Effects of Dietary Olive Leaf Powder and L-Carnitine, Alone or in Combination, on Growth Performance and Feed Efficiency of Broiler Chickens

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Abstract:

This study investigated the effect of adding dried leaf powder from a local olive tree (OLP) and L-carnitine were evaluated as dietary supplements for broiler chickens in this study. The experiment was carried out in the broiler chicken farm of the faculty of Medicinal and Industrial Plants at Kirkuk University from 9/8 to 2023/10/12 . A total of 270 broiler chicks were divided into six treatments and three replicates of 15 birds. The treatments were a basal diet without additives (T1), 1 g OLP/kg diet (T2), 2 g OLP/kg diet (T3), 500 mg L-carnitine/kg diet (T4), 1 g OLP + 500 mg L-carnitine/kg (T5), and 2 g OLP + 500 mg L-carnitine/kg (T6). The parameters measured were feed intake, live body weight, body weight gain and feed conversion ratio (FCR). All data were presented as mean±SE and means of the treatments compared by Duncan's multiple range test at $P \leq 0.05$. As a result, the T6 treatment (high-OLP) consistently resulted in the highest performance with regards to later period body weights and gains and the best cumulative FCR. Final body weight was 1929.83±8.83 g in T6 compared with a provisionally corrected control value of 1642.44±6.69 g; cumulative gain was 1889.33±8.17 versus 1599.61±5.48 g, respectively. Cumulative FCR was lowest in T6 1.047±0.006 compared with T1 1.266±0.003, while cumulative feed intake was slightly lower 1979.83±3.51 vs. 2026.00±2.13 g. T4 and T5 in addition gave an improvement in cumulative gain and FCR when compared with the control. The results of this study suggest that the best growth and feed-use efficiency were obtained when 2 g OLP/kg diet and 500 mg L-carnitine/kg diet was used. But substantial inherent variations between the body weight of the two experimental groups, and the lack of raw replicates data, restrict causal interpretation and independent reanalysis of the treatment by supplement interaction.

Keywords: broiler chicken; Olea europaea; olive leaf powder; L-carnitine; body-weight gain.

Introduction:

Modern broilers are fast growing, have a feed conversion ratio that is high and short production cycle, and broiler production is a part of the world supply of animal protein. Nutrition management is a critical element to reach such high productivity, which is critical in carcass composition and meat quality, health and resistance to environmental and metabolic stressors[10]. Other factors that can boost performance are the natural nutrients (PFA and others) that act as antioxidants, antimicrobial, digestive and metabolic processes, according to [18] and ABGP common food use. Olive leaves are a crucial by-product of agriculture and are used as feed. The phenolic and triterpenoid compounds present in olive tree leaves are known to be antioxidants and antimicrobial [5, 22].

In addition, the phenolic profile is also determined by the cultivar and the process. Dried olive leaves were used for flavonoids, iridoids, phenylethanoids and triterpenic acids extraction by [24], who showed an important effect of drying on bioactive constituents and antioxidant activity of the extract. Olive leaf powder at different levels also increased body weight gain and feed conversion and decreased fat deposit in the abdomen [6]. Olive leaf extract with

oleuropein also had a beneficial effect on broilers' growth and FCR improvement and Escherichia coli reduction [13]. Olive leaf extract also had a growth and antioxidant effect [23, 21]. [4] also found similar results. [17]found that olive leaf powder therapy in broilers increased weight gain and weight metabolism, decreased feed intake and FCR, enhanced antioxidant status, and augmented the caecal microbiota. [17] found that 1 or 2 grams of olive leaf powder per kg of diet would improve growth, feed efficiency and antioxidant and immune status and gut bacteria balance. L-carnitine is also an interesting additive in feed, as it is involved in the energy metabolism. It is best known for its physiological function of carrying long chain fatty acyl to the mitochondria for β-oxidation to produce energy [2].

L-carnitine levels in the body are controlled by dietary intake, endogenous synthesis, tissue uptake and renal reabsorption [1,3,7,19]. The metabolic effect has led to speculation that L-carnitine supplementation is beneficial to burn energy in food, decrease fat storage or to fight metabolic or environmental stress. There is no widespread acceptance that L-carnitine has a direct growth promoting effect in broilers. [11] did not find a significant difference in growth performance with 100 mg/kg L-carnitine in broilers. [15] did not find any growth benefits when high levels of inclusion (900 mg/kg) were provided to broilers fed with animal fat. However, [14] found that 200 mg/kg did not increase the growth performance, but it did reduce lipid peroxidation, abdominal fat and cardiopulmonary indices at high altitude. [9]did modify the acute phase response but did not show any performance response with 15 or 100 mg/kg. Supplementation in poultry has shown a variety of responses with the dose, basal diet, age, and environment, with higher levels of supplementation leading to increased weight or feed efficiency [8,19, 20].

The combination of both bioactive compounds may have a beneficial nutritional actions: the phenolics in olive oil are antioxidants which may help to keep the microbial balance in the gut, and the fatty acids may contribute to the utilisation by mitochondria and L-carnitine. However, these responses do not necessarily add up - and it is not a linear functional response - so we need to quantify it by direct statistical analysis of interaction.

The current study tested the effect of olive leaf powder , L-carnitine, and combinations of these on feed intake, live body weight, body weight gain and feed conversion ratio of grill chickens.

2. Materials and Methods:

2.1. Experimental site and birds/management:

The experiment was carried out in the poultry farm belonging to the College of Medicinal and Industrial Plants, Kirkuk University covering the period from August 9 to October 12 / 2023. The source materials read the treaits lasted 35 days. A total of 270 broiler chicks with an average initial weight of around 42 g were purchased from a hatchery and kept in floor pens of 1 x 2 m. Three replicates with 15 chicks each were used for each of 6 dietary treatments, with the birds being randomly distributed. Food and water were offered freely in 5-L food and water cups.

2.2. Olive leaf powder, L-carnitine and experimental treatments:

The olive leaves were harvested from the area, dried in an oven and ground into powder. L-carnitine powder was bought locally and supplied by TEAM ONE. The basal diet was provided to the birds without any additives in the first week. Thereafter, the respective additives were added to the birds' diets during the remainder of the treatments.

The treatment structure was:

Treatment	Dietary supplementation
T1	Basal diet without additives (control)
T2	Basal diet supplemented with 1 g /kg powdered dried olive leaf
T3	Basal diet + 2 g olive leaf powder/kg diet
T4	Basal diet supplemented with 500 mg L-carnitine per kg diet
T5	Basal diet 1 g olive leaf powder and 500 mg L-carnitine/kg
T6	Basal diet + 2 g olive leaf powder + 500 mg L-carnitine/kg

2.3. Basal diets:

The feed-composition table with three diet phases, the grower and finisher ingredient columns sum to 100%, were shown in table 1.

Table 1: composition of the basal diets ingredients and calculated nutrient contents

Feed ingredient and nutrients	Starter 7-21 day	Grower 21-35 day
Wheat flour %	39.29	43.68
Yellow corn %	17.31	20.12
Soya meal (48.42%),	34.75	29.15
Salt %	0.30	0.22
Sunflower oil inclusion (%)	4.00	4.00
Lime stone ground (%)	1.00	0.60
Dicalcium phosphate (%)	2.66	1.32
Vitamins-mineral % (a)	0.10	0.10
Methionine, (%)	0.27	0.25
Lysine, (%)	0.32	0.32
Choline chloride (60%)	—	0.24
Reported total, %	100	100
Calculated ME (kcal/kg) diet (b)	3000.53	3097.76
Crude protein content (%)	23.67	21.75
Calcium, (%)	1.01	0.54
Available phosphorus, %	0.47	0.23
Dig. Methionine, %	0.59	0.55
Dig Lysine (%)	1.44	1.31

(a)each 5kg of the vit and mineral premix supplies: Vitamin A (520000IU), Vit D 3(210000IU), Vitamin E (200mg), K 8(20mg), B 5(20mg), B 2(10mg).), B 6(80mg), B 52(510mcg), folic acid (50mg), niacin (800 mg), calcium (%3), magnesium (400mg), zinc (510mg), iron (18mg) , copper (48mg), choline (40mg) (b) According

to the chemical composition of feed materials based on what was stated in the US National Research Council NRC [16].

2.4. Performance measurements:

During the successive periods of the experiment, feed intake for each replicate was determined. The live body weight was measured at the start of the measurement, and at other measurement points. Body weight gain was determined by the difference in body weight acquired during each interval. The final gain column is cumulative gain. Grams of feed consumed per gram of body-weight gain was used for feed conversion ratio (FCR). Values in the final column of FCR are cumulative FCR, since these are the values of feed intake divided by body weight gain between start and finishing.

2.5. Statistical analysis:

The data obtained were analyzed by completely randomized design (CRD) that was applied in the SAS software. The model used was $Yij = \mu + Ti + Eij$, where Yij is the actual value for replicate j of treatment i, μ is the average value and Ti is the effect of the treatment. Duncan's multiple range test ($P \leq 0.05$)[12] was used to separate treatment means.

3. Results:

Feed intake differed significantly among treatments across the experimental periods (Table 2). During Period 1, T6 recorded the highest feed intake at 162.66 ± 1.452 g/bird (a) and was significantly higher than T1 154.33±1.802, T2 157.16±0.726, T3 153.83±1.607, T4 155.16±2.333, and T5 154.83±1.755. During Period 2, the highest feed intake was observed in T1 at 414.00±1.878 g/bird, followed by T2 at 402.16±3.192, T3 at 395.16±2.351, T5 at 384.50±2.127, T4 at 384.16±1.666, and T6 at 374.66±1.855.

In Period 3, T1 showed the significant feed intake at 707.16±0.726 g/bird. T2 recorded 695.50±2.351 and did not differ significantly from either T1. T3 and T4 recorded 683.50±1.364 and 689.33±0.577, respectively, whereas the lowest values were recorded in T5, 663.83±5.751, and T6, 658.83±7.000. During Period 4, T6 showed the highest feed intake, 783.66±2.403 g/bird. T4 and T5 recorded 772.16±1.013 and 773.50±2.242, respectively, while T2 showed an intermediate value of 766.66±1.878. T3 recorded 762.83±4.072, whereas T1 had the lowest intake at 750.50±1.301. For cumulative feed intake, T1 recorded the highest value, 2026.00±2.127 g/bird. T2 and T4 recorded 2021.50±6.330 and 2000.83±2.362, respectively, whereas T5 and T6 had significantly lower cumulative intakes of 1976.67±3.345 and 1979.83±3.511, respectively. The T6 value was approximately 2.3% lower than the control.

Table 2: Feed intake (g/bird) during the experimental periods and cumulatively

Treatment	Period 1	Period 2	Period 3	Period 4	Cumulative
T1	154.33±1.802^{b}	414.00±1.878^{a}	707.16±0.726^{a}	750.50±1.301^{d}	2026.00±2.127^{a}
T2	157.16±0.726^{b}	402.16±3.192^{b}	695.50±2.351^{ab}	766.66±1.878^{bc}	2021.50±6.330^{b}
T3	153.83±1.607^{b}	395.16±2.351^{c}	683.50±1.364^{b}	762.83±4.072^{c}	1995.33±1.892†
T4	155.16±2.333^{b}	384.16±1.666^{d}	689.33±0.577^{b}	772.16±1.013^{b}	2000.83±2.362^{b}
T5	154.83±1.755^{b}	384.50±2.127^{d}	663.83±5.751^{c}	773.50±2.242^{b}	1976.67±3.345^{c}
T6	162.66±1.452^{a}	374.66±1.855^{e}	658.83±7.000^{c}	783.66±2.403^{a}	1979.83±3.511^{c}
Sig.	*	***	***	***	***

Live body weight was significantly affected by treatment at the different measurement times (Table 3). At the beginning of the experiment, T1 recorded 42.83±1.32 g/bird, while T3 and T6 showed intermediate values of 41.16±0.60 and 40.50±0.72, respectively. T2, T4, and T5 recorded 39.33±0.76, 40.33±0.28, and 39.16±0.33, respectively. At Measure 1, T6 achieved the highest body weight at 166.16±1.25 g/bird. T3 and T5 recorded 161.83±1.48 and 160.60±1.32, respectively, whereas T1, T2, and T4 had lower values of 156.16±1.75, 155.00±0.44, and 153.83±1.64.

At Measure 2, T6 remained significantly superior, recording 534.66±6.12 g/bird. T2, T3, T4, and T5 recorded statistically similar values of 505.33±5.84, 499.66±7.18, 506.10±4.188, and 502.20±2.76, respectively. The control, T1, had the lowest body weight at 454.33±5.811. At Measure 3, T6 showed the highest live body weight at 1188.50±2.75 g/bird. T4 and T5 followed with 1107.83±4.910 and 1116.50±3.96, respectively. T2 recorded 1058.50±9.65, T3 recorded 1037.33±0.44, and T1 had the lowest value of 989.11±0.93. At the final measurement, T6 maintained the highest body weight at 1929.83 8.83 g/bird. T4 and T5 formed the second significance group at 1808.10±2.34 and 1818.53±2.50, respectively. T2 and T3 were statistically similar at 1756.17±15.23 and 1740.00±7.37, whereas T1 recorded the lowest value, 1642.44±6.69.

Table 3: Live body weight (g/bird) during the experiment

Treatment	Initial	Measure 1	Measure 2	Measure 3	Final
T1	42.83±1.32^{a}	156.16±1.75^{c}	454.33±5.811^{c}	989.11±0.93^{e}	1642.44±6.69^{d}
T2	39.33±0.76^{b}	155.00±0.44^{c}	505.33±5.84^{b}	1058.50±9.65^{c}	1756.17±15.23^{c}
T3	41.16±0.60^{ab}	161.83±1.48^{b}	499.66±7.18^{b}	1037.33±0.44^{d}	1740.00±7.37^{c}
T4	40.33±0.28^{b}	153.83±1.64^{c}	506.10±4.188^{b}	1107.83±4.910^{b}	1808.10±2.34^{b}
T5	39.16±0.33^{b}	160.60±1.32^{b}	502.20±2.76^{b}	1116.50±3.96^{b}	1818.53±2.50^{b}
T6	40.50±0.72^{ab}	166.16±1.25^{a}	534.66±6.12^{a}	1188.50±2.75^{a}	1929.83±8.83^{a}
Sig.	*	***	***	***	***

Body-weight gain was significantly influenced by dietary treatment throughout the experiment (Table 4). During Period 1, T6 recorded the greatest gain at 125.66±1.30 g/bird. T3 and T5 recorded 120.66±0.88 and 121.50±1.58, respectively, whereas T1, T2, and T4 recorded significantly lower gains of 113.33±1.04, 115.66±0.726, and 113.50±1.58. In Period 2, T6 again recorded the greatest gain at 368.50±5.19 g/bird. T4 recorded 352.26±5.67 and therefore did not differ significantly from treatments carrying either a or b. T2, T3, and T5 recorded 348.33±6.24, 337.83±7.54, and 341.53±3.97, respectively. T1 showed the lowest gain at 298.16±5.73. During Period 3, T6 remained significantly superior at 653.83±5.89 g/bird. T4 and T5 recorded 601.73±9.09 and 614.30±6.04, respectively, whereas T1, T2, and T3 recorded statistically similar and lower values of 534.77±6.74, 555.16±3.84, and 537.66±6.88.

In Period 4, T6 again recorded the greatest body weight gain at 741.33±7.68 g/bird. T2, T3, T4, and T5 were statistically similar, recording 697.66±5.60, 702.66±7.15, 700.26±2.63, and 702.03±2.05, respectively. The control T1 recorded the lowest gain at 653.33±7.59. For cumulative body-weight gain, T6 achieved the highest value at 1889.33±8.171 g/bird. T4 and T5 recorded 1767.77±2.170 and 1779.37±2.65, respectively. T2 and T3 had intermediate and statistically similar values of

1716.83±15.111 and 1698.83±7.373, while T1 showed the lowest cumulative gain at 1599.61±5.475.

Table 4: Body-weight gain (g/bird) by experimental period and cumulatively

Treatment	Period 1	Period 2	Period 3	Period 4	Cumulative
T1	113.33±1.04^{c}	298.16±5.73^{c}	534.77±6.74^{c}	653.33±7.59^{c}	1599.61±5.475^{d}
T2	115.66±0.726^{c}	348.33±6.24^{b}	555.16±3.84^{c}	697.66±5.60^{b}	1716.83±15.111^{c}
T3	120.66±0.88^{b}	337.83±7.54^{b}	537.66±6.88^{c}	702.66±7.15^{b}	1698.83±7.373^{c}
T4	113.50±1.58^{c}	352.26±5.67^{ab}	601.73±9.09^{b}	700.26±2.63^{b}	1767.77±2.170^{b}
T5	121.50±1.58^{b}	341.53±3.97^{b}	614.30±6.04^{b}	702.03±2.05^{b}	1779.37±2.65^{b}
T6	125.66±1.30^{a}	368.50±5.19^{a}	653.83±5.89^{a}	741.33±7.68^{a}	1889.33±8.171^{a}
Sig.	***	***	***	***	***

Feed conversion ratio was significantly affected by dietary treatments, particularly after the first experimental period (Table 5). Because a lower FCR represents better feed efficiency, the lowest values indicate the most favorable response. During Period 1, T3 and T5 recorded the lowest FCR values of 1.275±0.021 and 1.274±0.022, respectively. T6 recorded 1.294±0.012 and therefore overlapped statistically with groups b and c. T1 and T2 recorded 1.362±0.024 and 1.358±0.012, whereas T4 showed the highest numerical FCR of 1.367±0.028. During Period 2, T6 recorded the lowest and therefore best FCR at 1.017±0.016. T4 recorded 1.091±0.021, whereas T2 and T5 had intermediate values of 1.155±0.021 and 1.126±0.014. T3 recorded 1.171±0.030, and T1 showed the poorest FCR at 1.389±0.029.

In Period 3, T6 again showed the best feed conversion at 1.007±0.003, followed by T5 at 1.080±0.003 and T4 at 1.146±0.018. T2 and T3 were statistically similar at 1.252±0.004 and 1.271±0.017, respectively, while T1 had the highest FCR at 1.322±0.017. During Period 4, T6 continued to record the lowest FCR at 1.057±0.007. T2, T3, T4, and T5 recorded 1.099±0.006, 1.085±0.014, 1.102±0.004, and 1.101±0.001, respectively, whereas the control T1 had the highest value of 1.148±0.011. For cumulative FCR, T6 showed the best feed efficiency at 1.047±0.006, followed by T5 at 1.110±0.0029 and T4 at 1.131±0.0002. T2 and T3 were statistically similar at 1.177±0.007 and 1.174±0.005, respectively, whereas T1 had the poorest cumulative FCR at 1.266±0.003.

Table 5: Feed conversion ratio (g feed/g body-weight gain)

Treatment	Period 1	Period 2	Period 3	Period 4	Cumulative
T1	1.362±0.024^{ab}	1.389±0.029^{a}	1.322±0.017^{a}	1.148±0.011^{a}	1.266±0.003^{a}
T2	1.358±0.012^{ab}	1.155±0.021^{bc}	1.252±0.004^{b}	1.099±0.006^{b}	1.177±0.007^{b}
T3	1.275±0.021^{c}	1.171±0.030^{b}	1.271±0.017^{b}	1.085±0.014^{b}	1.174±0.005^{b}
T4	1.367±0.028^{a}	1.091±0.021^{c}	1.146±0.018^{c}	1.102±0.004^{b}	1.131±0.0002^{c}
T5	1.274±0.022^{c}	1.126±0.014^{bc}	1.080±0.003^{d}	1.101±0.001^{b}	1.110±0.0029^{d}
T6	1.294±0.012^{bc}	1.017±0.016^{d}	1.007±0.003^{e}	1.057±0.007^{c}	1.047±0.006^{e}
Sig.	*	***	***	***	***

During period 1, T3 and T5 had the lowest FCR values, while T6 was intermediate. From period 2 onward, T6 consistently showed the lowest FCR. Cumulative FCR improved progressively across the treatment ranking, from 1.266 in T1 to 1.047 in T6. Relative to the control, this represents an approximately 17.3% reduction in feed required per unit of gain. T5 (1.110) and T4 (1.131) also showed marked cumulative improvements.

4. Discussion:

The performance pattern revealed that the treatment group T6 (2 g olive leaf powder/kg diet and 500 mg L-carnitine/kg diet) had the highest overall performance pattern. The lowest cumulative FCR and the highest body weight at the end of the trials were found to be achieved with T6 in all trials. Importantly, cumulative feed intake was not increased but rather an increase in gain improvement and cumulative feed intake in T6 was slightly lower than in the control. This is evidence of greater nutrient efficiency of use and not just increased feed intake. This response is biologically plausible and is due to the olive-leaf component. Olive foliage contains high percentage phenolic constituents such as (oleuropein , hydroxytyrosol, flavonoids and triterpenes) which could contribute to antioxidant and antimicrobial properties [22, 24]. Better redox balance and better gastrointestinal microbial environment may help to maintain digestive and absorptive function, which can help in utilization of nutrients and growth. [6]showed that olive leaf powder (OLP) at various concentrations in broiler diets improved the gain and feed conversion ratio and reduced the fat in the abdomen of broilers.

A similar trend was found by [13]for the growth performance and FCR and decreased E. coli in the caeca of broilers fed increasing doses of oleuropein from OLE. These observations guide the performance results of this study. The inclusion level of the powder (1g OLP/kg and 2g OLP/kg) in this study is particularly interesting in a recent study by[17], where the enhancement of selected growth periods, FCR, antioxidant and immune markers and caecal microbiota were reported. [4] found that the olive leaf powder supplementation led to a decrease in FCR, as well as weight gain and gain. The cumulative gain and F. C. R. were improved when olive leaf powder was used alone (T2 and T3), against T1 and the same performance was not improved in 2 g/kg compared with 1 g/kg for all performance measurements. It shows that the dose response pattern of phytogenic responses could be possible and may be mediated by both the quantity and bioavailability of the phenolics in the plant material.

L-carnitine could play a role in an alternative pathway. L-carnitine allows the transfer of long-chain fatty acids into the mitochondria and is thus directly linked to fatty-acid β-oxidation and cellular energy metabolism[19]. L-carnitine alone (T4) was observed to be beneficial in cumulative gain and cumulative FCR compared to the control; and the combination treatments (T5 and T6) were even more beneficial in the cumulative FCR. However, the literature cited in this paper is not entirely favorable literature previously written about broilers. No growth or FCR advantage was found with 100 mg/kg L-carnitine[11], 900 mg/kg in broilers fed animal fat[15], or immune modulation[9]. At 200 mg/kg, [14]found decreased levels of lipid peroxidation as well as abdominal fat, but no change in growth. These different findings suggest that the effect of L-carnitine on the birds is dose-dependent, dependent on basal diet, dependent on metabolic state, dependent on stress and may be dependent on birds' endogenous carnitine status.

The higher performance of T5 and more so of T6 may be due to complementary, but not necessarily synergistic, effects. Olive phenolics are likely to have their main effect on oxidative balance, intestinal environment and L-carnitine has a possible role in substrate handling in mitochondria. But a statistical finding of synergy is dependent upon testing the interaction olive-leaf × L-carnitine with a factorial analysis. The treatment structure has been changed to 3 x 2 factorial (0, 1 or 2 g OLP/kg × 0 or 500 mg L-carnitine/kg) but raw replicate data is not available, and source analysis treated the treatments as 6 levels in a 1-way CRD. For this reason, the present manuscript describes T6 as the best observed combination but does not make any claim of significant interaction. The temporal feeding behavior should also be considered. The intake of T6 was high in the first and last reported intervals, and lower in the middle intervals, resulting in slightly less cumulative intake than the control. Meanwhile, T6 showed an increasing trend in weight gain in each interval and was the lowest FCR. This along with an improved conversion of consumed nutrients into tissue growth is possible. The same improvements in feed efficiency have been noted with olive leaf products by [6, 13, 4 and 17].

5. Conclusion:

The current study concluded that adding powdered olive leaves along with carnitine was associated with improved broiler growth and feed efficiency compared with the unsupplemented control. The co-supplementation of 2 g olive leaf meal /kg diet and 500 mg carnitine /kg diet (T6) produced the highest final body weight and cumulative gain and the lowest cumulative FCR, while cumulative feed intake remained slightly below that of the control. The combined treatment therefore appears promising as a nutritional strategy for improving productive performance.

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