Scientific Papers. Series D. Animal Science. Vol. LXIX, No. 1, 2026
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

# THE POTENTIAL OF MINT (*Mentha* spp.) AS A FUNCTIONAL FEED ADDITIVE IN POULTRY NUTRITION

**Laurian Cristian COJOCARIU[1], Roxana Georgiana BOBEICĂ[1], Ioana Miruna BALMUȘ[2], Mircea LAZĂR[1], Alexandru USTUROI[1], Răzvan-Mihail RADU-RUSU[1]**

[1]"Ion Ionescu de la Brad" Iași University of Life Sciences,
8 Mihail Sadoveanu Alley, Iași, Romania
[2]"Alexandru Ioan Cuza" University of Iași, 26 Alexandru Lăpușneanu Street, Iași, Romania

Corresponding author email: cojocariulaurian@gmail.com

***Abstract***

*The powerful antioxidant, antibacterial, and anti-inflammatory qualities of mint, a commonly grown herb, are attributed to its abundance of bioactive chemicals, particularly essential oils (such as menthol, menthone, and limonene), flavonoids, and phenolic acids. Because of its calming, digestive, and carminative properties, mint has long been employed in both traditional human medicine and the culinary arts. Its use in animal nutrition is becoming more popular as a sustainable substitute for artificial growth boosters. The potential to improve nutritional absorption, boost appetite, strengthen the immune system, and promote intestinal integrity are just a few of the many health advantages of poultry. Studies indicate that dietary mint supplementation can enhance growth performance, improve feed conversion ratio, and elevate the quality of poultry products while reducing pathogen burden in the gastrointestinal system. In order to optimise the inclusion levels of various mint preparations (such as dried leaf, essential oil, and extract) for sustainable and efficient application in contemporary poultry production systems, this abstract emphasises the need for additional research.*

***Key words****: broiler, essential oils, mint, phytobiotics, poultry.*

## INTRODUCTION

The poultry industry plays a critical role in global food security, providing affordable sources of high-quality animal protein. However, intensive poultry production systems are often associated with challenges related to disease control, feed efficiency and animal welfare. For several decades, antibiotic growth promoters (AGPs) were routinely used to improve feed efficiency and reduce disease incidence. Nevertheless, concerns regarding antimicrobial resistance and consumer demand for antibiotic-free poultry products have led to restrictions on AGP use in many regions worldwide (Abreu et al., 2023).

As a result, considerable attention has been directed toward natural alternatives such as probiotics, prebiotics, organic acids and phytogenic feed additives. Phytogenic feed additives derived from herbs and medicinal plants are particularly attractive because they contain diverse bioactive compounds that can improve digestion, modulate gut microbiota and enhance immune responses (Oni & Oke, 2025).

Mint (*Mentha* spp.) is one of the most widely cultivated aromatic plants belonging to the *Lamiaceae* family (Mishra & Chandra, 2022). Species such as *Mentha piperita* (peppermint), *Mentha spicata* (spearmint) and *Mentha longifolia* are widely used in food, pharmaceutical and cosmetic industries due to their characteristic aroma and medicinal properties (Saqib et al., 2022). The plant contains a variety of biologically active compounds, particularly essential oils rich in menthol and menthone, which are responsible for many of its pharmacological effects (Mikaili et al., 2013).

In recent years, mint has been increasingly investigated as a phytogenic feed additive in poultry nutrition. Several studies have reported improvements in growth performance feed conversion efficiency and gut microbiota composition following dietary supplementation with mint preparations. For example, Lv et al. (2026) showed that supplementation with peppermint leaves or menthol increased body weight gain and improved feed conversion ratio in broiler chickens.

Given the growing interest in plant-based feed additives, a comprehensive synthesis of available literature is needed to evaluate the potential role of mint in poultry nutrition. Therefore, the objective of this narrative review is to summarize current knowledge on the phytochemical composition of mint, its biological activities, mechanisms of action in poultry and the effects of dietary mint supplementation on performance, health and product quality.

## MATERIALS AND METHODS

The methodology used for this narrative review-type paper was established to facilitate and replicate the synthesis and use of the existing literature regarding the use of mint as a feed additive in poultry nutrition.

The literature search was conducted on five databases and repositories: MDPI, Web of Science, Google Scholar, PubMed and ScienceDirect. The period of the literature search was restricted to the last ten years to maximize the last advancements in the field of phytobiotics research, but a few older research papers were selected. Also, to be more selective were used only articles published in English.

To have a higher search sensitivity search, Boolean operators were used (AND, OR, NOT) and various search strings were formed to facilitate integration of related terms for host species, compounds and performance outcomes. The primary search strings followed these combinations: (poultry OR broiler) AND (phytobiotics OR functional feed OR plant extracts); (Mint OR Peppermint OR Mentha spp.) AND (poultry OR broiler) and (meat OR eggs); (poultry AND broiler) NOT (ruminants OR swine OR farm animals).

Articles shown on the initial search were selected based on the evaluation of the titles, abstracts and conclusions. Also, articles that lack a phytobiotics or phytogenic component or were focused primarily on synthetic growth promoters were excluded.

The selected studies were categorised thematically within the discussion framework: botanical characterisation and phytochemical composition, biological properties of mint relevant to poultry nutrition, mechanism of action of mint in poultry, effects on growth performance, intestinal health and microbiota and quality and safety of poultry products.

To conclude the schematic analysis, a dedicated section addressing limitations was incorporated also the emerging conclusions.

## RESULTS AND DISCUSSIONS

### BOTANICAL CHARACTERISTICS AND COMPOSITION OF MINT

Mint species belonging to the genus *Mentha* are perennial aromatic herbs characterized by square stems, opposite leaves and highly aromatic essential oils (Yosefian et al., 2023). The genus includes more than 25 species and numerous hybrids widely distributed across temperate regions of the world, the most common being: *Mentha piperita (*good mint or peppermint). *Mentha spicata* (spearmint) and *Mentha crispa (*curly mint) (Tiwari, 2016).

The biological properties of mint are primarily attributed to its rich phytochemical composition. The essential oil content of peppermint leaves typically ranges between 1% and 4% of dry matter and contains a variety of monoterpenes and other volatile compounds (Pintilia et al., 2025). Major constituents include: menthol, menthone, isomenthone, cineole, limonene, pulegone and linalool, as shown in Table 1.

Table 1. Comparative essential oils profile and biological roles of various mint species

| | *Mentha spicata* (%) | *Mentha piperita* (%) | Biological role |
|---|---|---|---|
| Menthol | 11 | 38-70 | Antimicrobial, analgesic |
| Menthone | 21-23 | 0.4-35 | Digestive stimulant, metabolic precursor |
| Carvone | 40 | 3.5 | Pathogene inhibitor, carminative |
| Limonene | 21 | 0.6-4.5 | Antioxidant, gut health modulator |
| Pulegone | 0-10 | 0-7 | Bactericidal, hepatotoxic at high levels |
| 1,8-Cineole | 17 | 0.4-12 | Respiratory support, anti-inflamatory |
| Source | (Snoussi et al., 2015) | (Hudz et al., 2023) | - |

In addition to essential oils, mint contains a variety of phenolic compounds and flavonoids such as rosmarinic acid, caffeic acid, luteolin and apigenin. These compounds possess potent antioxidant activity and contribute to the plant's anti-inflammatory and antimicrobial properties (Ćavar Zeljković et al., 2021).

The concentration of these phytochemicals varies depending on several factors, including plant species, cultivation conditions, harvesting stage and extraction method. Such variability may partly explain the differences in efficacy reported among studies investigating mint supplementation in animal diets (Chrysargyris et al., 2024).

Phytochemical compounds present in mint can exert multiple biological effects relevant to poultry nutrition, including antimicrobial activity against pathogenic bacteria, stimulation of digestive enzymes and modulation of oxidative stress (Mnisi et al., 2022).

## BIOLOGICAL PROPERTIES OF MINT RELEVANT TO POULTRY NUTRITION

### Antioxidant activity

Oxidative stress is a major factor affecting poultry health and productivity, particularly under conditions of environmental stress such as high temperature. Phenolic compounds and flavonoids found in mint have strong antioxidant properties capable of neutralizing reactive oxygen species and protecting cellular structures from oxidative damage (Oke et al., 2024).

Experimental studies have shown that dietary peppermint supplementation can enhance antioxidant enzyme activities, including superoxide dismutase, catalase and glutathione peroxidase, while reducing lipid peroxidation markers. These antioxidant effects may contribute to improved physiological resilience in poultry, particularly during periods of heat stress (Abou Zaid et al., 2025).

### Antimicrobial effects

Mint essential oils exhibit antimicrobial activity against a wide range of pathogenic microorganisms, including *Escherichia coli*, *Salmonella* spp. and *Staphylococcus aureus* (Puvača et al., 2021). The antimicrobial action of mint is mainly attributed to monoterpenes such as menthol and menthone, which disrupt microbial cell membranes and interfere with metabolic processes (Zhao et al., 2023).

Studies in broiler chickens have demonstrated that diets supplemented with peppermint or other phytogenic additives can reduce pathogenic bacterial populations in the gastrointestinal tract while increasing beneficial bacteria such as *Lactobacillus* spp. Such modulation of intestinal microbiota may improve nutrient digestion and reduce disease susceptibility (Obianwuna et al., 2024; Cojocariu et al., 2026).

### Anti-inflammatory and immunomodulatory effects

Inflammation and immune responses play critical roles in poultry health and disease resistance. Mint extracts have been shown to exhibit anti-inflammatory properties by inhibiting the production of inflammatory mediators and cytokines (Ma et al., 2024).

Recent research indicates that dietary peppermint oil supplementation can enhance immune responses and improve haematological and biochemical parameters in broiler chickens. These effects suggest that mint may support immune function and contribute to improved disease resistance in poultry (Bernard et al., 2025).

## MECHANISMS OF ACTION OF MINT IN POULTRY

The beneficial effects of mint supplementation in poultry diets are mediated through several physiological mechanisms.

First, essential oils present in mint stimulate the secretion of digestive enzymes such as amylase, protease and lipase, thereby improving nutrient digestion and absorption. Enhanced digestive efficiency contributes to improved growth performance and feed conversion ratio (Ghazanfari et al., 2024).

Second, the antimicrobial properties of mint essential oils help regulate the composition of intestinal microbiota. By suppressing pathogenic bacteria and promoting beneficial microbial populations, mint can improve gut health and nutrient utilization (Angane et al., 2026).

Third, antioxidant compounds in mint reduce oxidative stress and protect intestinal epithelial cells, maintaining intestinal integrity and improving nutrient absorption (Hejna et al., 2021).

Finally, mint compounds may influence metabolic processes by modulating lipid metabolism and reducing serum cholesterol and triglyceride levels. Experimental studies have

reported reductions in serum lipid levels in broilers fed diets supplemented with peppermint (Khatun et al., 2026).
Together, these mechanisms contribute to the overall beneficial effects of mint supplementation on poultry performance and health.

## EFFECTS ON GROWTH PERFORMANCE

### Body weight gain and feed intake

Numerous studies have investigated the effects of dietary mint supplementation on growth performance in broiler chickens. Overall, most studies report improvements in body weight gain and feed intake when mint is included at moderate levels in the diet.
For example, after Alkassar S.A. (2025) and his collaborators, supplementation with peppermint leaves at levels up to 15 g/kg diet significantly increased body weight and feed intake in broiler chickens during a 35 day feeding trial.
Similarly, another study by Asadi N. and his colleagues (2017) reported that dietary peppermint powder improved average daily weight gain and feed conversion ratio in broilers, with the optimal level identified as approximately 4.5 g/kg feed.
These improvements in growth performance are likely associated with enhanced digestive efficiency and improved gut health.

### Feed Conversion Ratio

Feed conversion ratio (FCR) is a critical parameter in poultry production, reflecting the efficiency with which animals convert feed into body mass.
Several experimental studies (Salinas-Chavira et al., 2024; Reda et al., 2025; Ghazanfari et al., 2024) have demonstrated improvements in FCR following dietary supplementation with mint or mint-derived compounds. For instance, broilers receiving diets supplemented with peppermint essential oil exhibited improved feed efficiency compared with control groups.
Improved feed conversion may be attributed to enhanced nutrient digestibility and better gut microbial balance.

## EFFECTS ON INTESTINAL HEALTH AND MICROBIOTA

Gut health is a key determinant of poultry productivity and disease resistance. Phytogenic feed additives such as mint can positively influence intestinal morphology and microbial populations (Shehata et al., 2022).
Studies have shown that mint supplementation increases villus height and improves intestinal barrier function, leading to enhanced nutrient absorption (Cetingul et al., 2015; Bai et al., 2023; Mustafa, 2025). Furthermore, peppermint supplementation has been associated with increased populations of beneficial bacteria such as *Lactobacillus* spp. and reduced populations of pathogenic bacteria including *E. coli* (Adaszyńska-Skwirzyńska et al., 2025; Ţuţulescu et al., 2023).
Under heat stress conditions, mint leaf powder supplementation has been shown to improve intestinal morphology and reduce physiological stress responses in broiler chickens (Al-Saadi & Al-Musawi, 2024).
These findings suggest that mint may play an important role in maintaining intestinal health under challenging environmental conditions.

## EFFECTS ON CARCASS AND MEAT QUALITY

In addition to growth performance, mint supplementation may influence carcass traits and meat quality in poultry.
Research indicates that dietary peppermint supplementation can reduce abdominal fat deposition and improve carcass yield (Narimani-Rad et al., 2011; Habashy et al., 2025; Zapletal et al., 2026).
Furthermore, improvements in meat quality parameters such as reduced cooking loss and enhanced oxidative stability have been reported in broilers fed diets containing peppermint leaves or menthol (Abdel-Wareth et al., 2019, Abdel-Wareth et al., 2023; Ashraf et al., 2025).
The antioxidant properties of mint may contribute to improved meat quality by reducing lipid oxidation during storage (Kanatt Abdel-Wareth et al., 2008; Domínguez Abdel-Wareth et al., 2019; Hejna et al., 2021, Mnisi et al., 2022; Alkassar et al., 2025).

## FORMS OF MINT USED AND OPTIMAL INCLUSION LEVELS

Mint can be incorporated into poultry diets in several forms, each with different concentrations of active compounds.
Dried mint leaves are the most commonly used form due to availability and cost effectiveness followed by essential oils which are highly concentrated sources of bioactive compounds.
Plant extracts are standardized preparations used in experimental studies and aqueous solutions are added to drinking water (Tafrihi et al., 2021; Hutsol et al., 2023; Gavarić et al., 2025).
The choice of preparation influences the bioavailability of active compounds and the overall efficacy of supplementation.
Determining the optimal inclusion level of mint in diets for poultry remains challenging due to variations in plant species, preparation methods and experimental conditions (Abdelli et al., 2021; Ștef et al., 2025; Urban et al., 2025).
Studies have reported beneficial effects with peppermint leaf inclusion levels ranging from approximately 5 to 15 g/kg diet (Ma et al., 2024; Abdel-Wareth & Lohakare, 2023).
Other experiments using mint leaf powder have reported positive effects at levels between 0.6% and 1.8% of the diet (Ahmed et al., 2016; Abdel-Wareth & Lohakare, 2023; Alkassar et al., 2025).
Excessive inclusion levels, especially for essential oils and hydro-alcoholic extracts may negatively affect feed intake due to strong aroma or potential toxicity of certain compounds, highlighting the need for careful dose optimization (Rais et al., 2025; Kolygas et al., 2025; Nayak et al., 2025).

## LIMITATIONS AND RESEARCH GAPS

Despite the promising results found in the literature, several limitations remain regarding the use of mint in poultry nutrition.
First, the phytochemical composition of mint varies widely among species and cultivation conditions, which may lead to inconsistent results across studies.
Second, many experiments have been conducted under controlled laboratory conditions rather than commercial production environments.
Third, long-term studies evaluating the effects of mint supplementation on poultry health, productivity and economic efficiency are limited.
Finally, interactions between mint and other dietary components, including probiotics and enzymes, remain poorly understood.
Addressing these gaps will be essential for developing standardized recommendations for the use of mint as a feed additive in poultry production.

## CONCLUSIONS

Mint (*Mentha* spp.*)* represents a promising phytogenic feed additive with a high potential to improve poultry health and productivity.
Its rich content of essential oils, phenolic compounds and flavonoids contributes to a wide range of biological activities, including antimicrobial, antioxidant and anti-inflammatory effects.
Evidence from experimental studies indicates that dietary supplementation with mint can enhance growth performance, improve feed conversion efficiency, support intestinal health and improve meat quality in poultry. Furthermore, mint may help mitigate the negative effects of environmental stressors such as heat stress.
However, variability in mint species, preparation methods and inclusion levels highlights the need for further research to standardize its application in poultry diets. Future studies should focus on large-scale commercial trials, dose optimization and synergistic interactions between mint and other feed additives.
Overall, mint represents a sustainable and natural alternative to antibiotic growth promoters, contributing to more environmentally friendly and consumer-acceptable poultry production systems.

## ACKNOWLEDGEMENTS

The authors would like to address thanks to their colleagues from Faculty of Food and Animal Sciences and to the Doctoral School of Engineering Sciences, “Ion Ionescu de la Brad” Iași University of Life Sciences, Romania.

## REFERENCES


Abdel-Wareth, A. A., Kehraus, S., & Südekum, K. H. (2019). Peppermint and its respective active component in diets of broiler chickens: growth performance, viability, economics, meat physicochemical properties, and carcass characteristics. *Poultry science*, 98(9), 3850-3859.

Abdel-Wareth, A. A., & Lohakare, J. (2023). Bioactive lipid compounds as eco-friendly agents in the diets of broiler chicks for sustainable production and health status. *Veterinary Sciences*, 10(10), 612.

Abdelli, N., Solà-Oriol, D., & Pérez, J. F. (2021). Phytogenic feed additives in poultry: achievements, prospective and challenges. *Animals*, 11(12), 3471.

Abou Zaid, A. A., Mohammed, N. H., Elshafey, A. E., Hussein, E. E., El-Gamal, A. M., & Abo-Al-Ela, H. G. (2025). Mentha piperita supplementation promotes growth, immunity, and disease resistance in Nile tilapia against *Aeromonas hydrophila*. *Pathogens*, 14(4), 378.

Abreu, R., Semedo-Lemsaddek, T., Cunha, E., Tavares, L., & Oliveira, M. (2023). Antimicrobial drug resistance in poultry production: Current status and innovative strategies for bacterial control. *Microorganisms*, 11(4), 953.

Adaszyńska-Skwirzyńska, M., Zych, S., Dzięcioł, M., Konieczka, P., Kowalik, B., Witkowska, D., & Bucław, M. (2025). Potential of essential oils from different mint species against multidrug-resistant escherichia coli strains isolated from clinical cases in poultry. *International Journal of Molecular Sciences*, 26(23), 11263.

Ahmed, A. M., El-Sanhoury, M. H., & Mostafa, M. M. (2016). Research article effect of peppermint extracts inclusion in broiler chick diet on chick performance, plasma constituents, carcass traits and some microbial populations, enzymatic activity and histological aspects of small intestine. *Asian J. Anim. Vet. Adv*, 11, 441-451.

Al-Saadi, M. J., & Al-Musawi, J. E. (2024). Effects of heat stress on some productive and histological traits in broiler feed 3% and 5% mint powder supplement. *J. Anim. Health Prod*, 12(2), 128-135.

Alkassar, S. A. S. A. M., Alkassar, A. M. A., Hassan, M. I., & Ahmed, H. A. (2025). Productive and physiological effects of peppermint powder as a substitute for antibiotics and antioxidants in broiler diets. *Open Veterinary Journal*, 15(11), 5748.

Angane, M., Paturi, G., Butts, C. A., & Quek, S. Y. (2026). Synergistic effects of plant essential oils and extracts on gut microbiota in rats. *Foods*, 15(2), 358.

Asadi, N., Husseini, S. D., Tohidian, M. T., Abdali, N., Mimandipoure, A., Rafieian-Kopaei, M., & Bahmani, M. (2017). Performance of broilers supplemented with peppermint (*Mentha piperita* L.) powder. *Journal of evidence-based complementary & alternative medicine*, 22(4), 703-706.

Ashraf, N., Arshad, Z., Sami, R., Almehmadi, A. M., Alsanei, W. A., Bedaiwi, R. I., ... & Helal, M. (2025). Effect of peppermint essential oil and ultrasonication on microbiology evaluation and quality parameters of stored chicken meat. *Frontiers in Sustainable Food Systems*, 9, 1552570.

Bai, M., Liu, H., Zhang, Y., Wang, S., Shao, Y., Xiong, X., ... & Kong, X. (2023). Peppermint extract improves egg production and quality, increases antioxidant capacity, and alters cecal microbiota in late-phase laying hens. *Frontiers in Microbiology*, 14, 1252785.

Bernard, B., Joshi, H., & Fan, P. (2025). Menthol in livestock: unveiling its multifaceted properties and future potential for sustainable agriculture. *International Journal of Molecular Sciences*, 26(6), 2679.

Mishra, B., & Chandra, M. (2022). Evaluation of phytoremediation potential of aromatic plants: A systematic review. *Journal of Applied Research on Medicinal and Aromatic Plants*, 31, 100405.

Ćavar Zeljković, S., Šišková, J., Komzáková, K., De Diego, N., Kaffková, K., & Tarkowski, P. (2021). Phenolic compounds and biological activity of selected Mentha species. *Plants*, 10(3), 550.

Cetingul, I. S., Abdur Rahman, A. R., Aykut Ulucan, A. U., Hikmet Keles, H. K., Ismail Bayram, I. B., Cangir Uyarlar, C. U., & Gultepe, E. E. (2015). Effect of Mentha piperita on some morphological characteristics of intestine in Japanese quails (*Coturnix coturnix japonica*). *Archiva Zootechnica* 18(2), 53-60.

Chrysargyris, A., Petrovic, J. D., Tomou, E. M., Kyriakou, K., Xylia, P., Kotsoni, A., ... & Tzortzakis, N. (2024). Phytochemical profiles and biological activities of plant extracts from aromatic plants cultivated in Cyprus. *Biology*, 13(1), 45.

Domínguez, R., Pateiro, M., Gagaoua, M., Barba, F. J., Zhang, W., & Lorenzo, J. M. (2019). A comprehensive review on lipid oxidation in meat and meat products. *Antioxidants*, 8(10), 429.

Cojocariu, L. C., Usturoi, M. G., Usturoi, A., Lazăr, M., Balmuş, I. M., Simeanu, D., & Radu-Rusu, R. M. (2026). Phytobiotics as Dietary Natural Growth Promoters in Producing High-Quality and Safe Poultry Products - A Narrative Review. *Agriculture*, 16(4), 443.

Gavarić, N., Radovanović, K., Milošević, N., Jovičić-Bata, J., Lalić-Popović, M., Možina, S. S., & Samojlik, I. (2025). Chemical, Biochemical, Antimicrobial, and Pharmacological Assessment of Postdistillation Waste Material Extracts of Mentha x piperita. *Pharmaceuticals*, 18(12), 1782.

Ghazanfari, S., Ghzghapan, A. S., & Honarbakhsh, S. (2024). Effects of peppermint essential oil and artifier on growth performance, carcass characteristics and nutrient digestibilities in broiler chickens fed with low energy diets. *Veterinary and Animal Science*, 24, 100354.

Hejna, M., Kovanda, L., Rossi, L., & Liu, Y. (2021). Mint oils: In vitro ability to perform anti-inflammatory, antioxidant, and antimicrobial activities and to enhance intestinal barrier integrity. *Antioxidants*, 10(7), 1004.

Hudz, N., Kobylinska, L., Pokajewicz, K., Horčinová Sedláčková, V., Fedin, R., Voloshyn, M., ... & Lipok, J. (2023). *Mentha piperita*: Essential oil and extracts,

their biological activities, and perspectives on the development of new medicinal and cosmetic products. *Molecules*, 28(21), 7444.

Hutsol, T., Priss, O., Kiurcheva, L., Serdiuk, M., Panasiewicz, K., Jakubus, M., ... & Kukharets, M. (2023). Mint plants (Mentha) as a promising source of biologically active substances to combat hidden hunger. *Sustainability*, 15(15), 11648.

Kanatt, S. R., Chander, R., & Sharma, A. (2008). Chitosan and mint mixture: A new preservative for meat and meat products. *Food chemistry*, 107(2), 845-852.

Khatun, A., Bari, M. S. U., Rabbi, M. F., Shihab, S. M., Begum, M., Islam, R., ... & Das, S. C. (2026). Phytogenic modulation of broiler physiology: effects of tulsi, moringa, mint, and thankuni on growth, meat quality, blood chemistry, and gut microbiota. *Poultry Science*, 106476.

Kolygas, M. N., Bitchava, K., Nathanailides, C., & Athanassopoulou, F. (2025). Phytochemicals: essential oils and other extracts for disease prevention and growth enhancement in aquaculture: challenges and opportunities. *Animals*, 15(18), 2653.

Lv, Y., Elokil, A., Feng, B., Elsharkawy, M., Wang, S., Zhang, Y., ... & Chen, W. (2026). Effect of dietary mint leaf powder (*Mentha piperita*) supplementation on growth, intestinal integrity and molecular responses in broilers under heat stress. *Poultry Science*, 106520.

Ma, D., Zhang, M., & Feng, J. (2024). Dietary peppermint extract inhibits chronic heat stress-induced activation of innate immunity and inflammatory response in the spleen of broiler chickens. *Animals*, 14(8), 1157.

Mikaili, P., Mojaverrostami, S., Moloudizargari, M., & Aghajanshakeri, S. (2013). Pharmacological and therapeutic effects of *Mentha longifolia* L. and its main constituent, menthol. *Ancient science of life*, 33(2), 131-138.

Mnisi, C. M., Mlambo, V., Gila, A., Matabane, A. N., Mthiyane, D. M., Kumanda, C., ... & Gajana, C. S. (2022). Antioxidant and antimicrobial properties of selected phytogenics for sustainable poultry production. *Applied Sciences*, 13(1), 99.

Mustafa, N. (2025). Effectiveness of phytobiotic oils dietary addition as antioxidant on broiler growth performance, gut health, and immune response to alleviate cold stress. *Mesopotamia Journal of Agriculture*, 53(2), 146-159.

Narimani-Rad, M., Nobakht, A., Shahryar, H. A., Kamani, J., & Lotfi, A. (2011). Influence of dietary supplemented medicinal plants mixture (Ziziphora, Oregano and Peppermint) on performance and carcass characterization of broiler chickens. *Journal of Medicinal Plants Research*, 5(23), 5626-5629.

Nayak, S., Hegde, R. B., Rao, A. S., & Poojary, R. (2025). Unlocking the potential of essential oils in aromatic plants: a guide to recovery, modern innovations, regulation and AI integration. *Planta*, 262(1), 6.

Obianwuna, U. E., Chang, X., Oleforuh-Okoleh, V. U., Onu, P. N., Zhang, H., Qiu, K., & Wu, S. (2024). Phytobiotics in poultry: revolutionizing broiler chicken nutrition with plant-derived gut health enhancers. *Journal of animal science and biotechnology*, 15(1), 169.

Oke, O. E., Akosile, O. A., Oni, A. I., Opowoye, I. O., Ishola, C. A., Adebiyi, J. O., ... & Abioja, M. O. (2024). Oxidative stress in poultry production. *Poultry Science*, 103(9), 104003.

Oni, A. I., & Oke, O. E. (2025). Gut health modulation through phytogenics in poultry: mechanisms, benefits, and applications. *Frontiers in Veterinary Science*, 12, 1616734.

Pintilia, S., Petcu, E., Ionescu, E., Ion, V. A., Bădulescu, L. (2025). A comprehensive review of mint essential oils – composition, quality and applications. *Scientific Papers. Series B. Horticulture*, 69(2), 881-891.

Puvača, N., Milenković, J., Galonja Coghill, T., Bursić, V., Petrović, A., Tanasković, S., ... & Miljković, T. (2021). Antimicrobial activity of selected essential oils against selected pathogenic bacteria: In vitro study. *Antibiotics*, 10(5), 546.

Rais, R., Ziyate, N., Soubai, Z., Chaqchaq, R., Al-Eissa, M. S., Al-Zharani, M., ... & Bouyahya, A. (2025). Harnessing essential oils for sustainable food preservatives: Chemical composition, mechanisms, applications, and safety insights. *Food Chemistry: X*, 102943.

Reda, F. M., Kamal, M., Mahmoud, H. K., Rudayni, H. A., Allam, A. A., Khafaga, A. F., ... & Mohamed, R. S. (2025). Effect of a mixture of peppermint and clove oils on growth performance, carcass traits, blood parameters, and gut microbiota in broiler chickens. *Poultry Science*, 105718.

Salinas-Chavira, J., & Barrios-García, H. B. (2024). Essential oils, chemical compounds, and their effects on the gut microorganisms and broiler chicken production. *Agriculture*, 14(11), 1864.

Saqib, S., Ullah, F., Naeem, M., Younas, M., Ayaz, A., Ali, S., & Zaman, W. (2022). Mentha: nutritional and health attributes to treat various ailments including cardiovascular diseases. *Molecules*, 27(19), 6728.

Shehata, A. A., Yalçın, S., Latorre, J. D., Basiouni, S., Attia, Y. A., Abd El-Wahab, A., ... & Tellez-Isaias, G. (2022). Probiotics, prebiotics, and phytogenic substances for optimizing gut health in poultry. *Microorganisms*, 10(2), 395.

Snoussi, M., Noumi, E., Trabelsi, N., Flamini, G., Papetti, A., & De Feo, V. (2015). Mentha spicata essential oil: Chemical composition, antioxidant and antibacterial activities against planktonic and biofilm cultures of *Vibrio* spp. strains. *Molecules*, 20(8), 14402-14424.

Stef, L., Corcionivoschi, N., Julean, C., Callaway, T., Simiz, E., Marcu, A., ... & Balta, I. (2025). Integrative Feeding Strategies with Essential Oils and Probiotics to Improve Raw Meat Quality and Carcass Traits in Broiler Chickens. *Agriculture*, 15(22), 2356.

Tafrihi, M., Imran, M., Tufail, T., Gondal, T. A., Caruso, G., Sharma, S., ... & Pezzani, R. (2021). The wonderful activities of the genus Mentha: Not only antioxidant properties. *Molecules*, 26(4), 1118.

Tiwari, P. (2016). Recent advances and challenges in trichome research and essential oil biosynthesis in Mentha arvensis L. *Industrial Crops and Products*, 82, 141-148.

Tuțulescu, F., Niculae, L.G., Ristea, C.R. (2023). The effect of peppermint, clove, cinnamon, sage and orange essential oils on lactobacillus bulgaricus bacteria. *Annals of the university of Craiova, Biology, Horticulture, Food products processing technology, Environmental engineering,* 28(64), 115-124.

Urban, J., Kareem, K. Y., Matuszewski, A., Bień, D., Ciborowska, P., Lutostański, K., & Michalczuk, M. (2025). Enhancing broiler chicken health and performance: the impact of phytobiotics on growth, gut microbiota, antioxidants, and immunity. *Phytochemistry Reviews*, 24(2), 2131-2145.

Yousefian, S., Esmaeili, F., & Lohrasebi, T. (2023). A comprehensive review of the key characteristics of the genus Mentha, natural compounds and biotechnological approaches for the production of secondary metabolites. *Iranian Journal of Biotechnology*, 21(4), e3605.

Zapletal, D., Kosťuková, M., Rozsypalová, L., Šimek, V., Ježek, F., Kameník, J., & Dobšíková, R. (2026). Effect of dietary administration of Mentha piperita alone and in combination with *Artemisia abrotanum* on growth performance, body composition, physicochemical properties and amino acid composition of meat in Eimeria-challenged broilers. *Czech Journal of Animal Science*, 71(2), 67.

Zhao, W., Yang, C., Zhang, N., Peng, Y., Ma, Y., Gu, K., ... & Zhao, L. (2023). Menthone exerts its antimicrobial activity against methicillin resistant *Staphylococcus aureus* by affecting cell membrane properties and lipid profile. *Drug design, development and therapy*, 219-236.