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Impact of Marjoram, Basil, and Thyme Supplementation on Behavior, Welfare Indices, and Immune Response of Commercial Broilers

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ABSTRACT

Natural plants have gained attention in their dietary supplementation of birds as antibiotic alternatives and growth promoters. This experiment aimed to study the effect of *Origanum majorana*, *Ocimum basilicum*, and *Thymus vulgaris* as feed-additives on the behavior, welfare, performance, some hematological, and biochemical parameters and immune response [against Newcastle Disease Virus (NDV)]. A total of 80 healthy one day old chicks (Ross 308) were randomly allotted into 4 groups according to ration; each group contained 20 birds divided into 2 replicates (10 birds each). The dietary treatments consisted of basal diet without additive (control) (G1), basal diet supplemented with 1% marjoram (G2), basal diet supplemented with 1% basil (G3), and basal diet supplemented with 1% thyme (G4). Results revealed that body weight and body weight gain were significantly improved in broilers supplemented with 1% basil and 1% thyme. The feed conversion ratio (FCR) was significantly better in marjoram and thyme groups than others. Birds fed marjoram, basil, and thyme exhibited higher feeding, drinking, resting, and comfort behaviors than control birds. Control birds showed more walking, standing and preening behaviors than diet supplemented birds. Supplementation of diet with marjoram, basil, and thyme improved welfare (reduce stress and decrease fear responses). Total protein and globulin were significantly improved in supplemented groups. Basil and thyme increased hemoglobin concentrations. Supplemented birds had higher antibody titers against NDV than un-supplemented birds. It is concluded that herbal plants including marjoram, basil, and thyme had positive effects on commercial broilers' behavior, welfare, performance, immune response and economy.

1. INTRODUCTION

Livestock has a significant impact on the national economy and is an essential component of the agriculture industry [1]. Poultry production systems have undergone the most development of the entire livestock sector, particularly in the subjects of breeding, disease prevention, feeding, management, and organizing nutritional needs [2].

Since broiler chickens have extremely quick production, short breeding times, and relatively low investment compared to other livestock production sectors, which enables quicker turnover and, consequently, efficient and economical production, broiler chicken production is currently the most intensive area of animal husbandry [3-5].

Global health issues like drug resistance and the negative side effects of synthetic pharmaceuticals have created an urgent need for natural chemical substitutes for traditional medications. Because of their positive safety profiles and ability to alleviate side effects, plant extracts are regarded as an alternative [6]. Natural herbal products provide therapeutic and economic advantages by resolving health concerns, augmenting dietary nutrient effectiveness, and promoting body weight gain, productivity, and feed efficiency [7]. Adaptogens are herbs that enable appropriate responses to stress without excessive reactions from the organism [8].

Origanum majorana, also known as sweet marjoram, is a creeping aromatic medicinal herb that belongs to the Lamiaceae family and is indigenous to the Mediterranean region [9]. The primary active components include carvacrol, thymol, sabinene, y-terpinene, geraniol, linalool, camphene, a-thujene, rosmarinic acid, naringin, hesperetin, borneol, ß-caryophyllene, and ß-bisabolene [10]. [11] reported that adding oregano plants improved body weight gain when incorporated in chicken diets. The improvement in feed intake and conversion may be due to the ability of marjoram to increase the efficiency of digestion by increasing digestive enzymes, curing or preventing basic intestinal infections and alleviating diarrhea [12]. The increased MCV suggests that OM has a hematopoietic effect, as RBCs (both new and young) are more prominent and include a higher Hb amount [13].

Ocimum basilicum is typically grown in warm temperatures and tropical climates worldwide. It is additionally referred to as Rehan and Sweet Basil [14]. An in vivo study performed in male albino mice showed that O. basilicum L. leaf extract supplemented orally had the potential to improve neuromuscular coordination, active behavior, the ability to recognize matters, and short-term memory [15]. Significant anti-aging, anti-cancer, antiviral, antimicrobial, immunostimulatory, hepatoprotective, immunomodulatory, antihyperglycemic, hypolipidemic, antitoxic, and anti-inflammatory capabilities are all exhibited by the extracts of *Ocimum basilicum* leaves [16]. A higher ratio of protein efficiency and performance index values achieved when 1.0 g./kg of sweet basil was added to the feed of chickens during the growth and finishing phases. When added to broiler diets at levels of 0.5 or 1.0 g/kg, sweet basil enhanced carcass features, immunological status, and productivity [17].

An aromatic evergreen herb with medicinal applications, Thymus vulgaris is a member of the Lamiaceae family [18]. The antioxidant and bactericidal characteristics of thyme powder are well known. The two primary phenolic components of thyme, carvacrol and thymol, have strong antioxidant properties, antibacterial action against a variety of pathogens, antifungal and anticoccidial properties, and no cytotoxic effects. These characteristics enhance the general well-being of broilers [19,20]. Thymus vulgaris powder provides several benefits for chicken production, including improved feed conversion, immune-stimulating actions, and the potential to strengthen defenses [21].

The current study was designed to investigate the effects of diet supplementation with 1% marjoram, 1% basil and 1% thyme on the behavior, welfare, performance, some carcass traits, some blood and biochemical parameters and immune response against Newcastle Disease Virus (NDV) in broilers.

2. MATERIALS AND METHODS

2.1 Broilers' ethics statement:

The experiments were carried out during the period from December 2023 to February 2024. All chicken-handling procedures as well as samples' collection and disposal were approved by the Animal Ethics Committee of Menoufia University, Faculty of Veterinary Medicine (Approval number: MN/VET/BHV/25/03/03/01).

2.2. Broilers Management:

A total of eighty healthy unsexed one day old chicks (Ross 308) were obtained from private poultry farm, Menoufia Governorate, Egypt. Chicks were weighed on arrival (Average body weight on arrival was 44.15±.1gm) and randomly allotted according to dietary treatments into 4 groups (20 birds each) with

two replicates for each treatment (10 birds / replicate). Temperature at first week of life was 33°C, and then reduced by 3°C weekly until 21°C was reached. Artificial lightening provided 24 hours per day for the first 2 days to help chicks find feed and water [22], then one hour of darkness was applied daily until the end of the experiment at 35 days of age. Feed and water were provided *ad libitum*. Chicks were fed on commercial diet free from antibiotics (Table 1). The dietary treatments were consisting of: Group 1 (control group): chicks were fed on basal ration. Group 2 (marjoram group): chicks were fed on basal ration supplemented with 1% marjoram powder (10g/kg diet) [23, 24]. Group 3 (basil group): chicks were fed on basal ration supplemented with 1% basil powder (10g/kg diet) [25-27]. Group 4 (thyme group): chicks were fed on basal ration supplemented with 1% thyme powder (10g/kg diet) [27-29]. All birds were vaccinated according to a standard protocol. Chickens were vaccinated at 7th day against avian influenza, Newcastle, and infectious bronchitis diseases by EgyFlu®-ND7-3 in 1 (HARVAC, China) and MEVAC LASOTA+ H120® (MEVAC, Cairo, Egypt). Then at 14th day they were administered the second dose from these vaccines by MEVAC IBD 818® (MEVAC, Cairo, Egypt) and RINNOVAC ELI-7® (MEVAC, Cairo, Egypt).

Table [1]: Composition of basal ration (%).

Item (%)	Starter	Grower	Finisher
Yellow corn, ground	٥٧.٣	63.1	67.97
Soybean meal	٣٦.٢٤	30.38	26
Corn. Gluten	١.٥	1.5	1
Soya Oil	٠.٨	1.3	1.5
L-Lysine HCL (99%)	0.25	0.22	0.2
DL-Meth (99%)	0.32	0.28	0.25
Dicalcium phosphate	1.50	1.25	1.2
Limestone	1.25	1.17	1.1
Sodium bicarb	0.18	0.14	0.12
c.salt	0.25	0.25	0.25
Premix	0.1	0.1	0.1
Biological antimycotoxine	0.05	0.05	0.05
Anticoccidal drugs	0.05	0.05	0.05
physical toxin binder	0.10	0.10	0.10
Choline chloride	0.05	0.05	0.05
Phytase enzyme	0.01	0.01	0.01
NSPase enzyme	0.01	0.01	0.01
	Calculated analysis		
Crude protein	22.9	20.8	19
Calcium	1.02	0.92	0.86
available Phosphorus	0.51	0.48	0.46
Lysine	1.46	1.26	1.14
Methionine	0.7	0.62	0.55
Meth+cyst	1.05	0.97	0.86
ME (kcal/kg diet)	3010	3105	3150

2.3. Data Collection:

2.3.1. Growth Performance Parameters:

Growth performance parameters including broilers weekly body weight (BW), total body weight gain (BWG), and feed intake (FI) were documented. Feed conversion ratio (FCR) was calculated according to [29].

2.3.2. Carcass Traits Parameters:

Carcass traits were measured at forty-two days of age, three birds per pen were randomly chosen, weighed, slaughtered, eviscerated to calculate the dressing percent and their spleen, gizzard, liver, bursa and heart were weighed and computed as a percentage of live body weight [30].

2.3.3. Behavioral Observations:

Chicks of each treatment were directly observed in two periods/day, the 1st period was during morning (8.00-10:00) and the 2nd period was during afternoon (13.00-15.00) according to [31]. Each pen was observed for 15 minutes in each observation period. Bird's observation was performed two days a week for 5 consecutive weeks. The instantaneous sampling method was used to record the behavior of the chickens in each group [32]. The number of chickens engaged in feeding, drinking, resting, walking, standing, foraging, preening, wing-leg stretching and flapping, dust bathing, and feather pecking behaviors was scanned by one observer for the entirety the experiment. All scan samples in each pen at various ages were used to determine the percentage of chicks participating in each behavior.

2.3.4. Welfare Parameters:

At the 5th week, there were some behavioral tests done on 3 birds from each pen including:

2.3.4.1. Tonic immobility (fear test):

Tonic immobility (TI) reaction was assessed for 5–min test period, as described by [33,34].

2.3.4.2. Feather score:

Back, rump, breast, wing, and total feather coverage scores were displayed to the chicks. A score of 1 denoted minimum coverage, or less than 25%; a score of 2 meant 25–50%; a score of 3 meant 50–75%; a score of 4 meant more than 75%; and a score of 5 meant full coverage [35].

2.3.4.3. Gait score:

The gait score is considered a symbolic sign in broilers [36], For instance, (0) = its gait is smooth and the foot curls when lifted, and the bird appears well-balanced; (1) = it is challenging to determine which side has the injured leg or foot, the gait is irregular, and the foot may or may not curl when raised; (2) = its stride is reduced, its foot stays flat when raised, its gait is irregular, and it may have trouble balancing and rely on its wings for support; (3) = similar to gait score of 2 but remains to lie down unless gently nudged to move, more likely to use wings for balance and support; also, it cannot stand for more than 25 s and typically lies down after a series of steps; (4) = the bird can only take a few steps before lying back down, and it needs up to five seconds before it stands on both feet and walks using its wings as crutches; (5) = when forced to move, it will shuffle because it is incapable of taking a single step.

2.3.4.4. Footpad lesion score and hock burns score:

The footpad was evaluated on a scale that went from 0 (healthy foot) to 3 (severely afflicted foot) [37]. The hock condition was assessed using a scale that went from 0 (healthy hock) to 2 (severely suffering hock) [38]. Both legs were examined for footpad and hock condition. If a bird has a healthy foot and the other was affected, subsequently, score taken onto affected one.

2.3.4.5. Latency to Lie (LTL):

LTL test was designed to detect the health condition of the leg, by calculating the time at which the bird can continue preserve abstain from taking a seat in shallow, fortunes warm water (5-minute test period) [39].

2.3.5. Hematological and Biochemical Parameters:

At the 35th day of age, blood samples were collected (three chicks from each pen, 6 chicks per treatment). A 5 ml blood sample was taken into two portions. The first portion was received into a heparinized tube for hematological measurements (RBCs count, PCV, Hb, MCV, MCH and MCHC). To determine the differential leukocytic count, blood smears had been carried out. One hundred leucocytes were counted using a light microscope equipped with an oil immersion lens x 40 and May-Gunwald-Giemsa stain. The ratio of heterophils to lymphocytes was evaluated.

The second portion was collected into plain non heparinized tube and left to clot, then centrifuged at 3000 rpm for 15 minutes to extract serum [40].

Collected serum samples were stored at -20°C until used for the determination of the following

biochemical parameters: total protein, albumen, globulin, urea, creatinine and cholesterol levels.

2.3.6. Immune Response:

Antibody titer against NDV was determined at 14th and 35th days of age. Random blood samples were obtained from 5 chicks per treatment from the wing vein without anticoagulant to gather serum which was kept at -20°C for subsequent analysis. The antibody titers, which were represented as the log2, were ascertained using the HI test [41].

2.3.7. Economic Efficiency:

Total production costs included the price of chicks, feed (basal diet and natural plants), and management. Net revenue was calculated as the difference between the selling price of live broilers and total production costs. Economic feed efficiency (EFE) and relative economic feed efficiency (REFE) were determined as follows:

$$(EFE) = \text{Net revenue} / \text{Total production costs}$$

$$(REFE) = \frac{\text{EFE of group}}{\text{EFE of control}} \times 100$$

The European performance efficiency factor (EPEF) was calculated using the following formula: body weight (kg) × % viability ×100/ feed conversion ratio × trial duration in days of commercial broilers.

2.3.8. Statistical Analysis:

IBM SPSS statistics (version 22) were used for the statistical analysis. Analysis of variance, one-way ANOVA, and Duncan's multiple range were performed on the data. The obtained results were presented as mean ± standard error. $P \leq 0.05$ was used to declare the data to be different. [42].

3. RESULTS

3.1. Growth performance parameters:

In the present study, BW, BWG and FCR were significantly influenced by the addition of natural plants to diets.

Effect of dietary treatments on body weight of broiler chicks is presented in Table (2). At the end of the 2nd week of supplementation, BW of broilers supplemented with 1% basil and 1% thyme was significantly higher than body weight of birds in control group. Additionally, BW of broilers supplemented with 1% basil was significantly higher than BW of control group during 3rd week and 4th week. The final BW of birds fed on 1% basil and 1% thyme `was higher than un-supplemented control birds (P<0.05). BW of birds fed diet contain 1% marjoram not significantly differed from control birds or birds fed 1% basil and 1% thyme.

Effects of dietary treatments on BWG and FCR are shown in Table (3). Results indicated that the highest BW was recorded in broilers supplemented with 1% thyme compared with control group during 2nd week (P<0.05).

Table [2]: Effect of dietary treatments on body weight (g) of commercial broilers (Mean±SE).

Groups	Weekly Body Weight					
	Wk0	**Wk1**	**Wk2**	**Wk3**	**Wk4**	**Wk5**
G1	44.28 ± 0.14	203.50 ± 3.14	514.50^{b} ± 13.86	983.50^{b} ± 36.303	1546.00^{b} ± 58.52	2275.00^{b} ± 92.63
G2	44.06 ± 0.04	211.31 ± 4.16	533.68^{ab} ± 12.77	1010.52^{ab} ± 23.91	1604.73^{ab} ± 46.16	2426.11^{ab} ± 50.50
G3	44.17 ± 0.08	210.00 ± 4.24	558.50^{a} ± 10.22	1088.00^{a} ± 20.46	1752.50^{a} ± 37.54	2485.25^{a} ± 49.60
G4	44.08 ± 0.13	199.73 ± 3.61	552.25^{a} ± 10.43	1049.25^{ab} ± 24.82	1666.05^{ab} ± 57.21	2562.33^{a} ± 69.04
P- value	NS	NS	0.045	0.043	0.031	0.031

$^{a-b}$ Means (± SE) within the same column carry different superscript letters are significantly different at (p≤0.05). NS: non-significant. **G1**: control (supplemented basal diet), **G2**: marjoram (supplemented basal diet + 1% marjoram), **G3**: basil (supplemented basal diet + 1% basil), **G4**: thyme (supplemented basal diet + 1% thyme).

Total weight gain was significantly (P<0.05) higher in broilers supplemented with 1% basil and 1% thyme than broilers in control group, with birds supplemented with 1% marjoram were intermediary but not different from them. FCR was significantly (P<0.05) better in marjoram and thyme groups compared to the control group, but basil group showed non-significant effect on FCR.

Table [3]: Effect of dietary treatments on body weight gain (g), and feed conversion ratio of commercial broilers (Mean±SE).

Groups	Weekly Body Weight Gain					Total Body Weight Gain	FCR	EPEF
	Wk1	Wk2	Wk3	Wk4	Wk5			
G1	159.22 ± 3.20	311.00^{b} ± 14.52	469.00 ± 34.59	562.50 ± 51.01	723.94 ± 111.44	2230.66^{b} ± 92.61	1.59^{a} ±0.10	408.80 ±8.10^{b}
G2	167.25 ± 4.17	322.36^{ab} ± 13.71	476.84 ± 30.43	594.21 ± 42.84	829.41 ± 62.09	2382.08^{ab} ± 50.50	1.34^{b} ±0.03	517.29 ±7.55^{a}
G3	165.83 ± 4.24	348.50^{ab} ± 11.32	529.50 ± 19.64	664.50 ± 41.49	731.75 ± 63.86	2441.07^{a} ± 49.60	1.42^{ab} ±0.03	500.30 ±8.55^{a}
G4	155.65 ± 3.60	362.50^{a} ± 15.83	497.00 ± 21.24	614.21 ± 62.04	888.66 ± 83.69	2518.12^{a} ± 69.00	1.36^{b} ±0.04	538.30 ±8.55^{a}
P- value	NS	0.042	NS	NS	NS	0.03	0.024	0.01

$^{a-b}$ Means (± SE) within the same column carry different superscript letters are significantly different at (p≤0.05). NS: non-significant. **G1**: control (supplemented basal diet), **G2**: marjoram (supplemented basal diet + 1% marjoram), **G3**: basil (supplemented basal diet + 1% basil), **G4**: thyme (supplemented basal diet + 1% thyme).

3.2. Carcass Traits:

Results from Table (4) demonstrated that 1% marjoram, 1% basil, and 1% thyme supplementation for broilers resulted in significantly increased of carcass % (P<0.01) and bursa of Fabricius relative weight (P<0.05) compared to control birds. However, there were no significant differences among control and all supplemented groups in the weights of spleen, liver, heart, and gizzard.

Table [4]: Effect of dietary treatments on carcass traits of commercial broilers (Mean±SE).

Groups	Carcass Traits					
	Carcass %	Spleen (%)	Bursa of Fabricius (%)	Liver (%)	Heart (%)	Gizzard (%)
G1	0.74^{b}±0.01	0.15±0.01	0.06^{b}±0.01	2.42±0.10	0.45±0.01	1.47±0.16
G2	0.77^{a}±0.01	0.21±0.01	0.13^{a}±0.01	2.31±0.05	0.46±0.01	1.69±0.12
G3	0.76^{a}±0.01	0.18±0.02	0.11^{a}±0.02	2.24±0.18	0.42±0.02	1.55±0.18
G4	0.77^{a}±0.01	0.19±0.03	0.10^{a}±0.01	2.07±0.04	0.45±0.02	1.67±0.14
P- value	0.01	NS	0.013	NS	NS	NS

$^{a-b}$ Means (± SE) within the same column carry different superscript letters are significantly different at (p≤0.05). NS: non-significant. **G1**: control (supplemented basal diet), **G2**: marjoram (supplemented basal diet + 1% marjoram), **G3**: basil (supplemented basal diet + 1% basil), **G4**: thyme (supplemented basal diet + 1% thyme).

3.3. Behavioral Observations:

Data presented in Table (5) revealed that marjoram, basil and thyme supplementation for broilers had a significant effect on broilers behavior. Feeding and drinking behaviors were significantly decreased in the birds of control group (P<0.01 and P<0.05 respectively) compared with the birds of supplemented groups. Significant high proportion of birds supplemented with 1% basil and 1% thyme were engaged in resting behavior (P<0.01) compared to control un-supplemented birds, while those fed on 1 % marjoram showed intermediate proportion in comparison with un-supplemented

ones. Control group showed significantly (P<0.01) increased walking, standing, and preening behaviors compared with other supplemented groups. Birds supplemented with 1 % marjoram exhibited significantly higher (P<0.01) foraging behavior while birds fed 1 % basil exhibited the lowest one. Birds fed on 1 % basil showed significantly higher (P<0.01) wing/leg stretching and flapping compared to birds in other groups. Higher proportion of birds supplemented with 1 % basil and 1 % thyme were recorded as engaged in more dust bathing behavior (P<0.05) compared to the control one, with birds supplemented with 1 % marjoram were intermediary but not different from them (P>0.05). However, feather pecking was not significantly affected by the dietary treatment.

Table [5]: Effect of dietary treatments on behavioral patterns (%) of commercial broilers (Mean±SE).

Behavioral patterns %	Groups				p-value
	G1	G2	G3	G4	
Feeding	11.94^{b}±0.65	15.71^{a}±0.82	15.00^{a}±0.72	16.75^{a}±0.73	0.01
Drinking	7.47^{b}±0.44	9.23^{a}±0.51	9.32^{a}±0.52	9.33^{a}±0.50	0.016
Resting	45.44^{c}±1.14	48.52^{bc}±1.15	52.08^{a}±1.07	49.85^{ab}±1.11	0.01
Walking	4.25^{a}±0.45	1.46^{b}±0.18	1.17^{b}±0.17	1.53^{b}±0.19	0.01
Standing	4.15^{a}±0.39	1.56^{b}±0.16	1.17^{b} ±0.16	1.19^{b}±0.15	0.01
Foraging	6.52^{b}±0.37	8.06^{a}±0.45	4.83^{c}±0.36	7.38^{ab}±0.46	0.01
Preening	16.44^{a}±0.67	11.12^{b}±0.56	10.73^{b}±0.50	9.80^{b}±0.47	0.01
Stretching/ Flapping	2.83^{b}±0.29	3.54^{b}±0.28	4.56^{a}±0.30	9.80^{b}±0.47	0.01
Dust- bathing	0.06^{b}±0.03	0.27^{ab}±0.07	0.38^{a}±0.10	0.31^{a}±0.08	0.031
Pecking	0.87±0.13	0.52±0.10	0.74±0.12	0.58±0.11	NS

$^{a-b}$ Means (± SE) within the same column carry different superscript letters are significantly different at (p≤0.05). NS: non-significant. **G1**: control (supplemented basal diet), **G2**: marjoram (supplemented basal diet + 1% marjoram), **G3**: basil (supplemented basal diet + 1% basil), **G4**: thyme (supplemented basal diet + 1% thyme).

3.4. Welfare Parameters:

There was a significant decrease in the duration of tonic immobility in birds supplemented with 1% marjoram, 1% basil and 1% thyme than birds in control group (P<0.05) as shown in (Table 6). Dietary supplementation with 1% marjoram, 1% basil and 1% thyme had no significant effect on latency to lie test duration (P>0.05) (Table 6).

Data presented in Table (7) indicated that, hock burns were significantly (P<0.01) increased in control group than other supplemented groups. Dietary supplementation with 1% marjoram, 1% basil and 1% thyme had no effect on feather score, gait score and footpad lesion scores (P>0.05).

Table [6]: Effect of dietary treatments on Tonic immobility (TI) (duration/second) and LTL (duration/second) of commercial broilers (Mean±SE).

Groups	TI (Second)	LTL (Second)
G1	215.50^{a} ±23.45	139.83±51.31
G2	62.83^{b} ±16.54	122.50±38.38
G3	113.83^{b} ±39.60	117.83±34.91
G4	114.16^{b} ±33.12	99.66±41.85
P- value	0.012	NS

$^{a-b}$ Means (± SE) within the same column carry different superscript letters are significantly different at (p≤0.05). NS: non-significant. **G1**: control (supplemented basal diet), **G2**: marjoram (supplemented basal diet + 1% marjoram), **G3**: basil (supplemented basal diet + 1% basil), **G4**: thyme1% thyme

Table [7]: Effect of dietary treatments on feather score, gait score, foot pad lesion score, and hock burns score of commercial broilers (Mean±SE).

Groups	Feather score					Gait score	Foot pad lesion score	Hock burns score
	Back	rump	breast	wing	Total			
G1	4.83 ±0.16	5.00 ±0.00	1.00 ±0.00	4.66 ±0.34	15.5 ±0.34	0.16 ±0.016	0.83 ±0.016	1.50^{a} ±0.22
G2	4.50 ±0.34	4.66 ±0.33	1.00 ±0.00	4.83 ±0.16	15.00± 0.44	0.33 ±0.021	0.66 ±0.021	1.00^{b} ±0.00
G3	4.83 ±0.16	4.83 ±0.16	1.00 ±0.00	4.66 ±0.21	15.33± 0.21	0.66 ±0.033	0.50 ±0.22	1.00^{b} ±0.00
G4	4.66 ±0.33	4.66 ±0.33	1.00 ±0.00	4.66 ±0.33	15.01± 0.68	1.16 ±0.047	0.66 ±0.021	1.00^{b} ±0.00
P- value	NS	NS	NS	NS	NS	NS	NS	0.01

$^{a-b}$ Means (± SE) within the same column carry different superscript letters are significantly different at ($p \leq 0.05$). NS: non-significant. **G1**: control (supplemented basal diet), **G2**: marjoram (supplemented basal diet + 1% marjoram), **G3**: basil (supplemented basal diet + 1% basil), **G4**: thyme (supplemented basal diet + 1% thyme).

3.5. Hematological and Biochemical Parameters:

Marjoram, basil, and thyme supplementation as feed additives had effect on some hematological and biochemical responses of broilers. Groups supplementation with 1% marjoram, 1% basil, and 1% thyme showed significantly increased total protein ($P<0.01$) and globulin ($P<0.05$) levels compared to control group. While dietary supplementation had no effect on the estimated albumen, creatinine, urea, and cholesterol ($P>0.05$) as shown in Table (8).

Table [8]: Effect of dietary treatments on hematological parameters of commercial broilers (Mean±SE).

Hematological Parameters	Groups				P-value
	G1	G2	G3	G4	
RBCs (10^6 /mm3)	1.96±0.08	2.046±0.06	2.076±0.04	2.02±0.09	NS
PCV (%)	26.05±1.00	26.11±1.79	25.24±1.05	28.21±0.76	NS
Hb (g/dl)	8.09^{b}±0.30	8.82^{ab}±0.13	9.79^{a}±0.49	9.33^{a}±0.43	0.02
MCV (μ^3)	133.75±7.43	129.58±11.98	121.76±4.45	140.98±8.15	NS
MCH (fl)	41.45±1.59	43.51±1.61	47.27±2.38	46.30±1.99	NS
MCHC (%)	31.15±0.87	34.41±1.82	39.43±3.40	33.29±2.07	NS
Heterophil%	28.00^{a}±1.97	19.20^{b}±0.58	20.20^{b}±0.91	21.40^{b}±0.50	0.01
Lymphocyte%	62.40^{b}±2.22	72.80^{a}±1.15	73.00^{a}±1.30	72.40^{a}±1.36	0.01
Monocyte%	5.00±0.31	5.20±0.37	4.00±0.44	4.20±0.66	NS
Basophil%	2.40±0.40	1.00±0.31	1.60±0.50	1.20±0.37	NS
Eosinophil%	2.20±0.37	1.80±0.58	1.20±0.48	0.80±0.20	NS
H/L ratio	0.45^{a} ±0.05	0.26^{b} ±0.01	0.27^{b} ±0.02	0.29^{b} ±0.01	0.01

$^{a-b}$ Means (± SE) within the same column carry different superscript letters are significantly different at ($p \leq 0.05$). NS: non-significant. **G1**: control (supplemented basal diet), **G2**: marjoram (supplemented basal diet + 1% marjoram), **G3**: basil (supplemented basal diet + 1% basil), **G4**: thyme (supplemented basal diet + 1% thyme).

Results from table (9) demonstrated that birds fed on 1% basil and 1% thyme showed significantly ($P<0.05$) increased hemoglobin concentrations compared to control birds, with birds fed on 1 % marjoram were intermediary but not different from them. On the other hand, there was no effect of

dietary treatment on RBCs, PCV, MCV, MCH, and MCHC. Birds fed Supplemented diet had significantly (P<0.01) more lymphocyte % compared to control birds, however, heterophil % was significantly higher (P<0.01) in the birds of control group compared with chicks in all supplemented diet groups. Also, broilers fed the control diet had a significant increase (P<0.01) in H/L ratio when compared with chicks fed 1% basil, 1% marjoram and 1% thyme.

Table [9]: Effect of dietary treatments on biochemical parameters of commercial broilers (Mean±SE).

Groups	Biochemical Parameters					
	Total protein (g/dl)	**Albumen (g/dl)**	**Globulin (g/dl)**	**Creatinine (mg/dl)**	**Urea (mg/dl)**	**Cholesterol (mg/dl)**
G1	3.93^{b} ±0.14	2.64 ±0.09	1.29^{b} ±0.18	0.36 ±0.03	16.26 ±0.29	156.07 ±11.88
G2	4.82^{a} ±0.33	2.86 ±0.23	1.96^{a} ±0.33	0.34 ±0.02	15.45 ±0.72	139.98 ±16.42
G3	4.55^{a} ±0.08	2.52 ±0.11	2.03^{a} ±0.17	0.44 ±0.03	16.33 ±0.29	146.54 ±8.21
G4	5.10^{a} ±0.14	2.97 ±0.15	2.12^{a} ±0.02	0.38 ±0.03	16.65 ±0.40	140.86 ±11.65
P- value	0.003	NS	0.04	NS	NS	NS

$^{a-b}$ Means (± SE) within the same column carry different superscript letters are significantly different at (p≤0.05). NS: non-significant. **G1**: control (supplemented basal diet), **G2**: marjoram (supplemented basal diet + 1% marjoram), **G3**: basil (supplemented basal diet + 1% basil), **G4**: thyme (supplemented basal diet + 1% thyme).

3.6. Immune response:

Results from table (10) indicated that birds supplemented with 1% basil and 1% thyme showed significantly (P<0.05) higher antibody titer against NDV at 14th day of age compared to control birds, with birds fed 1% marjoram were intermediate but not differed from them (P>0.05). At 35th day of age birds fed 1% marjoram, and 1% thyme had higher (P<0.05) anti boy titer than un-supplemented birds, with birds fed 1% basil were intermediate but not differed from them (P>0.05).

Table [10]: Effect of dietary treatments on antibody titer (log2 HI) against NDV of commercial broilers (Mean±SE).

Groups	14th day	35th day
G1	5.40^{b}±0.16	6.12^{b} ±0.29
G2	5.90^{ab}±0.27	7.37^{a} ±0.49
G3	6.10^{a}±0.27	7.12^{ab}±0.35
G4	6.30^{a}±0.15	7.50^{a} ±0.26
P- value	0.044	0.050

$^{a-b}$ Means (± SE) within the same column carry different superscript letters are significantly different at (p≤0.05). NS: non-significant. **G1**: control (supplemented basal diet), **G2**: marjoram (supplemented basal diet + 1% marjoram), **G3**: basil (supplemented basal diet + 1% basil), **G4**: thyme (supplemented basal diet + 1% thyme).

3.7. Economic Efficiency:

The results observed in Table (11) cleared that, the economic parameters and economic efficiency measures differ significantly (P<0.01) among different examined groups. The productive parameters including feed intake and herb intake showed that, the feed intake showed a higher level in basil group that was 3.45 kg and the lower feed intake observed in marjoram group that was 3.13 kg

and the herb intake it value ranged from 0 in control group and the higher level that observed in basil group and thyme group that was 0.03 kg. European production efficiency factor (EPEF) showed a higher level in thyme group, followed by its level in marjoram group and basil group and the lower level observed in control group.

Table [11]: Effect of dietary treatments on economic parameters and economic efficiency measures among different groups (Value / bird) of commercial broilers.

Item	G1	G2	G3	G4
Productive parameters				
Feed intake (Kg)	3.37±0.37^{a}	3.13±0.13^{a}	3.45±0.45^{a}	3.40±0.40^{a}
Natural plants intake (1% of bird feed intake) (KG)	0^{b}	0.032±0.001^{a}	0.035±0.002^{a}	0.035±0.001^{a}
EPEF	408.80±8.10^{b}	517.29±7.55^{a}	500.05±7.80^{a}	538.30±8.55^{a}
Variable costs parameters				
Feed price	80.98±9.80^{a}	74.99±9.80^{b}	82.93±7.90^{a}	81.67±6.77^{a}
Herb cost	0^{b}	2.52±0.21^{a}	2.80±0.21^{a}	2.75±0.15^{a}
Total feed cost	80.98±9.80^{b}	77.51±9.89^{c}	85.73±8.90^{a}	84.42±7.78^{a}
Chick price	30^{a}	30^{a}	30^{a}	30^{a}
Management costs	15±1.55^{a}	15±1.55^{a}	15±1.55^{a}	15±1.55^{a}
Other costs	5±1.44^{a}	5±1.44^{a}	5±1.44^{a}	5±1.44^{a}
Total variable costs	130.98±8.89^{b}	127.51±7.55^{c}	135.73±7.44^{a}	134.42±7.33^{a}
Fixed costs parameters*				
Depreciation of building	20^{a}	20^{a}	20^{a}	20^{a}
Equipment depreciation	5^{a}	5^{a}	5^{a}	5^{a}
Total fixed costs	25^{a}	25^{a}	25^{a}	25^{a}
Total costs				
Total costs	155.98±9.88^{d}	152.50±7.89^{c}	160.73±7.78^{b}	169.92±9.66^{a}
Return parameters				
Final weight	2.27±0.77^{d}	2.42±0.42^{c}	2.48±0.40^{b}	2.56±0.55^{a}
Litter sale	10±0.14^{a}	10±0.14^{a}	10±0.14^{a}	10±0.14^{a}
Total return	184.27±2.77^{d}	196.51±3.49^{c}	201.30±3.11^{b}	207.54±4.55^{a}
Net profit				
Net profit	28.29±2.91^{d}	44.01±4.11^{a}	40.57±4.55^{b}	37.08±3.77^{c}
Economic efficiency measures				
Feed costs/ Total variable costs	61.83±3.88^{c}	60.79±4.71^{d}	63.17±3.17^{a}	62.81±3.81^{b}
Feed cost/total costs	51.92±4.91^{b}	50.83±4.80^{c}	53.34±4.81^{a}	49.69±6.91^{d}
Feed costs/total returns	43.50±5.41^{a}	39.45±3.17^{d}	42.59±4.41^{b}	40.68±4.11^{c}
Net profit / Feed costs	34.94±4.11^{d}	56.78±4.11^{a}	47.33±3.47^{b}	43.93±4.13^{c}
Net profit/Total costs	18.14±2.11^{d}	28.86±2.89^{b}	25.25±2.51^{a}	21.83±2.13^{c}
Net profit/variable costs	21.59±2.14^{d}	34.51±2.42^{a}	29.89±2.14^{b}	27.58±3.14^{c}
Benefit / cost ratio	227.56±6.15^{d}	253.53±5.12^{a}	234.80±6.11^{c}	245.84±8.11^{b}

$^{a-b}$ Means (± SE) within the same column carry different superscript letters are significantly different at ($p\leq0.05$). NS: non-significant. **G1**: control (supplemented basal diet), **G2**: marjoram (supplemented basal diet + 1% marjoram), **G3**: basil (supplemented basal diet + 1% basil), **G4**: thyme (supplemented basal diet + 1% thyme).

The variable costs level showed a higher level in basil group that was 135.73 LE and the lower level 127.51 LE in marjoram group. The fixed costs parameters not differ significantly among the different groups ($P>0.05$) that was 25 LE/bird. The total costs level showed a higher level in basil group that was 160.73 LE and the lower level 152.50 LE in marjoram group.

The final weight of the bird showed a higher level in thyme group that was 2.56 kg/bird and in control group that was 2.27/kg and the total return showed a higher level in thyme group that was 207.54 LE/bird and 184.27 LE/bird in control group. The higher net profit was observed in marjoram group that was 44.01 / bird and the lower net profit observed in control group that was 28.29 LE.

The results of Economic efficiency parameters cleared that, the higher feed costs/total variable costs showed a higher level in basil group that 63.17 % and the lower value observed in control group that was 61.83. While, the higher feed costs/total costs showed a higher level in basil group that 53.34 % and the lower value observed in thyme group that was 49.69. The results of feed costs / total returns showed a higher level in control group that was 43.50 and the lower value observed in marjoram group that was 39.45. The results of net profit / feed costs showed a higher level in marjoram group that was 56.78 and the lower level observed in control group that was 34.94 LE.

The results of net profit / total costs showed a higher level in marjoram group that was 28.86 % and the lower level observed in control group that was 18.14 LE. The results of net profit / variable costs showed a higher level in marjoram group that was 34.51 % and the lower level observed in control group that was 21.59 LE. The results of Benefit / cost ratio showed a higher level in marjoram group that was 253.53 % and the lower level observed in control group that was 227.56.

Our study concluded that, the marjoram group is the best group economically followed by thyme group and basil group and all of them is better than the control group.

4. DISCUSSION

In the current study, BW, BWG and FCR were significantly influenced by the addition of herbal plants to diets. Birds supplemented with 1% basil and 1% thyme had significantly higher BW and BWG than control birds (P<0.05). Birds supplemented with 1% marjoram had better BW and BWG than control birds however, the differences do not reach to significant value. FCR was significantly (P<0.05) better in marjoram and thyme groups compared to the control group. Supplemented birds' increased productivity may be due to antibacterial, growth-stimulating, immunostimulant, and antioxidant substances [12,16,20].

Results from productive performance in this study were in close agreement with [17,43] who reported that, Growth performance was enhanced when basil leaves and seeds were added to the diet. [25] reported that the incorporation of 0.5%, 1.0% and 1.5% basil in Ross 308 diet improved the performance and feed conversion ratio. [44] showed that feed consumption, and feed conversion ratio were unaffected by the addition of 1, 2, or 3% basil flour to the chick diet. [45] revealed that comprising sweet basil powder significantly (P<0.05) increased live body weight, and body weight gain as compared with the control. [46] indicated that, live body weight and body weight gain were significantly (P<0.05) raised by 1% basil powder and 1% thyme. [47] showed that broiler hens that had 0.5 and 1% thyme added to their diet gained more weight and had a lower feed conversion rate. [48] concluded that thyme leave powder at the level of 1, 2 and 3 g/kg of diet significantly improved BW, BWG and FCR of broiler chicks. [49,50] indicated that broiler diets supplemented with *Origanum majorana* showed improvements in BW and BWG. [24] concluded that, the addition of 1% powdered marjoram leaves to broiler chick nourishment resulted in a significant improvement in body weight, daily weight gain, and FCR. The enhanced weight increase and feed conversion ratio are likely indicated that nutritional addition with elevated levels of Marjoram enhances economic efficiency by improving carcass features, immunological performance, and production [17]. This increase in body weight was due to the presence of phytochemicals in the leaf powder of OM which act as growth promoters through enhancing the digestion and absorption action in the intestine [50].

Additionally, administering elevated levels of marjoram (1.58 g feed/g gain) resulted in an improved feed conversion ratio, enhanced performance guide values, and superior protein efficiency ratio [51]. On the contrary, [52] reported neither feed conversion nor body weight were affected by adding marjoram to the broiler diet. Also, [53] showed that feed conversion ratio significantly (P<0.05) increased by the supplementation with sweet basil powder. [54] indicated no differences in BWG and FCR of broilers fed diets enriched with five herbal feed additives and an antibiotic growth enhancer from day 0 to 42 of age.

1% marjoram, 1% basil, and 1% thyme supplementation for broilers significantly increased carcass % and bursa of Fabricius weight compared to control birds. [55] indicated that bird's immune

state is indicated by the relative weight of its lymphoid organs. It has been reported that the supplementation of medicinal plants stimulates the growth of immune organs of broilers and causes a significant increase in their weight [56]. [57] stated that the poultry immune response can be affected by several extrinsic or intrinsic factors; one of the important extrinsic factors affecting bird immunity level is the diet and its composition. The lymphoid organs responsible for poultry immunity include primary and secondary organs. The primary organs are the thymus and bursa of Fabricius [58]. These organs are the homes for maturation, differentiation, and immunocompetence of T and B types of lymphocytes [59]. Functional T and B cells migrate from the primary to the secondary lymphoid organs, including the bone marrow and spleen [60].

In the current study, the bursa showed significant increment in their weight, which means that the presence of flavonoids and phenolics, which have antibacterial, antioxidant, and immune-modulating properties, may be the explanation for why broiler immune responses improved when supplemented with herbal plant powder [12,16,20]. The presence of bioactive compounds probably stimulates cell proliferation in the immune organs. [61] found increased bursal weight as a consequence of supplementing thyme. [62] found 1% basil supplementation resulted in an increase in bursal weight. On the other hand, [24] mentioned that the proportion of bursa was not significantly affected by the marjoram supplementation. [63] found that the broiler chicks' relative weights of the spleen and bursa were unaffected by the addition of thyme and ginger.

Results in this study agreed with [64] who reported notable improvements in carcass yield in broilers fed extract-supplemented diets and those fed diets with varying concentrations of thyme powder and extract [61]. [65] showed that the percentage of carcass was higher in birds fed a low-energy diet supplemented with a blend of cumin and thyme. Similarly, adding 10g/kg of basil seed resulted in the highest dressing percentage [66]. In the same trend, [45] stated that the effect of basil in broiler chicken diets was reported to increasing the dressing percentage. Also, the carcass weight increased considerably when 0.5% marjoram was fed [67].

Weights of the liver, heart, and gizzard did not show any significant difference when marjoram [23,49], basil [45,66] or thyme [61,63,68] were added to broiler diet. Our study revealed that marjoram, basil and thyme supplementation for broilers had a significant increase in broiler feeding (P<0.01) and drinking (P<0.05) behaviors, which was in turn reflected on final BW, BWG and other productive performance. The increased feed intake in supplemented groups may be due to appetizing effects of ingredients. [17] stated that, Natural feed additives have the capacity to increase broiler appetite because they are abundant in a wide range of secondary metabolites, including terpenoids, which have been found to have antimicrobial properties [69], and antioxidant activity [70], It finally enhances the health of the bird and improves body weight and weight gain by improving the bacterial population, lower gastrointestinal health, and nutrient absorption and utilization.

[71] indicated that poultry feeding behavior may be improved by using fragrant herbs and their extracts. The results of [72] study on the fear response of birds acknowledged the existence of a negative relationship between fear and feeding behaviors in poultry, since a reduction in the fear reaction resulted in an increased in feeding behavior. Results from ingestive behavior are in accordance with [36] who observed that the birds' eating and drinking behaviors increased when marjoram powder was added, but this increase was insignificant. Additionally, [73,74] reported that feeding behavior was significantly higher in thyme supplemented birds compared to control birds. These results were disagreed with [63,75,76] who indicated that diet supplemented with thyme had no impact on feed intake in broilers. Moreover, [53] indicated that Compared to the control group, birds fed basil reported lower feed intake.

Control group showed significant (P<0.01) increased in walking, standing, and preening behaviors compared with other supplemented groups. Similar results found in the study of [72] that found increased standing and walking behaviors in the control and ginger-supplemented birds, which could be connected to the groups' poor feeding behavior, and this reflect on body weight. [77] reported that pacing and consumption rate had a negative relationship. Moreover, [78] observed that the percentage of time spent feeding, scratching, and pecking activities decreased as the percentage of time spent standing and walking increased.

Birds supplemented with 1% of herbal plants were engaged in significantly (P<0.01) more resting behavior in contrast to birds in control group. Wing stretching and/or wing flapping and dust bathing behaviors were increased in groups supplemented with 1% of herbal plants compared to control group.

The chemical components of herbal plants, which strengthen the bird's immune system and lessen the effects of stress and fear, may be responsible for the improved comfort behaviors in the supplemented groups. This in turn, may have an impact on the comfort behaviors and welfare of the birds.

There was a significant decrease (P<0.05) in duration of tonic immobility (second) in the birds supplemented with 1% marjoram, 1% basil and 1% thyme than control birds. Similarly, [72] mentioned that compared to birds fed with garlic, ginger, thyme, and antibiotics, the un-supplemented control group exhibited a much longer duration in the TI test and appeared to be frightened. [79] showed that a prolonged period of TI is believed to be a sign of elevated fearfulness. Fearfulness may be the cause of control birds' poor productivity. [80,81] indicated a detrimental relationship between emotions of fear and the welfare and overall performance of birds.

Our results indicated that control birds had worse (P<0.01) hock burns score compared to birds in all supplemented groups. Dietary supplementation had no effect on plumage cover scores, footpad lesion scores, and latency to-lie-test. These results indicate a positive effect of herbal plants supplementation on bird's welfare not only on hock burns score but also, despite resting behavior and body weight were higher in supplemented birds their welfare indices measured in this study related to gait, feather, footpad lesion scores, and latency to-lie-test were not severely affected and not differed from control birds.

Birds fed 1% marjoram, 1% basil, and 1% thyme showed significantly (P<0.05) increased serum total protein and globulin than control birds. [23] indicated that the significant increase in globulin levels showed that the OM can boost broiler chick' immune state. [82] found that the greatest concentrations of albumen, globulin, and total protein were detected when 0.4 dried OM plants were added. This suggests that the treatment improved immunity or enhanced it, possibly as a result of a better balance between albumen and globulin values and a higher concentration of globulin value. Furthermore, a higher globulin content is indicative of improved bird immune response and disease resistance as indicated by [83]. Bird blood proteins are a key indicator of both production characteristics and health state, and their analysis provides a baseline in general biochemistry that enables the detection of metabolic changes [84,85]. Considering that blood proteins play a variety of physiological functions in the body and help maintain homeostasis, determining the amounts of these proteins in broilers is extremely important for assessing both body condition and health [86]. Furthermore, the amount and composition of proteins in the blood may be strongly impacted by the manner in which proteins are incorporated into the tissues [87]. Considering how rapidly hens gain body mass over the comparatively brief fattening period, this component is crucial. Chicken meat's high protein level makes it the perfect nourishment for anyone in need of high-quality, easily digestible protein [27].

This finding was in close agreement with [54] who demonstrated that including marjoram powder (1 g/kg) into boiler feed increased total serum protein levels. Moreover, [88] reported blood biochemical indicators, particularly total proteins, improved in broilers fed diets containing 0.3% and 0.6% basil seeds. Also, [89] indicated that broiler chicks fed a meal containing different percentages of sweet basil, thyme, and their oils showed a significant increase in globulin and total protein. Supplementing with marjoram significantly raised serum globulin levels while having no effect on serum cholesterol levels [24]. Also, [17] found that adding the grounds of rosemary, marjoram and sweet basil did not significantly impact any of blood cholesterol (mg/dl), creatinine (mg/dl). Contrary, [24] indicated that feeding basal diets with marjoram supplementation had no influence on total protein level however, albumen level was significantly reduced compared to control group. Nope effect on blood total protein and globulin was found when thyme powder and extract were combined [61]. Also, [68] reported that at all dietary supplementation levels, the impact of thyme on total protein, albumin, and globulin was shown to be less than significant (P>0.05). This is in line with findings of [63,90].

Groups fed 1% basil, and 1% thyme showed significant (P<0.05) increased in hemoglobin content (Hb) in comparison to control group. This result was agreed with [45] who found that the supplementation of basil seeds to the diet significantly (P<0.05) raised hemoglobin levels. Also, [91,92] found significant increases in hemoglobin in birds that received thyme powder supplements, however, the same authors found increased the values of, RBCs, and PCV levels. On the other hand, [23] observed that marjoram had an improving effect on blood hematology, increasing Hb, HCT, and MCV levels and mentioned that powdered OM caused a significant increment in both RBC and Hb (with 1% OM), which are

responsible for oxygen transfer. Moreover, high PCV (%) and high Hb (g %) are markers of high efficiency in feed conversion [93] and thus increasing body weight. Also, [63] reported that thyme supplementation failed to elicit any statistically significant improvement on the hematological parameters of broilers. The greater iron content of herbal plants, which is thought to be a necessary nutrient for hemoglobin creation, may be the cause of their beneficial effects on hemoglobin [94].

Groups with Supplemented diet showed significantly (P<0.05) more lymphocyte %, lower heterophil % (P<0.05), and lower H/L ratio when compared to control birds, this indicates that control chicks had higher levels of stress compared to those in supplemented groups. In accordance with these results, [95] indicated that the H/L ratio is thought to be a more accurate indicator of persistent stress, with stressed birds exhibiting a rise in H/L ratio. [96] mentioned that increased production of interferon could bring about from lymphocytosis. [23] found that providing with marjoram powder increased the percentage of lymphocytes, however, there was a notable decline in the percentage of heterophils and the ratio of heterophils to lymphocytes.

Birds fed basil, and thyme had higher antibody titers against ND at 14 days of age in comparison to birds fed control diet. At 35th day of age control birds showed lower anti body titers compared to supplemented birds with 1% marjoram and 1% thyme. This finding was in close agreement with [64,97] who found advantageous effect of drinking thyme extract on broiler hens' immunological responses. Also, [17] stated that, when compared to the control group, giving experimental meals including either basil, marjoram, or rosemary increased antibody levels against NDV. The use of 1% basil leaves [62] or basil seeds [16] increased significantly HI antibodies to NDV vaccines. Contrary, treatment with marjoram [24] or thyme [61,90] had an insignificant effect on NDV antibody titers in comparison to the control.

In the current study, supplemented groups showed higher antibody titers against ND, the bursa showed significant increases in their weights, and there was a significant increase in WBCs, Globulin, and H/L ratio. All these parameters are good indicators for improving the bird immunity. Improve the immune status hence, broilers productive performance also improved [68].

Results revealed that supplementation of natural plants (marjoram, basil, and thyme) at dose of 1% has an impact on economic efficiency. Supplemented broilers had better FCR, EPEF, net profit and benefit/cost ratio compared to control group. Our study concluded that, the marjoram group is the best group economically followed by thyme group and basil group and all of them are better than the control group. In accordance with these results, [98] showed that there was a significant (P≤0.05) increase in economic value in supplemented groups, and the highest value was recorded in group 3 (received control diet + 600 µL of freshly prepared oregano essential oil extract per kg of diet), followed by group 2(received control diet + 300µL of freshly prepared oregano essential oil extract per kg of diet). Also, there was a significant (P≤0.05) increase in relative economic efficiency in group (3) compared to groups (2, 1) and the highest impact was observed in group (3). Also [99] stated that from economic viewpoint, it is obvious that all dietary oregano supplemented groups had better EEF values relative to control. The improvement in EFF ranged between 7.43 and 16.71%. Furthermore, [89] pointed out that broiler fed basal diet supplemented with different levels of basil powder, low level of thyme powder and different levels of thyme oil had significantly higher BW, BWG, economic efficiency and production index. Additionally, [100] observed that concerning the feed cost of production, the antibiotic treatment had the highest cost (P< 0.05) at the starter period, but the ginger, nano-thyme, and nano-ginger groups had the lowest (P< 0.05) cost of production at the grower phase of the experiment. European production efficiency factor (EPEF) in our study showed a higher level in thyme group, followed by its level in marjoram group and basil group and the lower level observed in control group. Also, [101] indicated that the EPEI was significantly greater in the group fed the basal diet supplemented with 30 g/kg dried thyme powder than the control, group that fed the basal diet supplemented with 20 g/kg dried thyme powder and group that fed the basal diet supplemented with 1 g Zinc Bacitracin /kg diet (ZnB). In addition, the control group and group that fed the basal diet supplemented with 10 g/kg dried thyme powder had greater EPEI than the ZnB group.

5. CONCLUSIONS:

In conclusion, supplementation of natural plants (marjoram, basil, and thyme) at dose of 1% (10kg/ton feed) improved behavior, productive performance (BW, BWG and FCR), economic

efficiency and could be used as natural alternatives to feed antibiotics in broiler diets as a growth promoter. Supplementation of diet with marjoram, basil, and thyme resulted in improved welfare (reduce stress and decrease fear responses), serum total protein and globulin values and enhanced bird's immunity and health.

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Authors' declarations

Publication consent

All authors have given their consent for the publication of this manuscript.

Data and material availability

All relevant data of this study are available upon request.

Conflict of interests

The authors declare no conflict of interest.

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