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

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ABSTRACT: The current experiment aimed to study impacts of feeding on peppermint leaves powder (PLP) and its respective L-menthol crystal (LMC) supplementations on performance, plasma biochemistry, antioxidant, impregnability, microbial content, digestibility and digestive enzymes in laying Japanese quail. A total of 504 birds were randomly assigned to seven test groups, each one with 6 replicates and 12 birds. First group received a standard diet, whereas treatments from second to four obtained standard diet plus PLP at 1.5, 2.0, and 2.5%, respectively. While, five to seven groups received control diet plus LMC at levels being 17, 22 and 27 ppm, respectively. Birds fed diets that contain 27 ppm had the highest DC ($p \leq 0.001$) of dry matter, organic matter, nitrogen free extract and protein retention, while the group fed with LMC at a level of 22 and 17 ppm recorded the higher digestibility coefficients (DC) of ether extract and crude fiber, respectively. Quail fed diets supplemented with PLP 2.0 % followed by LMC 27 ppm and PLP 2.5 %, respectively showed significantly ($p \leq 0.001$) higher trypsin enzyme. All performance traits except feed intake (FI) were significantly influenced by PLP 2.5% followed by LMC 27 and 22 ppm, respectively compared to the standard treatment. Berds fed LMC 27 ppm had dramatically lower lipid, liver enzymes, Salmonella and Escherichia coli population ($p \leq 0.001$) with the better thyroid function, antioxidant measures, Lactobacilli population amount, immune and best fertility and hatchability percentage. Finally, adding 27 ppm LMC followed by 2.5% PLP to the standard diet enhanced digestibility of nutrients, digestive enzymes, performance, antioxidant properties, plasma biochemical, immune, and microbial count in the gut in laying Japanese quails. With economical point of view, the diet with 2.5% PLP was the best.

Key Words: Laying quail, antioxidant indices, peppermint, L-menthol crystal, blood.

1 | INTRODUCTION

According to experiments, using natural medicinal substance could play an important role in developing safe (organic) ingredients as well as enhancing the productivity **(**Baharvand-Ahmadi *et al.* 2016). In fact, using different medicinal plants as food additives may improve poultry performance and health. The most medicinal plants have bioactive components such bitters, glycosides, guinones, tannins Alkaloids, flavonoids, bioflavonoids, mucilage, saponins, phenols, coumarins, oils, and polypeptides (Vandergrift 1998 and Cowan 1999). Peppermint (*Mentha piperita* L.) is a pharmacological plant containing natural ingredients like mentone, piperitone, menthol, methyl acetate, and cavone (Kizil *et al.,* 2010), these natural oils promote bioactivities including antibacterial agent producing (Dzˇamic´*et al.,* 2010) and increment of bile gastric secretion (Mkaddem *et al.*, 2009 and Baliga and Rao, 2010). These ingredients are widely used in the nutrition, fragrance, beauty products, and pharmacological industries all over the globe (Farhadi *et al.,* 2016). Menthol is the principal chemical component and phenolic constituent in the oil of peppermint that has antibacterial activity (Cabuk *et al.*, 2006).

Using mint powder in broiler diets can improve performance and primary immune activation by boosting the amount of antibody-forming cells (Galib and Al-Kassie, 2010; Abdulkarimi and Abdullahzadeh, 2011). Indigenous medicinal diet supplemented in the diet of Japanese quail and chickens can have an influence on growth and performance. Moreover, quails egg have a nutritional value and has great important to support poultry industry, the information available about the use of *Mentha piperita* leaves powder and his bioactive components (L-menthol) as a natural feed additives in laying quail feeding is a limited. Therefore, the current experiment was designed to investigate the influences of feeding on peppermint leaves powder (PLP) and L-menthol supplementations on laying performance, blood biochemistry, antioxidant parameters, immunity indices, microbial content, digestibility and digestive enzymes in laying Japanese quail.

2 | MATERIALS AND METHODS

The present research was performed at EL-Azab Poultry Research Station in Egypt's EL-Fayoum Governorate. The chemical examination 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. The research on live animals adhered to the guidelines approved by Egypt's Organizational Animal Welfare and Use Committee (Code No. of the proposal: AEC 2217).

2.1. Experimental design, birds and diets:

At the beginning of laying period, a total number of 504 birds were randomly assigned to seven equal treatments, each treatment containing 72 birds in six replicates of 12 birds each (8 females plus 4 males). At 7th week of age, hens were given a diet containing 20% CP and 2900 kcal ME/ kg until the end of experiment at 25th week of age, and were housed in batteries.

Birds were reared under the normal environmental conditions of Fayoum University Poultry Farms. Birds were exposed to light 16-h/ day, feed and water were *ad-libitum* all over the experimental period. The first group received a basal diets (control group), the second, third and four received a basal diets plus PLP at levels being 1.5, 2.0 and 2.5 %, respectively. While, groups five, six and seven received control diet plus LMC at levels being 17, 22 and 27 ppm, respectively. Table 1 demonstrates the feed ingredients and chemical structure of the experimental diets.

2.2. Laying birds performance:

Feed consumption was recorded weekly; egg production and weight were recorded daily. Thereafter, feed consumption, feed efficiency, hen-day egg production, egg mass output and mortality were calculated.

2.3. Blood constituents:

At 25 weeks of age, 12 birds (6 males and 6 females) were slaughtered by Islamic method per treatment to obtain a blood sampling (5 mL per bird), then it's were kept individually in clean dry centrifugal tubes. Samples were centrifuged at 3000 rpm for 20 minutes to take serum samples and stored in a tube of Eppendorf at −20℃ till analysis. According to James (2001), lipid profile including total cholesterol (Chol), high-density lipoprotein (HDL), low-density lipoprotein (LDL) and triglycerides (Trig) were estimated while thiobarbituric acid-reactive substances (TBARS), glutathione peroxidase (GPx) and total antioxidant capacity were measured according to Paglia and Valentine, 1967. Liver function including aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were determined amylase and lipase enzymes were assayed by Friedman and Young, 2001 and according to Bovine Trypsin ELISA Kit MBS706461 trypsin enzyme assayed.

Immunoglobulins of birds including IgM, IgG and IgA were assayed conforming to Erhard *et al.*, 1992.

2.4. Microbial analysis:

Intestinal content were gathered in sterilized glass bottles instantaneously after slaughter, and digesta was emptied and combined. The closed containers were preserved at 4°C in the research lab until the number of bacteria was identified. Samples (1g of the combined fresh mass) were taken into sterilized test tubes, diluted 1:10 in sterile 0.1% peptone solution and homogenized for 3 min in a Stomacher homogenizer. Ten fold serial dilutions up to 10-7 of each sample were prepared in nine 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, France) after incubation in an anaerobic chamber at 37 °C for 72 h. *Salmonella and E. coli* colonies were counted on 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 determined as colony forming units (cfu) per gram of sample.

2.5. Egg yolk cholesterol:

After 28 days from the start of the experiment, eight eggs were taken randomly from each pen to determine yolk cholesterol. The yolk was dried in a forced-air oven at 70°C for 3 days. Extraction of yolk cholesterol was done using the modified method of Washburn and Nix, 1974.

2.6. Nutrient digestibility:

At 25 weeks old, 42 quail males (one per replicate) were reared individually to study the droppings digestibility. Over a six-day collection period, the digestibility experiment was carried out Ratriyanto *et al.,* 2014. During the digestibility trial, procedures were implemented according to Ratriyanto and Prastowo, 2019.

Nutrients proximate analyses were analyzed as summarized by the Association of Official Analytical Chemists (AOAC, 2001). Separation of urinary nitrogen from fecal nitrogen was carried out according to Jakobsen *et al.*, 1960 Calculation of nutrient digestibility coefficients was implemented (Emamzadeh and Yaghobfar, 2009), as follows:

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

2.7. Fertility and hatchability:

After 6 weeks of laying period, eggs from each treatment were collected throughout 7 successive days and incubated in an automatic incubator at 37.7 ^{o}C for 18 days. After 17 days of incubation period fertility was determined by fertile eggs from the total egg set. In fertile eggs or clear eggs were broken out and examined. Fertility % = (Number of fertile eggs / Number of total set eggs) × 100.

Hatched chicks and un-hatched eggs were counted to calculate hatchability percentage at the end of incubation period.

Hatchability % = (Number of hatched chicks / Number of fertile eggs) × 100.

2.8. Statistical analysis:

The results were analyzed using analysis of variance by the statistics tools of Infostat (Di Rienzo, 2017). The model used was:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where: Y_{ij}: observation of traits, μ: overall mean, T_i: treatment effect, e_{ij}: random error.

Means of treatments were compared using multiple range test Duncan, 1955. The significance level was at 0.05.

3. RESULTS

3.1. Digestive enzymes and digestibility coefficients:

According to Table 2, the data showed that digestibility coefficients (DC) of all nutrients digestibility (except CP) were influenced by PLP and LMC especially at levels LMC 27 and 22 ppm, respectively. Where, quail hens fed diets contain 27 ppm had the highest DC ($p \leq 0.001$) of dry Matter, organic matter, nitrogen free extract and protein retention, being 75.56, 81.60, 81.45 and 83.68%, respectively. While the group fed with LMC at a level of 22 ppm recorded the higher DC ($p \leq 0.001$) of ether extract (86.54%). Lastly, quails fed with LMC 17 ppm had significantly ($p \leq 0.001$) higher DC of crude fiber (48.83%) than that fed control diets (19.59%). The treatments had non-affected significantly on digestive enzymes (except trypsin). The groups fed diets supplemented with PLP 2.0 % followed by LMC 27 ppm and PLP 2.5 %, respectively showed significantly ($p \leq 0.001$) higher trypsin (423.70, 420.31 and 417.99 U/L, respectively) compared with the control diets (238.98 U/L).

3.2. Laying performance:

Results found in Table 3 showed that the group fed on diet supplemented with PLP 2.5% had the highest egg number (EN), egg weight (EW), egg mass (EM), egg production % (EP) and the best feed conversion ratio (FCR), followed by that received LMC 27 and 22 ppm, respectively. In the current trail, there was no significant difference in feed intake between all experimental groups. The highest EN, EP, EW, EM and the best FCR were significantly ($p \leq 0.001$) recorded for group that fed a diet supplemented by 2.5% PLP (0.87, 87.38, 13.76, 12.02 and 2.38, respectively), followed by LMC 27ppm (0.87, 87.26, 13.36, 11.66 and 2.57, respectively) and LMC 22 ppm (0.85, 85.48, 13.50, 11.53 and 2.56, respectively), in comparison with the control. The present study, the diet supplemented with PLP and LMC has highly significant ($p \leq 0.001$) on EM, EN, EW, EP and FCR; but has insignificant impact on feed intake.

3.3. Serum biochemistry:

Quail fed a diet supplemented with LMC 27 ppm showed significantly ($p \leq 0.001$) lower total cholesterol (195.13), triglycerides (125.75), LDL (128.33), uric acid (2.42), creatine (0.28), ALT (1.71) and AST (169.63) with the higher HDL (51.13), T3 (36.88) and T_4 (2.59) values. Results showed that quail hens fed diets supplemented with LMC 27 ppm followed by PLP 2.5 % recorded lower total Chol, Tri G, LDL, uric acid, creatine, ALT and AST with higher HDL than the control (Table 4).

3.4. Antioxidant indices and immunological parameters:

Antioxidant parameters and immune responses was significantly influenced by experimental treatments. Where, quail hens fed the diet with LMC 27 ppm had the highest significantly ($p \leq 0.001$) T-AOC (1.37), GPx (10.80) and IgG (1191.18) with the lowest TBARS (0.87) followed by group received diet supplemented by PLP 2.5 % being 1.27, 10.31, 1178.98 and 0.94, respectively compared to control and other groups. In the current experiment, there was no significant difference in IgA and IgM between all experimental groups(Table 5).

3.5. Microbial Content:

Quail hens treated by LMC 27 ppm followed by that received PLP 2.5 % caused significantly ($p < 0.001$) increasing in the beneficial intestinal bacteria *Lactobacillus* population number (7.05 and 6.73, respectively) and decreasing the harmful intestinal bacteria *Salmonella* (4.95 and 5.15, respectively) and *E. coli* (4.73 and 4.80, respectively) population number compared with the control group (4.86, 6.77 and 6.37, respectively). Feeding the LMC and PLP-treated diets significantly augmented the intestinal beneficial *Lactobacilli* population number and significantly declined the population number of intestinal *E. coli and Salmonella* (Table 6).

3.6. Internal egg components:

The results summarized in Table 7 displayed that the quails fed on diets supplemented with LMC 27 ppm showed the lowest yolk cholesterol and the highest HDL, T-AOC, GSH-PX and immunoglobulins (IgG, IgA and IgM). Both groups fed LMC 27 and 22 ppm recorded the best values compared to the control group. The best yolk cholesterol was shown for both groups fed LMC 27 and 22 ppm (106.33 and 126.30, respectively) and the highest value for the control group (172.73). Birds fed on diets containing LMC 27 ppm recorded significantly ($p < 0.001$) the best lipid profile (except TG), antioxidant indices and immunological parameters, followed by those received LMC 22 ppm and PLP 2.5 %. While the worst values was recorded in the control group. On the other hand, there were no significant differences in triglycerides values between all experimental groups. In other words, supplementing diets with graded levels of PLP and LMC have improved internal egg components.

3.7. Fertility and Hatchability, %:

Quails fed on the diet supplemented with LMC 27 ppm significantly ($p \leq 0.001$) presented the best fertility and hatchability percentage over all groups being 91.88 and 86.32 respectively followed by LMC 22 ppm (90.67 and 84.33, respectively) as compared to the control group. On the other hand, there were no significant differences in comparing with other PLP and LMC groups. Generally, the fertility and hatchability percentage were observed to move up constantly with increasing dietary levels of PLP and LMC (Table 8).

3.8. Economic efficiency (EEf):

As showed in Table 9, quails fed with PLP 2.5 % resulted in the greatest value of EEf (160.90) followed by LMC 27 ppm (147.87) than the control diet and other treatments. Quail hens fed with a basal diet (control group) had the poorest EEf value. It can be noted that PLP 2.5 % was the best diet regarding the economical point of view and this result partly supported by the best performance for quail birds.

4 | DISCUSSION

In the exiting study, digestibility coefficients (DC) of all nutrients digestibility (except CP) were affected by PLP and LMC especially at levels LMC 27 and 22 ppm, respectively. Where, laying hens fed diets that contain 27 ppm LMC had the best digestibility coefficients. In this regard, peppermint essential oils act as digestibility enhancers, improving the gut microbial environment with increasing the secretion of endogenous digestive enzymes and thus enhancing the performance quail hens (Cross *et al.,* 2007). Moreover, mint has a lot of active compounds may incentive digestibility coefficients through stimulate digestive tract and promote secretion enzymes from pancreatic that increment the carbohydrates metabolism and proteins (Mellor, 2000). Therefore, the elevated levels of mint leafs (2%) may be enhanced the digestive enzyme more than low levels (1%). In addition, menthol that found in peppermint act antiseptic characteristic inhibits growth harmful bacteria in the digestive system, which has participated to improved digestion and absorption (Movaseghi, 1990). According to, Spirling and Daniels, 2001, mint has a beneficial impact on digestive process and therefore can dramatically improve feed consumption. Furthermore, Mimica-Dukiæ *et al,*. 2003, observed that the active ingredients of mint oil enhanced gut ecology, overall bile exudation, liver cell oxidative stress, and thus increased absorption rate and digestion in intestinal. According to Khan *et al.,* 2011, antioxidants protect pancreatic cells from reactive oxygen species, and they could possibly enhance pancreatic enzymes secretions and enhance nutrient absorption and digestion.

Peppermint have many active components that may reduce potentially harmful bacteria whereas raising healthy bacteria, which may reduce competition for nutrients and dietary energy between of animal and its bacterial, which can increase egg production and laying performance **(**Yang et al., 2011). The current findings are consistent with those of Torki et al., 2014, who discovered a beneficial impact of cinnamon oil on laying hen productivity characteristics. In addition, Akbari et al., 2016, observed that hens receiving a diet augmented with a mixture of mint oil and thyme essential oil had the better FCR, and the best EP and EM than those consumed other diets. EW and FI enhanced in the hens supplied the mint oil enriched diet when compared with the standard diet. The FI and EW in birds receiving a diet incorporating mint oil were greater compared to animals supplied a normal diet ($P \leq 0.05$). Finally, because menthol is an appetiser ingredient, the above rise can be attributed in part to the menthol action. In contrast, Zeweil et al,. 2006, found that 1.0 - 2.0 g/ kg of thyme flowers in the diet had no influence on EP, EW, EM, or FCR in Japanese quails. Furthermore, Torki et al., 2021, noticed that complementing mint oil alone or in mixture with lavender oil substantially lowered productive performance and egg weight throughout 42 - 46 weeks ($p \leq 0.05$). Additionally, during 42-56 weeks, lavender oil feeding substantially enhanced productive performance in comparison to mint oil and lavender oil + mint oil treatments ($p \leq 0.05$). Moreover, lavender oil feeding enhanced egg weight in comparison to the mint oil treatment during the same period ($p \leq 0.05$).

Concerning to FI and FCR, Abbas *et al*., 2021, discovered significant ($P \leq 0.05$) variations among nutritional treatments in terms of FI and FCR over the period of the study. Basil and mint oil augmented therapies have substantially lower FI with better FCR than the standard diet (control) especially with basil oil addition at 250 (mg/ kg). The addition of basil and mint powder (leaf or seed), oil and extracts to birds feed increased FI with better FC (Riyazi *et al*, 2015). In addition, Jamroz *et al.,* 2005 and Zhang *et al.,* 2005, discovered that incorporating mint oils to broiler ration enhances FCR. Furthermore, Wade *et al.* 2018, noticed that feeding thyme oil at 100mg/ kg enhanced FCR. Furthermore, Amasaib *et al.,* 2013, found that adding spearmint (Mentha spicata) to birds commercial feed had no influence on FI or FCR. El-Speiy *et al.,* 2020, observed that FI did not change statistically. When compared with the untreated group. While the treatments given mint oil, VALex, or both improved their FCR by 22.66%, 24.7%, and 20.9%, respectively.

Results showed that quail hens fed diets supplemented with LMC 27 ppm followed by PLP 2.5 % recorded lower total Chol, Tri G, LDL, Uric acid, Creatine, ALT and AST with higher HDL than the control. The decrement in total serum cholesterol levels observed in birds fed PEO could be attributable to phytobiotics' inhibition activity on liver cell 3-hydroxy-3-methylglutaryl Coenzyme A (HMG-CoA) and hepatic reductase, which restricts cholesterol synthesis inside the hepatic (Arab Ameri *et al.*, 2016). The reason in the decrease in TC may be due to the role of phenolic compounds in mint extract and volatile phenols like oils: menthol, mentyl acetate, menthofuran, menthone and azolen. Some other researchers indicated that the decrease in cholesterol level might be caused by changes in the small intestinal microorganism surroundings, which enhances lactic acid bacteria, potentially creating an acidic environment for the gastrointestinal system, leading to reduced lipid uptake in the digestive tract (Ghazaghi *et al*, 2014). A previous investigation revealed that active components in mint extract could also avoid or decrease cholesterol absorption by the digestive tract, leading to decreased blood cholesterol and plasma fat levels (Crossland, 1980). Recently, Abbas *et al*., 2021, found that found that

PEO augmented therapies had substantially (P≤ 0.05) reduce (TC) in compare to untreated (control). Similarly, Abdel-wahab *et al.,* 2018, observed that quail receiving a diet augmented with mint at level 3% had lower TC, as well as lower LDL, Tri G and AST in compare to control treatment. In contrast, Akbari and Torki, 2014, indicated that dietary additional essential oil of mint had no influence on the plasma cholesterol content of chicks. In addition, Hood *et al.* 1978, observed no major influence of thyme oil ingredients (citronellol, terpineol and geraniol) on laying hen blood cholesterol.

Regarding to T_3 and T_4, Alallawee, *et al.*, 2020, observed that experimental diets treated with 200 mg of mint leafs powder/ kg of diet had a substantial influence on blood T3 and T4 concentrations. Moreover, thyroid hormones concentrations in chicken blood were enhanced in compare with untreated groups. On the opposing side, this finding contradicts Ahmadi, 2010, who finding that adding rapeseed meal to the diets did not enhance T_3 and T_4 levels in chicken plasma. The main reason in increasing thyroid hormones may be due mint includes polyphenols, that may have powerful antioxidant properties (Dorman *et al.,* 2003). From the above point, all performance parameters may have been was enhanced through increasing thyroid activity and promoting the secretion of T_3 and T_4 from the thyroid gland into chicken plasma. Furthermore, Abdel-Latif *et al*., 2004, linked the increment in growth and FC of birds fed thyme leaf to an increase thyroid action with the pharmacological job of this natural herb in metabolic activities and hormones biosynthesis.

In the present study, antioxidant parameters and immune responses in blood and internal egg were significantly influenced by experimental treatments. Where, quail hens fed the diet with LMC 27 ppm had the highest significantly T-AOC, GPx and IgG with the lowest TBARS followed by group received diet supplemented by PLP 2.5 % compared to untreated and other groups. In the current experiment, there was no significant variations in IgA and IgM between all experimental groups. In this respect, Morshedy *et al.* (2019) demonstrated that rabbits fed untreated diet (control) recorded a significant decline ($P \leq 0.001$) in TAC plasma in compare to that received natural feed additives (mint oil, basil oil and mint plus basil oil) in summer season. When compared to the untreated treatment (control), the plasma MDA level was decreased with the essential oil therapies. Mint has antioxidant potential and can combat free radicals and oxidative stress with enhancing the immune response (Fallah *et al.,* 2013). Because antioxidants are known to resist a variety of illnesses, mint, which also has antioxidant property, may also have protective and improving influence on birds (Arab Ameri *et al.,* 2016).

Regarding to immunological, Awaad *et al.* (2010) reported that drink water involving 0.25 mL of mint oil enhances from the levels of antibodies to against Newcastle virus vaccine in birds. Furthermore, Abdel-Wahab *et al.,* 2018, found that diets treated by mint at 3% followed bymint 1% recorded the best IgG, IgA, IgM and GPx with the lowest TBAR level in compare to untreated treatment (control). Moreover, the immunological results from this research confirmed those of El-naggar and El-

Tahawy, 2018, who found that chicken fed diets augmented with mint, had better IgG levels. According to, (Sokovic *et al.,* 2009 and Mehri *et al.,* 2015), the high inhibition efficiency of mint's active substances retarded lipid oxidation in meat and decreased the lipid levels of plasma, from through reducing Chol and Tri G for quails at growing period. Morshedy *et al.,* 2019, indicated that mint oil, basil oil and mint plus basil oil addition caused theoretical improvements in plasma IgM and IgG values when compare to untreated group (control).

Quail regarded with LMC 27 ppm followed by PLP 2.5% had substantially higher population numbers of the beneficial gut bacteria *Lactobacillus* while reduced population numbers of the deleterious intestinal bacteria *Salmonella and E. coli.* In this regard, Akyurek *et al.* (2011) observed that poultry fed organic acid composition diets recorded lower levels of pathogenic bacteria such as coliforms and Clostridia. Thymol and cinnamaldehyde caused promoting healthy intestinal bacteria while lowering harmful microbes (Bento, *et al.,* 2013). Abbas *et al*., 2021, reported that a substantial decline in the total E. coli. pathogens and overall fungi population. While, the Lactobacilli population was increment substantially in therapies supplemented by basil oil and mint oil in compare to untreated (control). According to Pramila *et al.* (2012), methanolic leaf extract of mint demonstrated antibacterial effects against strains isolated of E. coli, Staphylococcus aureus and two fungi, Candida albicans and Candida glabrata. Furthermore, adding mint (dried leafs) to quail diets reduced the number of harmful *E. coli* bacteria while increasing the number of useful *Lactobacillus* bacteria (Mehri *et al.,* 2015 and Abdel-Wahab *et al.,* 2018).

Regarding to yolk cholesterol and other lipid profiles, Mohammadabadi and Zarei, 2018, observed that adding *Mentha pulegium* to hens' diets recorded the lowest cholesterol level in compare to standard treatment (control) in terms of yolk cholesterol and other lipid levels. Similarly, Nobakht and Shahryar, 2008, demonstrated that applying 2% of Mentha pulegium in laying hens diet have substantially decreased the amount of cholesterol levels. In addition, Bayram *et al.* (2007) found that no statistical variations in yolk cholesterol levels between treated groups with anise oil. The results of the present trial supported the findings of Cetingul *et al,* 2008, who investigated the influence of adding *Thymus vulgaris* leaf to the laying quail diet on yolk cholesterol. According to Aydin *et al.* (2008), putting *Nigella sativa* to the diet of laying hens lowered triglyceride levels and serum total cholesterol while enhancing serum High - density lipoprotein. The process by which medical plants decrease yolk cholesterol is unknown. Cholesterol biosynthesizes in the liver of laying hens, which flow into the bloodstream and are absorbed by the growing egg via endocytic. As a result, it has been proposed that the decrease in yolk cholesterol is a result of a reduction in cholesterol synthesis in the liver (Aydin *et al.* 2008).

Quails fed a diet augmented with LMC 27 ppm had the greatest fertility and hatchability percentage in comparison to other groups, followed by that received LMC 22 ppm in compare to untreated group (control). Moreover, there was a positive and significant impact on fertility for fertile eggs when herbs were added to hens' diets. In this regard, Radwan *et al.,* 2008, discovered that including 1% oregano, rosemary, or 0.5% curcuma longa to hen diets substantially enhanced fertility percentages in compare to that fed basal diets. Furthermore, Ali *et al.*, 2007, showed that laying hens diet treated by thyme at 0.25% have the higher fertility and hatchability percentages in compare to that received basal diets, and that may be due to thyme reducing total lipid, LDL, and increase antioxidant in blood were reducing the sources of free -radical able to pass to egg. Radwan *et al*. (2007) confirmed the beneficial impact of herbal antioxidants on reproductive performance by adding artichoke leafs meal as an antioxidant compounds to Mandarah hen diets at different levels. They discovered that feeding artichoke leaves at 6, 8, and 10% gave the greatest fertility and hatchability percentages. Kelso *et al*., 1996 and Aitken, 1994, clarified the enhancing benefits of organic antioxidants on percentages of fertility, hatchability, and semen quality by revealing that birds spermatozoa are marked by the presence of large levels of polyunsaturated fatty acids within the phospholipids. The presence of such polyunsaturated fatty acids generally requires the presence of an effective antioxidant system to protect sperm cell walls from oxidative damage.

In terms of economic efficiency, the diet that contains 2.5% PLP provided the best value. In this regard, Abdel-Wareth *et al.*, 2019, observed that the net economic income was relatively high in the birds fed mint or menthol with growing availability, or vice versa, lower mortality than the control treatment. Similarly, dietary mint levels improved viability rate linearly (P = 0.033) over the course of the experiment. However, between all therapies, the combination of menthol (26, 52, or 78 mg/ kg of diet) had no substantial (P > 0.05) influence on viability percentage. Mint leafs and menthol supplementation gradually improved the European production efficiency factor.

5 | CONCLUSION

The dietary supplementation of LMC and PLP at levels of 27 ppm and 2.5%, respectively can improve the nutrients digestibility, digestive enzymes, productive performance, lipid profile, kidney functions, liver functions, thyroid hormones, antioxidant parameters, immunological indices intestinal microbiota and economical efficiency of quails. Thus, LMC and PLP can be used as a feed additives and a health status enhancer for laying Japanese quail. And the diet containing 2.5% PLP had the best relative economic efficiency value.

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

Ingredients	**Control 0.0%**	**PLP 1.5%**	**PLP 2.0%**	**PLP 2.5%**	**LMC 17ppm**	**LMC 22ppm**	**LMC 27ppm**
Corn	53.50	53.50	53.50	53.50	53.50	53.50	53.50
Soybean meal (44%).	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Corn gluten meal (60%)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
wheat, bran	3.00	1.50	1.00	0.50	3.00	3.00	3.00
Corn oil.	3.00	3.00	3.00	3.00	3.00	3.00	3.00
L-Lysine.	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL Methionine.	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Calcium carbonate.	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Calcium phosphate, di.	1.30	1.30	1.30	1.30	1.30	1.30	1.30
Salt, NaCl.	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Peppermint leaves powder.	0.00	1.50	2.00	2.50	0.00	0.00	0.00
L menthol.	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	100.00	100.00	100.00
Cost (P.T.) /Kg**.	908.0	930.5	938	945.5	910.6	911.3	912.1
Calculated Analysis***:							
Dry Matter, %.	86.27	86.27	86.27	86.27	86.274	86.27	86.27
Crude Protein, %.	19.90	19.94	19.96	19.97	19.90	19.90	19.90
M.E. kcal/ kg	2890	2910	2920	2930	2890	2890	2890
Ether Extract, %.	5.38	5.40	5.41	5.42	5.38	5.38	5.38
Crude Fiber, %.	3.87	3.83	3.82	3.81	3.87	3.87	3.87
Calcium, %.	3	3	3	3	3	3	3
Available Phosphorus, %.	0.38	0.37	0.37	0.37	0.38	0.38	0.38
Lysine, %.	1.22	1.21	1.21	1.20	1.22	1.22	1.22
Methionine, %.	0.61	0.61	0.61	0.61	0.61	0.61	0.61
Methionine + Cysteine, %.	0.94	0.93	0.93	0.93	0.94	0.94	0.94
Determined Analysis:							
Dry Matter, %.	91.4	91.2	91.1	91.3	91.4	91.3	91.0
Crude Protein, %.	20.5	20.5	20.5	20.5	20.5	20.0	20.5
Ether Extract, %.	6.0	5.6	5.3	5.6	5.6	5.9	5.7
Ash, %.	5.0	5.0	5.0	5.2	4.8	5.2	5.1
Crude Fiber, %.	2.8	2.8	2.9	3.0	2.5	2.7	3.0
Nitrogen Free Extract, %****.	65.7	67.1	66.3	65.7	66.6	66.2	65.7

*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.B_1,1g; Vit.B2,5g; Vit.B_6,1.5g; Vit.B_{12},10g; Biotin 50mg; Folic acid, 1g; Nicotinic acid, 30g; Ca pantothenate, 10g; Zn, 55g; Cu, 10g; Fe, 35g; Co,250mg; Se, 150mg; I, 1g; Mn,60g; and antioxidant, 10g. NFE; nitrogen free extract. ** According to the local market prices of 2022., ***According NRC, 1994. ****NFE; calculated by the following equation: NFE= 100 - (Crude Protein% + Ether Extract% + Ash% + crude fiber% + moisture%).

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

Treat. Items	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.	330.38	450.38	493.00	508.25	410.38	495.00	508.88	61.32	0.3397
Lipase,U/L.	126.13	143.63	174.00	183.00	119.63	174.75	183.75	24.77	0.3086
Trypsin, U/L.	238.98^{b}	380.01^{ab}	423.70^{a}	417.99^{a}	367.72^{ab}	376.01^{ab}	420.31^{a}	46.35	0.0948
Digestibility Coefficients*:									
DM, %.	65.59^{d}	67.58^{bcd}	69.40^{abcd}	66.86^{cd}	73.52^{abc}	74.08^{ab}	75.56^{a}	2.13	0.0151
OM, %.	74.61^{b}	74.63^{b}	77.06^{ab}	73.13^{b}	78.48^{ab}	80.59^{a}	81.60^{a}	1.70	0.0130
CP, %.	84.86	86.74	88.45	87.86	88.57	88.35	86.63	1.12	0.2410
EE, %.	83.58^{ab}	81.63^{b}	83.53^{ab}	81.96^{b}	86.51^{a}	86.54^{a}	86.17^{a}	1.05	0.0072
CF, %.	19.59^{b}	35.99^{a}	37.71^{a}	21.87^{b}	48.83^{a}	46.11^{a}	42.24^{a}	4.44	0.0005
NFE, %.	75.47^{bc}	74.64^{bc}	75.52^{bc}	72.49^{c}	76.85^{abc}	79.78^{ab}	81.45^{a}	1.77	0.0274
PR, %.	73.99^{b}	75.58^{b}	81.67^{a}	75.85^{b}	80.49^{a}	83.22^{a}	83.68^{a}	1.49	0.0003

*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 in the same rows for each treatment having different letter(s) are significantly different ($P \leq 0.05$).
SE: Standard Error.

Table (3): Effect of dietary peppermint leaves powder (mentha piperita L.) and L-menthol crystal on laying performance in laying Japanese quail.

Treat. Items□	Control 0.0%	PLP 1.5%	PLP 2.0%	PLP 2.5%	LMC 17ppm	LMC 22ppm	LMC 27ppm	SE	P-value
EN	0.75^{c}	0.82^{abc}	0.85^{ab}	0.87^{a}	0.79^{bc}	0.85^{ab}	0.87^{a}	0.03	0.0187
EP (%)	74.52^{c}	81.67^{abc}	84.52^{ab}	87.38^{a}	78.69^{bc}	85.48^{ab}	87.26^{a}	2.63	0.0187
Av. EW	13.41^{ab}	13.03^{b}	13.10^{b}	13.76^{a}	13.35^{ab}	13.50^{ab}	13.36^{ab}	0.16	0.0777
EM	10.00^{c}	10.64^{bc}	11.07^{abc}	12.02^{a}	10.51^{bc}	11.53^{ab}	11.66^{ab}	0.40	0.0211
FI	28.96	28.42	28.89	28.66	28.48	29.47	29.98	0.58	0.4849
FCR	2.97^{a}	2.67^{ab}	2.61^{ab}	2.38^{b}	2.72^{ab}	2.56^{ab}	2.57^{ab}	0.13	0.1185

□EN: Egg Number (per bird/day), EP (%): Egg production (%), Av. EW: Average egg weight (g), EM: Egg mass (g/~~hen~~ bird/day), FI: Feed consumption (g feed/bird/day), FCR: feed conversion Ratio (kg feed/kg egg mass).
$^{a-c}$: means in the same rows for each treatment having different letter(s) are significantly different ($P \leq 0.05$).SE: Standard Error.

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 laying Japanese quail.

Treat. Items	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	278.50[a]	237.13[b]	213.00[b]	195.63[b]	213.13[b]	214.75[b]	195.13[b]	13.60	0.0010
TG , mg/dL	214.38[a]	181.75[ab]	156.13[ab]	167.75[ab]	159.38[ab]	161.25[ab]	125.75[b]	24.67	0.3234
HDL, mg/dL	38.88[c]	41.25[bc]	45.13[abc]	46.13[abc]	49.63[a]	48.88[ab]	51.13[a]	2.54	0.0111
LDL, mg/dL	175.96[a]	162.58[ab]	141.58[ab]	139.56[ab]	146.18[ab]	131.50[ab]	128.33[b]	14.21	0.2157
Kidney Functions□:									
Uric, mg/dL	4.05[a]	3.18[b]	2.70[b]	2.91[b]	2.60[b]	2.51[b]	2.42[b]	0.26	0.0007
Creatine, mg/dL	0.41[a]	0.32[b]	0.32[b]	0.27[b]	0.34[ab]	0.30[b]	0.28[b]	0.03	0.0149
Liver Functions□:									
ALT, U/L	2.53[a]	1.98[ab]	1.83[b]	1.81[b]	2.18[ab]	1.98[ab]	1.71[b]	0.18	0.0417
AST, U/L	366.88[a]	253.13[b]	237.00[bc]	204.38[bc]	200.88[bc]	196.38[bc]	169.63[c]	23.87	0.0001
Thyroid Hormones									
T_3	30.91[b]	32.41[ab]	32.99[ab]	36.56[a]	32.81[ab]	35.31[ab]	36.88[a]	1.50	0.0496
T_4	2.03[b]	2.22[ab]	2.37[ab]	2.46[ab]	2.17[ab]	2.45[ab]	2.59[a]	0.13	0.0635

□Abbreviations: Total Chol: Total Cholesterol, TG: triglycerides, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, ALT: Alanine Aminotransferase, AST: Aspartate Aminotransferase,
[a-c]: means in the same rows for each treatment having different letter(s) are significantly different ($P \leq 0.05$).
SE: Standard Error.

Table (5): Effect of dietary peppermint leaves powder (mentha piperita L.) and L- menthol crystal on antioxidant parameters and immune response in laying Japanese quail.

Treat. / Items	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	0.85^{c}	0.92^{bc}	1.20^{abc}	1.27^{ab}	0.93^{bc}	1.23^{ab}	1.37^{a}	0.12	0.0159
GSH-PX	6.08^{b}	7.86^{ab}	9.23^{ab}	10.31^{a}	7.39^{ab}	9.15^{ab}	10.80^{a}	1.20	0.0947
TBARS,µgg.	1.48^{a}	1.30^{ab}	1.08^{bc}	0.94^{c}	1.26^{ab}	1.02^{bc}	0.87^{c}	0.10	0.0004
Immune Response□									
IgG	1089.04^{bc}	1154.38^{abc}	1166.48^{abc}	1178.98^{ab}	1080.09^{c}	1165.09^{abc}	1191.18^{a}	29.26	0.0535
IgA	54.53	56.04	62.39	65.43	54.99	64.99	60.11	3.92	0.2281
IgM	84.18	86.28	88.39	90.16	84.40	87.80	91.34	2.24	0.2003

□Abbreviations: T-AOC: Total Antioxidant Capacity, GSH-PX: Glutathione Peroxidase TBARS: Thiobarbaturic Acid- Reactive Substances, IgG: Immunglobin G, IgA: Immunglobin A, IgM: Immunglobin M,

$^{a-c}$: means in the same rows for each treatment having different letter(s) are significantly different ($P \leq 0.05$).SE: Standard Error.

Table (6): Effect of dietary peppermint leaves powder (mentha piperita L.) and L- menthol crystal on intestinal bacteria in laying Japanese quail.

Treat. / Items	Control 0.0%	PLP 1.5%	PLP 2.0%	PLP 2.5%	LMC 17ppm	LMC 22ppm	LMC 27ppm	SE	P-value
E.coli	6.37^{a}	5.62^{ab}	5.10^{bc}	4.80^{bc}	5.34^{bc}	4.93^{bc}	4.73^{c}	0.27	0.0007
Salamonella	6.77^{a}	5.79^{b}	5.65^{b}	5.15^{b}	5.79^{b}	5.19^{b}	4.95^{b}	0.30	0.0018
Lactobacillus	4.86^{e}	5.19^{de}	6.28^{bc}	6.73^{ab}	5.68^{cd}	6.47^{ab}	7.05^{a}	0.22	0.0001

a-e: means in the same rows for each treatment having different letter(s) are significantly different ($P \leq 0.05$).
SE: Standard Error.

Table(7): Effect of dietary peppermint leaves powder (mentha piperita L.) and L- menthol crystal on internal egg component in laying Japanese quail.

Treat. Items	Control 0.0%	PLP 1.5%	PLP 2.0%	PLP 2.5%	LMC 17ppm	LMC 22ppm	LMC 27ppm	SE	P-value
Lipids Profile□:									
Y.chol.mg/dL	172.73^{a}	159.73^{ab}	135.43^{ab}	128.00^{ab}	142.23^{ab}	126.30^{ab}	106.33^{b}	18.48	0.2485
TG , mg/dL	351.30	310.40	310.40	295.67	318.53	314.93	294.82	23.16	0.6685
HDL, mg/dL	28.10^{b}	35.33^{ab}	39.18^{ab}	40.50^{ab}	34.75^{ab}	39.30^{ab}	41.88^{a}	3.93	0.2488
Antioxidant Indices□:									
T-AOC	1.36^{c}	1.47^{bc}	1.53^{ab}	1.57^{ab}	1.39^{c}	1.56^{ab}	1.61^{a}	0.04	0.0024
GSH-PX	7.40^{b}	8.18^{ab}	8.45^{ab}	9.05^{ab}	7.85^{ab}	9.03^{ab}	9.25^{a}	0.52	0.1540
Immune Response:									
IgG	1026.75^{b}	1160.75^{a}	1167.75^{a}	1185.25^{a}	1102.50^{ab}	1173.00^{a}	1194.00^{a}	41.57	0.1022
IgA	53.58^{c}	62.76^{bc}	63.25^{bc}	78.03^{a}	62.20^{bc}	69.58^{ab}	78.45^{a}	3.65	0.0007
IgM	90.78^{c}	92.80^{c}	93.55^{c}	94.08^{bc}	90.00^{c}	99.95^{ab}	100.85^{a}	2.00	0.0043

Abbreviations: Y. Chol: Yolk Cholesterol, TG: triglycerides, HDL: High-density lipoprotein, SE: Standard Error, PPM: Part per Million, PLP: Peppermint leaves Powder, LMC: L-Menthol Crystal,

$^{a-c}$: : means in the same rows for each treatment having different letter(s) are significantly different ($P \leq 0.05$).

SE: Standard Error.

Table (8): Effect of dietary peppermint leaves powder (mentha piperita L.) and L- menthol crystal on fertility and hatchability percent in laying 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
Fertility, %.	79.20^{b}	88.87^{a}	88.36^{a}	90.67^{a}	89.54^{a}	90.67^{a}	91.88^{a}	2.51	0.0330
Hatchability,%.	67.42^{c}	77.21^{ab}	77.49^{ab}	82.15^{ab}	75.22^{bc}	84.33^{ab}	86.32^{a}	2.82	0.0022

a-c: means in the same rows for each treatment having different letter(s) are significantly different ($P \leq 0.05$).

SE: Standard Error.

Table (9): Effect of dietary peppermint leaves powder (mentha piperita L.) and L-menthol crystal on economical efficiency of laying 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	2.97	2.67	2.61	2.38	2.72	2.56	2.57
Price Kg feed (L.E) *b	908.0	930.5	938.0	945.5	910.6	911.3	912.1
Total feed cost C= (a×b)	2,697	2,485	2,448	2,250	2,477	2,333	2,344
Price / one Kg egg (L.E) ** d	40	40	40	40	40	40	40
Net revenue (L.E) = d-c = e	1,303	1,515	1,552	1,750	1,523	1,667	1,656
Economic efficiency *** (e/c)	0.483	0.610	0.634	0.778	0.615	0.715	0.706
Relative efficiency ****	100	126.23	131.17	160.90	127.27	147.87	146.20

* 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.

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الملخص العربى

تأثير إضافة مسحوق أوراق النعناع (Mentha piperita L.) والمنتول كريستال على معاملات هضم العناصر الغذائية والأداء الإنتاجي وإنزيمات الهضم وهرمونات الغدة الدرقية والمناعة ومؤشرات مضادات الأكسدة والمحتوي الميكروبي للسمان الياباني البياض

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هدفت التجربة الحالية إلى دراسة تاثير التغذية على مسحوق أوراق النعناع (PLP) والمنتول كريستال-L menthol (LMC) على الأداء الإنتاجي، بعض مقاييس الدم، معايير مضادات الأكسدة، مؤشرات المناعة، المحتوى الميكروبي، معاملات الهضم والإنزيمات الهاضمة للسمان الياباني البياض. أستخدم في هذه الدراسة عدد 504 طائر سمان بالغ قسمت عشوائياً إلى سبع مجموعات تجريبية كل منها مكونة من ستة مكررات، بواقع 12 طائراً لكل مكرر (8 إناث و 4 ذكور)، حيث غذيت المجموعة الأولى عليقة أساسية بدون أي إضافات (الكنترول)، بينما المجموعات من الثانية إلى الرابعة غذيت على عليقة الكنترول مضافا إليها مسحوق أوراق النعناع (PLP) بمستويات 1.5 و 2.0 و 2.5 ٪ على التوالي. بينما غذيت المجموعات من الخامسة إلى السابعة عليقة الكنترول مضافا إليها المنتول كريستال (LMC) بمستويات 17 و 22 و 27 جزء في المليون على التوالي.

وقد أظهرت النتائج أن السمان البياض المغذى على علائق تحتوي على 27 جزء في المليون أعطى أعلى معاملات هضم لكل من المادة الجافة والمواد العضوية والمستخلص الخالي من النيتروجين بالإضافة إلى البروتين المحتجز، بينما سجلت المجموعة التي تم تغذيتها بـ LMC عند مستوى 22 و 17 جزء في المليون أعلى معامل هضم لكل من الدهون والألياف الخام على التوالي. أيضا أظهرت المجموعة التي تم تغذيتها بمسحوق أوراق النعناع PLP عند مستوى 2.0% يليها المجموعة التى تغذت على المنتول كريستال LMC بمستوى 27 جزء في المليون والمجموعة المغذاه على 2.5 % من مسحوق أوراق النعناع على التوالي أعلى مستوى من إنزيم التربسين. جميع مؤشرات الأداء الإنتاجي للسمان البياض باستثناء الغذاء المأكول تأثرت معنويا بالعلائق المضاف إليها مسحوق أوراق النعناع بنسبة 2.5 % يليها العلائق المضاف إليها المنتول كريستال بمعدل 27 و22 جزء في المليون على التوالي . أظهرت المجموعة المغذاه على عليقة مضاف إليها المنتول كريستال بمعدل 27 جزء في المليون أقل نسبة دهون، أنزيمات الكبد، السالمونيلا وبكتيريا القولون مع أعلى مستوى لهرمونات الغدة الدرقية، مؤشرات مضادات الأكسدة، الاستجابات المناعية وزيادة عدد بكتيريا حامض اللاكتيك مع أفضل نسبة خصب وفقس وكفاءة إقتصادية مقارنة بمجموعة الكنترول.

عموما، أدت إضافة المنتول كريستال LMC عند 27 جزء في المليون متبوعًا بمسحوق أوراق النعناع PLP عند مستوى 2.5 % إلى علائق الكنترول إلى تحسين معاملات هضم العناصر الغذائية والإنزيمات الهاضمة والأداء الإنتاجي والقدرة المضادة للأكسدة والكيمياء الحيوية للدم والمؤشرات المناعية والتعداد الميكروبي في الأمعاء في السمان الياباني البياض. ومن وجهة النظر الإقتصادية؛ كانت العليقة التى تحتوى على مسحوق أوراق النعناع بنسبة 2.5 % هى الأفضل.

الكلمات الداله

البياض، مؤشرات مضادات الأكسدة، مسحوق أوراق النعناع، المنتول كريستال، مناعة، كيمياء الدم، السمان.