Journal of Insights in Basic and Applied Sciences

مجلة رؤى في العلوم الأساسية والتطبيقية

Volume 1, Issue 2, 2025, Pages: 127-139

Journal homepage: https://jibas.com.ly/index.php/jibas/en

Evaluation of Peppermint and Clove oils on Growth Performance and Hematological Parameters of Broiler Chickens

Abdul Majid Al-Fatyouri Lameen [1 *], Ramadan Daw Mohamed [2]

[1,2] Faculty of Agriculture, Bani Waleed University, Bani Walid, Libya

تقييم زيوت النعناع والقرنفل على أداء النمو والمعايير الدموية لدجاج التسمين

عبد المجيد الفيتوري لامين [1*]، رمضان ضو محمد [2]

[2،1] كلية الزراعة، جامعة بني وليد، بني وليد، ليبيا

[*]Corresponding author: zbeda5446@gmail.com

Received: October 18, 2025	Accepted: December 19, 2025	Published: December 26, 2025

Abstract:

The impact of peppermint and clove oils on the growth performance and hematological parameters of broiler chickens was investigated during the 2025 season on a private farm in Bani Walid, Libya. We bought 41-day-old broiler chicks (Ross 308) from a nearby hatchery. Based on a fully randomized design, the birds were weighed upon arrival and then randomly assigned to one of nine treatments, each consisting of three replicates of 12 birds. Peppermint (PO) (200, 400, 600, and 800 mg/kg) and clove oils (CO) (150, 300, 450, and 600 mg/kg) were the dietary treatments; the control treatment was a baseline diet. The average active ingredient concentration of clove and peppermint oils was taken into consideration when selecting the dosages of dietary supplements as treatments. The results obtained indicated that increasing the amount of clove oil up to 600 mg/kg resulted in a higher value of weight gain, whereas increasing the amount of peppermint oil up to 600 mg/kg resulted in a higher value of weight gain. Additionally, the control treatment recorded higher values of feed intake and feed: grain ratio, respectively. Furthermore, increasing the amount of clove oil up to 600 mg/kg resulted in greater values of RBC, WBC, Hb, HCT, PCV, MCV, and MCH than the control treatment, which had lower values of these parameters. In contrast to the control treatment, which recorded greater values of glucose, total cholesterol (TC), triglyceride (TG), and LDL, increasing the amount of peppermint up to 800 mg/kg resulted in higher values of total protein and HDL. When taken as a whole, these results show that peppermint and clove oils can be useful natural substitutes for growth stimulants, supporting not only enhanced performance but also improved intestinal health and immunological status in broiler production systems.

Keywords: Broiler chickens, peppermint oil, clove oil, Growth performance, Hematological and biochemical parameters.

الملخص

أُجريت هذه الدراسة خلال موسم 2025 في مزرعة خاصة بمدينة بني وليد، ليبيا، لدراسة تأثير زيوت النعناع والقرنفل على معدل النمو والمعايير الدموية لدجاج التسمين. تم شراء 240 كتكوتًا من دجاج التسمين (روس 308) بعمر يوم واحد من مفرخ محلي. عند وصولها، وُزنت الطيور ووُزعت عشوائيًا على تسع مجموعات علاجية، بواقع ثلاث مكررات لكل مجموعة، تضم كل منها 12 طائرًا، وفقًا لتصميم عشوائي كامل. شملت المعاملات الغذائية زيوت النعناع (200، 400، 600، و800 مجم/كجم) وزيوت القرنفل (150، 300، 450، 600 مجم/كجم)، بالإضافة إلى علف ضابط وعلف أساسي كمعاملة كنترول. تم اختيار كميات المكملات الغذائية كمعلاجات بناءً على متوسط محتوى المكونات الفعالة في زيوت النعناع والقرنفل. أظهرت النتائج أن زيادة مستوى زيت القرنفل حتى 600 مجم/كجم سجلت أعلى قيمة لزيادة الوزن، بينما سجلت

زيادة مستوى زيت النعناع حتى 600 مجم/كجم أعلى قيمة لزيادة الوزن. بالإضافة إلى ذلك، سجلت المجموعة الضابطة أعلى قيمة لاستهلاك العلف ونسبة العلف إلى الحبوب. علاوة على ذلك، سجلت زيادة مستوى زيت القرنفل حتى 600 مجم/كجم أعلى قيمة لعدد كريات الدم الحمراء والبيضاء، والهيموجلوبين، والهيماتوكريت، وحجم الكريات المكدسة، ومتوسط حجم الكرية، ومتوسط محتوى الهيموجلوبين في الكرية، مقارنةً ببمعاملة كنترول الضابطة التي سجلت أقل القيم نفسها. من جهة أخرى، أظهرت زيادة مستوى النعناع حتى 800 ملغم/كغم ارتفاعًا في قيم البروتين الكلي والكوليسترول عالي الكثافة (HDL)، مقارنةً بالمجموعة الضابطة التي سجلت ارتفاعًا في قيم الجلوكوز والكوليسترول الكلي والدهون الثلاثية والكوليسترول منخفض الكثافة (LDL) على التوالي. تشير هذه النتائج مجتمعةً إلى أن زيوت النعناع والقرنفل يمكن أن تكون بدائل طبيعية فعالة لمُحفزات النمو، إذ تدعم ليس فقط تحسين الأداء، بل أيضًا تعزيز الحالة المناعية وصحة الأمعاء في أنظمة إنتاج الدجاج اللاحم..

الكلمات المفتاحية: دجاج التسمين، زيت النعناع، زيت القرنفل، أداء النمو، المعايير الدموية والكيميائية الحيوية.

Introduction

The production of broiler chicken meat is expected to rise from 103.5 million metric tons in 2023 to 104.2 million metric tons in 2025. In order to reach this goal, certain feed additives must be used to maximize chicken health and performance. Bioactive and flavorful compounds are found in phytogenic feed additives, which include plant-based materials like extracts, spices, herbs, and essential oils **(Shahbandeh, 2024).** The chicken business has experienced significant expansion due to the worldwide need for highly appealing and reasonably priced protein sources **(Bist *et al.,* 2024; El-Abasy *et al.,* 2025).** The production of broiler chickens is currently the most intensive area of animal husbandry due to their rapid reproduction, short breeding periods, and relatively low investment. These characteristics allow for faster turnover and, consequently, more economical and efficient production when compared to other livestock production branches **(Puvańca, 2018).** In addition to being essential for fulfilling production priorities, the safety and quality of feed for broiler chickens also play a major role in boosting output and raising the caliber of animal-based foods like meat **(Haque *et al.,* 2018).** The usage of medicinal herbs in the poultry business has grown in popularity, but choosing the best plant is necessary. In human laboratories, various researches have demonstrated the antibacterial qualities of certain medicinal herbs **(Amanpour *et al.,* 2015).** These days, broiler farms are using pharmaceutical additives as antimicrobial growth accelerators. However, some research has indicated that using certain antibiotic growth promoters can have negative effects **(Baharvand-Ahmadi *et al.,* 2015).** The widespread use of these antibiotics in broiler farms has several drawbacks, including increased production costs and a threat to public health due to the consumption of goods containing pharmaceutical residues. Research indicates that in addition to increasing productivity, the use of medicinal herbs can effectively contribute to the creation of organic, healthful goods **(Baharvand-Ahmadi *et al.,* 2016).** One of the oldest therapeutic herbs in the world, peppermint belongs to the Labiate family **(Bahmani *et al.,* 2015).** Rich in essential oils, the Labiate family has both commercial and therapeutic uses. These herbs are widely used in the culinary, flavor, cosmetic, and pharmaceutical industries and are found all over the world **(Farhadi *et al.,* 2016).**

Improved production characteristics **(Brenes and Roura, 2010)** and the capacity to boost the body's immune response **(AbdEl-Hack *et al.,* 2016)** are indicative of the beneficial and therapeutic qualities of essential oils in broiler chicken diets. This has a positive impact on maximizing the genetic potential of chickens, lowering mortality, and ultimately raising profitability. Furthermore, phytobiotics and essential oils have hypocholesterolemic effects by blocking the key enzymes involved in the synthesis of lipids and cholesterol, which dramatically lowers the proportion of abdominal fat in broiler chickens and the amount of cholesterol in the blood and edible tissues **(Puváca *et al.,* 2015).**

As a result, natural substitutes like supplements made from plants have drawn more attention due to their capacity to improve poultry carcass characteristics, growth performance, and immunity **(Kamal *et al.,* 2023a; Abd El-Hack *et al.,* 2024a, b).** In animal production, the use of environmentally friendly feed additives, such as plant essential oils (EO), as performance-enhancing agents has drawn interest. According to studies, EO's bioactive components, which include phenols, lectins, polyphenols, and terpenoids, may enhance the immune system, digestive health, product quality, growth dynamics, and nutrient utilization in chicken diets **(Ogbuewu *et al.,* 2025).** Ten percent of the more than 3000 EO that have been found are thought to be of commercial or economic value **(Nehme *et al.,* 2021).**

Due to their ability to support gut health, essential oils are being used more frequently in animal production since they are considered safe feed additives in animal nutrition **(Caroprese *et al.,* 2023; Islam *et al.,* 2024).** The impact of EO additions on the growth dynamics and health status of broiler chickens has not yet been thoroughly reviewed in the literature. Researchers have emphasized the use of reviews as a tool to comprehend the current state of knowledge on a specific topic **(Zeng *et al.,* 2020; Puvaca *et al.,* 2022).** Due to their inherent antibacterial and anti-inflammatory properties, essential oils have become viable substitutes for antibiotic growth boosters in broiler diets **(Zhang *et al.,* 2022).**

Essential oils, also known as volatile oils, are organic compounds with biological activity that are extracted from various plant parts, such as seeds, bark, stems, roots, etc. Steam distillation or solvent extraction techniques are used to extract essential oils, which are not really lipids. Depending on the particular section utilized, a single plant's EO composition and concentration can change **(Puvaca *et al.,* 2022).**

In addition to promoting improved performance and gastrointestinal health, the use of these natural chemicals enhances meat characteristics and oxidative stability while lowering the dangers associated with antibiotic resistance and residues **(Ashour *et al.,* 2025a, b).** Peppermint essential oil (PEO) is one of these natural additives that has been extensively researched and demonstrated to have positive impacts in broiler productivity **(Abd-El-Hack *et al.,* 2023).** PEO has shown promise as a natural antibacterial agent and growth promoter, promoting the growth of good gut bacteria **(Ashour *et al.,* 2025b).** Anti-inflammatory, antibacterial, antiviral, immunomodulatory, anticancer, neuro-protective, and antioxidant effects are among the many pharmacological characteristics of its complex variety of bioactive secondary metabolites.

Menthol, menthone, neomenthol, and iso-menthone are important constituents of PEO (**Bardaweel *et al.,* 2018).** A range of bioactive terpenoids with low molecular weight, such as carvacrol, thymol, menthol, linalool, borneol, and α-terpineol, are found in essential oils (EOs), which are extracted from plants and herbs by steam distillation. These oils have been demonstrated to have a positive impact on a number of metabolic processes, such as lipid metabolism, increasing digestive enzyme activity **(Ghanima *et al.,* 2020),** and providing antioxidant, antimicrobial, anti-inflammatory, and immunomodulatory benefits **(Arif *et al.,* 2022),** all of which improve gut health and broiler growth performance. Because of this, EOs are being explored as possible antibiotic substitutes in broiler feeding; each EO's efficacy varies according to its unique bioactive components.

Because of its active ingredients, which include phenols, polyphenols, terpenoids, alkaloids, lectins, and polypeptides, peppermint essential oil has antimicrobial and immune-stimulating effects, gastrointestinal stimulant qualities, lower blood fat and cholesterol concentrations, antioxidant and anthelmintic qualities, and ultimately promotes growth **(Rezvani *et al.,* 2019).** The use of 200 ppm peppermint essential oil improved protein digestibility in comparison to other treatments, according to research on the effects of peppermint essential oil on broiler chick performance and digestibility **(Khodambashi Emami *et al.,* 2012).** By acting as an antibacterial agent in the digestive tract, peppermint essential oil seems to have the potential to replace antibiotic growth boosters. According to **Nanekarani *et al.* (2012),** peppermint essential oil's antibacterial qualities may assist regulate bacterial development in broiler hens' gastrointestinal tracts, improving performance and nutrient digestibility while reducing belly fat deposition.

According to **Hesabi Nameghi *et al.* (2019),** peppermint essential oil has demonstrated antioxidant, antibacterial, antiviral, anticarcinogenic, antiparasitic, anti-inflammatory, and immunomodulatory effects on animal physiology, with a focus on the digestive system. In comparison to rabbits fed a baseline diet, Elspeiy et al. (2020) found that rabbits given peppermint oil showed enhanced feed conversion ratio (FCR) and higher average daily gain (ADG). Additionally, their results showed that supplementing with peppermint oil increased concentrations of immunoglobulin G, total antioxidant capacity (TAC), high density lipoprotein (HDL), and triglycerides while lowering serum levels of cholesterol, low-density lipoprotein (LDL), and malondialdehyde (MDA). Peripheral blood mononuclear cells (PBMCs) stimulated with lipopolysaccharide plus 10% peppermint oil showed greater proliferation rates than the positive control (PBMCs stimulated with concanavalin A alone), according to **Ciliberti *et al.* (2024).** Furthermore, compared to the positive control, the peppermint oil treatment raised the concentration of anti-inflammatory cytokines and decreased pro-inflammatory cytokine levels.Clove oil in particular has drawn interest because of its antibacterial, antioxidant, and digestive-improving qualities. The bioactive ingredients found in clove oil, which comes from *Syzygium aromaticum*, include Eugenol, which has been shown to enhance poultry immunological responses and feed efficiency **(Naser *et al.,* 2023).**

Optimizing feed conversion efficiency while preserving gut health and immunological function is one of the fundamental issues in broiler production. Traditionally, antibiotic growth promoters (AGPs) were employed to improve these features; however, other approaches are being investigated in light of growing concerns regarding antibiotic resistance **(Brown *et al.,* 2017).** Because they can alter gut flora and enhance digestion, phytogenic additives such as essential oils have become attractive alternatives **(Brown *et al.,* 2017).** According to studies, adding clove oil improves immunological responses, lowers oxidative stress, and increases nutrient absorption, all of which have a good impact on broiler performance **(Elbaz *et al.,* 2022).**

However, the formulation and amount of clove oil can affect its efficacy. One technique that has been proposed to increase essential oils' bioavailability and possibly boost their advantages is emulsification **(Karaca *et al.,* 2023).** According to studies, adding clove oil improves immunological responses, lowers oxidative stress, and increases nutrient absorption, all of which have a good impact on broiler performance **(Elbaz *et al.,* 2023).** However, the formulation and amount of clove oil can affect its efficacy. One technique that has been proposed to increase the bioavailability of essential oils and possibly increase their effects is the inclusion of an emulsifier. Emulsifiers aid in more efficiently distributing the oil throughout the meal, increasing its accessibility to the digestive tract **(Henao-Ardila *et al.,* 2024).**

The medicinal benefit of several species of mint and clove oils is also attributed to their rich profiles of active ingredients, including as carvone, limonene, menthone, β-pinene, α-pinene, geraniol, and menthol **(Aydın and Barbas, 2020).** According to studies, peppermint oil's bioactive components, especially menthol, enhance chicken feed efficiency and weight increase **(Abdel-Wareth et al., 2019).** Its antibacterial effect has been demonstrated to improve nutritional absorption by modifying the gut microbiota in favor of beneficial species **(Salinas-Chavira and Barrios-García, 2024)** and to lessen intestinal illnesses brought on by pathogens like *E. coli* and *Salmonella* **(Zhao *et al.,* 2022).**

Thus, the purpose of the current study is to determine how peppermint and clove oils affect broiler chicken growth performance and hematological parameters.

Materials And Methods

This study was conducted during the 2025 season on a private farm in Bani Walid, Libya, to study the effect of peppermint and clove oils on growth performance and hematological parameters of broiler chickens. Two hundred and forty-one-day-old broiler chicks (Ross 308) were purchased from a local hatchery. Upon arrival, the birds were weighed and randomly distributed into one of nine treatments, with three replicates of 12 birds each, based on a completely randomized design. The dietary treatments consisted of the basal diet as the control treatment, with 200, 400, 600 800 mg/kg of peppermint oil and 150, 300, 450 and 600 of clove oil and control treatment were added to the basal diet. The amounts of dietary supplements were chosen as treatments considering the average active ingredient content in peppermint and clove oils.

Data recorded

- **Growth performance**

Broiler weight increase and feed intake were measured. Weight gain and food consumption were tracked throughout time, and the feed conversion ratio (feed intake/weight gain) was computed. The weight of each bird was recorded to the closest gram. On the first day of the experiment and subsequently once a week until the trial was over, each subject's body weight was recorded. By deducting the final body weight concurrently from the average initial body weight during the pertinent time period, body weight increase was computed. Up until the experiment's conclusion, each replicate's feed intake (FI) was tracked on a weekly basis. The average feed intake/chick was calculated by dividing the weekly grams by the total number of chicks. Each group's feed conversion ratio (FCR), which is derived by dividing feed intake in grams by body weight growth in grams, was determined on a weekly basis, taking into account the weight gain of the dead birds. Eight birds, one for each treatment duplicate, were randomly chosen and slaughtered at the end of the experiment after an overnight fast. The weight of the carcass and internal organs was calculated in relation to the weight of the living body.

- **Blood samples collection:**

Six chicks from each group were randomly selected at 8:00–9:00 am when they were 42 days old, and approximately 3 ml of blood was drawn from the wing vein and placed in vacationer tubes with 1 mg/ml of K3-EDTA. Two portions of non-coagulated blood were separated. Shortly after collection, the first portion was utilized to estimate the blood image, while the second portion was spun for 15 minutes at 4000 rpm to separate the clear plasma, which was then kept in a deep freezer at -20°C until biochemical analysis. Commercial kits were used to determine all blood biochemical variables calorimetrically.

- **Hematological parameters**

The total number of RBCs and WBCs was measured using a Neubauer Hemocytometer **(Abuoghaba, 2018). Wakenell's (2010)** DLC standard techniques were used to count lymphocytes and monocytes. Using a compound microscope, PLT counting was carried out during DLC **(Mayengbam *et al.,* 2020).** The concentration of hemoglobin was measured using Sahli's hemoglobinometer **(Patil *et al.,* 2013).** The Microhematocrit Capillary Tube was used to determine Ht, and it was centrifuged for five minutes at 10,000 RPM **(López *et al.,* 2018; Duah *et al.,* 2020).**

The red blood cell count (RBCs106/ml^3) was calculated in accordance with **Feldman *et al.* (2000).** According to **Drew *et al.* (2004),** measurements of hemoglobin (Hb) concentration (g/dl) and the percentage of packed cells volume (PCV %) were made. The average weight of hemoglobin in RBC (MCH, pg) = [hemoglobin concentration (g/dL)/ RBC] × 10 and the average volume (size) of RBC (MCV, μm3) = [hematocrit (%)/ RBC] × 10 were computed. A little drop of blood was used to create a thin blood film. Giemsa stain was applied when the blood film had completely dried.

- **Blood biochemical parameters**

Protein profile: Using specific kits and a spectrophotometer (Beckman DU-530, Germany) in accordance with **Armstrong and Carr's (1964)** criteria, plasma total protein (g/dl) was measured to assess changes in the protein profile at 42 days of age in chickens. Using particular kits, plasma total cholesterol (mg/dl) was measured on an individual basis in accordance with **Bogin and Keller's (1987)** recommendations. For every treatment, blood samples were taken from the birds during their killing. The materials were put in sterile 2 mL containers and allowed to coagulate for four hours. After centrifuging the serum for 10 minutes at 2000 rpm, it was kept at -20

EC until analysis. Using particular kits, plasma total cholesterol (mg/dl) was measured on an individual basis in accordance with **(Bogin and Keller, 1987)** recommendations. Commercial diagnostic kits were used to measure triglycerides by Fossati and Prencipe10, low-density lipoprotein (LDL) by **Wieland and Seidel (1983),** and high-density lipoprotein (HDL) by **Lopez-Virella *et al.* (1977).**

- **Statistical analysis:**

The General Linear Model techniques of the **SAS Institute (1997)** were used to expose the data to analysis of variance procedures suitable for a fully randomized design.

Results And Discussion

A) Growth performance

Table (1) and Fig. (1) present the findings of the impacts on growth performance of the four additional levels of peppermint (PO) (200, 400, 600, and 800 mg/kg) and clove oils (CO) (150, 300, 450, and 600 mg/kg) and control after 42 days. The results, however, indicated that increasing the amount of clove oil up to 600 mg/kg resulted in a higher value of weight gain (59.53 g), followed by 300 mg/kg (57.13 g), while increasing the amount of peppermint oil up to 600 mg/kg resulted in a higher value of weight gain (62.6 g), followed by 400 mg/kg (59.52 g). Additionally, the control treatment recorded higher values for feed intake (107.58 g) and feed: grain ratio (1.95), followed by clove oil at 150 mg/kg (1.85).

Numerous investigations with varying EO types **Hashemipour *et al.* (2013)** used thymol with carvacrol, **Nameghi *et al.* (2019)** used mix EOs from thyme, peppermint, and eucalyptus, and **Abdel-Wareth *et al.* (2019)** used peppermint and menthol supported this conclusion. Because EOs encourage nutrition utilization, broiler chickens' final BW and FCR have improved. Numerous studies have verified that poultry given essential oils have improved nutritional digestibility **(Altop *et al.,* 2019).** EOs' immune-boosting and antibacterial qualities are crucial for raising the bird's general performance **(Arif *et al.,* 2022).** Additionally, a number of studies indicated that the EOs action would increase the palatability of feed **(Altop *et al.,* 2019).** The benefits of adding EOs to chicken feed as a growth stimulant and a successful substitute for antibiotics are all confirmed by the information above.

Agostini *et al.* (2012) found that birds fed diets containing varying amounts of clove oil (0, 100, 200, 1000, and 2500 mg/kg) performed better when 100 and 200 mg/kg of clove oil were added, which is consistent with the current study. Growth performance increase was not linear in the current study. In a similar vein, **Ertas *et al.* (2005)** discovered that broiler hens fed 100 or 200 mg/kg of a mixture of essential oils (oregano, clove, and anise) grew better than those fed a 400 mg/kg dose. According to **Jouany and Moravi (2007),** essential oils are a component of plant defense mechanisms against pathogens.

Animals may be poisoned by an excessive amount, or at the very least, they may react negatively. Additionally, they discovered that adding 850–1000 mg/kg of eugenol and clove cinnamaldehyde to the food considerably reduced the rat intestine's absorption of alanine. According to **Toghyani *et al.* (2010),** a larger thyme dosage may negatively impact some beneficial microbial populations, such Lactobacillus, which would hinder the herb's ability to improve performance and lead to a lower FCR. Additionally, dietary clove oil improved feed intake, growth rate, and weight gain without negatively impacting gut microbiota or serum cholesterol levels, according to **Mohammadi *et al.* (2014).**

Additionally, **Khodambashi Emami *et al.* (2012)** found that adding 200 mg/kg of peppermint oil to the food of broilers enhanced their performance. However, the 400 mg/kg therapy had no effect on performance. This improved the chicks' health and safety and stopped harmful bacteria populations from breaking down proteins and amino acids, which ultimately improved the birds' overall performance **(Lee *et al.,* 2003).** Because they are rich in essential oils, a variety of mint plant species are frequently used. For example, it has been demonstrated that peppermint essential oils lengthen the intestine and enhance the surface area of contact between the colon and the digested contents. More chances for nutrition absorption result from this increase in contact surface **(Alcicek *et al.,* 2003).**

Peppermint contains menthol, which disinfects the digestive tract and may lessen the presence of dangerous bacteria. Furthermore, it increases the secretion of gastric fluids and other digestive organs, which improves nutrition absorption and digestion and eventually leads to increased growth per formance **(Motejaded *et al.,* 2013).** In one study, birds fed 200 ppm peppermint essential oil with the antibiotic virginiamycin had greater feed conversion ratios than birds fed control diets and 400 ppm peppermint essential oil **(Khodambashi Emami *et al.,* 2012)**. According to studies, peppermint oil's bioactive components, especially menthol, enhance chicken feed efficiency and weight increase **(Abdel-Wareth *et al.,* 2019).**

Additionally, peppermint essential oil's active compounds have been shown to enhance digestibility, balance the intestinal microbial ecosystem, and promote endogenous enzyme secretion, all of which improve poultry growth performance **(Khodambashi Emami *et al.,* 2012).** According to **Shiri Ghzghapan *et al.* (2023),** using peppermint essential oil and artifier simultaneously in low-energy diets of broiler chickens increased blood biochemistry parameters and meat shelf life while maintaining the same performance and feed cost as the control diet.

Suliman et al. (2021) and Dong *et al.* (2024) found similar results, showing enhanced growth performance and profitability in broilers fed diets based on cloves or a combination of essential oils. Furthermore, **Shil *et al.* (2023)** discovered that the nutritional supplementation of clove oil and probiotics in the broiler chicken feed may increase BWG and FCR. Furthermore, **Ghazanfari *et al.* (2024)** discovered that adding 300 ppm artifier and 150 ppm peppermint essential oil to a low-energy diet for broiler chickens enhanced growth. This demonstrated the potential advantages of these compounds by improving growth performance and efficiency in addition to meat quality. This outcome was consistent with the findings of **Ocak *et al.* (2008).** It appears that the beneficial impact of varying peppermint concentrations on raising average daily weight gain was caused by its reducing effects on gastrointestinal disorders, strengthening the digestive system and enhancing feed efficiency **(Mehranpoor, 1995).** This could have been because, in comparison to the control diet, the treatments containing single or blended essential oils had higher feed conversion ratios and greater body weights. The economics of broiler production have been observed to vary when EOs are added to the diet. According to recent research by **Wade *et al.* (2018) and Omar *et al.* (2020),** chicks fed essential oils (EOs) outperformed the control group in terms of economic and relative efficiency.

Table (1): Effect of feeding different levels of peppermint (PO) and clove oils (CO) on weight gain, feed intake and Feed: gain ratio of growth performance of broiler, during 2025 season.

Treatments	Weight gain (g)	Feed intake (FI) (g)	Feed: gain ratio (FCR)
Control	55.29	107.58	1.95
PO at 200 mg/kg	58.71	104.78	1.78
PO at 400 mg/kg	59.52	101.26	1.70
PO at 600 mg/kg	62.60	97.14	1.55
PO at 800 mg/kg	56.81	89.29	1.57
CO at 150 mg/kg	55.08	101.64	1.85
CO at 300 mg/kg	57.13	98.22	1.72
CO at 450 mg/kg	59.53	94.23	1.58
CO at 600 mg/kg	56.64	86.61	1.53
$LSD_{(0.05)}$	**0.004**	**0.36**	**0.02**

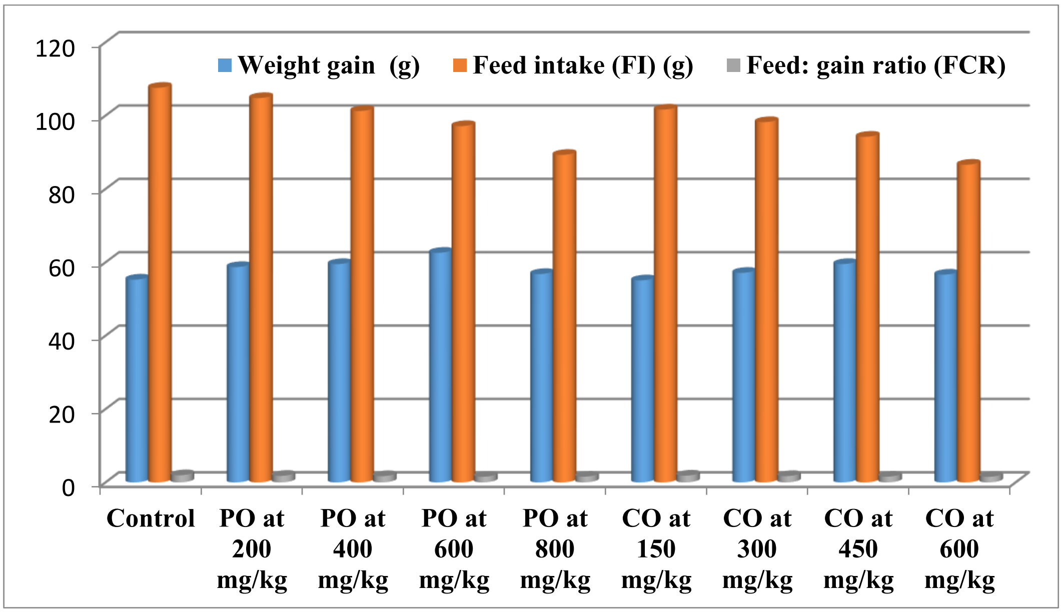

Figure 1: Effect of feeding different levels of peppermint (PO) and clove oils (CO) on weight gain, feed intake and Feed: gain ratio of growth performance of broiler, during 2025 season.

B) Chemical composition (haematological and biochemical constituents of blood)

- **Haematological constituents of blood**

Table (2) and Fig. (2) present the findings of the effects on blood haematological values following 42 days of the three additional levels of peppermint (PO) (200, 400, 600, and 800 mg/kg) and clove oils (CO) (150, 300, 450, and 600 mg/kg) and control. In contrast to the control treatment, which recorded lower values of RBC (3.01 mil/mm3), WBC (55.62 thous/mm3), Hb (13.36 g/dL), HCT (39.11%), PCV (44.77%), MCV (201.21 µm3), and MCH (76.87pg), increasing levels of clove oil up to 600 mg/kg recorded higher values of RBC (2.97 g/dL), Hb (12.72 g/dL), HCT (37.25%), PCV (42.64%), MCV (191.63 µm3), and MCH (73.21 pg).

Table (2): Effect of feeding different levels of peppermint (PO) and clove oils (CO) on haematological constituents of blood values during 2025 season.

Treatments	RBC (mil/mm^3)	WBC (m/mm^3)	Hb (g/dL)	HCT (%)	PCV (%)	MCV (µm^3)	MCH (pg)
Control	2.49	40.79	10.13	29.73	23.10	129.67	44.77
PO at 200 mg/kg	2.69	43.56	11.57	31.54	31.13	132.57	56.47
PO at 400 mg/kg	2.73	45.80	12.13	33.45	34.65	146.48	62.90
PO at 600 mg/kg	2.87	49.13	12.41	35 35	39.00	189.66	67.41
PO at 800 mg/kg	2.91	52.97	12.72	37.25	42.64	191.63	73.21
CO at 150 mg/kg	2.61	45.74	12.15	33.12	35.84	139.20	59.29
CO at 300 mg/kg	2.82	48.09	12.74	35.12	36.38	153.80	66.05
CO at 450 mg/kg	2.87	51.59	13.03	37.12	44.10	199.14	70.78
CO at 600 mg/kg	3.01	55.62	13.36	39.11	44.77	201.21	76.87
LSD$_{(0.05)}$	**3.06**	**0.22**	**0.27**	**0.13**	**0.21**	**0.39**	**0.22**

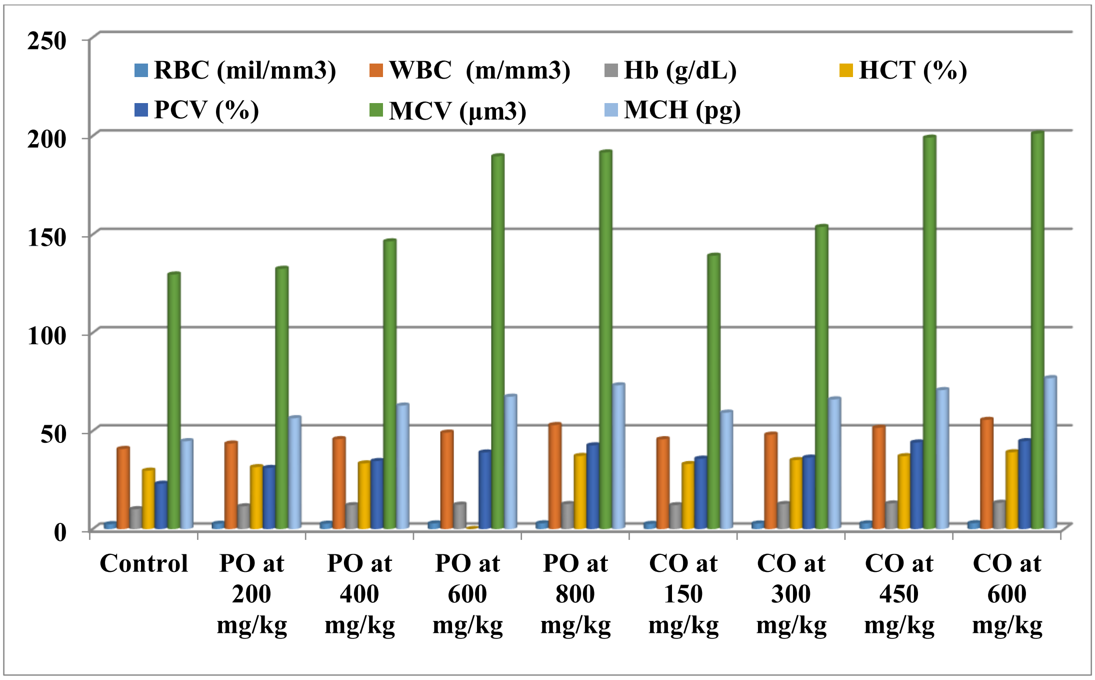

Figure 2: Effect of feeding different levels of peppermint (PO) and clove oils (CO) on haematological constituents of blood values during 2025 season.

- **Biochemical constituents of blood**

Table (3) and Fig. (3) present the findings of the effects on blood biochemical constituent values following 42 days of the four additional levels of peppermint (PO) (200, 400, 600, and 800 mg/kg) and clove oils (CO) (150, 300, 450, and 600 mg/kg) and control. In contrast to the control treatment, which recorded higher values of glucose (228 mg/dL), total cholesterol (TC) (167.01 mg/dL), triglyceride (TG) (145.25 mg/dL), and LDL (56.24 mg/dL), increasing levels of peppermint up to 800 mg/kg recorded higher values of total protein (5.17 g/dL) and HDL (55.39 mg/dL).

Nevertheless, the concentration of triglycerides and glucose was unaffected by the addition of clove essential oil. Clove EOs' bioactive constituents, including caryophyllene, eugenol, humulene, and humulene epoxide, are clearly engaged in the metabolism of lipids, especially serum cholesterol **(Arif *et al.*, 2022).** This is in line with a number of investigations that used various sources of clove essential oil **(Abdel-Wareth *et al.*,**

2019). Research by **Ahmad *et al.* (2011) and Nameghi *et al.* (2019)** revealed that feeding chickens a meal containing EO reduced their levels of LDL and total blood cholesterol. Since 3 hydroxy-3-methylglutaryl coenzymes A reductase is a key enzyme for the formation of cholesterol, it was discovered that some biologically active chemicals of EO decreased rate-limiting enzymes involved in cholesterol synthesis **(Irawan *et al.,* 2021).**

The impact of essential oils' antioxidants and anti-peroxide on liver activity, which influences the manufacture of cholesterol, may be the cause of the shift in lipid metabolism levels **(Elbaz et al., 2022).** These findings demonstrate that adding clove essential oils improves lipid metabolism by lowering cholesterol and boosting lipid stability, which lessens lipid oxidation issues in hot temperatures. It has been noted that essential oil has a hypocholesterolemic impact. Hepatic 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase activity, a crucial regulatory enzyme in cholesterol synthesis, may be inhibited, which would explain the drop in cholesterol levels **(Hong *et al.,* 2012).** It is well recognized that an animal's breed, gender, age, and feed composition all affect whether or not essential oils have cholesterolaemic effects **(Lee *et al.,* 2003).** According to **Baker *et al.* (2008),** using medicinal herbs can lower blood glucose levels by promoting insulin secretion and preventing cellular resistance to insulin. **Tabari *et al.* (2018)** similarly found similar findings, noting that broiler chicken fed with clove aqueous extract had considerably lower serum glucose levels than the control group.

According to **Sabu and Kuttan (2002),** clove (*Eugenia caryophyllus*) aqueous extract has anti-hyperglycemic effects in rats without changing basal plasma glucose levels. Clove extract's high polyphenol content may be the cause of this action, as it increases muscle cells' uptake of glucose. Additionally, compared to the control, **Mohammadi *et al.* (2014)** found that adding clove essential oil to the diet reduced the concentration of glucose. **Tabari *et al.* (2018)** found that broiler chickens given clove aqueous extract had significantly lower cholesterol concentrations. Hepatic 3-hydroxy-3 methylglutaryl co-enzyme (HMG-COA) reductase activity, a crucial regulating enzyme in cholesterol production, is inhibited by the primary constituent of clove (Eugenia caryophyllus) essential oils, resulting in hypocholestrolemia **(Shimaa, 2015).** According to **Clegg and Mbada (1980),** a 5% inhibition of HMG COA reductase reduces poultry serum cholesterol levels by 2%. Additionally, **Jin and Cho (2011)** discovered that in a hyperlipidemic zebra fish model, cold-pressed clove oil (CCPO) decreased blood cholesterol and triacylglycerol levels by 68% and 80%, respectively. Additionally, **Khaksar et al. (2012)** found that supplementing Japanese quails with thyme essential oil reduced their serum levels of glucose, triglycerides, and total cholesterol. Because of its active ingredients, which include phenols, polyphenols, terpenoids, alkaloids, lectins, and polypeptides, peppermint essential oil has antimicrobial and immune-stimulating effects, gastrointestinal stimulant qualities, lower blood fat and cholesterol concentrations, antioxidant and anthelmintic qualities, and ultimately promotes growth **(Rezvani *et al.,* 2019).** The use of 200 ppm peppermint essential oil improved protein digestibility in comparison to other treatments, according to research on the effects of peppermint essential oil on broiler chick performance and digestibility **(Khodambashi Emami *et al.,* 2012).**

Table (3): Effect of feeding different levels of peppermint (PO) and clove oils (CO) on biochemical constituents of blood values during 2025 season.

Treatments	Glucose (mg/dl)	Total protein (g/dI)	TC (mg/dL)	TG (mg/dL)	HDL (mg/dL)	LDL (mg/dL)
Control	228	4.10	167.01	145.25	46.93	56.24
PO at 200 mg/kg	215	4.55	152.58	133.86	43.12	42.29
PO at 400 mg/kg	212	4.85	143.04	109.61	45.85	37.03
PO at 600 mg/kg	209	4.94	138.25	90.21	46.22	40.18
PO at 800 mg/kg	207	5.17	133.46	78.57	48.53	31.59
CO at 150 mg/kg	220	4.41	155.97	138.33	45.20	41.02
CO at 300 mg/kg	192	4.70	151.02	113.78	51.33	35.92
CO at 450 mg/kg	211	4.79	137.04	93.45	54.20	38.97
CO at 600 mg/kg	212	5.01	129.03	81.49	55.39	30.64
$LSD_{(0.05)}$	**0.05**	**0.99**	**0.02**	**0.09**	**0.16**	**0.04**

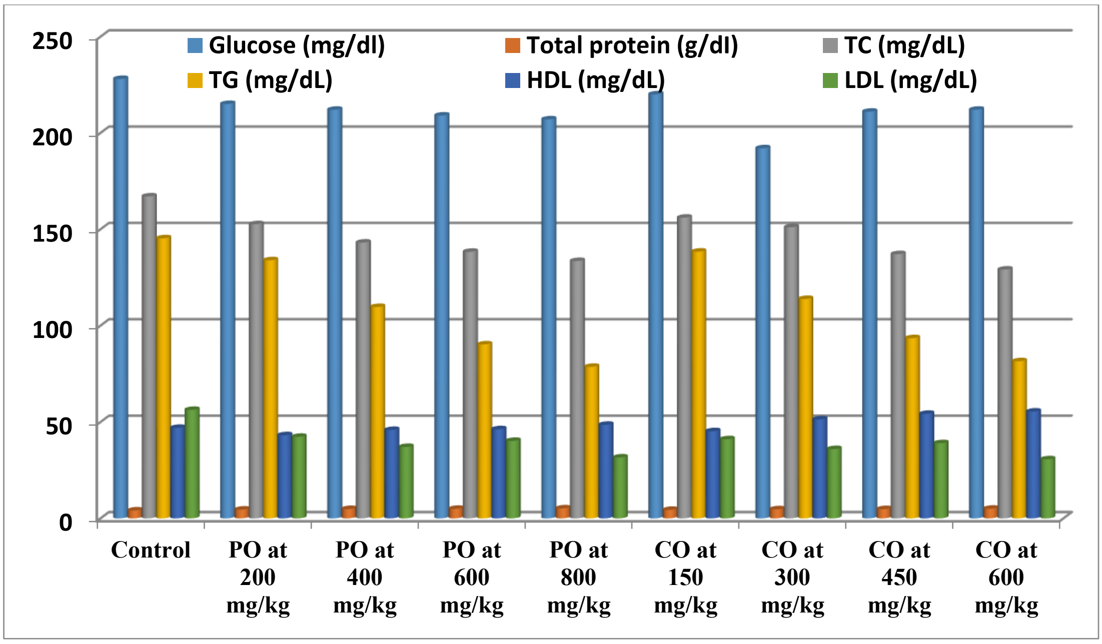

Figure 3: Effect of feeding different levels of peppermint (PO) and clove oils (CO) on biochemical constituents of blood values during 2025 season

Conclusion

The current experiment's findings showed that supplementing broiler chickens with clove oil greatly improved their blood biochemical profile. For improved output and optimal health, clove oil can be added to broiler chicken rations as an alternative growth stimulant (as essential oil). To determine the appropriate amount of clove oil for dietary supplementation in broiler chicken rations for improved responsiveness and health, however, further thorough research involving a large number of birds is appreciated. When taken as a whole, these results show that peppermint and clove oils can be useful natural substitutes for growth stimulants, supporting not only enhanced performance but also improved intestinal health and immunological status in broiler production systems.

References

1. **Abd El-Hack, M.E., Ashour, E.A., Aljahdali, N., Zabermawi, N.M., Baset, S.A., Kamal, M. and Bassiony, S.S. (2024a).** Does the dietary supplementation of organic nano-zinc as a growth promoter impact broiler's growth, carcass and meat quality traits, blood metabolites and cecal microbiota? Poult. Sci., 103(5):103550.
2. **Abd El-Hack, M.E., Ashour, E.A., Baset, S.A., Kamal, M., Swelum, A.A., Suliman, G.M. and Bassiony, S.S. (2024b).** Effect of dietary supplementation of organic selenium nanoparticles on growth performance and carcass traits of broiler chickens. Biol. Trace Elem. Res., 202 (8): 3760–3766.
3. **Abd El-Hack, M.E., Kamal, M., Altaie, H.A., Youssef, I.M., Algarni, E.H., Almohmadi, N. H. and Swelum, A.A. (2023).** Peppermint essential oil and its nano-emulsion: potential against aflatoxigenic fungus *Aspergillus flavus* in food and feed. Toxicon., 234: 107309.
4. **AbdEl-Hack, E. M., Alagawany, M., Ragab F. M., Tiwari, R., Karthik, K., Dhama, K., Zorriehzahra, J. and Adel, M. (2016).** Beneficial impacts of thymol essential oil on health and production of animals, fish and poultry: A Review. J. Essent. Oil Res., 28: 365–382.
5. **Abdel-Wareth, A.A., Kehraus, S. and 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. Poult. Sci. 98 (9): 3850–3859.
6. **Abuoghaba, A.A.K. (2018)** 'Impact of bee pollen supplementation on productive performance, some hematological parameters, blood constituents and semen physical characteristics of Sinai chickens' Egyptian Poultry Science J., 38: 621-635.
7. **Agostini, P.S., Sola-Oriol, D., Nofrari, M., Barroeta, A.C., Gasa, J. and Manzanilla, E.G. (2012).** Role of in feed clove supplementation on growth performance, intestinal microbiology and morphology in broiler chicken. Livest. Sci., 147: 113-118.
8. **Ahmad, A.A., Männer, K., Wendler, K.R., Neumann, K. and Zentek, J. (2011).** Effects of a phytogenic feed additive on growth performance and ileal nutrient digestibility in broiler chickens. Poult Sci., 90: 2811-2016.

9. **Alcicek, A., Zkurt, M. and Cabuk, M. (2003).** The effect of an essential oil combination derived from selected herbs growing wild in turkey on broiler performance. South Afri. J. Anim. Sci., 33: 89–94.
10. **Altop, A., Erener, G., Duru, M.E. and Isik, K. (2018).** Effects of essential oils from Liquidambar orientalis Mill. leaves on growth performance, carcass and some organ traits, some blood metabolites and intestinal microbiota in broilers. Br Poult Sci., 59: 121-7.
11. **Amanpour, R., Abbasi-Maleki, S., Neyriz-Naghadehi, M. and Asadi, S. M. (2015).** Antibacterial effects of *Solanum tuberosum* peel ethanol extract in vitro. J. Herbmed Pharmacol., 4(2):45-48.
12. **Arif, M., UrRehman, A., Naseer, K., Abdel-Hafez, S. H., Alminderej, F. M., El-Saadony, M. T., Abd El-Hack, M. E., Taha, A. E., Elnesr, S. S., Salem, H. M. and Alagawany. M.(2022).** Effect of Aloe vera and clove powder supplementation on growth performance, carcass and blood chemistry of Japanese quails. Poult. Sci., 101:101702.
13. **Armstrong, W.D. and Carr, C.W. (1964).** Physiological Chemistry: Laboratory directions 3: 75 Buger Puplishing Co. Minneapolis, Minnesota, U.S.A.
14. **Ashour, E.A., Aldhalmi, A.K., Ismail, I.E., Kamal, M., Elolimy, A.A., Swelum, A.A. and Abd El-Hack, M.E. (2025a).** The effect of using Echinacea extract as an immune system stimulant and antioxidant on blood indicators, growth efficiency, and carcass characteristics in broiler chickens to produce a healthy product. Poult. Sci. 104 (1): 104392.
15. **Ashour, E.A., Aldhalmi, A.K., Kamal, M., Salem, S.S., Mahgoub, S.A., Alqhtani, A.H. and Swelum, A.A. (2025b).** The efficacy of Artichoke leaf extract conjugated with organic zinc nanoparticles on growth, carcass traits and blood biochemical parameters of broilers. Poult. Sci. 104 (1): 104521.
16. **Aydın, B. and Barbas, L.A.L. (2020).** Sedative and anesthetic properties of essential oils and their active compounds in fish: a review. Aquac., 520, 734999.
17. **Baharvand-Ahmadi, B., Bahmani, M. and Rafieian-kopaei, M. (2016).** Asummary onthe prominent herbalmedicine effective for beauty, skin hygiene and wound healing in Iran. J. Chem. Pharm. Sci., 9(1): 28-33.
18. **Baharvand-Ahmadi, B., Rafieian-Kopaei, M., Zarshenas, M.M. and Bahmani, M.** (**2015).** Contrasting actions of various antioxidants on hyper lipidemia: a review and new concepts. Der Pharmacia Lett., 7(12):81-88.
19. **Bahmani, M., Saki, K., Shahsavari, S., Rafieian-Kopaei, M., Sepahvand, R. and Adineh, A. (2015).** Identification of medicinal plants effective in infectious diseases in Urmia, northwest of Iran. Asian. Pac. J. Trop. Biomed., 5: 858-864.
20. **Baker, W.L., Gutierrez-Williams, G., White, C.M., Kluger, J. and Coleman, C.I. (2008).** Effect of cinnamon on glucose control and lipid parameters. Diabetes Care, 31: 41-43.
21. **Bardaweel, S.K., Bakchiche, B., ALSalamat, H.A., Rezzoug, M., Gherib, A. and Flamini, G. (2018).** Chemical composition, antioxidant, antimicrobial and antiproliferative activities of essential oil of *Mentha spicata* L.(Lamiaceae) from Algerian Saharan atlas. BMC Complement. Altern. Med., 18: 201.
22. **Bist, R.B., Bist, K., Poudel, S., Subedi, D., Yang, X., Paneru, B. and Chai, L., (2024).** Sustainable poultry farming practices: a critical review of current strategies and future prospects. Poult. Sci., 103: 104295.
23. **Bogin, E. and Keller, P. (1987).** Application of clinical biochemistry to medically relevant animal models and standardization and quality control in animal biochemistry. J. Clin. Chem. Biochem., 25: 873-878.
24. **Brenes, A. and Roura, E. (2010).** Essential oils in poultry nutrition: main effects and modes of action. Anim. Feed Sci. Technol., 158: 1–14.
25. **Brown, K., Uwiera, R. R., Kalmokoff, M. L., Brooks, S. P. and Inglis, G. D. (2017).** Antimicrobial growth promoter use in livestock: a requirement to understand their modes of action to develop effective alternatives. Int. J. Antimic. Agents, 49(1): 12-24.
26. **Caroprese, M., Ciliberti, M. G., Marino, R., Santillo, A., Sevi, A. and Albenzio, M. (2023).** Essential oil supplementation in small ruminants: a review on their possible role in rumen fermentation, microbiota, and animal production. Dairy, 4: 497-508.
27. **Ciliberti, M.G., Albenzio, M., Sevi, A., Frabboni, L., Marino, R. and Caroprese, M. (2024).** Immunomodulatory role of *Rosmarinus officinalis* L., *Mentha* x *Piperita* L., and *Lavandula angustifolia* L. essential oils in sheep peripheral blood mononuclear cells. Vet. Sci., 11(4): 157.
28. **Clegg, R.J. and Mbada, W. (1980).** Inhibition of hepatic cholesterol synthesis and 3-hydroxy-3-methylglutaryl-coA reductase. Biochem. Pharmac., 29: 2125-2127.
29. **Dong, Y., Gao, X., Qiao, C., Han, M., Miao, Z., Liu, C., Li, J., 2024.** Effects of mixed organic acids and essential oils in drinking water on growth performance, intestinal digestive capacity, and immune status in broiler chickens. Animals 14 (15), 2160.
30. **Drew, P., Charles, R. J. S., Trevor, B. and John, L. (2004).** Oxford Handbook of Clinical Haematology. 2th Edition, Oxford University Press, USA.
31. **Duah, K.K., Essuman, E.K., Boadu, V.G., Olympio, O.S. and Akwetey,W. (2020)** 'Comparative study of indigenous chickens on the basis of their health and performance' Poultry science, 99, pp. 2286-2292.

32. **El-Abbasy, M.M., Aldhalmi, A.K., Ashour, E.A., Bassiony, S.S., Kamal, M., Alqhtani, A.H. and Swelum, A.A. (2025).** Enhancing broiler growth and carcass quality: impact of diets enriched with Moringa oleifera leaf powder conjugated with zinc nanoparticles. Poult. Sci., 104 (1): 104519.
33. **Elbaz, A. M., Ashmawy, E. S., Farahat, M. A. A., Ali, S. A., Amin, S. A., Thabet, H. A. and Gad, G. G. (2022)**.Effect of different levels of clove essential oil on the growth performance, lipid metabolism, immunity, and intestinal microbial structure of broiler chickens. Egyptian J. Nutri. Feeds, 25(3): 361-368.
34. **Elbaz, A.M., Ashmawy, E.S., Ali, S.A., Mourad, D.M., El-Samahy, H.S., Badri, F.B. and Thabet, H.A., (2023)**.Effectiveness of probiotics and clove essential oils in improving growth performance, immuno-antioxidant status, ileum morphometric, and microbial community structure for heat-stressed broilers. Scientific Rep., 13(1): 18846.
35. **Elspeiy, M., Abdella, M., Elaal, M. and Khalifah, A (2020).** Productive and physiological performance of growing rabbits as affected by peppermint oil and vitex agnus extract during summer season. Egypt. J. Rabbit. Sci., 30: 23–41.
36. **Ertas, O.N., Guler, T., Ciftci, M., Dalkilic, B. and Simsek, G. (2005).** The effect of an essential oil mix derived from oregano, clove and anise on broiler performance. Int. J. Poult. Sci., 4: 879-884.
37. **Farhadi, A., Hassanzad-Azar, H. and Pour-Anbari, P. (2016).** The most important medicinal plants affecting the brain and nerves: an overview on Iranian ethnobotanical sources. Der Pharma. Chemica, 8: 269-274.
38. **Feldman, B.F., Zinkl, J.G. and Jain, N.C. (2000)** Schalm's Veterinary Hematology. 5th Edition, Lippincott Williams & Wilkins, 1120-1124.
39. **Ghanima, M. M. A., Alagawany, M., Abd El-Hack, M. E., Taha, A., Elnesr, S. S., Ajarem, J., Allam, A. A. and Mahmoud, A. M. (2020).** Consequences of various housing systems and dietary supplementation of thymol, carvacrol, and euganol on performance, egg quality, blood chemistry, and antioxidant parameters. Poult. Sci., 99: 4384–4397.
40. **Ghazanfari, S., Ghzghapan, A.S. and 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. Vet. Anim. Sci., 24: 100354.
41. **Haque, M.H., Sarker, S., Islam, M.S., Islam, M.A., Karim, M.R., Kayesh, M.E.H., Shiddiky, M.J.A. and Anwer, M.S. (2020).** Sustainable antibiotic-free broiler meat production: current trends, challenges, and possibilities in a developing country perspective. Biol., 9: 411.
42. **Hashemipour, H., Kermanshahi, H., Golian, A. and Veldkamp T. (2013).** Effect of thymol and carvacrol feed supplementation on performance, antioxidant enzyme activities, fatty acid composition, digestive enzyme activities, and immune response in broiler chickens. Poult Sci., 92:2059-69.
43. **Henao-Ardila, A., Quintanilla-Carvajal, M. X. and Moreno, F. L. (2024).** Emulsification and stabilization technologies used for the inclusion of lipophilic functional ingredients in food systems. Heliyon.
44. **Hesabi, N. A., Edalatian, O. and Bakhshalinejad, R. (2019).** Effects of a blend of thyme, peppermint and eucalyptus essential oils on growth performance, serum lipid and hepatic enzyme indices, immune response and ileal morphology and microflora in broilers. J. Anim. Physiol. Anim. Nutr., 103(5): 1388–1398.
45. **Hong, J.C., Steine, 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. Livest. Sci., 144: 253-262.
46. **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. Anim. Biosci., 34(9):1499-513.
47. **Islam, Z., Sultan, A., Khan, S., Khan, K., Jan, A. U., Aziz, T., Alharbi, M., Alshammari, A. and Alasmari, A. F. (2024):** Effects of an organic acids blend and coated essential oils on broiler growth performance, blood biochemical profile, gut health, and nutrient digestibility. Italian J. Anim. Sci., 23: 152-163.
48. **Jin, S. and Cho, K.H. (2011).** Water extracts of cinnamon and clove exhibits potent inhibition of protein glycation and anti-atherosclerotic activity in vitro and in vivo hypolipidemic activity in zebrafish. Food Chem. Toxicol. 49: 1521-1529.
49. **Jouany, J.P. and Moravi, D.P. (2007).** Use of natural products as alternatives to antibiotic feed additives in ruminant production. Anim. 1, 1443-1466.
50. **Kamal, M., Aljahdali, N., Jaber, F.A., Majrashi, K.A., Kishk, W.H., Khalil, H.A. and Abd El-Hack, M.E. (2023a).** Influence of dietary chitosan supplementation on ovarian development and reproductive performance of New Zealand white rabbit does. Ann. Anim. Sci., 23 (3): 757–764.
51. **Karaca, N., Demirci, B., Gavahian, M. and Demirci, F. (2023).**Enhanced bioactivity of rosemary, sage, lavender, and chamomile essential oils by fractionation, combination, and emulsification. ACS omega, 8(12): 10941-10953.

52. **Khaksar, V., Krimpen, M.V., Hashemipour, H. and Pilevar, M. (2012).** Effects of thyme essential oil on performance, some blood parameters and ileal microflora of Japanese Quail. J. Poult. Sci. 25: 201-10
53. **Khodambashi Emami, N., Samie, A., Rahmani, H.R. and Ruiz Feria, C.A. (2012).** The effect of peppermint essential oil and ructooligosaccharides, as alternatives to virginiamycin, on growth performance, digestibility, gut morphology and immune response of male broilers. Anim. Feed. Sci. Technol., 175: 57-64.
54. **Khodambashi, E., Samie, N., Rahmani, H. R. and Ruiz-Feria, C. A. (2012).** The effect of peppermint essential oil and fructooligosaccharides, as alternatives to virginiamycin, on growth performance, digestibility, gut morphology and immune response of male broilers. Animal Feed Sci. Techn., 175: 57–64.
55. **Lee, K.W., H. Everts, H.J. Kappert, M. Frehner, R. Losa, A.C. Beynen, 2003:** Effects of dietary essential oil components on growth performance, digestive enzymes and lipid metabolism in female broiler chickens. Br. Poult. Sci. 44, 450-457.
56. **Lopes-Virella, M.F., Stone, P., Ellis, S. and Colwell, J.A. (1977).** Cholesterol determination in high-density lipoproteins separated by three different methods. Clin. Chem., 23: 882-884.
57. **López, D.P., Huaynate, R.R. and Tananta, R.V. (2018)** 'A comparative evaluation of the hematological parameters, biochemical profile and chemical composition of eggs of creole and Hy-line Brown laying hens' Livestock Research for Rural Development, 30.
58. **Mayengbam, P., Tolenkhomba, T. and Ali, M.A. (2020)** 'Blood cell morphometry and leukocyte-thrombocyte profile of indigenous chicken Sikhar of Mizoram' Indian J. Animal Sci., 90.
59. **Mehranpoor F. (1995)**. Antimicrobial effects of three species of saliva on three strains of intestinal pathogenic bacteria. Paper presented at: Proceedings of the 1st Medicinal Plants and Industrial Congress;
60. **Mohammadi, Z., Ghazanfari, S. and Moradi, M.A. (2014).** Effect of supplementing clove essential oil to the diet on microflora population, intestinal morphology, blood parameters and performance of broilers. Eur. Poult. Sci., 78: 1-11.
61. **Motejaded, V., Nassiri Moghaddam, H. and Hassanabadi, A. (2013).** Effects of mint powder on microbial population, carcass characteristics and performance of broiler chickens fed diets containing wheat. Iranian J. Animal Sci. Res., 5(1), 63–67.
62. **Nameghi, A.H., Edalatian, O. and Bakhshalinejad, R. (2019).** Effects of a blend of thyme, peppermint and eucalyptus essential oils on growth performance, serum lipid and hepatic enzyme indices, immune response and ileal morphology and microflora in broilers. J. Anim. Physiol. Anim. Nutr., 103: 1388-1398.
63. **Nanekarani, S., Goodarzi, M., Heidari, M. and Landy, N. (2012).** Efficiency of ethanolic extract of peppermint (*Mentha piperita*) as an antibiotic growth promoter substitution on performance, and carcass characteristics in broiler chickens. Asian Pacific J. Trop. Biomed., 2: 1611–1614.
64. **Naser, K. M. B., Sherif, B. M., Othman, S. M. and Asheg, A. A. (2023).** Effect of clove buds powder supplementation on hematological profile, biochemical parameters, lymphoid organs, and cell-mediated immunity of broilers. Open Veter. J., 13(7): 593 863.
65. **Nehme, R., Andrés, S., Pereira, R. B., Ben Jemaa, M., Bouhallab, S., Ceciliani, F., López, S., Rahali, F. Z., Ksouri, R., Pereira, D. M. and Abdennebi-Najar, L. (2021).** Essential oils in livestock: from health to food quality. Antioxid., 10: 330.
66. **Ocak, N., Frener, G., Burak, F., Sungu, A.K.M. and Ozmman, A. (2008).** performance of broilers fed diets with dry peppermint (peppermint) or thyme (*Thymus vulgaris* L.) leaves as promoter source. Anim Sci., 53: 169-175.
67. **Ogbuewu, I. P., Mabelebele, M. and Mbajiorgu, C. A. (2025).** Essential oils and their effect on growth performance, intestinal histomorphology, blood, carcass and immune organ characteristics of broiler chickens: a comprehensive review. Appli. Ecol. Environ. Res., 23(2): 3091-3106.
68. **Omar, E.M., Mohamed, W.H.A., Abdel Wahed, H. M. and Ragab, M. S. (2020). Addition** of essential oils and medium chain fatty acids in the diets and their effect on productive performance of broiler chickens. Egyptian J. Nutr. Feeds, 23(2):289-303.
69. Patil**, P.J., Thakare, G.V. and Patil, S.P. (2013)** 'Variability and accuracy of Sahli's method in estimation of haemoglobin concentration' National Journal of Integrated Research in Medicine, 4, pp. 38-44.
70. **Puvaˇca, N. (2018).** Honeybee and medicinal plants products in poultry postantibiotic Era Production. J. Agron. Technol. Eng. Manag., 1: 8–17.
71. **Puvaˇca, N., Ljubojevi´c, D., Kostadinovi´c, L., Lukaˇc, D., Levi´c, J., Popovi´c, S. and Đuragi´, O. (2015).** Spices and herbs in broilers nutrition: effects of Garlic (*Allium Sativum* L.) on broiler chicken production. Worlds Poult. Sci. J., 71: 533–538.
72. **Puvaca, 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*. Agric., 12: 874.

73. **Rezvani, M. R., Arab, M. and Kami, O. (2019).** Effect of peppermint, thyme and tarragon essential oils on the performance and antibody titer in broilers. Anim. Prod., 21 (3): 359–369.
74. **Sabu, M.C. and Kuttan, R. (2002).** Anti-diabetic activity of medicinal plants and its relationship with their antioxidant properties. J. Ethnopharmacol. 81: 155-160.
75. **Salinas-Chavira, J. and Barrios-García, H.B. (2024).** Essential oils, chemical compounds, and their effects on the gut microorganisms and broiler chicken production. Agric., 14 (11): 1864.
76. **SAS Institute, (1997).** SAS/STAT® User's Guide: Statistics, Version 6.12. SAS Institute Inc, Cary, NC.
77. **Shahbandeh, M. (2024).** Chicken meat production worldwide from 2012 to 2024.
78. **Shil, B., Sonowal, M., Gohain, A.K., Bhuyan, R., Borah, P. and Choudhury, D. (2023).** Evaluation of clove oil supplementation on the growth performance, nutrient digestibility and carcass traits of broiler chicken. Anim. Nutr. Feed Technol., 23 (3): 611–619.
79. **Shimaa, M.H. (2015).** Effect of some levels of cardamom, clove and anise on hepatotoxicity in rats caused by CCL4. World App. Sci. Jr., 33(6): 854-865.
80. **Shiri ghzghapan, A., Ghazanfari, S. and Honarbakhsh, S. (2023).** Effects of peppermint essential oil and artifier in low energy diets on production index, feed cost, blood biochemical parameters and meat quality of broiler chickens. Anim. Sci. J., 35(137): 101–116.
81. **Suliman, G.M., Alowaimer, A.N., Al-Mufarrej, S.I., Hussein, E.O., Fazea, E.H., Naiel, M. A. and Swelum, A.A., (2021).** The effects of clove seed (*Syzygium aromaticum*) dietary administration on carcass characteristics, meat quality, and sensory attributes of broiler chickens. Poult. Sci., 100 (3): 100904.
82. **Tabari, A.S. AL., Zuhairi, Z.A.A.L. and Abdulrazzaq M. (2018).** Study the effect of adding aqueous extract of clove (*Eugenia caryophyllus*) to drinking water in productivity and physiological efficiency of broiler chicken. Bas.J. Vet. Res. 17: 1.
83. **Toghyani, M., Gheisari, A., Ghalamkari, G. and Mohammadrezaei, M. (2010).** Growth performance, serum biochemistry and blood hematology of broiler chicks fed different levels of black seed (*Nigella sativa*) and peppermint (*Mentha piperita*). Livest. Sci.., 129: 173-178.
84. **Wade, M., Manwar, S., Kuralkar, S., Waghmare, S., Ingle, V. and Hajare, S. (2018).** Effect of thyme essential oil on performance of broiler chicken. J. Entomol. Zool. Stud, 6: 25-28.
85. **Wakenell, P. (2010)** 'Hematology of chickens and turkeys' Schalm's Veterinary Hematology. Sixth Edition. WileyBlackwell, pp. 967-958.
86. **Wang, W., Zhang, Y., Yang, Z. and He, Q., (2021).** Effects of incorporation with clove (*Eugenia caryophyllata*) essential oil (CEO) on overall performance of chitosan as active coating. Int. J. Biol. Macromole., 166:.578-586.
87. **Zeng, Z., Zhang, S., Wang, H. and Piao, X. (2020).** Essential oil and aromatic plants as feed additives in non-ruminant nutrition: a review. J. Anim. Sci. Biotech., 11: 50.
88. **Zhang, L., Gao, F., Ge, J., Li, H., Xia, F., Bai, H. and Shi, L. (2022).** Potential of aromatic plant- derived essential oils for the control of foodborne bacteria and antibiotic resistance in animal production: a review. Antibio., 11 (11): 1673.
89. **Zhao, H., Ren, S., Yang, H., Tang, S., Guo, C., Liu, M. and Xu, H. (2022)**. Peppermint essential oil: its **phytochemistry**, biological activity, pharmacological effect and application. Biomed. Pharmac., 154: 113559.