Egypt. Poult. Sci. Vol. (43) (I): (87-107) (2023) **(2302-1239)**

Egyptian Poultry Science Journal

http://www.epsj.journals.ekb.eg/

ISSN: 1110-5623 (Print) – 2090-0570 (Online)

EFFECT OF DIETARY PEPPERMINT LEAVES POWDER (*MENTHA PIPERITA L.*) AND/ OR L-MENTHOL CRYSTAL SUPPLEMENTATION ON NUTRIENTS DIGESTIBILITY, PERFORMANCE, DIGESTIVE ENZYMES, THYROID HORMONE, IMMUNITY, ANTIOXIDANT INDICES AND MICROBIAL POPULATION OF GROWING QUAIL

M.M.M. Aly[1], R. A. S. Abdelrasoul[1], N.Z. Boulos[2], M.A. Khalifa[1,2], A. A. Abdel-Wahab[1]

1-Poult. Prod. Dep., Fac. of Agric., Fayoum Uni., 63514 Fayoum, Egypt.

2- Anim. Prod. Res. Inst., Agric. Res. Center, Minis. of Agric., Dokki, Giza, Egypt

Corresponding author: A. A. Abdel-Wahab[1] Email: aaa16@fayoum.edu.eg

Received: 11/02/2022 Accepted: 28 /02/2023

ABSTRACT: The current trial was aimed to examine impacts of feeding ~~on~~ peppermint leaves powder (PLP) and its respective L-menthol crystal (LMC) supplementations on production performance, blood biochemistry, antioxidant parameters, immunity indices, microbial content, digestibility and digestive enzymes in growing Japanese quail. At ten-day-old, 700 unsexed Japanese quail were randomly splated into seven treatments, every treatment had five replecates of twenty chicks per each. The 1st treatment was given a normal diet (control), while other treatments from the 2nd to the 4th were given a standard diet with PLP at 1.5, 2.0, and 2.5%, respectively. Groups from the 5th to the 7th were received a control diet plus LMC at levels of 17, 22, and 27 part per million (ppm), respectively. Trypsin and amylase levels were significantly greater in the birds fed a diet containing 27 ppm LMC and 2.5% PLP compared to the control group, but lipase levels were not significantly different.. All nutrient digestibility (ND) and economic efficiency were significantly improved in chicks fed a diet supplemented with 27 ppm LMC compared to the control. Birds that given a diet supplemented with 27 ppm LMC and 2.5% PLP had the better-feed conversion ratio, live body weight and body gain, without any influence in feed intake. Finally, birds received 27 ppm LMC and 2.5% PLP had a dramatically lower lipid amount, liver enzymes, *Escherichia coli* and *Salmonella* population and the highest T3 and T4 levels, antioxidant parameters and *Lactobacilli* population number with the best impregnability compared to the control group. In conclusion, the addition of LMC at 27 ppm followed by PLP at 2.5%~~,~~ to the basal diet improved the nutrients digestibility, digestive enzymes, performance, antioxidant, plasma biochemical, immunological indices, intestinal microbiota and economical efficiency in Japanese quails during growing phase.

Key Words: Peppermint, L-menthol crystal, growth performance, serum biochemistry, quail.

1 | INTRODUCTION

Using antibiotics as growth promoter to decrease mortality and improve poultry production was one of the popular nutritional strategy. Nevertheless, in poultry feeding this plan unpleasant because of bacterial resistance (Neu, 1992 and Hoffman-Pennesi and Wu, 2010). Many studies were performed to know the important of application phytochemicals as natural alternative in poultry nutrition, for example herbal, their extracts and oils as useful alternatives to antibiotics to improve feed utilization and growth production (Kalia *et al.,* 2018 and Abdel-Wareth *et al.,* 2019). Jang *et al.* (2004) evidenced that the use of phytochemical compounds as natural feed additives is becoming necessary because of stimulatory influences on digestive system and antimicrobial effects. In addition, phytochemicals considered a perfect natural feed additive in animal production in comparing with synthetic antibiotics or inorganic chemicals due to less toxic and residue free (Hashemi and Davoodi, 2010). Moreover, medicinal plants such peppermint have many active component that are used to improve the intestinal microflora and growth performance throughout increasing poultry immunity, which is a prerequisite for cost suitable and organic poultry production (Guo *et al.,* 2004 and Windisch and Kroismayr, 2006). In broiler farms, increasing use of these antibiotics caused some problems such as altitude cost and negative effects on society health because of residues generated. Therefore, using herbal and medicinal plants such as peppermint leaves and menthol can use for producing safety foods (organic) with increasing production (Baharvand *et al.,* 2016).

Mint (Mentha piperita L.) is commonly used in medicinal herbal and is regarded to be highly helpful in immune system constructing, as well as for its antimicrobial and strong antioxidant properties, its ability to enhance appetite, digestion stimulating, and antimicrobial properties (Dorman *et al.,* 2003 and Yalcin *et al.,* 2012). Mint leaves and menthol have a variety of beneficial effects, including antibacterial activity against pathogenic microorganisms, antiviral activity, appetising, digestion stimulating, and antimicrobial properties (Alcicek *et al.,* 2004, Schelz *et al.,* 2006, Bupesh *et al.,* 2007 and Sharifi~~,~~ *et al.,* 2013).

Mint is a Labiate member of the family and one of world's oldest medicinal herbs (Bahmani *et al.,* 2015). Peppermint is widely grown throughout the world, including Egypt (Abdel-Wareth and Lohakare, 2014; Beigi *et al.,* 2018), and it is widely used in food, flavour, and pharmaceutical manufacturing (Farhadi *et al.,* 2016). Peppermint contains the chemicals menthol and menthone. Additionally, mint plant contains nearly 0.5 to 4% oils that are composed of 25 to 78% menthol, 2.8 to 10 % menthyl acetate, 14 to 36% menthone, 1.5 to 10% isomenthone, and 3.5 to 14% cineol~~.~~ (Grigoleit and Grigoleit, 2005; Bupesh *et al.,* 2007; Aziz *et al.,* 2011; Beigi *et al.,* 2018). Menthol is the most important and predominant polyphenol component in peppermint oil and it has antimicrobial properties as well as other activities that assist enhance broiler production (Cabuk *et al.,* 2006). According to researches, peppermint contains antibacterial, spasmolytic, and disinfecting effects that can improve performance and carcass characters in poultry industry (Demir *et al.,* 2003 and Gross and Siegel, 1983).

Nowadays, quail farming can become important in the industry and contribute to filling the deficit and the increasing demand for poultry meat. Furthermore, in recent years, the use of quail meat and its products has significantly increased (Awan *et al.,* 2017). Moreover, quails meat have a nutritional value and has great important to support poultry industry, the data available about the use of *Mentha piperita* leaves powder and his bioactive components (L-menthol) as a natural feed additives in quail feeding is limited. So, the current experiment was designed to investigate the influences of feeding peppermint leaves powder (PLP) and L-menthol supplementations on production performance, blood biochemistry, antioxidant parameters, immunity indices, microbial content, digestibility and digestive enzymes in growing Japanese quail.

2 | MATERIALS AND METHODS

The current study's research was carried out at the EL-Azab Poultry Research Station, EL-Fayoum Governorate, Egypt, from March to May 2022. The chemical analysis of the trial diets and mint leaves powder was carried out in the Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture laboratories in Dokki, Giza, Egypt.

2.1 | Experimental design, birds and diets

During the experiment, the birds' lodging and maintenance approaches were in accordance with Fayoum University's Institutional Animal Care Committee rules and procedures (Code No. of the proposal: AEC 2216). An aggregate number of 1200 1-day-old Japanese quail chicks were reared in battery system, and fed a control diet that includes 24% crude protein with 2900 Kcal ME/kg diet from one to ten day old, according to National Research Council (NRC, 1994). At day 10th of age, 700 unsexed quail chicks (average weight of 60.35 ± 0.33 g) were randomly disturbed to seven equal treatments, each one containing 100 birds in five replicates of 20 chicks each. The 1st treatment fed a basal diet without additives (control group), treatments from the 2nd to the 4th were received the control diet plus 1.5, 2.0 and 2.5% PLP, respectively. While groups from the 5th to the 7th fed the control diet plus 17, 22 and 27 ppm LMC, respectively, where addition levels were selected based on menthol concentrations in mint leaves and chicks were individually wing-banded by using small size plastic bands. Water and feed *ad libitum* with a continuous lighting program were applied during the experimental period. The experimental diets' feed ingredients and chemical composition are shown in Table (1). Peppermint dried leaves (4kg; 20 LB/ kg) were purchased from El-Rehab Company for the processing and export of aromatic and medicinal plants (Ibshawi, Fayoum, Egypt), and stored in a favorable environment until it was consumed. The L-menthol crystal was imported from Arora Aromatics Company (India) by Free Trade Egypt Company for Import and Export (Kafr El Dawar- Behira-Egypt), at February 2022 (Batch No. TLMC-160956). L-menthol was manually combined into the diets with a small portion of feed, then the amount was increased with better combining until reaching the desired uniform distribution, then, the mixture was saved in sealed and labelled bags according to every therapies to maintain the additives' effectiveness

2.2 | Chemical composition of peppermint dried leaves

According to determined analysis, PLP contain (air-dried) 11.0%, 18.2%, 4.35%, 8.58%, 10.1 and 47.77% for moisture, crude protein, crude fat, crude fiber, ash content and nitrogen-free extract (NFE) respectively, with 1.1 g/kg menthol. The concentration of menthol in L-menthol crystal 99.5%.

2.3 | Nutrient digestibility measurement

At the end of the trial (38 day), in metabolism cages 35 quail (one male around the average LBW of each replicate–were individually housed to study the faecal digestibility. Each cage had a drawer covered by filter paper cheat suitable for collecting the bird's excreta. The digestibility experiment was carried out over a 5-day collection period, and the excreta was daily sprinkle using H_2SO_4 (0.2 N) to avoid bacterial fermentation during collection. The collected excreta were pooled, homogenized in each replicate, and the excreta of each bird was collected and placed in aluminum dishes, and dried by oven on 60–70℃ for 36 h till dryness. Before analysis, the excreta samples were milled through a 0.5 mm mesh screen. The nutrients analyses were performed as outlined by AOAC (2001). According to Jakobsen *et al.* (1960) method, urinary nitrogen was separated from faecal nitrogen. Calculation of nutrient digestibility coefficients was performed as follows:

$$\text{Nutrient digestibility (\%)} = \frac{Nutrient\ intake,g - nutrient\ excreted,g}{nutrient\ intake,g} \times 100$$

2.4 | Growth performance

Chicks were individually weighed and feed intake (FI, g) per cage was recorded through the test period (10 –38 days of age), the body weight gain (BWG, g) was calculated by the following: $BWG_{10–38} = BW_{38}–BW_{10}$ and feed conversion ratio (FCR), was calculated as follows: FI (g)/BWG (g).

2.5 | Blood biochemistry, immunity and antioxidant parameters

At the end of the experiment (38 days), a blood sampling was collected from the slaughtered quails using randomly two birds (1 male and 1 female) from each replicate. The birds were initially weighed to the nearest g, slaughtered by cutting the Jugular vein (Islamic method), samples were gathered and centrifugated at 3000 rpm for 15 minutes, serum was isolated then stored at −20℃ in a tube of Eppendorf till analysis. Total cholesterol (Chol), triglycerides (TG), cholesterol high-density lipoprotein (HDL) and cholesterol low-density lipoprotein (LDL) were estimated by James (2001). According to Paglia and Valentine (1967) total antioxidant capacity, glutathione peroxidase (GPx) and thiobarbaturic acid-reactive substances (TBARS) were measured. Alanine aminotransferase (ALT), aspartate aminotransferase (AST) uric acid, creatinine, amylase and lipase enzymes were assayed by Friedman and Young (2005) and trypsin enzyme was determined according to Bovine Trypsin ELISA Kit MBS706461. Total T3 and T4 levels were analyzed by the ELISA technique using a commercial kit. Conforming to Erhard *et al.* (1992) the tool used to test birds immunoglobulins (IgG, IgA and IgM) in Sandwich ELISA was the absorbance measured on a 450 nm ELISA plate reader.

2.6 | Microbial analysis

Intestinal content was immediately collected in sterile glass containers, digesta was evacuated and mixed. Samples (1 g of the mixed fresh mass) were taken into sterile test tubes, diluted 1:10 in sterile 0.1% peptone solution, and homogenised for 3 min. in a stomacher homogeniser. Ten-fold serial dilutions of up to 10−7 of each sample were prepared in 9 ml of 0.1% sterile peptone solution. Viable counts of *Salmonella ssp, Escherichia coli (E. coli)* and *Lactobacilli ssp.* were performed. One milliliter of the serial dilution was incubated into sterile Petri dishes and sealed with an appropriate medium. *Lactobacillus spp.* colony count was determined using MRS agar (Biokar Diagnostic) after incubation in an anaerobic chamber at 37°C for 72 h. *Salmonella and E. coli* colonies were counted on a brilliant green agar plate and incubated at 37°C for 24 h. After cultivation in Petri dishes, the total colony count for *Lactobacilli*, *Salmonella* and *E. coli* was then calculated as the number of colonies by reciprocal of the dilution. The microbial counts were estimated as colony-forming units per gram (cfu/g) of the sample.

2.7 | Economical efficiency

Feeding cost was calculated on basis that the number of kg of feed intake (FI) from experimental diets per the number of kg of meat produced multiplied by the costs of the respective diets. The selling price (total revenue) was calculated by multiplying the number of kg of meat by 5000 Piasters (P.T.) which represents the selling price of one kg meat commonly offered in the market. The economic efficiency (net return per unit feed cost) of meat production for the different experimental treatments was calculated using the following equations:

Total Feed Cost = a x b = c, Total Revenue = d x e = f, Net Revenue = f-c =g and E. EF. = g/ c., Where: a = Average FI (Kg/ hen / period), b = Price / kg feed (PT). ; c= total feed cost (a x b), e = Price / kg meat (PT), d = meat (Kg/ hen/ period), f = Total Revenue (d x e). g = Net Revenue (f- c). It is worthy to note that, financial calculations were carried out according to the local market price of feed ingredients and additives dominated at the experimental, whereas other productive costs were disregarded since they were constant.

2.8 | Statistical analysis

The results obtained studied using the statistics tools (analysis of variance) of Infostat (Di Rienzo, 2017). As the following model:

$Yij = \mu + Ti + eij$

Where: Yij: observation of traits, μ: overall mean, Ti: treatment effect, eij: random error. All means were compared using multiple range test (Duncan, 1955). At significance level of 0.05.

3 | RESULTS

3.1 | Digestive enzymes and nutrients digestibility

Quails that given diets accompanied by LMC at 27 ppm and PLP at 2.5% recorded significantly ($P \leq 0.001$) higher trypsin (191.72 and 188.78) and amylase (674.90 and 670.00) levels for treatments LMC 27 ppm and PLP 2.5% compared to that received the control diet, being 125.22 and 485.50 respectively, without any important different in lipase levels in all experimental groups. Additionally, all nutrients digestibility (ND) were significantly ($P \leq 0.001$) influenced by all dietary groups. Where, quails fed diets supplemented with 27 ppm LMC and 2.5% PLP showed higher ND for dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), crude fiber (CF), nitrogen free extract (NFE), and protein retention (PR), in comparison with those fed the basal diet. The best values were obtained in birds fed diets supplemented with 27 ppm LMC being 74.95, 79.68, 89.90, 79.65, 46.61, 79.59 and 81.14 for DM, OM, CP, EE, CF, NFE and PR respectively, followed by those 2.5% received PLP , being 73.16, 75.48, 89.33, 75.83, 43.74, 77.76 and 78.06 as showed in Table (2).

3.2 | Growth performance

The data summarized in **Table (3)** presented that the experimental groups significantly affected ($P < 0.001$) growth performance during the studied period from 10 to 38 days of age (growing period). Where quail chicks fed diets supplemented with 27 ppm LMC presented the best LBW_{38d}, BWG_{10-38} and FCR_{10-38} being; 273.42, 212.54, and 3.02; respectively compared to the control group which recorded significantly ($P < 0.001$) the worst LBW_{38d}, BWG_{10-38} and FCR_{10-38} being; 245.65, 185.20g and 3.64; respectively. While there was no significant difference in FI_{10-38} values for all experimental groups. Additionally, both groups fed 27 ppm LMC and 2.5% PLP recorded the best values in comparison with the control group and nearly the other treated groups.

3.3 | Serum biochemistry

The results presented in Table (4) displayed that feeding PLP and LMC had a significantly substantial ($P < 0.001$) influence total blood lipids (total cholesterol, TG, LDL and HDL), kidney performance (uric acid and creatine), liver enzymes (ALT and AST), and thyroid hormones (T_3 and T_4) compared to the control group. Birds fed a diet supplemented with 27 ppm LMC had dramatically ($P < 0.001$) lesser cholesterol (192.80mg/dl), TG (136.60mg/dl), and LDL (118.16mg/dl), in addition to better HDL (49.50mg/dl) when compared to the control treatment. In comparison with other PLP and LMC treatments, there were no substantial variations. In terms of renal function (uric acid and creatine levels), the LMC at 27 ppm therapies had substantially lower values of 2.53 and 0.28U/L than the other groups. Except for the LMC at 17 ppm level, all diets augmented with PLP and LMC generated a significant (P < 0.001) declines in ALT and AST when compared to the control group. Treatment supplemented with 27 ppm LMC resulted in lower ALT and AST levels (1.81 and 186.50U/L), respectively. Thyroid hormone levels (T_3 and T_4) were dramatically (P < 0.001) higher over all different treatments supplemented with PLP and LMC compared to the control group. Thyroid hormones (T_3 and T_4) were 39.52 and 2.43 in chicks fed 2.5% PLP, respectively. Lastly, complementing diets with varying levels of PLP and LMC enhanced renal, hepatic and thyroid hormone activity.

3.4 | Intestinal bacteria

Table (5) showed the effect of dietary PLP and LMC on gut bacteria in Japanese quail at growing period. In our research, feeding PLP and LMC supplementation enhanced the healthy gut bacterial population (Lactobacillus population), while dramatically lowering (P > 0.001) the harmful diverse microbial population (Salmonella and E. coli population). Also, adding the PLP and LMC to diets substantially increased the total population of intestinal advantageous Lactobacilli while decreasing the population count of small intestine E. coli and Salmonella, particularly in treatment fed diet supplemented with 27 ppm LMC, which had the least E. coli and Salmonella population levels (4.73 and 4.99), respectively, and the greatest Lactobacilli population number (7.13).

3.5 | Antioxidant capacity and immunity

Table (6) showed that both antioxidant characteristics (T-AOC, GPx, and TBAR) and immune response index were strongly (P ≤ 0.001) affected by PLP and LMC therapies compared to the control treatment. Birds fed diets supplemented with PLP and LMC recorded the best IgG, IgA, IgM, T-AOC and glutathione peroxidase, with reduced thiobarbaturic acid-reactive compounds. Moreover, for T-AOC, GPx, TBAR, IgG, IgA, and IgM, the better impact was proved in the treated group with LMC at 27 ppm, with values of 1.54, 10.40, 0.86, 1201.41, 234.70, and 115.71, respectively. In terms of TBAR level, there was a substantial (P ≤ 0.001) variation preferring for 27 ppm LMC group (0.86) over all different treatments, while, the control group having the worst effect (1.45). In general, increasing dietary PLP and LMC rates enhanced values of immune index (IgM, IgA, and IgG), T-AOC and GPx.

3.6 | Economical efficiency

As showed in Table (7), diets containing LMC increased economical efficiency values compared to the control group. Quails fed diets supplemented with 27 ppm LMC had the greatest value of economical efficiency (165.16 %) followed by 22 ppm LMC (153.19 %), then the control and other groups. While, the worst economical efficiency value was recorded for chicks received diet supplemented by 17 ppm LMC (115.12 %) and those in the control group (100 %). It can be noted that 27 ppm LMC was the best diet regarding to the economical point of view and this result supported by the best performance for quails.

4 | DISCUSSION

In the present study, birds fed a diet supplemented with 27 ppm LMC and 2.5% PLP have significantly higher trypsin and amylase levels compared to the control group, without any significant variance in lipase levels in all treated groups. The increased levels of digestive enzymes (trypsin and amylase) may be due to PLP, which contains a lot of active ingredients like oils that enhance the production of endogenous digestive enzymes, thus also enhancing the effectiveness of poultry production (Cross *et al.*, 2007). The exiting study in the same line with Mimica- Dukiae *et al.* (2003) discovered that the medicinal effects of mint oil and other bioactive components could increment intestinal microbiota, total bile secretion, and increment growth production and diet consumption. Additionally, Nobakht (2011) reported that carvacrol enhancing pancreatic secretions with increase the enzymes which enhance absorption of more nutrients such as amino acids and increasing digestion in the digestive tract. The role of oils being in the modulation of gut microbiota and that increment nutrient utilization and enhancing production in poultry (Bento, *et al.,* 2013). Furthermore, mint have functional compounds can be increment feed digestion through of stimulating digestive system, boost liver function and rise secretion of digestive enzymes from pancreatic, which leads to improves the metabolism of carbohydrates and proteins (Mellor, 2000).

Concerning nutrients digestibility, all nutrients digestibility (ND) were significant influenced by all studies groups. Where, birds fed diets completed by 27 ppm LMC and 2.5% PLP showed higher ND for DM, OM, CP, EE, CF, NFE, PR in comparison with birds fed other diets. In this consideration, essential oils and other main ingredients such menthol in mint caused significant improving in digestibility coefficients, this could be because mint has antibacterial characteristics, which restrict the damaging growth of bacteria in the digestive tract, resulting in enhanced absorption and digestion (Movaseghi, 1990). The present findings in agree with Spirling and Daniels (2001) who showed that mint has a beneficial impact on digestive process and can dramatically increase feed consumption. Furthermore, Khan *et al.* (2011) revealed that including antioxidants in the diet protects pancreatic tissue from oxidative damage and may support the pancreas function properly which increasing enzymes secretions and nutrient digestibility. Additionally, Radwan and Abdel-Khalek (2007) explained that 0.5% supplementation level of a herb mixture of equal parts (sage, oregano, and sweet basal) increased crypt depth, villi height and absorption area, as well as increment production of rabbits. Emami *et al.* (2012) discovered that supplementing a broiler diet with 400 mg/kg peppermint oil significantly increased CP digestibility. Meanwhile, Khempaka *et al.* (2013) demonstrated that experimental diet that includes 0.5-2.0% peppermint powder had no negative influences on DM, OM, and CF digestibility or nitrogen retention in compare to the basal diet. In contrast, Morshedy *et al.* (2019) reported that various supplements on DM, CP, OM, EE, and CF digestibility were not significant when compared to the influence on the control group. Clearly, all experimental treatments have non-significant positive influence in nutritive values for DCP and TDN occurred in comparison with those of the basal diet.

The exiting trial's findings revealed that birds fed a diet accompanied with LMC at 27 ppm presented the good LBW_{38d}, BWG_{10-38} and FCR_{10-38} compared to control group with non-significant difference in FI_{10-38} values for all experimental groups. Additionally, both groups fed LMC at 27 ppm and PLP at 2.5% recorded the best values in comparison with control and nearly other treated groups. Peppermint leaves have active components (menthol and citral) have antioxidant and antimicrobial properties, as well as the ability to enhance absorption and digestion of feed ingredients, which may have increment performance (Bupesh *et al.,* 2007). Furthermore, the beneficial effect of peppermint leaves on rising daily weight gain was due to its anti-inflammatory properties, which enhanced the digestive system and improved feed utilization (Ocak *et al.,* 2008). In the same trend, Abdel-Wahab *et al.* (2018) found the same results in quails fed a diet augmented with 3% peppermint. Similarly, Abdel-Wareth, *et al.,* (2019) found that the addition of mint leaves at 5, 10, or 15 g/kg, and menthol at 26, 52, or 78 ppm in chicks diets improved weight gain compared to the control, with a significant impact on the conversion of digested feed into body gain and birds have better health. According to Abbas *et al*., (2021) the final body weight of quail birds fed diets containing of basil oil and mint oil was greatly higher than that of the control treatment birds. Prior researches in chicks discovered that basil oil and mint oil had a positive influence on body weight and weight gain (Witkowska *et al*, 2019) and in quails (Benchaar *et al*, 2007). In addition, Alallawee, *et al.* (2020) found that birds fed mint leaves (300 mg/kg diet) had a substantial increase in live weight compared to the control diet. The impact of peppermint's various active ingredients on digestive process, saliva production, bile acid synthesis in the liver, and bile excretion, which influences digestive process and fatty acid absorption, which, may clarify the increment in live weight and gains for treated groups (Frankic *et al*, 2009). Furthermore, Lee *et al.* (2003) found that oils of *Mentha Piperita* stimulate the secretion of endogenous digestive enzymes, which increment digestibility, and increases resistance against pathogens bacterial population, all of which can increment production. In contrast, Arab Ameri *et al.* (2016) revealed that chicks fed with 1% mint powder had lower average daily gain. Similarly, Akbari and Torki (2014) discovered that female broiler chicks fed mint oils had no impact on average live weight or gain. Also, Morshedy *et al.* (2019) revealed that various supplements had no significant impact on final live weight and gain of V-line growing rabbits during the feeding trial compared to control group.

Regarding to FI and FCR, birds given a diet augmented with 27 ppm LMC have the best $FCR_{10\text{-}38}$ compared to control group with non-significant difference in $FI_{10\text{-}38}$ values for all experimental groups. In this respect, peppermint leaves and menthol have many useful compounds that improve feed utilization and appetite caused increasing feed consumption and improved feed conversion ratio (Akbari *et al.*, 2016). The current results in agreement with Emami *et al.* (2012) who demonstrated that dietary supplementation with mint oil at a level of 200 mg/kg DM in broiler diets of enhanced FCR compared to control treatment. Similarly, Arab Ameri *et al*. (2016) demonstrated that consumed mint powder significantly enhanced FCR. Furthermore, Gole, *et al.* (2018) demonstrated that the addition of organic acids, mint oil, or their mixture resulted in significantly ($P\leq 0.01$) best FCR, with non-significant variations in feed intake. Moreover, Alallawee, *et al.* (2020) reported that feed consumption of broilers fed dried mint leafs diets at 35 days of age was reduced with improving in FCR compared to the control, which may be due to menthol properties (Lovkova *et al.,* 2001). Similarly, Mimica-Dukiae *et al.* (2003), used mint oil in broilers diet and noticed an increment in bile secretion yield, intestinal safety, enhanced growth with reduction feed consumption, which all resulted in a best FCR. Furthermore, adding both of mint and basil powder (leaf or seed), plant extracts and essential oil to broiler diets increment feed consumption with improved FCR (Riyazi *et al.*, 2015 and Abbas *et al*., 2021). El-Speiy *et al.* (2020) found that feed conversion was improved without statistical difference in feed intake compared to the control treatment. In contrast, Abdel-Wareth, *et al.* (2019) reported that feed consumption increment with increasing mint powder and menthol concentrations during study period, with the better FCR.

In the present research, all serum biochemical indices were significantly affected by feeding PLP and LMC. Where, all serum biochemical T. cholesterol, LDL, HDL, TG, creatine, uric acid, AST, ALT, T3 and T4 were affected by PLP and LMC supplemented diets. Birds received a diet supplemented with 27 ppm LMC showed enhanced total Chol, TG, LDL, uric acid, creatine, ALT, AST levels with better (higher) HDL, T3 and T4 levels compared to the control group. This can be explained that, peppermint powder has a lot of component phenolic and volatile phenolic such as oils (menthone, menthol and menthofuran) caused good impacts on all serum biochemical indices, these substances have antioxidative impacts that enhanced quails health. The decrease in cholesterol level could be caused by changes in the intestine microorganism surroundings that tends to increase lactic bacteria, which could create an acidic environment for the intestine, resulting in reduced lipid uptake in the intestines (Ghazaghi *et al.,* 2014). The present findings of the lipids agreed with Arab Ameri *et al*, (2016) who discovered that quails fed mint oils enriched diets had lower serum cholesterol. This decrease could be attributable to active compounds that have inhibitory influence on hepatic reductase and hepatic 3-hydroxy-3-methylglutaryl Coenzyme A (HMG-CoA), which controls cholesterol synthesis in liver. A beforehand study demonstrated that natural components in mint extract could reduce or inhibit absorption of cholesterol by the digestive tract, resulting in reduced blood cholesterol and serum fat levels (Crossland, 1980). Recently, Abbas *et al*., (2021) observed that birds received diets augmented by mint oil had dramatically lower TC compared to control group. Similarly, Abdel-wahab *et al.* (2018) noticed that quail chicks given diet augmented with 3% peppermint had best cholesterol with lower TG, LDL and AST levels in comparison with control group. Ali *et al.,* (2007) showed that the reduction in lipid and cholesterol could be attributed to the influence of oil present in these herbal ingredients on lipid accumulation. Furthermore, El-Speiy *et al.* (2020) confirmed that, the alternative therapies significantly enhanced blood serum chlosterol, HDL, triglyceride and LDL levels compared to control. In contrast, Toghyani *et al.,* (2010) revealed that mint diet had no influence on cholesterol amounts in chicken blood. Furthermore, Riyazi *et al.* (2015) found that broilers fed diets supplemented with 200, 400, and 600 ppm basil oil had no influence on blood lipid. In the same trend, Morshedy *et al.* (2019) observed that various treatments had no important impact on triglyceride, total lipid, cholesterol, HDL, LDL, and VLDL amounts compared to control treatment.

Regarding to T3 and T4, Alallawee, *et al.* (2020) demonstrated that birds received diets supplemented with 200 mg/kg of mint leaves powder had highly influenced plasma T3 and T4 levels. Where, the concentrations of T3 and T4 in broiler blood increased in in comparison with other therapies. The reason in improving thyroid hormones may be due to peppermint contains polyphenolic components that have significant antioxidant properties (Dorman *et al.,* 2003), and this may be enhance thyroid activity by encouraging the production of T3 and T4 from the thyroid gland into chicken plasma which leads to enhanced all performance parameters. Furthermore, (Abdel- Latif *et al*. 2004) linked the increment in performance and FCR for birds fed thyme leaves to a raise in thyroid action and the biological impact of such natural herb in hormone biosynthesis and metabolic activities. The above finding contradicts Ahmadi (2010) who explored that adding rapeseed meal to the diet did not enhance T3 and T4 amounts in chicken plasma.

Feeding the PLP and LMC-treated diets substantially enhanced the population number of small intestine favorable *Lactobacilli* while decreasing the harmful population count of small intestine *E. coli and Salmonella*, particularly in the LMC (27 ppm) therapies. The increase in useful bacteria and decrease in harmful bacteria could be attributed to polyphenols found in peppermint, which act as antibacterial agents by adjusting the pH within the digestive tract and improving the intra-intestinal environment. Also, Flavonoids and tannins that found in peppermint leaves and extracts act antibacterial agents, may also be accountable for the decrease of total microbial and *E-coli* count (Pramila *et al*, 2012). The present findings in the same line with Abdel-Wahab *et al.* (2018) noticed that adding mint at 3% and 1% to quail diets improved *Lactobacillus* numbers while decreasing *E- coli* and *Salmonella* numbers when comparison to those received diets treated by avilamycin and the control group. According to Darabighane *et al.* (2017) the *Lactobacilli* population was enhanced in birds fed a peppermint-aloevera combination, and the antimicrobial activities of peppermint essential oil are attributed with menthol (Iscan *et al.* 2002). Furthermore, Abbas *et al*. (2021) reported that there was a significant (P>0.05) decrease in *E. coli*. bacteria number and overall fungi population, while, the *Lactobacilli* numbers was substantially enhanced in groups treated by BEO and PEO compared to the control group. Additionally, Kang *et al.* (2019) discovered that peppermint essential oil (PEO) has antibacterial properties against harmful bacteria such *staphylococcus aureus*. Where, PEO caused damage the cell membrane of *S. aureus* and that have a strong inhibitory influence on *S. aureus* formalization and in activating and removing the mature biofilm formed by *S. aureus*.

In the existing study, all antioxidant indices (T-AOC, GPx and TBAR), and immunological indices were significantly influenced by PLP and LMC treatments. Where, diets containing PLP and LMC enhanced values of immune responses (IgG, IgA and IgM), T-AOC, glutathione peroxidase and decreased thiobarbaturic acid-reactive substances as compared to the control treatment. In this regard, peppermint has antioxidant potential and therefore can combat free radicals and oxidative stress and enhancing the immune response (Fallah *et al.*, 2013). Because antioxidants have been demonstrated to combat many diseases, peppermint, which has antioxidant property, may have defensive and improving impacts on birds (Arab Ameri *et al.,* 2016). Results in the present experiment agree with El-Speiy *et al.* (2020) who demonstrated that rabbits raised through the Egyptian summer interval have a substantial reduction in serum TAC compared to control treatment. Where, VALex, peppermint oil and their mixture addition dramatically reduced the influence of stress during the summer season, which reducing plasma MDA concentration and substantially improving TAC for treatments given peppermint oil and AEVex compared to the control treatment. Heat stress had a lower impact on broiler performance and viability when peppermint leaves or its active components were used. Phytogenic supplements can enhance poultry tolerance against heat stress and total antioxidant capacity (Song *et al.*, 2018).

In terms of immunological, Awaad *et al.* (2010) observed that birds treated by 0.25 mL of mint oils in drinking water increases levels of antibodies against the Newcastle virus vaccine. Additionally, Abdel-Wahab *et al.* (2018) reported that peppermint addition dramatically improved IgG, IgA, and IgM levels in quails. On another side, El-naggar and El-Tahawy (2018) observed that chicks augmented with mint had better IgG levels. Besides that, Morshedy *et al.* (2019) demonstrated that birds treated by basil oils and mint oils addition caused in numerical adjustments in plasma IgG and IgM levels compared to the control treatment.

In the current study, diets containing LMC increased economical efficiency values in comparison with control group. Quails fed diets supplemented with 27 ppm LMC had the greatest value of economical efficiency followed by 22 ppm LMC than the control diet and other treatments. In this regard, peppermint has active ingredients, and essential oils that can enhance nutrients utilization, resulting in better economic efficiency in broiler meat production (Amad *et al.,* 2011). The current findings are consistent with those of (Abdel-Wareth, *et al.*, 2019), who found that peppermint leaves and menthol dietary supplements substantially enhanced the European performance efficiency factor (EPEF) and economic efficiency values. Besides that, Abd El-Latif *et al.* (2002) noted that the addition of medicinal herbs as feed additives to the Japanese quail diets tends to lowering feed cost/Kg gain with the best percentage of economical efficiency compared to the control treatment. Abdo *et al.* (2003) obtained similar results, reporting that the inclusion amounts of medicinal herbs as feed additives in diets recorded lower cost/kg gain, with best percentage of economical efficiency when compared to basal diet. Moreover, Hassan *et al.* (2004) mentioned that the economical efficiency value at seven weeks of age was enhanced in chicks fed diets supplemented with medicinal herbs as feed additives compared to control treatment.

5 | CONCLUSION

Supplementing quails diet with 27 ppm LMC and/ or 2.5% PLP enhance nutrient digestibility, digestive enzymes, productive performance, lipid profile, kidney and liver functions, thyroid hormones, antioxidant parameters, immunological indices, intestinal microflora count and economic efficiency. Thus, LMC and PLP are able to encourage growth and improve the health of Japanese quail at growing period

.

Table (1): Composition and analysis of experimental diets containing peppermint leaves powder (*Mentha piperita* L.) and L-Menthol crystal during the growing period in Japanese quail.

Ingredients	Control 0.0%	PLP 1.5%	PLP 2.0%	PLP 2.5%	LMC 17ppm	LMC 22ppm	LMC 27ppm
Corn, %	50.12	50.12	50.12	50.12	50.12	50.12	50.12
Soya bean meal, 44%	37.53	37.53	37.53	37.53	37.53	37.53	37.53
Wheat bran, %	3.00	1.50	1.00	0.50	3.00	3.00	3.00
Corn gluten, 60%	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Corn oil	1.90	1.90	1.90	1.90	1.90	1.90	1.90
L-Lysine	0.13	0.13	0.13	0.13	0.13	0.13	0.13
DL Methionine	0.11	0.11	0.11	0.11	0.11	0.11	0.11
L-Thrionine	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Calcium carbonate	1.63	1.63	1.63	1.63	1.63	1.63	1.63
Di calcium phosphate,	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Salt, NaCl	0.35	0.35	0.35	0.35	0.35	0.35	0.35
PLP	0.00	1.50	2.00	2.50	0.00	0.00	0.00
LMC	0.00	0.00	0.00	0.00	0.0017	0.0022	0.0027
Premix, poultry *****	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.0017	100.0022	100.0027
Cost (P.T.) /Kg	940.8	959.3	966.8	978.3	939.3	940.1	940.8
Calculated analysis:**							
Dry Matter, %	86.95	86.95	86.95	86.95	86.95	86.95	86.95
Crude Protein, %	24.00	24.04	24.05	24.07	24.00	24.00	24.00
M.E. kcal/kg	2900	2927	2936	2945	2900	2900	2900
Ether Extract, %	4.28	4.30	4.28	4.31	4.28	4.28	4.28
Crude Fiber, %	4.58	4.55	4.58	4.53	4.58	4.58	4.58
Calcium, %	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Phosphorus non phytate %	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Lysine, %	1.30	1.29	1.29	1.29	1.30	1.30	1.30
Methionine, %	0.50	0.49	0.49	0.49	0.50	0.50	0.50
Methionine + Cysteine, %	0.89	0.88	0.88	0.87	0.89	0.89	0.89
Determined analysis:							
Dry Matter, %	90.73	90.93	90.83	90.70	90.60	90.60	90.60
Crude Protein, %	24.03	23.93	23.50	24.07	23.73	23.47	23.83
Ether Extract, %	4.70	4.53	4.77	4.30	4.63	4.77	4.53
Ash, %	5.60	5.43	5.73	5.43	5.60	5.60	5.27
Crude Fiber, %	4.16	4.27	4.60	4.17	4.40	4.43	4.27
NFE, %	52.24	52.77	52.23	52.73	52.23	52.33	52.70

***** Each 3.0 kg of premix supplies one ton of the diet with: Vit. A, 12000000 I.U; Vit. E, 10g; *Vit. D3, 2500000 I.U; Vit. K3, 2.5g; Vit.B1,1g; Vit.B2,5g; Vit.B6,1.5g; Vit.B12,10g; Biotin 50mg; Folic acid, 1g; Nicotinic acid, 30g; Capantothenate, 10g; Zn, 55g; Cu, 10g; Fe, 35g; Co,250mg; Se, 150mg; I, 1g; Mn,60g; and antioxidant, 10g.

****** According NRC, 1994.

Table (2): Effect of dietary peppermint leaves powder (*Mentha piperita* L.) and L-Menthol crystal on digestive enzymes, nutrients digestibility (%) and protein retention during growing period in Japanese quail.

Items / Treat.	Control 0.0%	PLP 1.5%	PLP 2.0%	PLP 2.5%	LMC 17ppm	LMC 22ppm	LMC 27ppm	SE	P-value
Digestive Enzymes									
Amylase U/L	485.50^{b}	573.70^{ab}	601.00^{a}	670.00^{a}	594.70^{a}	631.60^{a}	674.90^{a}	33.88	0.0035
Lipase U/L	79.20	96.70	98.80	99.40	93.80	99.30	99.80	7.29	0.4142
Trypsin U/L	125.22^{d}	154.57^{cd}	157.64^{bcd}	188.78^{ab}	156.21^{bcd}	168.93^{abc}	191.72^{a}	10.79	0.0008
Digestibility Coefficients									
DM	68.93^{bc}	69.64^{abc}	72.20^{abc}	73.16^{ab}	66.59^{c}	72.93^{ab}	74.95^{a}	1.81	0.0500
OM	71.66^{c}	74.18^{bc}	74.73^{bc}	75.48^{b}	73.36^{bc}	76.56^{ab}	79.68^{a}	1.12	0.0020
CP	82.65^{c}	86.62^{b}	87.99^{ab}	89.33^{a}	88.29^{ab}	88.65^{ab}	89.90^{a}	0.77	0.0001
EE	74.15^{b}	74.35^{b}	74.64^{b}	75.83^{b}	75.69^{b}	76.61^{b}	79.65^{a}	0.90	0.0049
CF	31.53^{d}	35.75^{cd}	42.24^{abc}	43.74^{ab}	37.83^{bcd}	40.90^{abc}	46.61^{a}	2.33	0.0031
NFE	73.81^{b}	77.14^{a}	77.92^{a}	77.76^{a}	73.10^{b}	77.21^{a}	79.59^{a}	0.95	0.0009
PR	73.65^{c}	75.12^{bc}	75.80^{bc}	78.06^{ab}	75.13^{bc}	77.11^{bc}	81.14^{a}	1.12	0.0028

Abbreviations: DM: Dry Matter, OM: Organic Matter, CP: Crude Protein, EE: Ether Extract, CF: Crude Fiber, NFE: Nitrogen Free Extract, PR: Protein retention, SE: Standard Error, PPM: Part Per Million, PLP: Peppermint leaves Powder, LMC: L-Menthol Crystal, a-d: Means within the same row with different superscript.

Table (3): Effect of dietary peppermint leaves powder (*Mentha piperita* L.) and L-Menthol crystal on growth performance in growing Japanese quail.

Items / Treat.	Control 0.0%	PLP 1.5%	PLP 2.0%	PLP 2.5%	LMC 17ppm	LMC 22ppm	LMC 27ppm	SE	P-value
Initial LBW	60.45	60.36	60.40	60.30	60.14	59.93	60.88	0.33	0.5985
LBW38d, g	245.65^{e}	257.21^{cd}	257.42^{cd}	263.45^{bc}	255.57^{d}	265.54^{b}	273.42^{a}	2.29	0.0001
BWG10-38,g	185.20^{e}	196.85^{cd}	197.02^{cd}	203.15^{bc}	195.43^{d}	205.61^{b}	212.54^{a}	2.23	0.0001
FI 10-38, g	650.73	652.49	655.87	656.26	655.99	656.38	656.28	3.36	0.8361
FC 10-38	3.64^{a}	3.34^{c}	3.29^{c}	3.26^{c}	3.48^{b}	3.12^{d}	3.02^{d}	0.05	0.0001

Abbreviations: LBW: Live Body Weight, BWG: Body Weight Gain, FI: Feed Intake, FCR: feed conversion ratio, SE: Standard Error, PPM; Part per Million, PLP: Peppermint leaves Powder, LMC: L-Menthol Crystal,

$^{a-e}$: Means within the same row with different superscript.

Table (4): Effect of dietary peppermint leaves powder (*Mentha piperita* L.) and L-Menthol crystal on lipid profile, kidney, liver functions and thyroid Hormone in growing Japanese quail.

Items / Treat.	Control 0.0%	PLP 1.5%	PLP 2.0%	PLP 2.5%	LMC 17ppm	LMC 22ppm	LMC 27ppm	SE	P-value
lipids profile									
Total chol. mg/dL	280.90^{a}	233.40^{b}	217.70^{bc}	198.60^{bc}	224.50^{bc}	210.00^{bc}	192.80^{c}	12.38	0.0001
TG , mg/dL	232.90^{a}	188.90^{ab}	167.00^{ab}	153.10^{b}	161.90^{b}	146.10^{b}	136.60^{b}	22.17	0.0591
HDL, mg/dL	38.30^{b}	43.10^{ab}	45.70^{a}	47.10^{a}	47.90^{a}	48.90^{a}	49.50^{a}	2.23	0.0099
LDL, mg/dL	169.25^{a}	161.11^{a}	142.55^{ab}	139.77^{ab}	142.71^{ab}	132.94^{ab}	118.16^{b}	12.73	0.1151
Kidney functions									
Uric, mg/dL	4.06^{a}	3.16^{b}	2.70^{b}	2.69^{b}	2.69^{b}	2.50^{b}	2.53^{b}	0.23	0.0001
Creatine, mg/dL	0.43^{a}	0.33^{b}	0.32^{b}	0.29^{b}	0.34^{b}	0.28^{b}	0.28^{b}	0.02	0.0008
liver functions									
ALT, U/L	2.55^{a}	1.94^{b}	1.89^{b}	1.82^{b}	2.09^{ab}	1.95^{b}	1.81^{b}	0.16	0.0328
AST, U/L	383.90^{a}	245.70^{b}	217.00^{b}	188.00^{b}	217.80^{b}	189.70^{b}	186.50^{b}	22.70	0.0001
Thyroid Hormones									
T3	30.04^{b}	36.15^{a}	38.53^{a}	39.52^{a}	35.39^{a}	37.87^{a}	39.07^{a}	1.63	0.0016
T4	2.07^{b}	2.34^{ab}	2.42^{a}	2.43^{a}	2.22^{ab}	2.38^{ab}	2.42^{a}	0.10	0.1135

Abbreviations: Total Chol: Total Cholesterol, TG: triglycerides, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, ALT: Alanine Aminotransferase, AST: Aspartate Aminotransferase, SE: Standard Error, PPM: Part per Million, PLP: Peppermint leaves Powder, LMC: L-Menthol Crystal,
$^{a-c}$: Means within the same row with different superscript.

Table (5): Effect of dietary peppermint leaves powder (*Mentha piperita* L.) and L-Menthol crystal on intestinal bacterial count in growing Japanese quail.

Items / Treat.	Control 0.0%	PLP 1.5%	PLP 2.0%	PLP 2.5%	LMC 17ppm	LMC 22ppm	LMC 27ppm	SE	P-value
E.coli log 10 cfug	6.20^{a}	5.57^{ab}	5.09^{bc}	4.89^{bc}	5.44^{b}	4.93^{bc}	4.73^{c}	0.22	0.0002
Salamonella log 10 cfug	6.70^{a}	5.95^{ab}	5.51^{bc}	5.02^{c}	6.07^{ab}	5.34^{bc}	4.99^{c}	0.27	0.0002
Lactobacillus log 10 cfug	4.98^{c}	5.30^{c}	6.17^{b}	6.58^{ab}	5.49^{c}	6.41^{b}	7.13^{a}	0.20	0.0001

Abbreviations: SE: Standard Error, PPM; Part per Million, PLP: Peppermint leaves Powder, LMC: L-Menthol Crystal,
a-c: Means within the same row with different superscript,

Table (6): Effect of dietary peppermint leaves powder (*Mentha piperita* L.) and L-Menthol crystal on antioxidant parameters and immune response in growing Japanese quail.

Items / Treat.	Control 0.0%	PLP 1.5%	PLP 2.0%	PLP 2.5%	LMC 17ppm	LMC 22ppm	LMC 27ppm	SE	P-value
Antioxidant Parameters									
T-AOC µgg	0.87[d]	1.21[bc]	1.38[ab]	1.48[ab]	0.99[cd]	1.40[ab]	1.54[a]	0.10	0.0001
GSH-PX µgg	6.32[b]	7.74[ab]	9.53[a]	10.30[a]	7.71[ab]	9.32[a]	10.40[a]	0.98	0.0335
TBARS µgg	1.45[a]	1.26[ab]	1.07[bcd]	0.92[d]	1.21[abc]	0.98[cd]	0.86[d]	0.08	0.0001
Immune Response									
IgG	996.73[d]	1131.24[bc]	1161.80[abc]	1194.33[ab]	1125.18[c]	1176.99[abc]	1201.41[a]	21.99	0.0001
IgA	145.37[e]	187.79[cd]	204.23[bc]	225.57[ab]	174.86[d]	209.97[abc]	234.70[a]	9.63	0.0001
IgM	87.37[e]	97.66[d]	103.20[bc]	108.38[b]	99.42[cd]	105.74[b]	115.71[a]	1.77	0.0001

Abbreviations: T-AOC: Total Antioxidant Capacity, GSH-PX: Glutathione Peroxidase TBARS: Thiobarbaturic Acid- Reactive Substances, IgG: Immunglobin G, IgA: Immunglobin A, IgM: Immunglobin M, SE: Standard Error, PPM: Part Per Million, PLP: Peppermint leaves Powder, LMC: L-Menthol Crystal,

[a-e]: Means within the same row with different superscript.

Table (7): Effect of dietary peppermint leaves powder (Mentha piperita L.) and L-Menthol crystal on economical efficiency of growing Japanese quail.

Items / Treat.	Control 0.0%	PLP 1.5%	PLP 2.0%	PLP 2.5%	LMC 17ppm	LMC 22ppm	LMC 27ppm
Av. Feed intake, Kg feed/ Kg a	3.64	3.34	3.29	3.26	3.48	3.12	3.02
Price Kg feed (P.T.) *b	940.8	959.3	966.8	978.3	939.3	940.1	940.8
Total feed cost C= (a×b)	3,425	3,204	3,181	3,189	3,269	2,933	2,841
Price / one Kg gain** d	5000	5000	5000	5000	5000	5000	5000
Net revenue (P.T) = d-c = e	1,575	1,796	1,819	1,811	1,731	2,067	2,159
Economic efficiency *** (e/c)	0.460	0.561	0.572	0.568	0.530	0.705	0.760
Relative efficiency ****	100	121.86	124.34	123.41	115.12	153.19	165.16

* Based on average price of diets during the experimental time. ** According to the local market price at the experimental time. *** Net revenue per unit feed cost. **** Assuming economic efficiency of control group equal 100.

REFERENCES

Abbas, R. J., AlShaheen, S. A., & Majeed, T. I. 2021. Effect of Different Levels of Basil and Peppermint an Essential Oils on Productive and Physiological Performance of Two Lines of Growing Quail (Coturnix Coturnix Japonica). Biochemical and Cellular Archives, 21(1), 27-37.

Abd El-Latif S. A.; Ahmed, A. F.; El Kaiaty, A. M. 2002. Effects of feeding dietary thyme, black cumin, dianthus and fennel on productive and some metabolic responses of growing Japanese quail. Egypt. Poult. Sci. J.; 22 (1): 106-125.

Abdel-Latif, S.; El-Yamany, A. and Edaly, E.A. 2004. Evaluation of using different levels and sources of medicinal herbs in growing Japanese quail diets. Egyptian Journal of Nutrition and Feeds 7, 69-81.

Abdel-Wahab, A. A., I. A. Abdel-Kader and Enas. A. M. Ahmad 2018. Evaluation of dried peppermint leaves as natural growth promoters alternative to antibiotics on Japanese quail. Egyptian Poultry Science Journal, 38(4), 943-958.

Abdel-Wareth, A. A. A., and J. D. Lohakare.2014. Effect of dietary supplementation of peppermint on performance, egg quality, and serum metabolic profile of Hy-Line Brown hens during the late laying period. Anim. Feed Sci. Technol. 197:114–120.

Abdel-Wareth, A. A. A., S. Kehraus and K.-H. S¨udekum.2019. Peppermint and its respective active component in diets of broiler chickens: growth performance, viability, economics, meat physicochemical properties, and carcass characteristics. Poultry Science, 98:3850–3859.

Abdo, Z. M. A.; Soliman, A.Z.M. and Barakat, O. S. 2003. Effect of hot pepper and marjoram as feed additives on the growth performance and the microbial population of the gastrointestinal tract of broilers. Egypt. Poult. Sci.; 23 (1): 91- 113.

Ahmadi, M. 2010. The Effect of Different Levels of Rapeseed Meal with and without Enzyme on the Performance and the Serum Level of Triiodothyronine (T3), Thyroxine (T4) and Thyroid Stimulating Hormone (TSH) in Broiler Chickens. Animal Science Applied of Iranian Journal. 6 (1): 203- 209.

Akbari M and Torki M 2014. Effects of dietary chromium picolinate and peppermint essential oil on growth performance and blood biochemical parameters of broiler chicks reared under heat stress conditions. Int. J. Biometeorol. 58, 1383-1391.

Akbari, M., Torki, M., & Kaviani, K. 2016. Single and combined effects of peppermint and thyme essential oils on productive performance, egg quality traits, and blood parameters of laying hens reared under cold stress condition (6.8±3 C). International journal of biometeorology, 60(3), 447-454.

Alallawee, M. H. A., AL-Mousawi, Z. A., Odhaib, K. J., & Abdulhussain, A. A. 2020. Effect of diet supplement of dry peppermint leaves on performance, productive index and thyroid hormones in a broiler. Plant Archives Volume 20 No. 2, pp. 8608-8612.

Alcicek A, Bozkurt M, Cabuk M. 2004. The effect of a mixture of herbal essential oils, an organic acid or a probiotic on broiler performance. South African Journal of Animal Science. 34(4):217-222.

Ali MN, Hassan MS, Abd El-Ghany FA 2007. Effect of strain, type of natural antioxidant and sulphate ion on productive, physiological and hatching performance of native laying hens. Intern J Poultry Sci 6(8): 539-554.

Amad, A. A., K. M¨anner, K. R. Wendler, K. Neumann, and J. Zentek. 2011. Effects of a phytogenic feed additive on growth performance and ileal nutrient digestibility in broiler chickens. Poult. Sci. 90:2811–2816.

AOAC. 2001. Official methods of analysis of the association of official analytical chemists. Washington DC.

Arab Ameri S, Samadi F, Dastar B and Zerehdaran S 2016. Effect of peppermint (Mentha piperita) powder on immune response of broiler chickens in heat stress. Iran. J. Appl. Anim. Sci. 6, 435- 445.

Awaad, M.; Abdel-Alim, G.; Sayed, K.; Ahmed, A.; Nada, A.; Metwalli, A. and Alkhalaf, A., 2010. Immunostimulant effects of essential oils of peppermint and eucalyptus in chickens. Pak. Vet. J., 30: 61-66.

Awan, F. N., Shah, A. H., Soomro, A. H., Barahm, G. S., & Tunio, S. G. 2017. Carcass Yield and Physico-chemical Characteristics of Japanese Quail Meat. Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences, 33(1): 111-120.

Aziz, E. E., N. Gad, and S. M. Khaled. 2011. Effect of cobalt on growth and chemical composition of peppermint plant grown in newly reclaimed soil. Aust. J. Basic. Appl. Sci. 5:628–633.

Baharvand-Ahmadi B, Bahmani M, Rafieian-kopaei M. 2016. A summary on the prominent herbal medicine effective for beauty, skin hygiene and wound healing in Iran. J Chem Pharm Sci.; 9(1):28-33.

Bahmani M, Saki K, Shahsavari S, Rafieian-Kopaei M, Sepahvand R, Adineh A. 2015. Identification of medicinal plants effective in infectious diseases in Urmia, northwest of Iran. Asian Pac J Trop Biomed.; 5:858-864.

Beigi, M., M. Torki-Harchegani, and A. G. Pirbalouti. 2018. Quantity and chemical composition of essential oil of peppermint (Menth × piperita L.) leaves under different drying methods. Int. J. Food Prop. 21:267–276.

Benchaar C, Calsamiglia S, Chaves A V, Fraser G R, Colombatto D, McAllister T A and Beauchemin K A 2007. A review of plantderived essential oils in ruminant nutrition and production. Anim. Feed Sci. Technol. 145, 209–228.

Bento M, Ouwehand A, Tiihonen K, Lahtinen S, Nurminen P, Saarinen M, Schulze H, Mygind T and Fischer J 2013. Essential oils and their use in animal feeds for monogastri animals effects on feed quality, gut microbiota, growth performance and food safety: A review. Vet. Med. **58**, 449–458.

Bupesh, G., C. Amutha, S. Nandagopal, A. Ganeshkumar, P. Sureshkumar, and K. M. Saravana. 2007. Antibacterial activity of Mentha piperita L. (peppermint) from leaf extracts – A medicinal plant. Acta. Agric. Slov. 89 (1):73–79.

Cabuk M, Ozkurt MB, Alcieck A, Akba SY. 2006. Effect of an herbal essential oil mixture on growth and weight of broiler from young and old breeder flocks. South Afr J Anim Sci.; 36:135-141.

Cross, D.E., R.M. McDevitt, K. Hillman and T. Acamovic 2007. The effect of herbs and their associated essential oils on performance, dietary digestibility and gut microflora in chickens from 7 to 28 days of age. Brit. Poult. Sci., 48: 496–506.

Crossland J., 1980. Lewis's Pharmacology. 5 th Edition. Churchill Livingston. London (UK), pp. 656–657.

Darabighane, B., Mirzaei Aghjeh Gheshlagh, F., Navidshad, B., Mahdavi, A., Zarei, A., & Nahashon, S. 2017. Effects of peppermint (Mentha piperita) and Aloe vera (Aloe barbadensis) on ileum microflora population and growth performance of broiler chickens in comparison with antibiotic growth promoter. Iranian Journal of Applied Animal Science, 7(1), 101-108.

Demir E, Sarica S, Ozcan MA, Suicmez M. 2003. The use of natural feed additives as alternatives for an antibiotic growth promoter in broiler diets. Br Poult Sci.; 44: S44-S45.

Di Rienzo, J. A. (2017). InfoStat versión 2009. Grupo InfoStat, FCA, Universidad Nacional de Córdoba. Argentina. http://www.Infos tat. Com.Ar

Dorman, H.J.D., M. Kosar, K. Kahlos, Y. Holm and R. Hiltunen 2003. Antioxidant properties and composition of aqueous extracts from Mentha species, hybrids, varieties, and cultivars. J. Agric. Food Chem., **51:** 4563-4569.

Duncan, D. B. (1955). Multiple range test and multiple F. test. Biometrics, 11, 1–42.

ELnaggar A Sh and El-Tahawy W S 2018. Productive performance, physiological and immunological response of broiler chicks as affected by dietary aromatic plants and their essential oils. Egypt. Poult. Sci. 38, 773-795.

El-Speiy, M.E., Abdella, M., Abd Elaal, M., & Khalifah, A. 2020. Productive and physiological performance of growing rabbits as affected by peppermint oil and vitex agnnus extract during summer season. Egyptian Journal of Rabbit Science, 30(1), 23-41.

Emami, N. K.; Samie, A.; Rahmani, H. and Ruiz-Feria, C. 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. Anim. Feed Sci. Technol., 175: 57-64.

Erhard, M. H., Von Quistorp, I., Schranner,I., Jüngling, A., Kaspers,B., Schmidt, P. and Kühlmann, R.,1992. Development of Specific Enzyme-Linked Immunosorbent Antibody Assay Systems for the Detection of Chicken Immunoglobulins G, M, and A Using Monoclonal Antibodies. Poultry Science, Volume 71, Issue 2, 1 February 1992, Pages 302–310.

Fallah, R., Kiani, A. and Azarfar, A., 2013. Effect of artichoke levels meal and Menthapiperita extract on immune cells and blood biochemical parameters of broilers. Global Veterinaria 10 (1): 99-102.

Farhadi A, Hassanzad-Azar H, Pour-Anbari P, et al. 2016. The most important medicinal plants affecting the brain and nerves: an overview on Iranian ethnobotanical sources. Der Pharma Chemica,; 8:269-274.

Frankic T, Voljc M, Salobir J and Rezar V 2009. Use of herbs and spices and their extracts in animal nutrition. Acta Agric. Slov. 94, 95-102.

Friedman, R. B., & Young, D. S. 2005. Effects of disease on clinical laboratory tests. Columbia University Press.

Ghazaghi M., Mehri M. and Bagherzadeh-Kasmani F., 2014. Effects of dietary Mentha spicata on performance, blood metabolites, meat quality and microbial ecosystem of small intestine in growing Japanese quail. Animal Feed Science and Technology. 194, 89-98.

Gole, MA, SJ Manwar, SV Kuralkar, SB Kawitkar, SP Waghmare, SP Chaudhary and SW Hajare, 2018. Studies on supplementation of peppermint essential oil and organic acids on performance and gut health of broilers. Journal of Entomology and Zoology Studies; 6(6): 453-459.

Grigoleit, H. G., and P. Grigoleit. 2005. Pharmacology and preclinical pharmacokinetics of peppermint oil. Phytomedicine 12:612– 616.

Gross WB, Siegel HS. 1983. Evaluation of heterophil/lymphocyte ratio as a measure of stress in chicken. Avian Dis.; 27:972-979.

Guo, F.C., B.A. Williams, R.P. Kwakkel, H.S. Li and X.P. Li 2004. Effects of Mushroom and herb polysaccharides as alternative for an antibiotic on the caecal microbial ecosystem and broiler chickens. Poult. Sci., **83:** 175-182.

Hashemi SR, Davoodi H (2010). Phytogenics as new class of feed additive in poultry industry. J. Anim. Vet. Adv. 9(17): 2295-2304. https://doi.org/10.3923/javaa.2010.2295.2304

Hassan, I. I. Asker, A.A. and Gehan El-Shourbagy, A. 2004. Influence of some medicinal plants on performance, physiological and meat quality traits of broiler chicks. Egypt. Poult. Sci. J. 24 (I): 247-266.

Hoffman-Pennesi, D., and C. Wu. 2010. The effect of thymol and thyme oil feed supplementation on growth performance, serum antioxidant levels, and cecal Salmonella population in broilers. J. Appl. Poult. Res. 19:432–443.

Iscan G., KIrimer N., Kürkcüoglu M.N., Baser H.C. and DEMIrci F. 2002. Antimicrobial screening of Mentha piperita essen-tial oils. J. Agric. Food Chem. 50, 3943-3946.

Jakobsen, P. E., Kirston, S. G., & Nelson, H. 1960. Digestibility traits with poultry. Bretning Far Forsgs Laboratoriet Udgivet Statens Husdybug Sudvalg Koberhann.

James, I. 2001. Executive summary of the third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). JAMA: the Journal of the American Medical Association, 285(19), 2486–2497. https://doi.org/10.1001/ jama.285.19.2486.

Jang, I. S., Y. H. Ko, H. Y. Yang, J. S. Ha, J. Y. Kim, S. Y. Kang, D. H. Yoo, D. S. Nam, D. H. Kim, and C. Y. Lee. 2004. Influence of essential oil components on growth performance and the functional activity of the pancreas and small intestine in broiler chickens. Asian-Aust. J. Anim. Sci. 17:394–400.

Kalia, S., V. K. Bharti, A. Giri, B. Kumar, A. Arora, and S. S. Balaje. 2018. Hippophae rhamnoides as novel phytogenic feed additive for broiler chickens at high altitude cold desert. Sci. Rep. 8:5954.

Kang J, Jin W, Wang J, Sun Y, Wu X and Liu L 2019. Antibacterial and anti-biofilm activities of peppermint essential oil against Staphylococcus aureus. LWT **101**, 639-645.

Khan RU, Nikousefat Z, JavdaniM, Tufarelli V, Laudadio V 2011. Zincinduced moulting: production and physiology. World Poult Sci J 67(3):469–497.

Khempaka, S., U. Pudpila, and W. Molee. 2013. Effect of dried peppermint (Mentha cordifolia) on growth performance, nutrient digestibility, carcass traits, antioxidant properties, and ammonia production in broilers. J. Appl. Poult. Res. 22:904–912.

Lee K W, Everts H, Kappert H J, Frehner M, Losa R and Beynen A C 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.

Lovkova, M.Y., G.N. Buzuk, S.M. Sokolova and N.I. Kliment'eva 2001. Chemical features of medicinal plants (a review). Appl. Biochem. Microbiol., 37: 229–237.

Mellor, S. (2000). Antibiotics are not the only growth promoters. World Poult., 16(1): 14-16.

Mimica-Dukiæ, N., B. Božin, M. Sokoviæ, B. Mihajloviæ and M. Matavulj 2003. Antimicrobial and antioxidant activities of three Mentha species essential oils. Plant. Med., 69: 413-419.

Morshedy S A, Zweil H S, Zahran S M, Ahmed M H and El-Mabrok B M 2019. Growth performance, carcass traits, immune response and antioxidant status of growing rabbits supplemented with peppermint and basil. Egypt. Poult. Sci. **39**, 61-79.

Movaseghi, S.H. 1990. Phytochemical Properties of Some Medicinal Plants in Iran. Tehran, Iran: Research Institute of Forests and Rangelands (RIFR): 67-74.

National Research Council (NRC). 1994. Nutrient requirements of poultry (9th revised ed.). National Academy Press.

Neu, H. C. 1992. The crisis in antibiotic resistance. Science 257:1064– 1073.

Nobakht, A., 2011. Effects of different levels of chicory (Cichorium intybus L.), zizaphora (Zizaphora tenuior L.), nettle (Urtica dioica L.) and savoury (Satureja hortensis L.) medicinal plants on carcass characteristics of male broilers. Journal of Medicinal Plants Research 5:4354-4359.

Ocak, N., Erener, G., Burak, A. K. F. M., Altop, S. A., Ozmen, A., 2008. Performance of broilers fed diets supplemented with dry peppermint (Mentha piperita L.) or thyme (Thymus vulgaris L.) leaves as growth promoter source. Czech Journal of Animal Sciences 53:169-175.

Paglia, D. E., & Valentine, W. N. 1967. Studies on the quantitative and qualitative characterization of erythrocyte glutathione peroxidase. The Journal of Laboratory and Clinical Medicine, 70(1), 158–169.

Pramila D M, Xavier R, Marimuthu K, Kathiresan S, Khoo M L, Senthilkumar M, Sathya K and Sreeramanan S 2012. Phytochemical analysis and antimicrobial potential of methanolic leaf extract of peppermint (Mentha piperita: Lamiaceae). J. Med. Plant Res. 6, 331-335.

Radwan, N.L. and A.M. Abdel - Khalek, (2007). Response of summer stressed growing rabbits to some dietary growth promoters. Tartu Estonia "Animal health, animal welfare and biosecurity", 1: 350-358.

Riyazi S R, Ebrahimnezhad Y, Hosseini S A, Meimandipour A and Ghorbani A 2015. Comparison of the effects of basil (Ocimum basilicum) essential oil, avilamycin and protexin on broiler performance, blood biochemistry and carcass characteristics. Arch. Anim. Breed. 58, 425-432.

Schelz, Z., J. Molnar and J. Hohmann, 2006. Antimicrobial and antiplasmid activities of essential oils. Fitoterapia, 77: 279-285.

Sharifi, S.D., S.H. Khorsandi, A.A. Khadem, A. Salehi and H. Moslehi, 2013. The effect of four medicinal plants on the performance, blood biochemical traits and ileal microflora of broiler chicks. Veterinarski Arhiv, 83: 69-80.

Song, Z. H., K Cheng, X C Zheng, H Ahmad, L L Zhang, and T Wang. 2018. Effects of dietary supplementation with enzymatically treated Artemisia annua on growth performance, intestinal morphology, digestive enzyme activities, immunity, and antioxidant capacity of heat-stressed broilers. Poult. Sci. 97:430–437.

Spirling, L. I., and I. R. Daniels. 2001. Botanical perspectives on health peppermint: more than just an after-dinner mint. JR. Soc. Promot. Health 121:62–63.

Toghyani, M., Toghyani, M., Gheisari, A., Ghalamkari, G., & 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). Livestock science, 129(1-3), 173-178.

Windisch W, Kroismayr A 2006. The effects of Phytobiotics on the performance and gut function in monogastric. http// en.engormix.com/ MA-Feed machinery/articles/the effect of phytobiotics-performance: 285.html.

Witkowska D, Sowiñska J, Murawska D, Matusevièius P, Kwiatkowska-Stenzel A, Mituniewicz T and Wójcik A 2019. Effect of peppermint and thyme essential oil mist on performance and physiological parameters in broiler chickens. S. Afr. J. Anim. Sci. **49**, 29-39.

Yalcin, S., S. Yal¸cin, K. Uzuno˘glu, H. M. Duyum, and ¨ O. Eltan. 2012. Effects of dietary yeast autolysate (Saccharomyces cerevisiae) and black cumin seed (Nigella sativa L.) on performance, egg traits, some blood characteristics and antibody production of laying hens. Livest. Sci. 145:13–20.

Peppermint, L-menthol crystal, growth performance, serum biochemistry, quail

الملخص العربى

تأثير التغذية على مسحوق أوراق النعناع (.Mentha piperita L) و/ أومستحضر L-منثول كريستال على هضم العناصر الغذائية ، والأداء الإنتاجى، والإنزيمات الهاضمة ، وهرمون الغدة الدرقية ، والمناعة ، ومؤشرات مضادات الأكسدة ، والعد الميكروبي للسمان اليابانى فى فترة النمو

محمود محمد محمد على[1]، رمضان علام سيد عبدالرسول[1]، ناصف زكي بوليس[2]، منتصر عدلى خليفة[1,2]
،عبدالوهاب عبدالله عبدالوهاب[1]
1. قسم إنتاج الدواجن – كلية الزراعة – جامعة الفيوم.
2. معهد بحوث الإنتاج الحيواني - مركز البحوث الزراعية - وزارة الزراعة – الدقي – الجيزة – مصر.

هدفت التجربة الحالية إلى دراسة تأثير التغذية على مسحوق أوراق النعناع (PLP) ومستحضر المنثول L-menthol (LMC) على الأداء الإنتاجى ، والكيمياء الحيوية للدم ، ومعايير مضادات الأكسدة ، ومؤشرات المناعة ، والمحتوى الميكروبي ، ومعاملات الهضم والإنزيمات الهضمية في فترة النمو للسمان الياباني. تم تقسيم 700 كتكوت سمان ياباني بعمر عشرة أيام بشكل عشوائي إلى سبع مجموعات (5 مكررات X 20 كتكوت/ مكررة) ، غذيت المجموعة الأولى على عليقة الكنترول (مجموعة المقارنة) ، غذيت المجموعات من الثانية إلى الرابعة على عليقة الكنترول بالإضافة إلى مسحوق أوراق النعناع بمستويات 1.5 و 2.0 و 2.5٪ على التوالي. بينما غذيت المجموعات من الخامسة إلى السابعة على عليقة الكنترول بالإضافة إلىمستحضر المنثول LMCبمستويات 17 و 22 و 27 جزء في المليون على التوالي. أظهرت النتائج أن السمان الذي تم تغذيته على عليقة تحتوى على المنثول LMC بمستوى 27 جزء في المليون ، و مسحوق أوراق النعناع بمستوى 2.5٪ كانت أعلى معنويا (P≤ 0.001) فى مستويات إنزيم التربسين والأميليز مقارنة بمجموعة الكنترول دون أي اختلاف معنوي في مستوى إنزيم الليبيز. تحسن معامل الهضم لجميع العناصر الغذائية والكفاءة الإقتصادية بشكل ملحوظ (P≤ 0.001) للمجموعة التي غذيت على عليقة بـها LMC بمستوى27 جزء في المليون. حققت الكتاكيت التي تم تغذيتها على عليقة بـها LMC بمستوى 27 جزء في المليون و PLP بمستوى2.5 ٪ أفضل وزن للجسم ، ومعدل زيادة فى وزن الجسم وكفاءة تحويل العلف دون أي فرق معنوي في تناول العلف مقارنة بمجموعة الكنترول. سجلت الكتاكيت التي غذيت على عليقة مضاف إليها LMC بمستوى27 جزء في المليون ، و PLP بمستوى 2.5٪ أقل نسبة دهون فى الدم ، وإنزيمات الكبد ، والسالمونيلا ، وأعلى فى هرمون الغدة الدرقية (T3 and T4) ، ومؤشرات مضادات الأكسدة ، والإستجابة المناعية وعدد بكتيريا حمض اللاكتيك مقارنة بمجموعة الكنترول. في الختام ، أدت إضافة مستحضر المنثول LMC بمستوى 27 جزء في المليون يليها مسحوق أوراق النعناع PLP بمستوى 2.5٪ إلى عليقة الكنترول إلى تحسين هضم العناصر الغذائية والإنزيمات الهاضمة والأداء الإنتاجي ومؤشرات مضادات الأكسدة والكيمياء الحيوية للدم والمؤشرات المناعية و البكتيريا المعوية والكفاءة الإقتصادية في فترة النمو للسمان الياباني.