FJARD VOL. 38, NO. 3. PP. 512-523 (2024)

Fayoum Journal of Agricultural Research and Development
ISSN:1110-7790
OnLine ISSN:2805-2528

Effect of basil leaves powder on productive and physiological performance in growing Japanese quail

Mahmoud M. Aly, Mohamed S. Bahnas, Somaya I.R. Soliman*

Department of Poultry Production, Faculty of Agriculture, Fayoum University, Fayoum 63514, Egypt

ABSTRACT

A feeding trial was conducted to study the influences of dietary basil leaves powder (BLP) supplements on productive and physiological performance in growing Japanese quail. A total number of 192 unsexed birds (9 days old) were randomly assigned to four equal treatments (48 birds), in six replicates, eight birds each. The 1st group was used as a control group. The 2nd, 3rd and 4th groups were fed diets containing 0.5%, 1%, and 1.5% BLP, respectively. The findings showed that control diets with BLP levels (especially, 1.5% BLP) had beneficial effects by improving feed conversion ratio (FCR) and decreasing feed intake (FI). Diets containing BLP significantly augmented carcass and depressed abdominal fat weight. Giblets and dressing had no significant effect. Diets with BLP resulted in increasing the absolute weights of the immune organs. The quail fed on a diet with 1.5% BLP achieved significantly the highest values of total protein, globulin, and albumen. A significant lowest value was recorded regarding serum glucose. Lipid profile and thyroid hormones triiodothyronine (T3) and thyroxin (T4) values in BLP-treated groups were significantly better than the control. There was a numerical increase in color, texture, and overall acceptability of quail meat values with the inclusion of all BLP levels compared to the control. Furthermore, net revenue and economic efficiency values were improved for quail-fed BLP diets. In conclusion, BLP can be used as feed additives to boost the productive and physiological performance of growing Japanese quail.

Keywords: Basil leaves powder, Growing quail, Growth performance, Blood indices, Economic efficiency

*Corresponding author: sir11@fayoum.edu.eg (S.I.R. Soliman-Mob.:01060831986)
https://doi.org/10.21608/FJARD.2024.301364.1056
Received: 08/07/2024
Accepted: 11/07/2024

1. Introduction

Basil (*Ocimum basilicum* L.) is considered a useful essential oil, nutritious herb and medicinal plant, belongs to *Lamiaceae* family, grows better in sub-tropical and tropical climates (**Aldarkazali *et al*., 2019**). Basil contains 90.91%, 8.98%, 20.88%, 1.12%, 13.01% and 55.33% for dry matter, ash, crude protein (CP), ether extract (EE), crude fiber (CF) and nitrogen free extract (NFE), respectively (**Kiczorowska *et al*., 2015**). **Gurbuz and Ismael (2016)** reported that CP and CF in basil were 22.08 and 25.52%, respectively. **Turcu *et al*. (2020)** stated that sage and thyme have similar CP content (14.19% and 14.67%) but lower than basil (18.06%). The content of CF in these herbs in relatively high (10.9% in basil, 24.6% in thyme and 20.2% in sage) could be a limiting factor for their use in the diet of broilers **(Turcu *et al*., 2020).** Basil has various pharmacological actions; anti-stress activities, immunological response, anti-inflammatory and antioxidant capacity **(Bilal *et al*., 2012)**. **Hussain *et al*. (2021**) announced that using herbs instead of synthetic products resulted in increased growth rates and improved feed conversion ratio (FCR) value in broiler chicks. Furthermore, active components in medical plants may improve digestive enzymes and stimulate immune responses in chickens (**Soltaninejad *et al*., 2022**). Dietary peppermint and basil powder (seed or leaf), extracts or essential oils (EOs) in broiler chickens were affirmatively influenced feed intake (FI) and FCR (**Abbas, 2010; Riyazi *et al*., 2015**a**; Gurbuz and Ismael, 2016**). Using peppermint and basil EOs in quail's diets displayed significantly lower FI and better FCR compared to the control group (**Abbas *et al*., 2021**). Basil, sage and thyme herbs and their EOs improved growth performance, FI and immune response in broiler chicken **(Vlaicu *et al*., 2022)**. **Helen *et al*. (2020)** stated that quail's diets with 20g BLP/kg diet had improved body weight gain (BWG) and FCR. Additionally, **Hadi and Jassim (2013)** provided support for the idea that increased food digestion and absorption efficiency was the cause of the improvement in FCR in growing quail fed diets containing 1.5 g BLP/kg diet. When compared to other plants, the basil plant had a moderate quantity of polyphenols and a strong antioxidant capacity, as observed by **Turcu *et al*. (2020)**. Regarding immune organs, **Elbaz *et al*. (2022a and b)** found variable results in the relative weight of immune organs as a result of using different natural feed additives. The relative weights of spleen and thymus were not affected with broiler fed diet containing clove EOs (**Elbaz *et al*., 2022a)**. While, adding garlic and lemon EOs individually or as a combination significantly augmented the relative weight of bursa in broilers under heat stress (**Elbaz *et al*., 2022b)**. Regarding blood constituents **Hadi and Jassim (2013)** found a reduction in cholesterol levels and a rise in total protein, globulin and albumen levels when growing quails were fed diets with 1.5g BLP /kg diet. Recently, **Al-Shaheen *et al*. (2023)** showed that basil oil (300 and 600 mg) and 600 mg peppermint oil supplementation significantly augmented total protein and albumen levels compared to the control. Also, total protein, albumen, globulin and cholesterol were significant effect due to basil and peppermint essential oils supplementation while, glucose was not affected (**Abbas et al., 2021**). The same author showed that quails fed diets with basil essential oils (BEO) or peppermint essential oils (PEO) have an increase in carcass weight compared with the control group; at the same time, there were significant differences in gizzard weight. While PEO and BEO did not significantly

affect the weights of liver, total giblets, gut and heart as well as dressing%. Adding 400 mg BEO, 400 mg PEO, and 200 mg BEO plus 200 mg PEO did not significantly change the carcass percentage, total edible and non-edible parts, giblets or liver in rabbits (**Morshedy *et al*., 2019**). Meat quality was shown to significantly enhance at 0.5% or 1.0% basil incorporation (**Kilany *et al*., 2018**). Regarding economic efficiency (EEf), **Hussain *et al*. (2021**) and **El-Kashef *et al*. (2017)** clarified that the higher EEf was in broiler chicks and quail fed on herbs compared to the control group. Recently, **Aly *et al*. (2023a)** stated that the highest economic efficiency ratio recorded with 27 ppm L-menthol crystal (LMC) group (165%) in growing quail, while the best ones was 161% in laying quail fed diet with 1.5% peppermint leaves powder (PLP) **Aly *et al*. (2023b)**. The current study aimed to examine the effect of dietary basil leaves powder (BLP) supplements on productive and physiological performance of growing Japanese quail.

2. Materials and Methods

The current experiment was carried out at the Poultry Research center, Faculty of Agriculture, Fayoum University, Egypt.

2.1. Birds, experimental design and diets

A total number of 300 1-days–old Japanese quails were reared in battery system and fed a control diet containing 2900 kcal ME/kg diet with 24%CP as recommended by **NRC (1994)**. At day 9 of age, 192 unsexed quails with an average weight of 52.82±0.21g were randomly disturbed to four equal groups, containing 48 birds each in six replicates of 8 chicks each. The 1st treatment was fed a control diet, where the second, third and fourth groups were fed the control feed containing 0.5%, 1.0% and 1.5% BLP, respectively. The compositions and calculated analysis of experimental diets are shown in Table 1.

Table 1. Composition and calculated analysis of experimental diets containing basil leaves powder (BLP) in growing Japanese quail

Ingredient (%)	Control (0.0% BLP)	0.5% BLP	1% BLP	1.5% BLP
Yellow corn	50	50	50	50
Soybean meal (46%)	41	41	41	41
Wheat, bran	2.00	1.50	1.00	0.50
Soya oil	2.50	2.50	2.50	2.50
DL Methionine	0.25	0.25	0.25	0.25
L-Lysine	0.15	0.15	0.15	0.15
Bone meal	1.50	1.50	1.50	1.50
Limestone	2.00	2.00	2.00	2.00
Salt, NaCl	0.30	0.30	0.30	0.30
BLP (21.4% CP)	0.00	0.50	1.00	1.50
Premix, poultry*	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00
	Calculated analysis**			
DM (%)	85.25	85.25	85.26	85.27
CP (%)	23.70	23.73	23.76	23.79
ME (Kcal/Kg)	2882	2876	2869	2863
Ca (%)	1.31	1.31	1.31	1.31
Non-phytate phosphorus (%)	0.33	0.33	0.33	0.33
EE (%)	4.80	4.81	4.81	4.81
CF (%)	3.55	3.59	3.63	3.67
Lysine (%)	1.47	1.47	1.47	1.46
Methionine (%)	0.61	0.61	0.61	0.61
Met+cys (%)	1.01	1.00	1.00	1.00

*Each 3.0 kg of premix supplies one ton of the diet with: Vit. E, 10g; Vit. A, 12000000 I.U; Vit. K3, 2.5 g; Vit. D3, 2500000 I.U; Biotin 50 mg; Vit.B12,10 g; Vit.B6,1.5 g; Vit.B 2.5 g; Vit.B1,1 g; Nicotinic acid, 30 g; Folic acid, 1 g; Capantothenate, 10 g; Zn, 55 g; Fe, 35 g; Cu, 10 g; Se, 150 mg; Co, 250 mg; I, 1g; Mn, 60 g; and antioxidant, 10g. **According to NRC (1994). Dry Matter (DM), Ether Extract (EE), Metabolizable Energy (ME), Crude Fiber (CF), Crude protein (CP), Calcium (Ca).

2.2. Growth performance

Birds were individually weighed and FI (g) per cage was recorded through the trial period (9-37 days of age), BWG (g) was calculated as follows: $BWG_{(9-37)} = W_{37} - W_9$; and FCR was calculated as follows: FI (g)/BWG (g); Growth rate (GR) was calculated based on **Brody (1945)** as follows:

$$\mathbf{GR} = \frac{(\mathbf{LBW37d} - \boldsymbol{LBW\ 9d})}{\mathbf{0.5(LBW9d} + \boldsymbol{LBW37d})} \mathbf{X\ 100}$$

2.3. Internal organs evaluation and carcass

At the end of experiment (37 days), 12 birds from each treatment (6 males and 6 females) of similar BW were individually weighed, and the weights of internal organs (liver, gizzard, gut, bursa and spleen) and digestive system were recorded. The dressing percentage was calculated by dividing the carcass weight by LBW × 100.

2.4. Blood constituents

On 37 days of age, blood samples were collected from 6 quails (3 ♂ and 3 ♀) during slaughtering in un-heparinized tubes, centrifuged (3000 rpm/20 minutes) to take blood serum. The serum was kept at -20 ^{o}C until analysis. Serum albumin (Alb), total protein (TP), and glucose were determined according to commercial reagent kits protocols. Serum globulin concentration was calculated (Total protein-albumin). Lipid profile including triglycerides (TG), total cholesterol (Chol), low-density Lipoprotein (LDL) and high-density lipoprotein (HDL) were estimated by **James (2001)**. Total antioxidant capacity (T-AOC) and glutathione peroxidase (GSH-Px) were estimated by **Paglia and Valentine (1967)**. Digestive enzymes, i.e., amylase and lipase were determined by **Junge *et al.* (2001)** and trypsin was determined according to Bovine Trypsin ELISA Kit MBS 706461. Thyroid hormones, T3 and T4 levels were analyzed by the ELISA technique using a commercial kit.

2.5. Quality of quail meat

Meat quality indices (color, taste, flavor, texture, appearance, overall acceptability) were determined according to **Peryam (1957)**.

2.6. Economic Efficiency (EEf)

Feeding cost was calculated on basis that the number of kg of feed intake (FI) from experimental diets per the number of kg of meat produced multiplied by the costs of the respective diets. The selling price (total revenue) was calculated by multiplying the number of kg of meat by 125 (L.E.) which represents the selling price of one kg meat commonly offered in the market.

The EEf (net return per unit feed cost) of meat production for the different experimental treatments was calculated using the following equations:

Total feed cost = a × b = c,

Total revenue = d × e = f,

Net revenue = f-c =g, and EEF = g/c

Where: a = average FI (Kg/quail/period).

b = Price/kg feed (L.E.); c= total feed cost (a × b).

e = Price/kg meat (L.E.); d = meat (Kg/bird/period).

f = Total revenue (d × e). g = Net revenue (f-c).

It is worthy to note that, financial calculations were carried out according to the local market prices of feed ingredients and additives dominated at the experimental diets.

2.7. Statistical Analysis

The results obtained studied using ANOVA by using InfoStat program (**Di Rienzo, 2017**), according to the following model:

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

Where:

Y_{ij}: is the observation of traits

μ: is the overall mean

L_i: is the influence of i^{th} treatment.

e_{ij}: is the random error term

To compare statistical differences between means, **Duncan (1955)** was used.

3. Results and discussion

3.1. Analysis of basil leaves powder

According to Table 2, the data revealed that basil leaves powder contain (air dried,%) 9.6% , 21.4%, 3.5%, 18.8%, 15.0% and 31.7%, for moisture, CP , EE, CF, ash and NFE, respectively . In this respect, **Vlaicu *et al*. (2022)** revealed that chemical composition of basil (all plant) was 9.35%, 22.53%, 1.51%, 12.22%, and 14.12% for moisture, CP, EE, CF, and ash; respectively. Meanwhile, the mineral composition (mg/kg) was 27.69, 624.51, 78.46 and 54.63 for Cu, Fe, Mn, and Zn, respectively. Besides, **Helen *et al*. (2020)** showed that basil contained 10.30, 3.60, 5.40, 21.7 and 52.10 % for moisture, ash, EE, CP and NFE%, respectively. **Turcu *et al*. (2020)** reported that basil contained 18.06% and 10.88% for CP and CF; respectively. Also, the basil herb is very low in calories and contains no cholesterol (**Filip 2017)**.

Table 2. Proximate analysis of basil leaves powder (air-dried)

Nutrient	(%)
Moisture	9.6
Crude protein	21.4
Crude fat	3.5
Crude fiber	18.8
Ash	15.0
Nitrogen free extract	31.7

3.2. Growth performance

The addition of graded levels of BLP in quail diets had a positive impact of growth performance as shown in Table 3. Birds fed 1.5% basil leaves powder (BLP) achieved the best LBW, BWG, FCR and GR, being 223.70g , 170.70g , 3.45 (g feed/g gain) and 123.25% ; respectively. The results showed that addition of BLP (especially 1.5% BLP) to control diet had beneficial effects by increasing BWG, improving FCR and decreasing feed intake. Some positive physiological and nutritional advantages of basil and other herbs have been established by previous studies. The inclusion of peppermint and basil powder (seed or leaf), extracts or EOs in broiler chicken diets were affirmatively influenced FI and FCR (**Abbas, 2010; Riyazi *et al*., 2015b; Gurbuz and Ismael, 2016**). In this regards **Abbas, *et al*. (2021)** reported that quails supplemented by PEO and BEO displayed significantly better FCR and lower FI than the control group. Also, **Al-Shaheen *et al*. (2023)** showed a significantly better FCR for the treated groups compared with the control group. They added that improving FCR with respect to levels of PEO and BEO could be attributed to their affirmative roles in boosting the performance. Finally, **Aly *et al*. (2023a)** elucidated that quail chicks fed diets with 27ppm LMC and 2.5% PLP had the better FCR, LBW and BWG, without any effect in FI. More recently, **Abdel-Kader *et al*. (2024a and b)** found that growing quails fed diets supplemented with CPE_X and MLE_X levels had significantly the highest LBW, BWG, GR and performance index. However, **Riyazi *et al*. (2015b)** demonstrated that the herbal natural feed additives (BEO: 200,400 and 600 ppm) had no impacts on BW, BWG, FI and FCR of broiler chicks.

Table 3. Influence of dietary basil leaves powder on growth performance in growing Japanese quail

Item	Basil leaves powder level				SE	*p*-value
	0.0%	0.5%	1.0%	1.5%		
Initial BW (9d)	53.40	52.46	52.87	52.56	0.54	0.6175
Final BW (37d)	208.94^{b}	220.52^{a}	220.49^{a}	223.70^{a}	2.42	0.0002
BWG (9-37d)	155.58^{b}	167.7^{a}	167.72^{a}	170.70^{a}	2.34	<0.0001
F cons (9-37d)	576.83^{b}	597.52^{a}	588.27^{ab}	581.77^{b}	4.16	0.0038
FCR (9-37)	3.74^{a}	3.60^{ab}	3.54^{b}	3.45^{b}	0.06	0.0041
Growth rate (9-37)	118.43^{b}	122.55^{a}	122.57^{a}	123.25^{a}	0.81	0.0001

BW: body weight. BWG: body weight gain. F cons: feed consumption. FCR: feed conversion ratio. $^{a-c}$Means within the same row with different superscript.

3.3. Carcass characteristics

3.3.1. Digestive organs

Results indicated that dietary BLP supplementation levels showed an increasing effect on all digestive organs traits. Moreover, birds fed with 1.5% BLP had the highest values being, 31.14, 6.70, 5.76, 1.84, 6.43, 78.91, 3.08, and 12.25 for digestive system, liver, gizzard, periventricular, small intestine weight, small intestine length, cecum weight, and cecum length, respectively (Table 4).

The findings of the current study demonstrated the positive effect of BLP supplementation diets on digestive organs. These results agree with those of **Giannenas *et al*. (2018)** who illuminated that herbal feed additives in broiler chickens improved gut morphology. However, **Abbas (2010)** reported that organs weights are not affected by adding 3 g basil seed/kg diet.

Table 4. Influence of dietary basil leaves powder on digestive organs in growing Japanese quail

Items	Basil leaves powder level				SE	*p*-value
	0.0%	0.5%	1.0%	1.5%		
Digestive System (g)	25.07^{b}	27.20^{b}	29.67^{a}	31.14^{a}	0.76	<0.0001
Liver (g)	4.67^{b}	6.13^{a}	6.65^{a}	6.70^{a}	0.46	0.0102
Gizzard (g)	4. 26^{b}	5.46^{a}	5.67^{a}	5.76^{a}	0.27	0.0007
Periventricular (g)	1.31^{b}	1.38^{b}	1.73^{a}	1.84^{a}	0.09	0.0002
Small intestine length (cm)	69.92^{b}	75.89^{ab}	77.55^{a}	78.91^{a}	2.36	0.0502
Small intestine weight (g)	4.31^{c}	5.27^{b}	5.58^{ab}	6.43^{a}	0.22	0.0001
Cecum length (cm)	10.17	10.78	11.17	12.25	0.62	0.1299
Cecum weight (g)	1.74^{b}	2.13^{b}	2.65^{a}	3.08^{a}	0.16	<0.0001

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

3.3.2. Carcass traits

Poultry has a substantial contribution to nutrition and food security (**Elnesr and Abdel-Azim, 2023**). The results from the current study indicated that diets containing BLP significantly augmented carcass (g) and depressed abdominal fat weights (g).Where, the dressing giblets (weights) were not significantly affected by BLP diets (Table 5). These results are in the same line as listed by **Abbas *et al*. (2021)** who showed that quails treated by diets with PEO or BEO have an increase in carcass weights compared with the control group. They added that diet with 250 mg/kg (BEO) and 500 mg/kg (PEO) did

not significantly affect dressing %, giblets weights and gut weights. On the other hand, **Riyazi *et al*. (2015a)** indicated that birds fed dietary treatments (200, 400 and 600 ppm BEO) caused no significant of carcass yields and relative weights of the thigh, breast, heart, liver and gizzard with decreasing abdominal fat by feeding 200 ppm BEO level.

Table 5. Influence of dietary basil leaves powder on carcass traits in growing Japanese quail

Item	Basil leaves powder level				SE	*p*-value
	0.0%	0.5 %	1.0%	1.5%		
Front (g)	89.63[b]	101.28[a]	100.36[a]	100.25[a]	2.4	0.0075
Rear (g)	50.89	52	53.47	53.49	1.1	0.3
Carcass (g)	141.25[b]	153.32[a]	153.85[a]	153.92[a]	3.21	0.027
Giblets (g)	11.88	10.89	10.57	11.15	0.92	0.77
Dressing (%)	71.7	71.28	72.68	73.31	1.33	0.68
Abdominal fat (g)	1.38[a]	0.96[b]	0.75[b]	0.67[b]	0.133	0.0026
Bursa (g)	0.22[b]	0.28[a]	0.29[a]	0.30[a]	0.02	0.0066
Spleen (g)	0.16[b]	0.19[b]	0.21[ab]	0.25[a]	0.02	0.002

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

3.3.3. Immune related organs

Table 5 shows the effect of BLP-supplemented diets on the immune organs (spleen and bursa weights). The findings of the current study indicated that BLP-containing diets augmented bursa and spleen weights. Greater weights of immune organs often indicate higher immunological functions, and this information can be utilized to assess immune health (**Ravis *et al*., 1988**). In this regard, the early reported by **Hanieh *et al*. (2010)** demonstrated that essential oil supplementation in White Leghorn chickens increased the immune organs' relative weights. While, **Toghyani *et al*. (2011)** clarified that the weight of the spleen in broiler chicks at 42 days of age was unaffected by dietary supplements containing several natural antioxidants.

3.4. Blood biochemical parameters

3.4.1. Serum glucose, protein and lipids profiles

Our results indicated that TP, Alb and Glo of the birds fed. BLP levels were higher significantly than the control, while, serum glucose was significantly lower than the control (Table 6). Tabulated regarding harmful serum lipid profile exhibited that total cholesterol, TG and LDL were significantly lower than the control, with higher HDL value. Our results in agreement with the previous investigation conducted by **Hadi and Jassim (2013)** who observed that feeding growing quail diets containing 1.5 g BLP/kg led to a decrease in cholesterol and a rise in TP, Alb, and Glo levels. In addition, BEO and PEO had a significant influence on the serum total cholesterol, TP, Alb, and Glo, while glucose levels were not affected by these additives **(Abbas *et al*., 2021)**. While **Elnaggar and El-Tahawy (2018)** reported that glucose level was significantly augmented when broilers were fed the control diet with thyme, sweet basil and their oils. Furthermore, many authors reported significantly lower cholesterol in broilers (**Abbas, 2010; Toghyani *et al*., 2011; Akbari and Torki, 2014)** and in Japanese quails **(Abdel-Wahab *et al*., 2018)** when the birds fed dried peppermint leaves in their diets. More recently, **Abdel-Kader *et al*. (2024a and b)** stated that quails fed with CPE_X and MLE_X had the lowest values for total cholesterol, LDL and TG with the highest HDL value. According to **Riyazi *et al*. (2015a)**, broiler plasma cholesterol, HDL and LDL levels

were not significantly affected by giving dietary BEO (200, 400, and 600 ppm).

Table 6. Influence of dietary basil leaves powder on blood biochemical parameters in growing Japanese quail

Item		Basil leaves powder level				SE	*p*-value
		0.0%	0.5%	1.0%	1.5%		
Glucose and protein profile	Glucose (mg\dl)	138.33	128.50	120.33	116.17	6.92	0.1283
	Total protein (g\dl)	3.99	4.29	4.5	4.76	0.25	0.1832
	Albumin (g\dl)	1.68	1.73	1.80	1.94	0.07	0.092
	Globulin (g\dl)	2.32	2.56	2.7	2.82	0.28	0.6152
Lipids profile	Cholesterol (mg\dl)	184.17^{a}	164.33^{ab}	160.00^{b}	151.67^{b}	7.07	0.0164
	Triglycerides (mg\dl)	155.67^{a}	144.00^{ab}	125.00^{bc}	116.17^{c}	8.04	0.0047
	HDL (mg\dl)	65.18^{c}	77.37^{b}	85.65^{a}	88.78^{a}	1.8	<0.0001
	LDL (mg\dl)	98.92^{a}	82.93^{ab}	70.95^{bc}	56.78^{c}	5.87	0.0001
Digestive enzymes	Trypsin (ng/ml)	96.55^{c}	109.62^{b}	114.40^{ab}	120.43^{a}	2.24	<0.0001
	Amylase (mg/dl)	544.5	566.15	603.17	624.65	23.31	0.0815
	Lipase (mg/dl)	74.23^{c}	93.53^{b}	97.68^{a}	98.35^{a}	1.17	<0.0001
Antioxidant parameters	TAOC (mmol/ml)	0.80^{b}	1.00^{ab}	1.29^{a}	1.34^{a}	0.14	0.0259
	GSH-PX (U/l)	1222.41^{c}	1262.77^{bc}	1302.85^{b}	1380.89^{a}	20.48	<0.0001
Thyroid hormones	T3 (ng\dl)	30.83^{b}	35.43^{a}	38.33^{a}	38.98^{a}	1.21	0.0001
	T4 (ug\dl)	2.25^{c}	2.93^{b}	3.22^{a}	3.24^{a}	0.08	<0.0001

Abbreviations: T4: thyroxine; T3: triiodothyronine; GSH-PX: glutathione peroxidase; TAOC: total antioxidant capacity; LDL: low-density lipoprotein; HDL: high-density lipoprotein; SE: standard error; $^{a\text{-}c}$Means within the same row with different superscript.

3.4.2. Digestive enzymes, antioxidant parameters, thyroid hormones

With respect of digestive enzymes, serum trypsin, and lipase values increased significantly as increasing dietary BLP levels (Table 6). Meanwhile, 1.5%. BLP group recorded the highest values of trypsin (120.43 ng/ml), amylase (624.65 mg/dl) and lipase (98.35 mg/dl). Furthermore, feeding broilers diets containing essential oils isolated from herbs enhanced the secretion of digestive enzymes, which in turn enhanced feed digestibility and broiler performance **(Jang *et al*., 2007)**. Recently, quails chicks with LMC (27 ppm) and PLP (2.5%) recorded significantly higher trypsin and amylase values compared with the control, without any significant different in lipase levels in all experimental groups. Where, quail hens fed diets with LMC group (27 ppm) and PLP (2%) achieved the highest trypsin, where no significant difference between all groups in amylase and lipase **(Aly *et al*., 2023a and b)**. Supplementing growing quail's diets with CPE_X or MLE_X levels caused significantly higher amylase, lipase and trypsin values compared with the control diets **(Abdel-Kader *et al*., 2024a and b).** Our results declared that antioxidant parameters, T-AOC and GSH-Px values were significantly greater than the control when birds fed BLP diets (Table 6). The current finding aligns with the findings published by **(Aly *et al*., 2023a and b)** who explained that PLP and LMC dietary supplement enhanced all antioxidant indices (T-AOC; GSH-Px) in growing and laying quails. Feeding quail diets with CPE_X and MLE_X levels resulted in improving GSH-Px value, with reducing thiobarbaturic acid (TBAR) value (**Abdel-Kader *et al*., 2024a and b)**. Regarding thyroid hormones (T3 and T4), our results showed that diets treated with BLP levels had significantly improvements influence on T3 and T4 values (Table 6). Additionally, our findings are in the same

line with those explained by **Aly *et al*. (2023a and b)** who found that feeding quail diets with peppermint leaves powder (PLP) and it's respective. L. menthol crystal (LMC) resulted in an increase in the values of T3and T4.

3.5. Quality of quail meat

Quails fed diets containing 0.5, 1 and 1.5% BLP had significantly the highest values of appearance while, color, taste, flavor, texture and overall acceptability had no significant influence by the experimental treatments (Table 7). In this regard, **Kilany *et al*. (2018**) showed significant improvement on meat quality due to 0.5% or 1% levels basil supplemented diets.

Table 7. Influence of dietary basil leaves powder on quality of quail meat in growing Japanese quail

Item	Basil leaves powder level				SE	*p*-value
	0.0%	0.5 %	1.0 %	1.5 %		
Color	7.04^{b}	8.14^{a}	7.38^{ab}	7.52^{ab}	0.24	0.034
Taste	7.75	7.29	7.57	7.86	0.29	0.58
Flavor	7.25^{b}	8.38^{a}	7.33^{b}	7.24^{b}	0.31	0.038
Texture	7.75	7.76	7.71	8.00	0.24	0.86
Appearance	7.54^{b}	8.52^{a}	7.76^{b}	7.43^{b}	0.22	0.0065
Overall acceptability	7.50	7.76	7.76	7.90	0.21	0.61

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

3.6. Economic efficiency (EEf)

Net revenue, EEf and economic efficiency ratio (EEfR) values were improved for quails given BLP-diets as shown in Table 8. Quails fed with 1.5% BLP recorded the best EEfR, being 140.91%, followed by 1% and 0.5% BLP treatments (127.27 and 118.18%, respectively) Similarly, **El-Kashef *et al*. (2017) and Hussani *et al*. (2021)** discovered that, in comparison to the control group, quail and broiler chicks fed medicinal plants had a greater EEf. Recently, **(Aly *et al*., 2023a and b)** found that quails fed diets with PLP or LMC had higher economic efficacy values compared with the control group.

Table 8. Influence of dietary basil leaves powder on economic efficiency (EEf) in growing Japanese quail

Item	Basil leaves powder level			
	0.0%	0.5%	1.0%	1.5%
Av. Feed intake (Kg feed/Kg BW)	3.74	3.60	3.54	3.45
Price Kg feed = b (L.E.)	27.45	27.55	27.64	27.73
Total feed cost C= (a×b), (L.E.)	102.68	99.17	97.85	95.68
Price/one Kg gain = d (L.E.)	125.00	125.00	125.00	125.00
Net revenue (L.E.) = d-c = e	22.32	25.83	27.15	29.32
Economic efficiency (e/c)	0.22	0.26	0.28	0.31
Relative efficiency	100.00	118.18	127.27	140.91

L.E. = Egyptian Pound

4. Conclusions

The addition of basil leaves powder at rates of 0.5, 1.0 and 1.5% resulted in significantly increasing body weight gain, improving feed conversion ratio and decreasing feed intake. basil leaves powder-diets augmented carcass weight and depressed abdominal fat weight. Immune response, antioxidant parameters, digestive enzymes, thyroid hormones and economic efficiency were improved due to basil leaves powder-diets in growing Japanese quail.

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