hispidinervum* derived essential oil has shown a complete (100%) anthelmintic effect against the acanthocephalan parasite. Additionally, EOs can impede the metabolic functions of parasites, hindering their ability to survive and reproduce. This disruption occurs through the inhibition of critical enzymes and metabolic pathways essential for parasite survival (Dawood *et al.,* 2021; Jamil *et al.,* 2022).

3.3 Antioxidant properties and anti-inflammatory properties

Essential oils safeguard biological molecules from oxidation through their antioxidant mechanisms, which involve the donation of hydrogen or electrons to free radicals and the delocalization of unpaired electrons within the aromatic structure (Fernandez-Panchon *et al.,* 2008). Phenolic compounds have shown to exhibit greater antioxidant potency compared to vitamins E and C, as well as carotenoids (Rice-Evans *et al.,* 1997). It was shown that dietary supplementation with a blend of essential oils, comprising carvacrol, cinnamaldehyde, and capsicum oleoresin, enhanced antioxidant properties by increasing hepatic levels of carotenoids and coenzyme Q10 in broiler chickens (Karadas *et al.,* 2014). Specifically, oregano essential oils have demonstrated antioxidant effects on the cell membrane of meat and abdominal fat in broiler chickens (Botsoglou *et al.,* 2002). Orally administering carvacrol essential oil demonstrates robust anti-inflammatory effects in broilers exposed to LPS challenge, achieved by modulating the TLRs/NF-κB pathway and inhibiting the secretion of inflammatory cytokines, including TNF-α, IL-1β, IL-6, and NF-κB (Liu *et al.,* 2019).

Essential oils can effectively neutralize free radicals within biological systems. They can also augment the body's innate antioxidant defense mechanisms, including the antioxidant enzymes superoxide dismutase and glutathione peroxidase, as well as boosting the levels of vitamin E. Chickens fed with thyme experienced decreased levels of malonaldehyde in their egg yolks, attributed to the transfer of antioxidant components; however, this effect was transient and returned to baseline levels after supplementation cessation (Botsoglou *et al.,* 1997). Notably, antioxidant activity has been observed in eggs and chicken meat when the feed was supplemented with thymol and carvacrol (Lev and Marshall, 2004). Essential oils harbor phenolic compounds renowned for their well-documented anti-inflammatory properties. Terpenoids and flavonoids represent the primary anti-inflammatory components within essential oils. These substances effectively impede inflammatory prostaglandin metabolism. Plants such as chamomile, calendula, licorice, and anise exemplify botanicals recognized for their anti-inflammatory attributes (Srinivasan, 2005).

3.4 Immunomodulatory properties

Numerous studies have explored the immune-modulating properties of various essential oils, such as extracts derived from garlic and oregano. Incorporating a modified garlic-derived product into poultry diets resulted in increased antibody production against *Salmonella enteritidis, Pasteurella multocida,* and *Leptospira Pomona* (Szigeti *et al.,* 1998). The immune-modulatory effects of garlic stem from its ability to enhance the synthesis of interleukins, tumor necrosis factor (TNF-α), and interferon (INF-γ). Additionally, garlic has been observed to boost the phagocytic activity of peritoneal macrophages, stimulate the metabolic processes of macrophages, display antioxidant properties, and regulate the function of antigen-presenting cells (Hanieh *et al.,* 2010). Supplementation of broiler diets with 0.1% garlic led to increased spleen and bursa of Fabricius weights, as well as enhanced antibody responses against the Ranikhet disease virus (Rahimi *et al.,* 2011).

Moreover, incorporating plant essential oils (EOs) into the diet of ducks has displayed the potential to improve both their growth performance and intestinal health. This enhancement is credited to several factors, including heightened antioxidative capacity, improved intestinal morphology and barrier function, increased abundance of short-chain fatty acid (SCFA)-producing bacteria, and decreased presence of enteric pathogens (Ge *et al.,* 2023). Similarly, supplementation with essential oils containing 3.05% thymol, 2.3% carvacrol, and 0.26% cinnamaldehyde has been proven to enhance broiler performance. This improvement is achieved through enhanced nutrient digestibility, up-regulation of transport proteins, modulation of intestinal morphology, and enhancement of immunity and antioxidant ability (Su *et al.,* 2021).

3.5 Metabolic function and growth promoter action of essential oil

Herbs and their essential oils harbor remarkable properties capable of reducing cholesterol levels, which in turn could offer a shield against cancer (Craig, 1999). Lemongrass oil, in particular, showcases a noteworthy capacity for lowering cholesterol. This beneficial effect is credited to its adeptness in inhibiting the activity of hepatic 3-hydroxy-3-methylglutaryl coenzyme A (HMG CoA) reductase, a pivotal enzyme in governing the production of cholesterol (Crowell, 1999). Various dietary essential oils, including borneol, cineole, citral, geraniol, menthone, menthol, fenchone, and β-ionone, have demonstrated the ability to inhibit the activity of hepatic HMG-CoA reductase (Yu *et al.,* 1994). The suppressive impact of essential oils on hepatic HMG-CoA reductase persists consistently, unaffected by factors such as the enzyme's diurnal rhythm and hormonal influences like insulin, glucocorticoids, tri-iodothyronine, and glucagon (Middleton and Hui, 1982). Even essential oils showed antiproliferative activity agent cancerous cells, *e.g.,* lavender (Gezici, 2018).

The utilization of essential oils, whether utilized individually or in combination, has shown promise as a growth enhancer in broiler production. These oils are permitted for use as growth promoters in the poultry industry, aiming to stimulate appetite, a crucial factor for the thriving of young animals and birds. Serving as dietary supplements with flavor-enhancing properties, they not only increase appetite but also facilitate nutrient utilization, optimize the gut microbial environment, and consequently lead to improved growth performance in chickens (Ibrahim *et al.,* 2018). Essential oils (EOs) containing compounds like cinnamaldehyde and thymol, when encapsulated and supplemented to broiler diets, have been shown to enhance growth performance, production efficiency, immune function, and nutrient digestibility in broilers. These EOs can increase the edible portion and dressing percentage of carcasses (Attia *et al.,* 2019). The growth-promoting abilities of EOs stem from their multifunctional roles as antimicrobials, antioxidants, and anti-inflammatory agents within various metabolic pathways. By modulating these pathways, EOs improve nutrient utilization, gut health, and metabolic processes, leading to better overall performance. While antibiotics have traditionally been used to promote growth, EOs present a more natural alternative with varying efficacies depending on their composition. Certain EO blends, such as those containing thymol, carvacrol, and cinnamaldehyde, have demonstrated superior performance in enhancing growth and feed efficiency compared to other EO types (Irawan *et al.,* 2021). This variation in outcomes highlights the importance of careful selection and formulation of EO supplements based on their specific bioactive compounds and functional properties. The growth-promoting mechanisms of EOs are multifaceted, involving their ability to modulate gut microbiota, reduce inflammation, scavenge free radicals, and potentially improve nutrient absorption and metabolic efficiency. By leveraging these diverse mechanisms, EOs can optimize various aspects of broiler performance, including weight gain, feed conversion, carcass yield, and overall production efficiency.

3.6 Intestinal morphology

The ratio of villus height to crypt depth in the small intestine is a critical indicator of digestive and absorptive capacity. A higher ratio suggests improved digestion and absorption, while a lower ratio can impair these processes (Pluske *et al.,* 1997). Antibiotics have been shown to cause thinning of intestinal walls, leading to weight loss and elongation of the intestines in hens (Hedemann *et al.,* 2003). In contrast, supplementation with essential oils (EOs) has demonstrated the ability to increase villus height, potentially enhancing nutrient absorption (Samanta *et al.,* 2009).

The antioxidant properties of EOs may contribute to their villus-enhancing effects. During digestion, oxygen radicals can damage the intestinal mucosal surface and lead to villus atrophy. Antioxidant enzymes like catalase, glutathione peroxidase, and superoxide dismutase can neutralize these radicals. Certain EO components, such as cinnamaldehyde, mitigate oxidative damage to villi by boosting antioxidant enzyme activity, with the phenolic groups in cinnamon oil acting as hydrogen donors (El-Baroty *et al.,* 2010).

Additionally, thymol supplementation has been shown to increase intestinal length, villus width, and crypt depth, creating favorable conditions for nutrient absorption (Alcicek *et al.,* 2003). Combinations of carvacrol, cinnamaldehyde, and capsicum oleoresin have also exhibited positive effects on villus length and intestinal diameter in birds (Awaad *et al.,* 2003). Furthermore, feeding *Mentha piperita* (peppermint) leaves can improve the histomorphological structure of the small intestine mucosa in broilers (Puvaèa *et al.,* 2022). Specific dosages of cinnamon oil have also led to increased villus height in the duodenum, jejunum, and ileum (Chowdhury *et al.,* 2018). Essential oils from thyme, oregano, and rosemary can promote beneficial gut bacteria, enhancing microbial balance and protecting against pathogens. This balance helps stabilize intestinal pH, improving pancreatic enzyme activity and nutrient digestibility. Additionally, these oils boost intestinal health by increasing villus height and crypt depth, which can enhance poultry production performance (Puvaèa et al., 2022).

3.7 Essential oil as an appetite enhancer

The digestive stimulating function is perhaps the most widely recognized and beneficial physiological impact of spices. Recent experimental studies on animals have shed light on this characteristic, providing empirical evidence. Essential oils and oleoresins derived from various sources like garlic, fenugreek, curcumin, onion, mint, black pepper, cinnamon, and capsicum are widely utilized as food flavorings. Their flavor-enhancing properties are attributed to their ability to stimulate three peripheral sensing mechanisms in the oral and nasal cavities: somatosensory, olfactory, and gustatory systems (Srinivasan, 2007). These oronasal sensing mechanisms play a crucial role in preparing the gastrointestinal tract for food intake by triggering the release of digestive secretions and enhancing gut motility (Laugerette *et al.,* 2005).

The somatosensory system, associated with cranial nerves, encompasses the entire oronasal epithelium and is responsible for detecting various sensations, including touch, proprioception, chemesthesis (chemical irritation), and pain. This system can detect the pungency caused by acids and spices, contributing to the overall flavor perception (Djouhri and Lawson, 2004).

Numerous studies have demonstrated that spices or their active components can increase the production of various digestive fluids. In humans, they can stimulate the production of saliva and salivary amylase, while in rats, they can enhance the secretion of stomach acids, bile acids, pancreatic enzymes (lipase, amylase, and proteases), and intestinal mucosa (Platel and Srinivasan, 2004). Specifically, essential oils have been shown to increase the production of trypsin, amylase, and jejunal chyme in broilers (Jang *et al.,* 2007). By activating these oronasal sensing mechanisms and stimulating digestive secretions, essential oils, and oleoresins can potentially improve the overall digestive process and nutrient utilization, contributing to their potential benefits in poultry production.

3.8 Feed consumption

The supplementation of essential oils in chick diets has been observed to have varying effects on feed consumption. A study showed that increasing dietary levels of a combination of thyme, star anise, and oregano leaves, along with their respective essential oils, led to a decrease in daily feed intake among broilers (Amad *et al.,* 2011). Similarly, it was found that broilers from young breeders had reduced feed intake when fed a blend of essential oils from oregano, laurel, sage, myrtle, fennel, and citrus peels, suggesting potential impacts on growth and development due to altered feed consumption patterns (Cabuk *et al.,* 2006).

Generally, the addition of essential oils to chick diets did not prompt notable changes in feed consumption, merely leading to a minor decrease. It was proposed that this observed reduction in feed intake could be linked to the presence of essential oils, which may emit an undesirable odor negatively affecting the meal's palatability for birds (Bozkurt *et al.,* 2012).

4. Conclusion

Essential oils have shown promise as natural growth promoters in poultry, offering multiple benefits such as antimicrobial, antiparasitic, antioxidant, and anti-inflammatory effects. These properties help improve gut health, nutrient digestibility, and overall poultry performance, making essential oils a viable alternative to antibiotics. The beneficial effects of essential oils are linked to their bioactive compounds, including terpenes, phenols, and flavonoids. These compounds enhance growth performance by modulating gut microflora, improving intestinal morphology, and stimulating enzyme secretion. However, the exact mechanisms by which essential oils exert these effects are not fully understood and require further research. Supplementation with essential oils in poultry diets has been associated with improved growth rates, feed conversion ratios, and overall health. Essential oils also help maintain the integrity of the intestinal lining, reducing the risk of infections and promoting better nutrient absorption. While essential oils have demonstrated potential as natural growth enhancers, their efficacy can vary depending on factors such as the specific essential oil used, its concentration, and the health challenges faced by the poultry. Further research is needed to optimize essential oil formulations and understand their long-term impacts on poultry health and productivity. The variability in the chemical composition of essential oils due to environmental and genetic factors highlights the need for standardization in their production and application. Consistent quality and composition are crucial for achieving reliable results in poultry farming.

More studies are required to fully elucidate the mechanisms through which essential oils influence poultry physiology and to determine the optimal dosages and combinations for maximizing their benefits. Additionally, research should focus on the long-term safety and sustainability of using essential oils in poultry diets.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

References

Alcicek, A.; Bozkurt, M. and Cabuk, M. (2003). The effect of an essential oil combination derived from selected herbs growing wild in Turkey on broiler performance. South African Journal of Animal Science, **33**(2):89-94. https://doi.org/10.4314/sajas.v33i2.3761

Aljuwayd, M.; Malli, I.A. and Kwon, Y.M. (2023). Application of eugenol in poultry to control Salmonella colonization and spread. Veterinary Science, **10**(3):151. https://doi.org/10.3390/vetsci10020151

Amad, A.; Manner, K.; Wendler, K.; Neumann, K. and Zentek, J. (2011). Effects of a phytogenic feed additive on growth performance and ileal nutrient digestibility in broiler chickens. Poultry Science, **90**:2811-2816. https://doi.org/10.3382/ps.2011-01515

Attia, Y.; Al-Harthi, M. and El-Kelawy, M. (2019). Utilisation of essential oils as a natural growth promoter for broiler chickens. Italian Journal of Animal Science, **18**(1):1005-1012. https://doi.org/10.1080/1828051X.2019.1607574

Awaad, M.H.H.; Elmenawey, M. and Ahmed, K.A. (2014). Effect of a specific combination of carvacrol, cinnamaldehyde and on the growth performance, carcass quality and gut integrity of broiler chickens. Veterinary World, 7(5):200-210. https://doi.org/10.14202/vetworld.2014.284-290

Barbour, E.K.; Bragg, R.R.; Karrouf, G.; Iyer, A.; Azhar, E.; Harakeh, S. and Kumosani, T. (2015). Control of eight predominant Eimeria spp. involved in economic coccidiosis of broiler chicken by a chemically characterized essential oil. Journal of Applied Microbiology, **118**:583-591. https://doi.org/10.1111/jam.12731

Bassole, I.H.N. and Juliani, H.R. (2012). Essential oils in combination and their antimicrobial properties. Molecules, **17**:3989-4006. https://doi.org/10.3390/molecules17043989

Botsoglou, N.A.; Florou–Paner, P.; Christaki, E.; Fletouris, D.J. and Spais, A.B. (2002). Effect of dietary oregano essential oil on performance of chickens and on iron–induced lipid oxidation of breast, thigh and abdominal fat tissues. British Poultry Science, **43**:223–230. https://doi.org/10.1080/00071660120121436

Botsoglou, N.A.; Yannakopoulos, A.L.; Fletouris, D.J.; Tserveni Goussi, A.S. and Fortomaris, P.D. (1997). Effect of dietary thyme on the oxidative stability of egg yolk. Journal of Agricultural and Food Chemistry, **45**:3711-3716. https://doi.org/10.1021/jf9703009

Bouatrous, Y. (2019). Antibacterial activity of an essential oil and various extracts of the medicinal plant *Thymus hirtus* sp. *algeriensis* Boiss. & Reut. Ann. Phytomed., **8**(2):108-114. http://dx.doi.org/10.21276/ap.2019.8.2.13

Bozkurt, M.; Aysul, N.; Küçükyilmaz, K.; Aypak, S.; Ege, G.; Çatli, A.U.; Aksit, H.; Cöven, F.; Seyrek, K. and Cinar, M. (2014). Efficacy of in feed preparations of an anticoccidial, multienzyme, prebiotic, probiotic, and herbal essential oil mixture in healthy and Eimeria spp.-infected broilers. Poultry Science, **93**:389-399. https://doi.org/10.3382/ps.2013-03368

Cabuk, M.; Bozkurt, M.; Alcicek, A.; Akbas, Y. and Kucukyýlmaz, K. (2006). Effect of a herbal essential oil mixture on growth and internal organ weight of broilers from young and old breeder flocks. South African Journal of Animal Science, **36**:135-141. https://doi.org/10.4314/sajas.v36i2.3996

Chowdhury, S.; Mandal, G.P.; Patra, A.K.; Kumar, P.; Samanta, I.; Pradhan, S. and Samanta, A.K. (2018). Different essential oils in diets of broiler chickens. Animal Feed Science and Technology, **36**:39-47. https://doi.org/10.1016/J.ANIFEEDSCI.2017.12.003

Craig, W.J. (1999). Health promoting properties of common herbs. The American Journal of Clinical Nutrition, **70**:491-499. https://doi.org/10.1093/ajcn/70.3.491s

Crowell, P.L. (1999). Prevention and therapy of cancer by dietary monoterpenes. Journal of Nutrition, **129**: 75-778.

Dawood, M. A. O.; El Basuini, M. F.; Zaineldin, A. I.; Yilmaz, S.; Hasan, M. T.; Ahmadifar, E.; El Asely, A. M.; Abdel-Latif, H. M. R.; Alagawany, M.; Abu-Elala, N. M.; Van Doan, H. and Sewilam, H. (2021). Antiparasitic and antibacterial functionality of essential oils: An alternative approach for sustainable aquaculture. Pathogens (Basel, Switzerland), **10**(2):185.

Deans, S.G. and Ritchie, G. (1987). Antibacterial properties of plant essential oils. International Journal of Food Microbiology, **5**:165-180. https://doi.org/10.1016/0168-1605(87)90034-1

Djouhri, L. and Lawson, S.N. (2004). Abeta-fiber nociceptive primary afferent neurons: A review of incidence and properties in relation to other afferent A-fiber neurons in mammals. Brain Research Reviews, **46**(2):131-145. https://doi.org/10.1016/j.brainresrev.2004.07.015

El-Baroty, G.S.; El-Baky, H.H.; Farag, R.S.; and Saleh, M.A. (2010). Characterization of antioxidant and antimicrobial compounds of cinnamon and ginger essential oils. African Journal of Biochemistry, **4**:167-174.

Franz, C. and Novak, J. (2009). Sources of essential oils. In: Baser, K.H.C., Buchbauer, G. (editors). Handbook of essential oils: science, technology, and applications. CRC Press/Taylor & Francis Group, Boca Raton, pp:39-82.

Fernandez-Panchon, M.S.; Villano, D.; Troncoso, A.M.; and Garcia-Parrilla, M.C. (2008). Antioxidant activity of phenolic compounds: From *in vitro* results to *in vivo* evidence. Critical Reviews in Food Science and Nutrition, **48**:649-671. https://doi.org/10.1080/10408390701761845

Ge, C.; Luo, X.; Wu, L.; Lv, Y.; Hu, Z.; Yu, D. and Liu, B. (2023). Plant essential oils improve growth performance by increasing antioxidative capacity, enhancing intestinal barrier function, and modulating gut microbiota in *Muscovy ducks*. Poultry Science, **102**(8):102813. https://doi.org/10.1016/j.psj.2023.102813

Gezici, S. (2018). Promising anticancer activity of lavender (*Lavandula angustifolia Mill.*) essential oil through induction of both apoptosis and necrosis. Ann. Phytomed., **7**(2):38-45.

Giannenas, I.; Florou-Paneri, P.; Papazahariadou, M.; Christaki, E. and Botsoglou, N.A. (2003). Effect of dietary supplementation with oregano essential oil on performance of broilers after experimental infection with *Eimeria tenella*. Archives of Animal Nutrition, **57**:99-106. https://doi.org/10.1080/0003942031000107299

Gill, A.O.; Delaquis, P.; Russo, P. and Holley, R.A. (2002). Evaluation of antilisterial action of cilantro oil on vacuum-packed ham. International Journal of Food Microbiology, **73**:83-92. https://doi.org/10.1016/s0168-1605(01)00712-7

Hammia, H. and Bouatrous, Y. (2021). Evaluation of antifungal potential of *Ruta chalepensis* L. essential oil against *Mauginiella scaettae*, fungus responsible for the inflorescence rot of date palm (*Phoenix dactylifera* L.). Ann. Phytomed., **10**(2):442-447. http://dx.doi.org/10.21276/ap.2021.10.2.58

Han, M.; Hu, W.; Chen, T.; Guo, H.; Zhu, J. and Chen, F. (2022). Anticoccidial activity of natural plants extracts mixture against *Eimeria tenella:* An *in vitro* and *in vivo* study. Frontiers in Veterinary Science, **9**:1066543. https://doi.org/10.3389/fvets.2022.1066543

Hanieh, H.; Narabara, K.; Piao, M.; Gerile, C. and Abe, A. (2010). Modulatory effects of two levels of dietary Alliums on immune response and certain immunological variables, following immunization, in White Leghorn chickens. Animal Science Journal, 81:673-680. https://doi.org/10.1111/j.1740-0929.2010.00798.x

Hay, R.K. M. and Waterman, P.G. (1993). Volatile oil crops: Their biology, biochemistry and production. Longman Scientific & Technical. pp:185

Hedemann, M.S.; Hojsgaard, S. and Jensen, B.B. (2003). Small intestine morphology and activity of intestinal peptidases in piglets around weaning. Journal of Animal Physiology and Animal Nutrition, 87:32-41. https://doi.org/10.1046/j.1439-0396.2003.00405.x

Hong, J.C.; Steiner, T.; Aufy, A. and Lien, T.F. (2012). Effects of supplemental essential oil on growth performance, lipid metabolites and immunity, intestinal characteristics, microbiota and carcass traits in broilers. Livestock Science, 144(3):253-262. https://doi.org/10.1016/j.livsci.2011.12.008

Ibrahim, I.E.; Mukhtar, M.A.; and Mohamed, K.A. (2018). Response of broiler chicks to different levels of Eucalyptus essential oil. World Journal of Pharmacy and Pharmaceutical Sciences, 7(4):167-176.

Irawan, A.; Hidayat, C.; Jayanegara, A. and Ratriyanto, A. (2021). Essential oils as growth-promoting additives on performance, nutrient digestibility, cecal microbes, and serum metabolites of broiler chickens: a meta-analysis. Animal Bioscience, 34(9):1499-1513. https://doi.org/10.5713/ab.20.0668

Jamil, M.; Aleem, M. T.; Shaukat, A.; Khan, A.; Mohsin, M.; Rehman, T. U.; Abbas, R. Z.; Saleemi, M. K.; Khatoon, A.; Babar, W.; Yan, R. and Li, K. (2022). Medicinal plants as an alternative to control poultry parasitic diseases. Life (Basel), 12(3):449.

Jamroz, D.; Wiliczkiewicz, A.; Wertelecki, T.; Orda, J. and Sukorupinska, J. (2005). Use of active substances of plant origin in chicken diets based on maize and locally grown cereals. British Poultry Science, 46:485-493. https://doi.org/10.1080/00071660500191056

Jang, I.S.; Ko, Y.H.; Kang, S.Y. and Lee, C.Y. (2007). Effect of a commercial essential oil on growth performance, digestive enzyme activity and intestinal microflora population in broiler chickens. Animal Feed Science and Technology, 134:304-315. https://doi.org/10.1016/j.anifeedsci.2006.06.009

Jerzsele, A.; Szeker, K.; Csizinszky, R.; Gere, E.; Jakab, C.; Mallo, J. and Galfi, P. (2012). Efficacy of protected sodium butyrate, a protected blend of essential oils, their combination, and *Bacillus amyloliquefaciens* spore suspension against artificially induced necrotic enteritis in broilers. Poultry Science, 91:837-843. https://doi.org/10.3382/ps.2011-01853

Karadas, F.; Pirgozliev, V.; Rose, S.P.; Dimitrov, D.; Oduguwa, O. and Bravo, D. (2014). Dietary essential oils improve the hepatic antioxidative status of broiler chickens. British Poultry Science, 55:1-6. https://doi.org/10.1080/00071668.2014.891098

Laugerette, F.; Passilly-Degrace, P.; Patris, B.; Niot, I.; Febbraio, M.; Montmayeur, J.P. and Besnard, P. (2005). CD36 involvement in orosensory detection of dietary lipids, spontaneous fat preference, and digestive secretions. Journal of Clinical Investigation, 115:3177-3184. https://doi.org/10.1172/JCI25299

Lee, H.S. and Ahn, Y.J. (1998). Growing-inhibiting effects of Cinnamomum cassia bark derived materials on human intestinal bacteria. Journal of Agricultural and Food Chemistry, 46:8-12. https://doi.org/10.1021/jf970548y

Levy, S.B. and Marshall, B. (2004). Antibacterial resistance worldwide: causes, challenges and responses. Nature Medicine, 10:122-129

Liu, S.D.; Song, M.H.; Yun, W.; Lee, J.H.; Kim, H.B. and Cho, J.H. (2019). Effect of carvacrol essential oils on immune response and inflammation-related genes expression in broilers challenged by lipopolysaccharide. Poultry Science, 98(5):2026-2033. https://doi.org/10.3382/ps/pey575

Middleton, B. and Hui, K.P. (1982). Inhibition of hepatic S-3-hydroxy-3-methylglutaryl-CoA reductase and in vivo rates of lipogenesis by a mixture of pure cyclic monoterpenes. Biochemical Pharmacology, 31:2897-2901. https://doi.org/10.1016/0006-2952(82)90261-1

Mitsch, P.; Zitterl Eglseer, K.; Köhler, B.; Gabler, C.; Losa, R. and Zimpernik, I. (2004). The effect of two different blends of essential oil components on the proliferation of Clostridium perfringens in the intestine of broiler chickens. Poultry Science, 83:669-675. https://doi.org/10.1093/ps/83.4.669

Moharreri, M.; Vakili, R.; Oskoueian, E. and Rajabzadeh, G. (2022). Effects of microencapsulated essential oils on growth performance and biomarkers of inflammation in broiler chickens challenged with *Salmonella enteritidis*. Journal of the Saudi Society of Agricultural Sciences, 21(5):349-357. https://doi.org/10.1016/j.jssas.2021.10.012

O'Bryan, C.A.; Pendleton, S.J.; Crandall, P.G. and Ricke, S.C. (2015). Potential of plant essential oils and their components in animal agriculture-in vitro studies on antibacterial mode of action. Frontiers in Veterinary Science, 2:1e8. https://doi.org/10.3389/fvets.2015.00035

Oyen, L.P.A. and Dung, N.X. (1999). Plant resources of South-East Asia No. 19. Essential-oil plants. Backhuys Publishers. pp:277

Platel, K. and Srinivasan, K. (2004). Digestive stimulant action of spices: A myth or reality? Indian Journal of Medical Research, 119:167-179.

Pluske, J.R.; Hampson, D.J. and Williams, I.H. (1997). Factors influencing the structure and function of the small intestine in the weaned pig - a review. Livestock Production Science, 51:215-236. https://doi.org/10.1016/S0301-6226(97)00057-2

Pol, V. S.; Ingle, Y. V. and Lengare, K. A. (2023). Antifungal effects of plant essential oils against Colletotrichum gloeosporioides, the fungus associated with citrus twig blight. Ann. Phytomed., 12(1):538-545. http://dx.doi.org/10.54085/ap.2023.12.1.12

Puvaèa, N.; Tufarelli, V. and Giannenas, I. (2022). Essential oils in broiler chicken production, immunity and meat quality: Review of *Thymus vulgaris, Origanum vulgare*, and *Rosmarinus officinalis*. Agriculture, 12(6):874. https://doi.org/10.3390/agriculture12060874

Rahimi, S.; Zadeh, T.; Karimi, M.A.; Omidbaigi, R. and Rokni, H. (2011). Effect of the three herbal extracts on growth performance, immune system, blood factors and intestinal selected bacterial population in broiler chickens. Journal of Agricultural Science and Technology, 13:527-539.

Rice-Evans, C.A.; Miller, N.J. and Papaganga, G. (1997). Antioxidant properties of phenolic compounds. Trends in Plant Science, 4:152-159. https://doi.org/10.1016/S1360-1385(97)01018-2

Samanta, S.; Haldar, S. and Ghosh, T.K. (2009). Comparative efficacy of an organic acid blend and bacitracin disalicylate as growth promoters in broiler chickens: Wffects on performance, gut histology and small intestinal milieu. Veterinary Medicine International, 4:651-654. https://doi.org/10.4061/2010/645150

Seow, Y.X.; Yeo, C.R.; Chung, H.L. and Yuk, H.G. (2014). Plant essential oils as active antimicrobial agents. Critical Reviews in Food Science and Nutrition, 54:625e644. https://doi.org/10.1080/10408398.2011.599504

Srinivasan, K. (2005). Spices as influencers of body metabolism: An overview of three decades of research. Food Research International, **38**:77-86. https://doi.org/10.1016/j.foodres.2004.09.001

Srinivasan, K. (2007). Black pepper and its pungent principle-piperine: a review of diverse physiological effects. Critical Reviews in Food Science and Nutrition, **47**:735-748. https://doi.org/10.1080/10408390601062054

Su, G.; Wang, L.; Zhou, X.; Wu, X.; Chen, D.; Yu, B.; Huang, Z.; Luo, Y.; Mao, X.; Zheng, P.; Yu, J.; Luo, J. and He, J. (2021). Effects of essential oil on growth performance, digestibility, immunity, and intestinal health in broilers. Poultry Science, **100**(8):101242. https://doi.org/10.1016/j.psj.2021.101242

Szigeti, G.; Palfi, V.; Nagy, B.; Ine, E. and Nagy, G. (1998). New type of immune stimulant to increase antibody production generated by viral and bacterial vaccines. Magyar Allatorvosok Lapja, **120**:719-721.

van de Braak, S. and Leijten, G. (1994). Essential oils and oleoresins: A survey in The Netherlands and other major markets in the European Union. CBI, Centre for the Promotion of Imports from Developing Countries, Rotterdam, pp:116.

Wenk, C. (2006). Are herbs, botanicals and other related substances adequate replacements for antimicrobial growth promoters? In: Barug D, de Jong J, Kies AK, Verstegen MWA (Eds.). Antimicrobial Growth Promoters. Wageningen Academic Publishers, The Netherlands, pp. 329-340.

Williams, R.B. (1997). Laboratory tests of phenolic disinfectants as oocysticides against the chicken coccidium *Eimeria tenella*. Veterinary Record, **141**:447-448. https://doi.org/10.1136/vr.141.17.447

Yu, S.G.; Abuirmeileh, N.M.; Qureshi, A.A. and Elson, C.E. (1994). Dietary β–ionone suppresses hepatic 3-hydroxy-3-methylglutaryl coenzyme A reductase activity. Journal of Agricultural and Food Chemistry, **42**:1493-1496. https://doi.org/10.1021/jf00043a019

Zulkifli, I.; Iman-Rahayu, H.S.; Alimon, A.R.; Vidyadaran, M.K. and Babjee, S.A. (2009). Gut microflora and intestinal morphology of commercial broiler chickens and red jungle fowl fed diets containing palm kernel meal. Archiv für Geflügelkunde, **73**:49-55.

Citation **T.J. Sheikh, Ranjan Rajeev, C. M. Modi, Amit Kumar Jha, and Rajesh Kumar (2024). Essential oils: A promising natural alternative to antibiotics in poultry production. Ann. Phytomed., 13(2):75-82. http://dx.doi.org/10.54085/ap.2024.13.2.8.**