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Study Productive and Physiological Performance of Sinai Laying Hens Supplemented with Fatty Acids During Late Period

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THIS trail was conducted to explore the effect of nutritional Short-chain fatty acids (SCFAs) such as butyric acid (BA) and medium-chain fatty acids (MCFAs), such as caprylic acid (CA), with or without cinnamon essential oil (CEO). Throughout the late-laying time, on the physiological and productive performance of Sinai hens. The study used 180 females and 18 males varying in age from 60-72 weeks. The results demonstrated that, contrasted with the group under control, including 150 mg cinnamon essential oil (CEO)/ kilogram (T4) or 1g caprylic acid (CA)/ kg (T3) into meals, the feed conversion ratio was significantly ($P \leq 0.05$) improved during the study period. By including CA and BA with or without, cinnamon essential oil to diets of the hens in comparison to the control group. the most notable and optimal value of globulin, albumin/globulin ratio, and total protein in plasma, calcium and estrogen hormone were recorded. Whereas, After CA and BA addition to the laying hens' diets, there was a drop (P0.05) in the total lipid levels and malondialdehyde (MDA) was seen in their plasma. Both with and without the CEO. The percentages of hatchability and fertility were ($P \leq 0.05$) higher in CA and BA with or without cinnamon essential oil (CEO) treated groups as opposed to the control group. In conclusion, whether adding cinnamon essential oil or not, the physiological as well as productive performance of the Sinai laying hens was enhanced by feeding them short and medium-chain fatty acids throughout the late laying stage.

Keywords: short and medium chain fatty acids, productive, physiological, late laying, Sinai strain.

Introduction

Short chain fatty acids (SCFAs) constitute a class of organic compounds generated by the fermentation of feed fibers by microorganisms in the hindgut of various animal species. It has been demonstrated that short-chain fatty acids are essential in maintaining intestinal health, immune function, and overall animal performance. Butyric acid (BA) is SCFA mostly produced because of dietary fiber been fermented by gut microbe [1]. The three main byproducts of microbial fermentation are acetic acid, propionic acid, and butyric acid [2]. Because it strengthens epithelial cells and aids in the prevention of gastrointestinal infections, butyrate is essential to animal health [3]. BA provides carbons, which provide energy to the intestinal epithelial cells and encourage their proliferation, development, and growth [4]. The insufficient synthesis of BA in the small intestine makes it vital that poultry diets include supplements of this acid [5]. Furthermore, BA may expedite intestinal healing by promoting enterocyte turnover through preservation of cell viability. It has been found that supplementing butyrate may increase villi height and deepen crypts, expanding the intestinal absorbent surface [4].

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The nutritional, metabolic, and antibacterial capabilities of medium-chain fatty acids (MCFA) are exceptional [6]. Microencapsulated organic acids containing MCFAs in the diet improve calcium content, fecal lactobacillus, eggshell strength, and egg production of laying hens [7]. MCFAs, such as caprylic acid (CA), are naturally produced constituents that are present in cow's milk, and coconut oil [8, 9]. Experiments conducted in vitro and during fattening, have demonstrated the positive benefits of CA on the digestive tract [10]. Some research indicates that CA has antimicrobial properties in chicken caecum against a wide range of pathogens; including Campylobacter jejuni and Salmonella enteritidis [11] as well as bovine rumen fluid contains Escherichia coli. [12].

Because of its distinctive flavor, cinnamon essential oil (CEO) usually employed in the livestock and poultry feed business [13]. Cinnamaldehyde and eugenol, which have the strongest antibacterial, antifungal, and antioxidant capabilities, are mostly responsible for the consequences of CEOs [14]. According to certain studies, CEO may be a healthy substitute for dietary antibiotics and improve the broiler chicks' growth performance [15] and boosted egg production [16,17,18]. Thus, study aimed to investigate the effects of dietary medium- and short-chain fatty acids, such as caprylic acid and butyric acid, with or without cinnamon essential oil on the physiological and productive performance of Sinai fowl during late-laying period.

Material and Methods

The study was carried out at Al-Serow Poultry Breeding Research Station, Animal Production Research Institute (APRI), Agricultural Research Center (ARC), Damietta Governorate, Latitude: 31° 24' 59.33" Longitude: 31° 48' 47.95" E, Egypt.

Experimental design

In total, 180 hens and 18 cocks at 60 weeks of age used in the study. Birds were weighed individually and separated into six similar groups (thirty females and three males in each). Each group contained 3 replicates, each with similar initial body weight. Floor pens (2x3 m2) were utilized to house replicates at random. The first group (T1) received a basal diet, as a control without supplementation. Birds were received the basal diet supplemented with 1g butyric acid/kg (T2), 1g caprylic acid/kg (T3), 150 mg cinnamon essential oil/kg (T4), 1g butyric acid + 150 mg cinnamon essential oil/kg (T5) and 1g caprylic acid + 150 mg cinnamon essential oil/kg (T6). The birds were fed the experimental diets for 12 weeks (from 60-72 weeks of age).

Management and feeding

All groups were housed in the same circumstances and was in good health. Between 60 and 72 weeks of age, the birds were housed with 16L: 8D photoperiod in the summer season, with 12 hours of daylight and 4 hours of artificial light. Birds have unrestricted access to water and feed. The ingredients and chemical composition of the basal diet are shown in Table 1. The basal diet was calculated to meet the nutrient requirements recommended by the Agriculture Ministry Decree [19].

Productive performance traits

Daily records were made of the egg number (EN), egg weight (EW) while feed intake (FI) was documented once a week. Egg percentage (egg number/egg production periodX100), egg mass (EN x EW), and ratio of feed conversion (g feed/g egg) were evaluated between 60 and 72 weeks of age, at the end of the week, for every replicate [20].

Egg quality parameters

Ninety eggs from each of the six treatment groups were randomly selected at 72 weeks of age (in one day) to assess egg quality criteria. The eggs were weighed individually and cracked, and their contents were placed on a leveled flat board. The thickness (ST) of the egg with membranes was measured at three different points using a micrometer. Additionally, the egg's width (mm), length (mm), albumen percentage (%), yolk percentage (%), height (mm), diameter (mm), and yolk index (derived from the ratio of yolk height to yolk diameter) were measured. Shape index (SI) was also determined [21].

Blood chemical analysis

Blood samples (5ml) were collected at 72 weeks of the trial using the manual slaughtering procedure in two distinct tagged heparinized test tubes. The hemoglobin, total red and differential counts for white blood cells, heterophils, and lymphocytes were ascertained in the first tube, while the plasma was entirely separated in the second tube by centrifuging it at 3000 rpm and storing it at -20°C until the values for total lipids, albumin (Al), calcium, Malondialdehyde (MDA), estrogen hormone and total protein (TP) were evaluated in accordance with the commercial kits' manufacturer's (Biodiagnostic, Giza, Egypt) instructions. The difference in TP and Al was used to determine plasma globulin (Gl).

Fertility and hatchability

After the experiment was over, one hundred twenty eggs from each group were gathered over the course of a last week of experiment, to study fertility and hatchability traits as follows: -

Fertility =

$$\frac{\text{Fertile egg number}}{\text{Total egg number}} \times 100$$

Hatchability of fertile eggs =

Hatched chicks' number x 100

Hatchability of total eggs =

$$\frac{\text{Hatched chicks' number}}{\text{Total egg number}} \times 100$$

As stated by [22] the contents within the slaughtered birds'. Fresh collective samples (caecum and ileum) were gathered in hygienic surroundings to quantify *Escherichia coli* (*E. Coli*) and the number of lactobacilli bacteria in their particular media, as stated by [23].

Statistical analysis

Statistical Analysis System SAS [24] was used to perform a one-way data analysis using variance analysis. The Duncan's multiple-range analysis was applied to ascertain variations between the means [25]. The arcsine equation was used to convert the percentage values to percentage angles before statistical analysis and the display of the actual means. The subsequent model was applied:

Yij = G + Ti + eij

Where, Yij = observation for each dependent variable; G = General mean;

Ti = Treatment effects (i = 1, 2... and 6); eij = Random error.

Results and Discussion

Production performance findings in Table (2) demonstrated that the laying hens given a diet that included 1g CA/kg (T3) exhibited best-feed conversion ratio (of egg production) a reference to the group under control. Moreover, the outcomes demonstrated notable differences between treatments in egg number, mass, weight, and production % of eggs. Regarding this, the quantity and percentage of eggs produced were significantly increased by adding 1g CA/kg (T3) or 150mg CEO/kg (T4) to diets. While there was no discernible difference between the control group and the experimental treatments. Adding essential fatty acids and cinnamon oil to chicken meals had notable ($P \leq 0.05$) effect on egg weight and egg mass during experimental period. However, the control group's egg weight was notably ($P \leq 0.05$) higher than that of the other treatment groups, except (T6) which fed diet supplemented with 1g CA/kg + 150mg CEO/kg. While, egg mass was significantly increased by adding 1g CA/kg (T3) during the experimental period as against the group under control. These outcomes somewhat concur with the findings of [26] who showed that adding medium chain fatty acids to diets for laying hens resulted in higher egg weight and production. The potential advantages of medium chain fatty acids could stem from enhanced nutrient usage, leading to a rise in these parameters in hens fed caprylic acid [27]. Oil fats will become more emulsified when saponins are added to the diet. Because saponins stabilize water or oil emulsions and increase the solubility of monoglycerides, they help make fats easier to digest. Furthermore, compared to long-chain fatty acids, medium-chain fatty acids, including acids like lauric (C12), capric (C10), caprylic (C8), and caproic (C6) are absorbed in the intestine more quickly, have strong antibacterial effects, and are more effectively used by animals. It has been shown that adding 2000 mg of CA/kg to the diets of laying hens had meaningfully ($P \leq 0.05$) enhanced feed conversion ratio, egg mass, and egg quantity in comparison to the control group [27]. [28] found that dietary administration of short-chain fatty acids resulted in a notable rise in the weight and quantity of eggs. Short-chain fatty acids have been linked to improvements in intestinal wellness, nutrient absorption, and metabolism, which may account for this increase. A study conducted by [29] found that Egg production was higher in the laying hen group fed a diet including 2% medium-chain fatty acids than in the control group. The reason behind this could be that the birds were able to obtain rapid energy due to the easy digestion and absorption of medium-chain fatty acids. Moreover, it has been discovered that medium-chain fatty acids have antiviral and antibacterial qualities, which may help lower the incidence of infectious disorders in chicken flocks [30]. However, butyric acid was found to increase egg production and daily egg weight [31]. Moreover, [32] found that the laying hens' egg weight and production increased when they were fed the essential oil of cinnamon. Feed conversion rate and egg production were greatly increased by adding dietary cinnamon essential oil, even though feed intake did not change significantly between the experimental groups. While, according to research by [33], laying hen diets supplemented with medium chain fatty acids significantly boosted feed intake and egg weight, but had no discernible effect on egg production.

The addition of fatty acids and cinnamon essential oil to Sinai laying hen diets had There is no noticeable effect on the egg's interior quality (except from albumen height) or exterior quality (except for the thickness of the shell and egg shape index) as shown in table 3.

Significant increases in eggshell thickness were seen in hens receiving a supplement of 1g CA/kg (T3), egg shape index of hens supplemented with 1g BA/kg + 150mg CEO/kg (T5) and albumen height in hens supplemented with 1g BA/kg + 150mg CEO/kg (T5) or those receiving 1g CA/kg + 150mg CEO/kg in their diet (T6) compared with control group. In this respect, [34] demonstrated that adding more acetic acid caused the exterior features of eggs, including weight, length, diameter, and color, to rise linearly. Supplementing with organic acid may improve the color of eggshells by enhancing reproductive organs like the oviduct's shell gland [35]. According to the studies mentioned above, the possibility of the improved absorption of proteins and minerals is what led to the improvement in eggshell quality. The greater amount of calcium and protein deposition in the shell, which improves its quality and could cause it to get thicker and heavier, is a reflection of the phenomenon of higher absorption. The organic acid improved the layers' ability to metabolize calcium. This could be a result of the diet's acidity being reduced by the addition of organic acids. Lowering the food's pH could enhance the minerals' absorption and solubility, increasing the effectiveness of calcium [36]. On the contrary, [27] discovered that adding varying amounts of caprylic acid to the diets of layer chickens had no discernible effect on the metrics measuring egg quality. [32] discovered that adding cinnamon essential oil to laying hens' meals increased the thickness of their eggshells. According to some experts, the antioxidant and anti-inflammatory properties of cinnamon essential oil, which might lessen stress and inflammation in the hens, may-be the cause of the improvement in egg quality. The Haugh unit and yolk color were both improved by treatment with butyric acid glycerides [31]. Furthermore, because butyric acid promotes the absorption and utilization of nutrients like calcium, consuming it may improve the quality of eggs [37, 38]. Some authors [39], reported that the breaking strength of laying hens at 46, 58, and 70 weeks of age was enhanced by supplementing them with 0.25% medium-chain fatty acid. The eggshell rate rose considerably ($P<0.05$) in the cinnamon essential oil group as compared to the control group; nonetheless, all treatment groups' percentages of egg yolk, egg albumen, and form index were similar, according to [16].

Table 4 shows a significant ($P\leq0.05$) difference in blood hemoglobin, the counts of red and white blood cells, and the percentages of heterophil and lymphocytes, although there were no significant variations found in heterophil/ lymphocytes (H/L) ratio due to adding the fatty acids and/or cinnamon essential oil to Sinai laying hen diets. However, the blood hemoglobin of hens who received a diet supplemented with 150mg CEO/kg (T4) or 1g BA/kg + 150mg CEO/kg (T5) compared to other groups, showed the highest hemoglobin concentrations. Additionally, compared to the other experimental groups, the control population had significantly ($P\leq0.05$) lower hemoglobin levels, counts of red and white blood cells, heterophils, and lymphocytes (%). Furthermore, the count of red blood cells was considerably ($P\leq0.05$) increased for hens fed 1 g BA (T2), 150 mg CEO (T4) and 1 g BA + 150 CEO/kg (T5) compared to the control group. Adding 1g CA (T3), 150 mg CEO (T4) and 1 g BA + 150 CEO/kg (T5) to the hen's diet resulted in a substantially ($P\leq0.05$) higher heterophil proportion in comparison to the control group. Furthermore, compared to the control group, the percentage of lymphocytes was considerably ($P\leq0.05$) enhanced when fatty acids, with or without cinnamon essential oil, were added to the hens' diet. Adding fatty acids and cinnamon essential oil to hens' meals resulted in a numerically insignificant difference in the heterophil/lymphocyte ratio value when compared to the control group, which recorded the lowest value. In this context, lymphocytes (L) are cells that produce antibodies, whereas heterophils (H) are a part of natural immunity and cellular defense against microbial diseases. According to Vleck and Bucher [40], the reduction in antibody titers may has been caused by the challenged chicks' higher secretion of corticosterone, ultimately causing the H/L ratio to rise. It has been proposed that elevated corticosteroid production causes stress-induced bursal atrophy [41]. In this respect, Toghyani *et al.* [42] have shown that hematological characteristics used in clinical assessments of the state of health to aid in diagnosis. Thus, the effects of dietary supplements and nutritional components can be assessed using hematological measures. Since leukocytes are one of the body's first lines of defense against infection, it is well known that their number increases when an infection begins [43]. Al-Kassie [44] demonstrated that adding oil extract from thyme and cinnamon to broiler feed diets significantly increases the amount of red and white blood cells, hematocrit, and hemoglobin. The H/L ratio considerably ($P \leq 0.05$) reduced when the layer chicken diets' content of caprylic acid increased El-Shafei et al [27]. Moreover, results of Begum *et al.* [45] shown that the effects of caprylic acid raised the lymphocyte and leukocyte concentrations. Furthermore, it was noted that the immune system of animals depends on the gastrointestinal tract and associated lymphoid organs [46].

Table 5 shows data on several blood plasma constituents of Sinai laying hens as influenced by nutritional supplementation. It is clearly demonstrated that dietary supplements containing fatty acids and/or cinnamon essential oil have raised ($P \leq 0.05$) the amounts of albumin, globulin, and plasma total protein when compared to the control group. Furthermore, the (A/G) ratio significantly increased for all treatment groups compared to the control group, which recorded the lowest value. These outcomes closely match the findings published by El-Shafei *et al.* [27], They demonstrated that the blood concentrations of albumin, globulin, and total protein of groups fed meals supplemented with varying amounts of caprylic acid were significantly ($P \leq 0.05$) higher than those of the control group. Increases in serum globulin and albumin levels could point to a healthier immune system [47]. The modulation of hormones involved in protein metabolism may be the cause of the increase in blood protein concentration in the tested groups when compared to the control group. Furthermore, the majority of tissues had higher protein levels due to an increase in glucocorticoids and corticosterone hormone [48, 49]. The increased serum protein of layers fed caprylic acid is in general agreement with the effect of medium-chain fatty acids on improving nutrient absorption including protein [27]. Moreover, alpha-monolaurin's function as a medium chain fatty acid in enhancing feed digestibility and blood protein levels can explain the increased levels of total protein and albumin [50]. Globulin concentration serves as an indication for gauging the immune response.

Regarding how dietary supplements of fatty acids and/or cinnamon essential oil affect the plasma amount of total lipids and calcium, Table (5)'s results indicate that supplementing laying hen diets with these nutrients reduced ($P<0.05$) the plasma levels of total lipids and increased ($P<0.05$) the plasma concentration of calcium when compared to the control group. However, supplemented diets with fatty acids and/or cinnamon essential oil had a significantly ($P \leq 0.05$) lower plasma MDA concentration as compared with the control. In this respect, the best value was recorded by hens supplemented with 1g CA/kg + 150mg CEO/kg (T6) in comparison to other treatment groups. However, hens given diets fortified with fatty acids and/or cinnamon essential oil demonstrated a notable ($P \leq 0.05$) increase in plasma estrogen hormone as compared with control. The results reported here agreement up with [27] who documented a substantial ($P \leq 0.05$) In comparison to the control group, blood total cholesterol levels decrease due to layer food containing caprylic acid. They also mentioned that caprylic acid significantly lowered the rate at which intestinal cholesterol was absorbed and might hasten the excretion of neutral sterol in the feces. Serum total cholesterol concentrations decreased significantly ($P \leq 0.05$) when caprylic acid consumption rose in the layer diets [27]. Fatty acids and cinnamon essential oil may reduce the plasma levels of total lipids by inhibiting the synthesis and secretion of lipoproteins in the liver, enhancing the lipolysis and oxidation of fatty acids in the adipose tissue and muscle, and modulating the expression of genes involved in lipid metabolism.

Fatty acids and cinnamon essential oil may increase the plasma concentration of calcium by stimulating the absorption of calcium in the intestine, enhancing the mobilization of calcium from the bone, and regulating the secretion of hormones that affect calcium homeostasis.

Fatty acids and cinnamon essential oil may lower the plasma MDA concentration by scavenging free radicals, increasing the activity of antioxidant enzymes, and inhibiting the lipid peroxidation process [27].

Fatty acids and cinnamon essential oil may increase the plasma estrogen hormone by activating the estrogen receptors, increasing the synthesis and secretion of estrogen in the ovary, and modulating the feedback mechanisms of the hypothalamic-pituitary-gonadal axis. [18,27]

These effects may have implications for the health and productivity of laying hens, as they may improve the egg quality, egg production, and reproductive performance.

Table (6) shows the impact of fatty acids and/ or cinnamon essential oil on fertility and hatchability percentages, as well as chick weight at hatch. The groups treated with fatty acids and cinnamon essential oil had considerably ($P \leq 0.05$) higher fertility percentages than the control birds. Also, in comparison to the control birds, hatchability % (overall and fertile egg hatchability) was significantly higher in all dietary treats. This increase may be because most treated birds' eggshells are thicker than those of control birds. These results are in accordance with those obtained by Şimşek *et al.* [16] who showed that all groups using cinnamon essential oil had higher fertility rates than the control group. Fertility rates may be increased by plant oils with bioactive qualities that include some active ingredients [51,52] and it might be connected to the extracts' vitamin and mineral content [53]. According to [54] Compared to the control group, the hatchability and fertility % of the eggs in the oregano-fed groups were significantly greater. Also, [55] discovered that 1% oregano supplements had greater fertility rates than control diets. However, in another investigation, hatchability and fertility were not significantly affected by butyric acid glycerides when compared to the control group [30].

Comparing the experimental group to the control, the findings indicated that the addition of short and medium chain fatty acids, with or without cinnamon essential oil, boosted the count of lactobacillus bacteria while decreasing the number of Escherichia coli (E. coli) bacteria (Table 7). However, the values were nearly the same for all treatments, including different types of short and medium chain fatty acids, whether or not cinnamon essential oil was employed. In general, hens fed 1 g CA/kg (T3) had the highest number of lactobacillus and the lowest number of E. coli bacteria when compared to other treatments and the control. In this sense, layers given a diet rich in caprylic acid showed increases in egg weight and feed efficiency while decreasing E. Coli transmission and blood and yolk cholesterol levels [11]. [56] discovered that because medium-chain fatty acids have antibacterial action, they have shown to be a good substitute for antibiotics in animals. They also observed that the blend of medium-chain fatty acids and organic acids enhanced digestibility, growth performance, and immunity. Penalver et al. [57] found that oregano essential oil, when widely used, exhibited antibacterial properties against E. coli. They suggested that the growth of some bacterial species, such as Bacillus cereus and E. coli, is inhibited by the presence of oregano essential oil. Can be widely credited for this possible antibacterial effect [58]. Thymol and carvacrol, two phenolic components, are responsible for the antibacterial and antioxidant qualities of oregano essential oil [59].

Conclusion

Fatty acids and/ or cinnamon essential oil had beneficial effect on egg production, egg quality, blood plasma constituents, decreased total lipids, plasma calcium, improved fertility and hatchability percentages, as well as chick weight at hatch, boosted the count of lactobacillus bacteria while decreasing the number of Escherichia coli (E. coli) bacteria.

In conclusion, feeding medium-chain (caprylic acid) and short-chain (butyric acid) fatty acids to Sinai hens during their late-laying phase, either with or without cinnamon essential oil, improved their physiological and productive performance.

Conflict of interest

«The authors declare no conflict of interest.» in the collection, analyses or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Ethics approval and consent to participate

Experiment was approved from Institutional Animal Care and Use Committee (ARC-IACUC) protocol number (ARC-APRI 57-23) Agricultural Research Center, Egypt.

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Consent to publish

All the authors have given their consent for publish this manuscript.

Author contributions

Conceptualization, study design and publication: Marwa Abd El-Maged, sample collection:Yaser Rizk and Sohair shazly Data analyses, Manuscript drafting:Mohamed Soliman, and Manuscript finalization: Marwa Abd ElMaged, Doaa M.M. Yassein ; Shereen S. Ghoneim; Hasan H. A. Abd El-Halim

TABLE 1. The composition of the experimental basal diets.

Ingredients	Percentage (%)
Yellow corn	61.57
Soya bean 44%	17.00
Wheat bran	6.70
Corn gluten 60%	4.50
Di Ca P export	1.39
Lime stone	8.16
Salt	0.37
*Premix	0.30
L Methionine	0.01
Total	100.00
Calculated values (%)	
Protein	16.5
Metabolizable energy (M.E.)	2699
Crude fiber (C. F.)	3.468
Ether extract	2.964
Calcium	3.399
Available Phosphorous	0.397
Total Phosphorous	0.610
Sodium	0.164
Arginine	1.28
Lysine	0.730
Methionine	0.335
Methionine & cysteine	0.619

*Premix added to the 1 kg of diet including Vit.A 10000 I.U; vit. D3 2000 I.U; vit. E 15 mg; vit. K3 1 mg; vit B1 1mg; vit. B2 5 mg; vit. B12 10 µg; vit B6 1.5mg; Niacin 30mg; Pantothenic acid 10mg; folic acid 1mg; Biotin 50 µg; choline 300 mg; zinc 50mg; copper 4mg; iodine 0.3 mg; iron 30mg; selenium 0.1mg; manganese 60mg; cobalt 0.1mg and carrier CaCo3 up to 1k

TABLE 2. Effect of dietary supplementation short and medium chain fatty acids with or without cinnamon essential oils on the performance of Sinai laying hens.

Item	T1	T2	T3	T4	T5	T6	SE
Initial body weight (g)	1597	1603	1606	1630	1613	1600	9.813
Final body weight (g)	1657	1698	1710	1727	1702	1673	21.038
Change in body weight (g)	60	95	104	97	89	73	14.402
Feed intake (g/hen/day)	91.99	91.14	92.84	92.07	92.41	93.12	0.558
Total feed intake (g/hen/period)	7727.16	7655.48	7798.56	7733.88	7762.16	7822.08	46.830
Feed conversion (g feed/g egg)	4.24 [a]	3.69 [ab]	3.31 [b]	3.42 [ab]	3.87 [ab]	3.44 [ab]	0.270
Egg number (egg)	33.73 [b]	38.37 [ab]	43.77 [a]	42.97 [a]	38.97 [ab]	41.63 [ab]	2.555
Egg production (%)	40.16 [b]	45.67 [ab]	52.10 [a]	51.15 [a]	46.39 [ab]	49.56 [ab]	3.042
Egg weight (g)	55.33 [a]	54.07 [bc]	53.80 [bcd]	52.81 [d]	52.99 [cd]	54.61 [ab]	0.366
Egg mass (g)	1867.20[b]	2074.81[ab]	2354.82[a]	2269.49[ab]	2063.31[ab]	2272.69[ab]	137.50

[a, b….] Means within each row have no similar letter(s) are significantly different (P ≤ 0.05)

T1=Control, T2 =Basal diet + 1g butyric acid/kg, T3=Basal diet + 1g caprylic acid/kg, T4=Basal diet + (150mg/kg) cinnamon essential oil, T5=Basal diet + 1g butyric + (150mg/kg) cinnamon essential oil acid, T6=Basal diet + 1g caprylic acid + (150mg/kg) cinnamon essential oil.

TABLE 3. Effect of dietary supplementation short and medium chain fatty acids with or without cinnamon essential oils on external and internal egg quality of Sinai laying hens at 72 weeks of ages.

Item	T1	T2	T3	T4	T5	T6	SE
External egg quality							
Egg length (cm)	5.63	5.53	5.43	5.53	5.33	5.37	0.100
Egg width (cm)	4.30	4.43	4.37	4.40	4.50	4.47	0.078
Shell thickness (mm)	0.257 [b]	0.313 [ab]	0.333 [a]	0.300 [ab]	0.277 [ab]	0.297[ab]	0.019
Shell weight (%)	11.90	11.15	10.90	10.87	10.34	12.08	0.542
Egg shape index	76.49 [b]	80.19 [ab]	80.42 [ab]	79.57 [ab]	84.42 [a]	83.23 [ab]	2.195
Internal egg quality							
Albumen height (mm)	6.52 [b]	7.24 [a]	6.64 [b]	6.76 [b]	8.28 [a]	6.56 [b]	0.462
Albumen (%)	56.16	57.44	57.95	57.84	58.14	57.06	1.473
Yolk height (mm)	17.52	17.93	17.63	18.64	18.99	18.22	0.686
Yolk diameter	38.17	37.40	40.70	38.27	38.83	38.33	1.150
Yolk (%)	31.94	31.41	31.15	31.28	31.52	30.85	1.346
Yolk index	40.24	42.40	42.32	43.17	45.87	43.45	1.761

[a, b….] Means within each row have no similar letter(s) are significantly different (P ≤ 0.05)

T1=Control, T2 =Basal diet + 1g butyric acid/kg, T3=Basal diet + 1g caprylic acid/kg, T4=Basal diet + (150mg/kg) cinnamon essential oil, T5=Basal diet + 1g butyric + (150mg/kg) cinnamon essential oil acid, T6=Basal diet + 1g caprylic acid + (150mg/kg) cinnamon essential oil.

TABLE 4. Effect of dietary supplementation short and medium chain fatty acids with or without cinnamon essential oils on haematological picture of Sinai laying hens at 72 weeks of ages.

Item	T1	T2	T3	T4	T5	T6	SE
Haemoglobin (g/dl)	10.700 [b]	10.900 [b]	11.300 [b]	12.967 [a]	12.700 [a]	10.737 [b]	0.196
Red blood cells (x 10^6/ul)	2.550 [c]	2.660 [ab]	2.620 [bc]	2.750 [a]	2.730 [a]	2.583 [bc]	0.032
White blood cells (x 10^3/ul)	11.200 [b]	12.100 [a]	12.350 [a]	12.350 [a]	12.367 [a]	11.700 [ab]	0.263
Heterophil (%)	20.667 [c]	21.500 [bc]	22.333 [ab]	23.000 [a]	22.000 [ab]	22.500 [c]	0.347
Lymphocyte (%)	44.000 [c]	47.333 [b]	51.000 [a]	51.333 [a]	48.333 [b]	48.333 [b]	0.861
Heterophil/Lymphocyte ratio	0.470	0.454	0.438	0.448	0.455	0.466	0.011

[a, b….] Means within each row have no similar letter(s) are significantly different ($P \leq 0.05$)

T1=Control, T2 =Basal diet + 1g butyric acid/kg, T3=Basal diet + 1g caprylic acid/kg, T4=Basal diet + (150mg/kg) cinnamon essential oil, T5=Basal diet + 1g butyric + (150mg/kg) cinnamon essential oil acid, T6=Basal diet + 1g caprylic acid + (150mg/kg) cinnamon essential oil.

TABLE 5. Effect of dietary supplementation short and medium chain fatty acids with or without cinnamon essential oils on some blood constituents of Sinai laying hens at 72 weeks of age.

Item	T1	T2	T3	T4	T5	T6	SE
Total protein (g/dl)	5.93 [e]	6.40 [d]	7.40 [ab]	7.00 [c]	7.30 [b]	7.60 [a]	0.072
Albumin (Al) (g/dl)	2.83 [b]	2.90 [ab]	3.00 [a]	3.03 [a]	2.93 [ab]	3.00 [a]	0.041
Globulin (Gl) (g/dl)	3.10 [d]	3.50 [c]	4.40 [a]	3.97 [b]	4.37 [a]	4.60 [a]	0.090
Al/Gl Ratio	0.913 [a]	0.829 [bc]	0.682 [c]	0.763 [bc]	0.670 [c]	0.652 [c]	0.023
Total lipids (mg/dl)	477.00 [a]	405.00 [b]	390.33 [b]	404.00 [b]	402.00 [b]	382.67 [b]	8.418
Calcium (mg/100 ml)	12.20 [c]	15.53 [a]	15.53 [a]	14.45 [b]	14.83 [ab]	15.83 [a]	0.411
) ng/mL (MDA	21.700 [a]	17.200 [b]	15.033 [bc]	16.600 [b]	15.867 [bc]	14.200 [c]	0.682
Estrogen (pg/ml)	103.67 [c]	147.00 [b]	176.33 [a]	164.00 [ab]	162.33 [ab]	166.00 [ab]	8.141

[a, b….] Means within each row have no similar letter(s) are significantly different ($P \leq 0.05$)

T1=Control, T2 =Basal diet + 1g butyric acid/kg, T3=Basal diet + 1g caprylic acid/kg, T4=Basal diet + (150mg/kg) cinnamon essential oil, T5=Basal diet + 1g butyric + (150mg/kg) cinnamon essential oil acid, T6=Basal diet + 1g caprylic acid + (150mg/kg) cinnamon essential oil.

TABLE 6. Effect of dietary supplementation short and medium chain fatty acids with or without cinnamon essential oils on fertility and hatchability percentages of Sinai laying hens at 72 weeks of age.

Item	T1	T2	T3	T4	T5	T6	SE
Fertility (%)	76.62 [c]	88.41 [b]	90.00 [ab]	94.68 [a]	97.73 [a]	87.50 [b]	4.614
Hatchability of total eggs (%)	71.14 [c]	78.53 [b]	79.57 [ab]	85.00 [a]	87.34 [a]	83.33 [a]	4.684
Hatchability of fertile eggs (%)	75.63 [b]	87.43 [a]	90.48 [a]	95.00 [a]	89.29 [a]	94.44 [a]	4.474

[a, b….] Means within each row have no similar letter(s) are significantly different ($P \leq 0.05$).

T1=Control, T2 =Basal diet + 1g butyric acid/kg, T3=Basal diet + 1g caprylic acid/kg, T4=Basal diet + (150mg/kg) cinnamon essential oil, T5=Basal diet + 1g butyric + (150mg/kg) cinnamon essential oil acid, T6=Basal diet + 1g caprylic acid + (150mg/kg) cinnamon essential oil.

TABLE 7. Effect of dietary supplementation short and medium chain fatty acids with or without cinnamon essential oils on bacteria count of Sinai laying hens at 72 weeks of age.

Treatment	Lacobacillus sp. count on MRS agar medium (cfu/1g)x10^2	Escherichia coli MacconKey broth medium (cfu/1g)x10^4
T1	63	1480
T2	84	1027
T3	97	998
T4	86	1050
T5	89	1080
T6	81	1020

T1=Control, T2 =Basal diet + 1g butyric acid/kg, T3=Basal diet + 1g caprylic acid/kg, T4=Basal diet + (150mg/kg) cinnamon essential oil, T5=Basal diet + 1g butyric + (150mg/kg) cinnamon essential oil acid, T6=Basal diet + 1g caprylic acid + (150mg/kg) cinnamon essential oil.

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دراسة الأداء الإنتاجي والفسيولوجي لدجاجات سيناء البياض المدعمة بالدهون خلال مرحلة وضع البيض المتأخر

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هدفت هذه التجربة إلى استكشاف تأثير الأحماض الدهنية قصيرة السلسلة (SCFAs) مثل حمض البيوتريك (BA) والاحماض الدهنية متوسطة السلسلة (MCFAs) مثل حمض الكابريليك (CA) مع أو بدون زيت القرفة الأساسي (CEO) على الأداء الفسيولوجي والإنتاجي لدجاجات بياض السيناء خلال فترة وضع البيض المتأخر.

استخدمت الدراسة ١٨٠ أنثى و ١٨ ذكرًا تتراوح أعمارهم بين ٦٠ و ٧٢ أسبوعًا. أظهرت النتائج أنه مقارنة بالمجموعة الضابطة، أدى اضافة ١٥٠ ملليجرام من زيت القرفة الأساسي (CEO) / كيلوغرام (T4) أو ١ جرام من حمض الكابريليك (CA) / كيلوغرام (T3) في الوجبات إلى تحسين معدل تحويل العلف بشكل كبير ($P \leq 0.05$) خلال فترة الدراسة.

من خلال اضافة CA و BA مع أو بدون زيت القرفة الأساسي إلى عليقة الدجاجات مقارنة بالمجموعة الضابطة، تم تسجيل أعلى وأفضل قيمة للجلوبيولين ونسبة الألبومين / الجلوبيولين والبروتين الكلي في البلازما والكالسيوم وهرمون الاستروجين.

في حين، بعد إضافة CA و BA إلى عليقة الدجاجات البياضة، لوحظ انخفاض ($P \leq 0.05$) في مستويات الدهون الكلية ومالونديالدهيد (MDA) في البلازما. سواء مع زيت القرفة الأساسي (CEO) أو بدونه.

كانت نسبة الفقس والخصوبة ($P \leq 0.05$) أعلى في المجموعات المعالجة بـ CA و BA مع أو بدون زيت القرفة الأساسي (CEO) مقارنة بالمجموعة الضابطة.

في الختام، الأحماض الدهنية و / أو زيت القرفة الأساسي كان له تأثير مفيد على إنتاج البيض وجودة البيض ومكونات البلازما الدموية وانخفاض الدهون الكلية وكالسيوم البلازما وتحسين نسبة الخصوبة والفقس ، بالإضافة إلى وزن الكتكوت عند الفقس ، وزيادة عدد بكتيريا اللاكتوباسيلاس مع تقليل عدد بكتيريا القولونية (E. coli).

سواء بإضافة زيت القرفة الأساسي أم لا، فإن الأداء الفسيولوجي والإنتاجي لدجاجات بياض سيناء قد تحسن من خلال تغذيتها باحماض دهنية قصيرة ومتوسطة السلسلة طوال مرحلة وضع البيض المتأخر.

الكلمات المفتاحية: احماض دهنية قصيرة ومتوسطة السلسلة، إنتاجية، فسيولوجية، عمر متأخر، سلالة سيناء.