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EFFECTS OF DIETARY ANISE, LEMON AND MINT OILS SUPPLEMENTATION ON GROWTH PERFORMANCE, CARCASS TRAITS AND BLOOD BIOCHEMICAL PARAMETERS OF BROILER CHICKENS

H.A. MAHMOUD; O.S. AFIFFY; H.Y. EL-HAMADY AND N.G. MOHAMED

Department of Poultry Production, Faculty of Agriculture, Assiut University, Assiut, Egypt

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ABSTRACT

The present research evaluated the influence of dietary supplementation of anise, lemon, and mint essential oils on growth performance, carcass traits, and biochemical parameters of broiler chickens. A total of 168 one-day-old, unsexed Ross (308) broiler chicks were randomly divided into four groups (42 chicks/group). The control group received the basal diet, while the other groups received the basal diet supplemented with anise, lemon, and mint oils at a level of 0.5 g/kg basal diet. The results revealed that all diets supplemented with oils had improved FCRو compared to the control group. Birds that fed lemon oil had an improvement in the average BW and BWG with nearly 10% and 11%, respectively. Birds that received mint oil had the highest breast yield (27.93%) and the lowest abdominal fat percentage (0.27%), while the best fat bad percentage (0.84%) was recorded for birds that received anise oil. The lowest value of LDL was recorded for birds whose diet contained lemon oil. On the other hand, the HDL values showed a contrary result for the same birds. Birds that received lemon oil had improved total antioxidant capacity (2.79 µmol/l), while the birds fed mint oil had the lowest total antioxidant capacity (0.16 µmol/l) as compared with other groups. The villus length (VL), width (VW), and crypt depth (CD) for the birds with a mint oil diet showed superior values as compared with others. This study revealed that the inclusion of essential oils (anise, lemon, and mint) in the broiler chicken diets improved both body weight and gain, increased feed conversion ratio, and breast yield. However, the lemon oil specifically enhanced the broiler chicken's antioxidant status and blood lipid profile. Additionally, it improved the bird's intestinal morphometric properties.

Keywords: Growth performance, Carcass traits, Essential oils, Lipid profiles, Histomorphological evaluations.

INTRODUCTION

The poultry industry plays a critical role in addressing nutritional deficiencies in many countries by providing protein-rich meat and eggs that are also rich in valuable nutrients, at a lower cost than other animal meat sources. Antibiotics have been criticized by both consumers and scientists, and significant attempts have been undertaken to ban the use of most growth-promoting antibiotics in animal diets (Okey, 2023). Many studies now focus on alternative feed additives as potential substitutes for antibiotics in the diet. These additives frequently have antibacterial and/or stimulant effects on the gastrointestinal system (Attia *et al.,* 2019 ; Abd El-Hack *et al.,* 2022).

Corresponding author: N.G. Mohamed
E-mail: nourgamalmohammad@gmail.com
Present address: Department of Poultry Production, Faculty of Agriculture, Assiut University, Assiut, Egypt

Essential oils, a complex combination of chemical components emitting an odor, have been discovered to have a wide spectrum of antibacterial, antifungal, and even antiviral activities (Sousa *et al.,* 2022). They have also been shown to suppress the growth of drug-resistant bacteria strains, which are difficult to treat with traditional antibiotics. Essential oils work against infections by disrupting membrane potential across the cell wall and interfering with ATP assembly, which causes cell wall destruction. (Drioiche *et al.*, 2024). Essential oils have been discovered to have antiviral effects against numerous RNA and DNA viruses, including the herpes simplex virus, Newcastle disease virus, influenza virus, and adenovirus (Wani *et al.,* 2022). Furthermore, essential oils can accelerate digestion and alleviate heat stress, in addition to working against *Clostridium* perfringens growth, helping to prevent coccidia infection and eventually lowering the occurrence of necrotic enteritis (Stefanello *et al.,* 2020; Iqbal *et al.,* 2021*)*. There are a lot of studies on the chemical components of essential oils (Dajic *et al.*, 2020), as they divided essential oils (EOs) into four major classes based on the secondary metabolites of plants: isoprenoids (terpenes), phenylpropanoids, polyketides, lipids, and amino acid derivatives other than l-phenylalanine. These compounds share common functional groups like benzyl rings, alkyls, hydroxyls, steroids, and alcohols, according to Abd El-Hack *et al.* (2022). Essential oils are classified into two types: terpenes and phenylpropene. Terpenes are composed of two, three, or four isoprene units that are categorized as monoterpenes, sesquiterpenes, or diterpenes. On the other hand, phenylpropenes are volatile molecules derived from the amino acid phenylalanine. The structure of phenylpropenes changes depending on the substituents on the benzene ring and the location of the double bond in the propenyl side chain. Many herbs and spices require phenylpropenes, such as eugenol, chavicol, estragole, and anethole, to maintain their scent and flavor. These chemicals are both antifungal and antibacterial, and they attract pollinators with their flowery scent.

Therefore, the objective of this study was to evaluate the effect of anise, lemon, and mint oil supplementation on the growth performance, carcass traits, and biochemical parameters of broiler chickens.

MATERIALS AND METHODS

The present study was carried out at the Poultry Research Farm, Faculty of Agriculture, Assiut University, Egypt.

Chickens and diets

The experiment was carried out on a total of 168 one-day-old, unsexed Ross (308) broiler chicks. The birds were distributed randomly for four treatments (three treated groups and one for the control one). Each treatment involved three replicates of 14 chicks. During the experimental period, chicks were fed diets containing anise, lemon, and mint oils at a level of 0.5 g/kg basal diet. Beginning with starter (0–14 days), followed by grower (15–28 days), and finally the finisher (29–35 days) phases (Table 1). Commercial essential oils were provided in the diets from one to 35 days of age. The chicks of each replicate were kept in a floor pen measuring 2 m in length × 0.75 m in width. Chickens of all treatments were kept under similar managerial and hygienic conditions, maintained on a 23-h constant light schedule, and allowed to consume feed and water *ad libitum*.

Histological examination was carried out in the National Laboratory for Veterinary Control of Poultry Production, Animal Health Research Institute, Dokki, Giza, Egypt. Serum analyses were done in the El Salam laboratory for medical and chemical analyses, Assiut, Egypt.

Performance criteria:

Body weight (BW), body weight gain (BWG), feed consumption (FC) and feed conversion ratio (FCR) for each group were recorded and calculated weekly. The averages of FCR and BWG were estimated all over the experimental period.

Carcass traits
At the end of the experiment (35 days of age), slaughtering 6 birds from each group (2 birds from each replicate around the average BW of each treatment) was done. Samples of liver, spleen, and bursa of Fabricius were taken from the carcasses, weighted individually, and calculated as a percentage in relation to live body weight.

Estimation of intestinal development of broiler chickens
Duodenum, jejunum, ileum, and ceca were removed from the slaughtered birds, weighed, and measured with a flexible meter. Data summaries were reported as relative weights (g/kg pre-slaughter) and lengths (cm/kg pre-slaughter), respectively (Mahdavi and Torki, 2009; Aghazadeh and Taha, 2012). Additionally, proventriculus, gizzard, and pancreas were weighed as well.

Histological examination
Intestinal tissue samples were collected from 2 slaughtered chickens of each replicate, fixed immediately in the neutral buffer formalin (10%), and stained by hematoxylin and eosin according to Suvarna *et al*. (2018). Histological indices were measured using the light microscope and digital photography; also, the villus height was measured from the apical to the basal region, and the crypt was measured from the basis to the region of transition between the villus and the crypt (Samanya and Yamauchi, 2002).

Serum biochemical analysis
Blood samples were collected at the slaughtering time in unsalted heparinized tubes (10.0 ml). Total protein, albumin, globulin, T3, T4, total cholesterol (TC), triglycerides (TG), low-density lipoproteins (LDL), high-density lipoproteins (HDL), total antioxidant capacity (TAC), hemoglobin (HB), red blood cells (RBCs), white blood cells (WBCs), platelets, lymphocytes, heterophilies were analyzed using commercial kits purchased from Shanghai Kehua Bio-engineering Co., Ltd. (KHB), Cairo, Egypt, by an auto-analyzer (SHIMADZU CL-8000 automatic autoanalyzer, Cairo, Egypt).

Statistical analysis
Percentage values were transformed using arcsine and natural logarithm-transformed before statistical analysis. However, the test of normal distribution was performed with Kolmogorov-Smirnov, Cramer-von Mises, and Anderson-Darling. The data were analyzed by analysis of variance (ANOVA) using general linear model procedure (GLM) of SAS software (SAS institute, 2004). Significant differences among treatment means were determined using the Duncan multiple test (Duncan, 1955). The following model was used:

$$\mathbf{Y_{ij} = u + T_i + e_{ij}}$$

Where;
$\mathbf{Y_{ij}}$ = is analyzed measurement
u = overall mean
$\mathbf{T_i}$ = treatment effect, I (1 – 4)
$\mathbf{e_{ij}}$ = random error.

Table 1: Composition of starter, grower and finisher diets

Calculated nutrients	Starter	Grower	Finisher
ME (kcal/kg)	3025	3150	3200
Crude protein (%)	22	21	19
Lysine (%)	1.43	1.30	1.09
Methionine + Cysteine (%)	1.07	0.95	0.86
Threonine (%)	0.94	0.90	0.85
Calcium (%)	1.05	0.90	0.85
Available phosphorus (%)	0.52	0.45	0.42

*Vitamins and minerals premix provided per Kg of the diet: Vit A, 10.000 IU; Vit D_3, 2000 IU; Vit E, 10 mg; Vit K_3 , 1 mg; Vit B1, 10 mg; Vit B2, 5 mg; Vit B6, 15000 mg; Vit B12, 10 mg; Nicotinic acid, 30 mg; Pantothenic acid, 10 mg; Folic acid, 1 mg; Biotin, 50 mcg; Chlorine chloride 50%, 500 mg; Iron, 50 mg; Copper, 10 mg; Zinc, 50 mg; Manganese, 60 mg; Iodine, 10 mg; Selenium, 0.1 mg; ** Calculated according to the NRC (1994).

RESULTS

The impacts of dietary supplements with anise, lemon, and mint oils on growth performance:

The results revealed significant differences between all groups that were developed from the second week of the experiment, as birds whose diet contained 0.5 g/kg of lemon oil (T3) consistently had the highest (p <0.0002) body weight, while T2 (anise) and T4 (mint oil) performed similarly, compared to the control group that had the lowest body weight (Table 2). The birds treated with lemon oil had the highest (p <0.0318) with a final body weight of 2245.47 g, nearly 10% more developed than the control group, followed by T4 (mint oil), which had 2160.18 g with nearly 6% development, while the control group had the lowest BW at 2034.83 g.

Table 2: The impacts of dietary supplements with anise, lemon, and mint oil on the **body weight** of each group**.**

Treatment	T1 (Control)	T2 (anise)	T3 (lemon)	T4 (mint)	P Value
Initial weight	49.67±0.27	48.33±0.18	49.00±0.15	48.035±0.27	NS
BW1	155.24±3.28	156.17±3.72	160.50±3.37	159.66±4.13	NS
BW2	380.24 ±7.70 ^{c}	405.83 ±10.61 ^{b}	433.50 ±9.71 ^{a}	421.90 ±9.33 ^{ab}	<0.0002**
BW3	814.48±15.75 ^{b}	819.77±23.52 ^{b}	845.77±32.05 ^{a}	858.45±17.90 ^{a}	<00351*
BW4	1397.62±25.91 ^{b}	1450.67±42.45 ^{ab}	1534.33±40.10 ^{a}	1513.04 ±31.98 ^{a}	<0.0182*
BW5	2034.83±45.95 ^{b}	2135.17 ±59.81 ^{b}	2245.47 ±57.40 ^{a}	2160.18 ±45.06 ^{ab}	<0.0318*

a, b and c Means (±SE) in the same row with different superscripts are significantly different
** is high significance * is significance NS is not significant

The birds with the lemon oil treatment consistently showed significant increases up to 688.57 g in the total body weight gain; it was considered the highest overall weight significance (p<0.0263) by 2196.47 g, with nearly 11% improvement than the control group, followed by the mint oil group, which had overall weight increase by 2112.15 g, nearly 6% more enhancement than the control group (Table 3).

Birds with lemon oil (T3) consumed much more (p<0.0001) feed intake by 148.50 g than the other groups, while the control group ate the least (111.79 g). The lemon oil group had the highest significant (p<0.0001) total feed consumption (3076.87 g), which means nearly 8% more than the control group (Table 4).

Table 3: The impacts of dietary supplements with anise, lemon, and mint oils on the **body weight gain** of all groups.

Treatment	T1 (Control)	T2 (anise)	T3 (lemon)	T4 (mint)	P Value
BWG1	105.57±2.59	107.84±3.25	111.50±2.76	111.62±2.78	NS
BWG2	225.00±5.57 ^{c}	249.66±7.82 ^{b}	273.00±7.32 ^{a}	262.24±6.21 ^{ab}	<.0001**
BWG3	434.24±10.58	413.93±15.29	412.27±31.41	436.55±11.86	NS
BWG4	583.14±15.12 ^{b}	630.90±23.73 ^{ab}	688.57±46.57 ^{a}	654.59±20.90 ^{ab}	<0.0441*
BWG5	637.21±23.74 ^{b}	684.50±25.55 ^{ab}	711.13±22.84 ^{a}	647.14±38.49 ^{b}	<0.0325*
Total BWG	1985.16±46.10 ^{b}	2086.84±59.50 ^{ab}	2196.47±56.95 ^{a}	2112.15±44.75 ^{ab}	<0.0263*

a, b and c Means (±SE) in the same row with different superscripts are significantly different
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The control group had the best ($p<0.0961$) FCR during the first week (FCR1), while the birds fed lemon oil had the worst value by 1.33. The values of FCR2 showed no significant differences for all groups. The values of FCR5 showed that the control birds had the worst value by 1.76. All diets supplemented with oils had improved FCR compared to the control group (T1). The anise oil group had the best value, by 1.38 with nearly 4% improvement compared to the control group, as shown in Table (5).

Table 4: The impacts of dietary supplements with anise, lemon, and mint oils on **feed consumption**

Treatment	T1 (Control)	T2 (anise)	T3 (lemon)	T4 (mint)	P Value
FC1	111.79±11.06 ^{c}	126.33±1.16 ^{b}	148.50±10.61 ^{a}	125.34±13.79 ^{b}	<.0001**
FC2	242.86±20.60 ^{c}	274.83±30.00 ^{b}	303.67±32.46 ^{a}	273.97±34.17 ^{b}	<.0001**
FC3	588.19±34.55 ^{c}	650.27±49.57 ^{ab}	680.20±2.63 ^{a}	629.24±67.09 ^{b}	<.0001**
FC4	794.17±48.46 ^{c}	868.00±26.23 ^{b}	926.17±18.22 ^{a}	921.07±95.95 ^{a}	<.0001**
FC5	1124.12±47.86 ^{a}	960.47±59.36 ^{c}	1018.33±20.93 ^{b}	1023.32±102.40 ^{b}	<.0001**
Total feed consumption	2861.13±28.34 ^{b}	2889.90±32.25 ^{b}	3076.87±23.46 ^{a}	2972.94 ±32.19 ^{ab}	<.0001**

a, b and c Means (±SE) in the same row with different superscripts are significantly different
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Table 5: The impacts of dietary supplements with anise, lemon, and mint oils on the **feed conversion ratio**

Treatment	T1 (Control)	T2 (anise)	T3 (lemon)	T4 (mint)	P Value
FCR1	1.06±0.07^{b}	1.17±0.09 ^{ab}	1.33±0.08 ^{a}	1.12±0.07 ^{b}	0.0961*
FCR2	1.08±0.03	1.10±0.04	1.11±0.04	1.04±0.04	NS
FCR3	1.36±0.04^{b}	1.57±0.06^{a}	1.65±0.12^{ab}	1.44±0.04^{ab}	0.0853*
FCR4	1.36±0.05	1.38±0.06	1.35±0.11	1.41±0.05	NS
FCR5	1.76±0.22 ^{a}	1.40±0.05 ^{b}	1.43±0.05 ^{b}	1.58±0.34 ^{b}	0.0729*
Total FCR	1.44±0.0	1.38±0.0	1.40±0.34	1.41±0.34	NS

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The impacts of dietary supplements with anise, lemon, and mint oils on carcass traits:

No significant differences ($p<0.0001$) were detected when comparing the values of dressing percentages (including giblets) for all groups. The data in Table (6) showed that the birds on T3 with a 0.5 gm lemon oil/kg diet had the highest ($P<0.0531$) breast yield percent by 29.53%, while the lowest percentage (21.93%) was recorded for the control birds. There were no significant differences ($p<.0001$) between drumsticks, femurs, and wings for all groups. The lowest ($p<0.0897$) abdominal fat percentage (0.27%) was recorded for the birds, which received a 0.5 gm mint oil/kg diet, while the highest value was recorded for T2, with 0.41% that received a 0.5 gm anise oil/kg diet. The best ($p<0.042$) fat bad was recorded for birds that received anise oil (0.84%), while the worst value was noted for the control one with 1.31%.

Table 6: Carcass traits as affected by studied essential oil

Treatments / Parameters	T1 (Control)	T2 (anise)	T3 (lemon)	T4 (mint)	P value
Live body weight	2145.80±20.31	2269.70±63.14	2257.50±74.18	2256.70±107.31	NS
Dressed carcass (g) (including giblets)	1687.03±5.81	1764.24±60.85	1771.10±24.13	1786.98±81.85	NS
Dressing (with giblets) %	78.62±2.84	77.73±3.68	78.45±2.57	79.19±4.26	NS
Breast (g) including sternum bone	562.33±18.59 [c]	616.00±30.79 [b]	667.67±58.48 [ab]	709.67 ±54.95 [a]	<0.0776*
Breast yield (g)	470.67 ±15.1 [b]	530.67 ±33.19 [b]	594.00 ±36.83 [ab]	630.33 ±52.13 [a]	<0.0626*
Breast yield%	21.93±2.35 [b]	23.38±4.16 [b]	29.58±3.95 [a]	27.93±3.17 [a]	<0.0531*
Drumstick (g)	98.00±3.51	115.67±14.25	124.33±14.17	106.67±4.67	NS
Femurs (g)	451.33±16.05	498.67±37.05	537.00±49.89	502.00±49.73	NS
Wings (g)	160.33±2.6	164.67±7.84	163.67±1.86	176.67±12.55	NS
Abdominal fat (g)	8.38±1.02 [b]	9.35±2.14 [a]	7.41±1.19 [b]	6.01±1.34 [c]	<0.0897*
Abdominal fat %	0.39±0.09 [a]	0.41±0.1 [a]	0.33±0.06 [b]	0.27±0. 05 [b]	<0.0329*
Fat pad (g)	28.17 ±2.01 [a]	19.00±2.79 [b]	22.50 ±1.89 [ab]	27.00 ±1.81 [a]	<0.0259*
Fat pad %	1.31±0.15 [a]	0.84±0.12 [c]	1.00±0.14 [b]	1.20±0.16 [a]	<0.042*

a, b and c Means (±SE) in the same row with different superscripts are significantly different
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The impacts of dietary supplements with anise, lemon, and mint oils on the bird organs:

From Table (7), statistics cleared that there was a significant decrease in the relative weight of the liver (p<0.003) in T2 (0.5 gm anise oil/kg diet), compared with other groups. No significant differences (p<0.0001) between all treatments, which have almost the same kidney/body weight percentage (0.13%). The birds fed the control diet had heights (p<0. 095) and gizzard percentages (2.79%), while the lowest gizzard % was recorded for T2 (1.98%). No significant differences (p<0.0001) were recorded between the bursal weight for all treatments compared with the control group.

Significant differences (p <0.0673) were detected in the intestinal weights between T2 (0.5 gm anise oil/kg diet) and T3 (0.5 gm lemon oil/kg diet), while the difference was immaterial for the intestinal weight/body weight percentage.

Table 7: Organs' weights as affected by studied essential oils

Treatments / Parameter	T1 (Control)	T2 (anise)	T3 (lemon)	T4 (mint)	P value
Heart (g)	7.36±0.71	7.91±0.84	8.10±0.6	9.98±0.74	NS
Liver (g)	47.00±3.07	47.17±2.48	44.17±2.39	49.50±2.78	NS
Liver%	2.57± 0.28[a]	1.83± 0.24[b]	2.17± 0.40[a]	2.25± 0.31[a]	<0.003*
Kidney (g)	2.84± 0.34[b]	2.94± 0.19[ab]	3.00± 0.15[a]	2.81± 0.27[b]	<0.0263*
Kidney %	0.132± 0.01	0.129± 0.02	0.132± 0.02	0.125± 0.03	NS
Gizzard (g)	22.50 ±1.23[b]	29.83 ±2.06[a]	26.83 ±1.47[ab]	26.67 ±2.75[ab]	<0.095*
Gizzard%	2.79±0.12[a]	1.98±0.15[b]	2.00±0.13[b]	2.20±0.15[b]	<0.004*
Bile (g)	2.09±0.26	1.66±0.21	1.31±0.21	1.69±0.33	NS
Spleen (g)	2.16±0.2	2.25±0.09	2.46±0.40	2.84±0.23	NS
Bursa (g)	2.76±0.2	2.65±0.44	2.64±0.44	2.45±0.46	NS
Bursa %	0.13± 0.02	0.12± 0.018	0.12± 0.017	0.11± 0.021	NS
Intestine (g)	87.83 ±3.89[b]	107.33 ±7.22[a]	101.33±4.21[a]	88.00 ±7.26[b]	<0.0673
Intestine %	4.09±0.41	4.73±0.38	4.49±0.47	3.90±0.59	NS

a, b and c Means (±SE) in the same row with different superscripts are significantly different
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The impacts of dietary supplements with anise, lemon, and mint oils on all examined parts of the intestine:

The largest (p <0.0073) small intestine length was detected for birds whose diet contained anise oil, while the smallest one was for birds that fed on mint oil, with a significant difference. However, there were significant differences detected in right caecum length between birds treated with anise oil compared with other groups, while no significant differences were detected in left caecum length for all groups, as shown in Table (8).

Table 8: The intestinal lengths as affected by studied essential oils compared with the control one.

Treatments / Parameter	T1 (Control)	T2 (anise)	T3 (lemon)	T4 (mint)	P value
Small L (cm)	178.83 ±6.02[b]	202.00 ±5.47[a]	189.00 ±1.15[ab]	176.50 ±5.82[b]	<0.0073*
Small L / Body weight (cm/kg)	0.083±0.01	0.089±0.014	0.084±0.011	0.078±0.016	NS
Large L (cm)	8.33±0.67	8.75±0.36	8.50±0.50	8.27±0.17	NS
Right caecum (cm)	19.97 ±0.49[a]	20.67 ±0.76[a]	21.00 ±0.45[a]	18.67 ±0.33[b]	<0.044*
Left caecum (cm)	18.83±0.6	19.17±0.87	20.42±0.88	18.25±0.17	NS

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The impacts of dietary supplements with anise, lemon and mint oils on the lipid profiles:

The results of low-density lipoprotein values explained that the highest (p<0.8032) value was detected for the control birds, while the lowest value recorded for birds fed diet contained the lemon oil, while high-density lipoproteins (HDL) values showed a contrary result (p<0.7992). There were no significant differences (p<0.0001) in triglyceride (TG) and total cholesterol (CHOL) between all treatments, as shown in Table (9).

The impacts of dietary Supplements with anise, lemon, and mint oils on the total antioxidant capacity (TAOC):

The data shown in Table (9) cleared that there were high significant differences (p<0.009) between the treatment groups, as the T3 birds with lemon oil had the highest total antioxidant capacity (2.79 µmol/l), compared with other groups. On the other hand, birds fed a diet that contained mint oil had the lowest total antioxidant capacity (0.16 µmol/l), compared with other groups.

Table 9: Comparison between **lipid profiles** and **antioxidant capacity** of the studied broiler chickens fed anise, lemon, and mint oils

Treatment	T1 (Control)	T2 (anise)	T3 (lemon)	T4 (mint)	P value
LDL (mg/dl)	71.61±10.57[a]	66.27±13.13[a]	53.00±1.96[b]	66.10±21.7 [a]	<0.8032*
HDL (mg/dl)	79.60±13.50[b]	93.53±15.75[a]	101.40±0.17[a]	89.90±23.27[b]	<0.7992*
TG (mg/dl)	144.80±3.75	147.07±10.69	155.10±4.50	140.23±0.30	NS
CHOL (mg/dl)	180.20±6.15	189.23±5.13	185.45±1.24	184.03±2.10	NS
TAOC (µmol/l)	0.33±0.01[b]	0.53±0.01[a]	0.69±1.13[a]	0.16±0.01[c]	<0.009**

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** is high significance * is significance NS is not significant

The impacts of dietary supplements with anise, lemon, and mint oils on the histomorphological examination:
The data obtained from Table (10) cleared that the villus length (VL), width (VW), and crypt depth (CD) for the birds with mint oil treatment (0.5 gm oil/kg diet) showed superior values (p<0.0001) when compared with other treatment groups. However, the birds whose diet contained lemon oil had the highest VL/CD ratio (p<0.0001). The addition of mint and lemon oils improved the villus length (VL) and width (VW) as compared with the control group.

Table 10: The impacts of essential oil on **intestinal morphology.**

Treatment	T1 (Control)	T2 (anise)	T3 (lemon)	T4 (mint)	P value
VL (µm)	740.00±35.19[b]	621.65±30.81[c]	733.48±20.92[b]	882.71±80.57[a]	<0.0001**
VW (µm)	150.82±15.41 [c]	148.73±15.67 [c]	187.96 ±10.18[b]	236.81±26.74[a]	<0.0001**
CD (µm)	139.44 ±8.21 [b]	144.32 ±14.84[b]	110.07 ±8.88[c]	168.01±9.22[a]	<0.0001**
VL/CD (µm)	5.31±0.57 [b]	4.31±0.43[c]	6.66 ±0.77[a]	5.25±0.68[b]	<0.0001**

a, b and c Means (±SE) in the same row with different superscripts are significantly different
** is high significance * is significance NS is not significant.

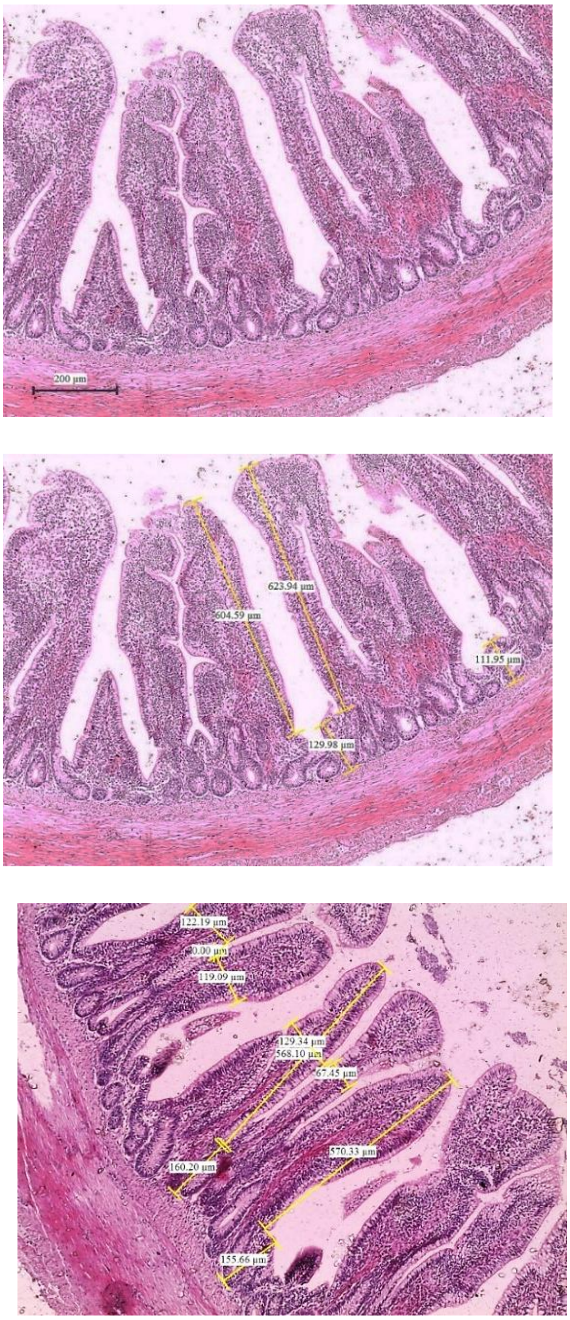

Fig. 1: Light microscopic photomicrographs showed morphological characteristics of the parameters evaluated in particular regions of the control birds. VH, VL, VW, CD, and thickness of intestinal mucosa.

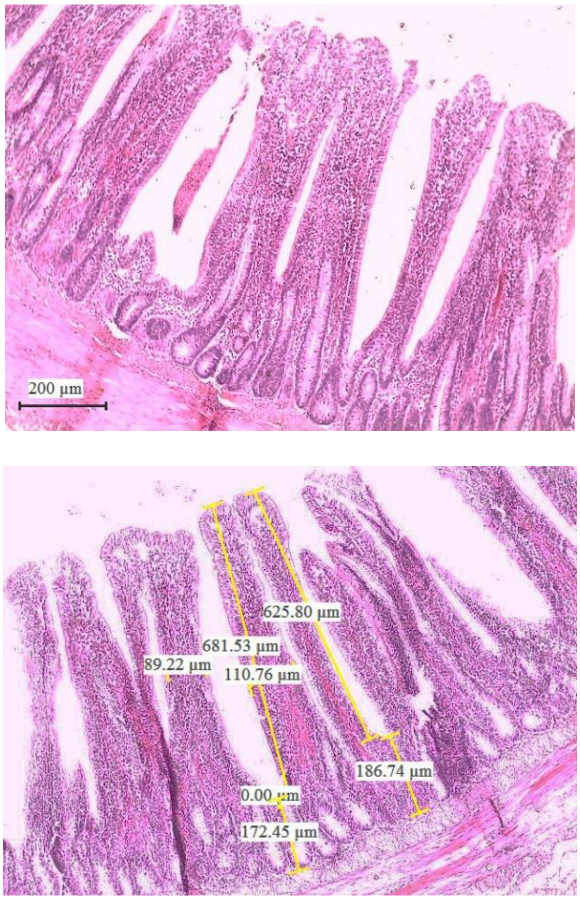

Fig. 2: Light microscopic photomicrographs showed morphological characteristics of the parameters evaluated in particular regions of the birds fed anise oil. VH, VL, VW, CD, and thickness of intestinal mucosa.

DISCUSSION

The results of this study indicated that the birds treated with lemon and mint oils had the highest final body weight with nearly 10% and 6% development than the control group, respectively. The birds that received EO had improved breast yield percent, and the highest (27.93%) was recorded for birds fed lemon oil. This is in the same line with Ding *et al.* (2020), Ismail *et al.* (2021), and Ahmed *et al.* (2022), since they noticed a 5% increase in the broilers' body weight whose diet

Fig. 3: Light microscopic photomicrographs showed morphological characteristics of the parameters evaluated in particular regions of the birds fed lemon oil. VH, VL, VW, CD, and thickness of intestinal mucosa.

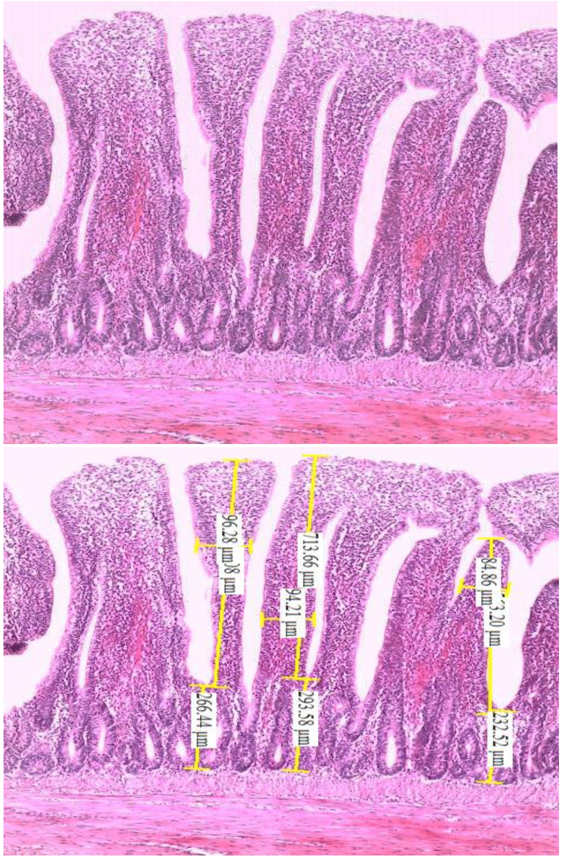

Fig. 4: Light microscopic photomicrographs showed morphological characteristics of the parameters evaluated in particular regions of the birds fed mint oil. VH, VL, VW, CD, and thickness of intestinal mucosa.

supplemented with 1.0% oregano oil. Gopi *et al.* (2012) observed an enhancement in body weight gain in broilers that received cinnamon powder at concentrations of 250-500 ppm. The present study's findings proved the beneficial response of the dietary essential oil supplements on weight gain, which agree with the previous studies by Akter and Asaduzzaman (2023) and Ghazanfari *et al.* (2024) reflecting on the improvement in nutrient digestion efficacy like CP, GE and amino acids as mentioned in other studies by Cross *et al.* (2003) and (2007); Bampidis *et al.* (2005); Saleh *et al.* (2014); Adaszyńska-Skwirzyńska and Szczerbińska (2017); Upadhaya *et al.* (2019); Ismail, *et al.* (2021);Yu *et al.* (2021); Ahmed *et al.* (2022); Elkomy *et al.* (2023); and Tufarelli *et al.* (2023).

Supplementation of the broiler diet with anise and lemon oils reduced the abdominal fat and fat bad percentages, which agreed with Ghazanfari *et al.* (2024), who stated the improvement of dry matter and fat digestibility as a reason for the decrease in abdominal fat and fat bad. Khattak *et al.* (2014) reported that adding 100 mg of lemon essential oil per kilogram of feed improved live weight gain by 7%. Anise, lemon, and mint's main bioactive components, including trans-anethole, D-limonene, and menthol, were shown to have antibacterial and growth-promoting properties in numerous investigations by Mancuso (2020); Yu *et al*. (2022); and Ewais *et al*. (2024).

The addition of anise and lemon oils to broiler diets improved the relative weight of kidney and gizzard, while mint oil supplementation improved the gizzard weight, which agreed with Akter and Asaduzzaman (2023). Since the EO helps to restore the balance of microbiota and boost nutrient absorption, its beneficial effects on the avian digestive system may be one of the other reasons contributing to improved production performance (Mountzouris *et al.,* 2011). However, EOs enhanced the feed's flavor and aroma, which encourages the production of gastric juices and saliva (Gopi *et al.,* 2013). EOs further stimulate the synthesis of digestive enzymes and enhance their action (Zhang *et al.,* 2020), which goes in the same hand with *Xue et al.* (202. On the other hand, adding EOs to broiler diets as a growth stimulant alternative does not always enhance production performance; in fact, it occasionally worsens it. (Kırkpınar *et al.,* 2011; Zeng *et al.,* 2016; and Adaszyńska-Skwirzyńska and Szczerbińska, 2017).

Villus and crypts are two crucial parts of the small intestine, and their geometry indicates the absorptive capacity of the small intestine (Heydarian *et al.,* 2020). The villus height to crypt depth (VH/CD) ratio is an important parameter for assessing poultry gut health. This ratio provides information about the functional capability and general health of the intestinal mucosa (Su *et al.,* 2021). Our results cleared that the birds whose diet contained anise oil had the lowest (VL/CD) ratio. The addition of mint and lemon oils had improved villus length (VL) and width (VW) as compared with the control group, which was similar to previous investigations (Kishawy *et al.,* 2019; Yarmohammadi *et al.,* 2020).

Total oxidative capacity (TAOC) was improved by the addition of lemon and anise oils; these findings are in harmony with Elkomy *et al.* (2023) and Hussein *et al.* (2023). However, the reduction in TAOC in the mint group is similar to the results in the study of Yu *et al.* (2022). Excessive oxidative stress and inflammation are common features in the occurrence and development of intestinal diseases. Excessive oxidative stress could cause intestinal inflammation and even cell apoptosis within intestine tissue, following the dysfunction of the intestinal barrier (Xue *et al.,* 2020). The enhanced immunity and antioxidant ability of lemon oil supplementation may improve intestinal integrity, function, and health. Improved immunity can encourage more nutrients to be used for growth; these may partly explain the superior growth performance in groups receiving EOs in the present study (Yarmohammadi *et al.,* 2020).

CONCLUSIONS

This study revealed that the inclusion of essential oils (anise, lemon, and mint) in the broiler chicken diets improved both body weight and gain, feed conversion ratio, and increased breast yield. However, the lemon oil specifically enhanced the broiler chicken's antioxidant status and blood lipid profile. Additionally, it improved the bird's intestinal morphometric properties.

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تأثير إضافة زيوت اليانسون والليمون والنعناع للعليقة على أداء النمو ، خصائص الذبيحة وقياسات الدم البيوكيميائية لدجاج اللحم

حسين عبد الفتاح محمود ، اسامة سامى عفيفى ، حاتم يوسف الحمادى ، نور جمال محمد

Email: nourgamalmohammad@gmail.com Assiut University web-site: www.aun.edu.eg

الهدف من هذه الدراسة هو تقييم إضافة الزيوت العطرية للينسون والليمون والنعناع على أداء النمو وسمات الذبيحة ومقاييس الدم البيوكيميائية لدجاج اللحم. تم اجراء التجربة على ١٦٨ كتكوت من سلالة روس (٣٠٨) التجارية غير محدد الجنس عمر يوم واحد وتم توزيعها عشوائيًا إلى أربع مجموعات (٤٢ كتكوت/مجموعة). غُذيت المجموعة الأولى (المجموعة الضابطة) على العليقة الأساسية بدون إضافات، بينما غُذيت المجموعات الثلاث الأخرى على العليقة الأساسية المضاف إليه زيوت اليانسون والليمون والنعناع بمستوى ٠,٥ جم / كجم من العليقة. أظهرت النتائج أن جميع العلائق المضاف إليها الزيوت قد أدى إلى تحسين معامل تحويل الغذاء مقارنة بمجموعة المقارنة. أظهرت الطيور التي غُذيت على العليقة التي تحتوي على زيت الليمون تحسنًا في متوسط وزن الجسم ومعدل الزيادة فى الوزن بنحو ١٠٪ و١١٪ على التوالي, وهو أعلى من المجموعة الضابطة. سجلت الطيور التي تغذت على عليقة إحتوت على زيت النعناع أعلى وزن للحم للصدر بنسبة 27.93٪ وأقل نسبة دهون في البطن (٠,٢٧٪)، بينما سجلت أفضل نسبة دهون غير مرغوبة (٠,٨٤٪) للطيور التي تلقت عليقة تحتوى على زيت الينسون. أقل قيمة للكوليسترول الضار تم تسجيلها للطيور التي غذيت على علائق تحتوي على زيت الليمون وأعلى قيمة لكوليسترول الجيد كانت في المجموعة التي تلقت عليقة تحتوي على زيت الليمون تحسنًا في القدرة الكلية المضادة للأكسدة (٢,٧٩ ميكرومول/لتر) مقارنة بالمجموعات الأخرى. بينما أظهرت الطيور التي غذيت على زيت النعناع أقل قدرة كلية مضادة للأكسدة (٠,١٦ ميكرومول/لتر) مقارنة بالمجموعات الأخرى. أظهر طول وعرض وعمق الخملات للطيور التي تلقت عليقة تحتوى على زيت النعناع قيمًا متفوقة مقارنة بالمجموعات الأخرى. وقد أظهرت هذه الدراسة أن إضافة زيوت الليمون, اليانسون والنعناع لعليقة دجاج التسمين أدى إلى تحسين كل من وزن الجسم, معدل الزيادة فى وزن الجسم و معدل تحويل الغذاء. بينما إضافة زيت الليمون قد حسن من تأثير مضادات الأكسدة, ومكونات الدهون وخصائص الأمعاء التشريحية.