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# Response the Productive Performance and Economic Cost of Broiler Chickens Exposed to Feed Restriction Regimes with Feed Additives

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**Abstract.** This study was conducted to evaluate the effect of two feed restriction methods with or without powders of peppermint leaves (PL) and organic zinc (OZ) added to diet from 2 to 3 weeks of age followed by compensatory growth stage from 4 to 5 weeks of age on growth performance and economic cost of broilers rearing. The research was included 420 broiler chicks Ross 308 distributed randomly into 7 groups (n=60 chicks per group) with 3 replications each. 1st group (control) was *ad libitum* feeding (G1), 2nd (G2), 3rd (G3) and 4th (G4) groups were quantitative feed restriction (40%) of control without any dietary additives, or with 1% PL or 50 mg OZ / kg of diet, respectively, whereas 5th (G5), 6th (G6) and 7th (G7) groups were temporal feed restriction (12 hours/day) only or with 1% PL or 50 mg OZ/ kg of diet, respectively. The obtained results revealed there was significant low ($p<0.01$) in feed intake for all feed restricted groups at 2-3 weeks and for G2, G3 and G4 at 1-5 weeks compared to G1. Similar final body weights to G1 were achieved by G3,G4,G5 and G7 whereas G2, G4, G6 and G7 had similar body weight gain to G1 at 1-5 weeks. It was there an improvement ($p<0.01$) in feed conversion ratio for all groups at 2-3 weeks and for G2, G3, G4 and G6 at 1-5 weeks compared to G1. Low ($p<0.05$) total mortality was registered for G3, G5, G6 and G7. High ($p<0.01$) protein or energy efficiency ratios was in favor of G2, G3, G4 and G7 at 2-3 weeks and an increase ($p<0.05$) for G3 and G4 at 1-5 weeks compared to G1. High values ($p<0.05$) of production efficiency factor for all groups except for G5 compared to G1. In comparison to G1, there was high ($p<0.01$) carcass yield without giblets for G2, G4 and G6 and high ($p<0.01$) carcass yield with giblets for G3 only. All feed restricted groups reduced the total expenses cost with increase in net revenue and economic efficiency of project. In conclusion, it was improved performance and lowering in economic cost of birds rearing exposed to feed restriction especially in groups potentiated by added PL and OZ in diet therefore, we recommend to follow these regimes in poultry nutrition protocols to support the sustainable development perspectives in poultry industry sector as one of the important agricultural part of a global food system**.**

**Keywords**: feed restriction, organic zinc, peppermint, broilers, production.

## INTRODUCTION

Poultry production has an important role in providing high-quality protein for human consumption. High growth rate of modern poultry can lead to metabolic diseases and skeletal disorders that lead to economic losses due to reduced growth performance, increase feed intake and deaths incidence with low grading of carcass in slaughterhouses [1], [2].Commercial broilers and broiler breeders are characterized by negative rapid growth rate at early growth stage, thus feed restriction at the early stage of birds' life is beneficial strategy in poultry feeding program to improve the feed conversion ratio and reduce feed intake and thus in turn reduce the economic cost of rearing [3], [4]. However, feed restriction at an early age reduces growth performance but it will be achieved by compensatory growth in the subsequent feeding period to accelerate the chick's growth for reaching the required market weight [5]. Some studies have shown that feed restriction could reduce abdominal fat content and increases protein deposition in carcass yield which leads to improved carcass quality [6].

Peppermint (*Mentha piperita*) leaves (PL) are one of nutritive medicinal plants which contains many bioactive compounds such as phenols, flavonoids and tannins which have great roles as antibacterials [7], [8] and potent antioxidants [8] by scavenging the harmful free radicals. The main action of PL and its flowers is due to the presence of abundant menthol and menthone which is the main phenolic component with many powerful activities

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*in vivo* [9]. PL are also contain other polyphenolic compounds and hence could possess strong immune stimulation [10]. Additionally, PL are characterized by some pharmacological properties via ability to improving the intestinal motility, secretion of bile acids, increasing hepatic antioxidant status, proliferation and differentiation of intestinal tissues which can be associated with improved productive performance and feed efficiency in broiler chickens [11], [12],[13].

Zinc (Zn) is one of the essential multipurpose mineral and its importance is due to its role in cell proliferation, increasing growth, improving fertility, immunity, and gene expression, as well as participates as an essential part of the activity of many enzymes [14]. It directly contributes in the metabolic pathways, which plays crucial roles in the biological processes into body system and strengthening general immunity via process of developing and effectiveness the immune system in birds [15]. Zn is necessary for the normal functioning of the immune system due to the increase in T cells [16], as well as it has own mechanism in variety of chemical processes [17] and acts as an antioxidant factor because it is part of the enzyme (superoxide dismutase) which has an antioxidant potential. Also, it was found that Zn enters into many enzymatic systems and affects their stability and activity as well as protein synthesis, carbohydrate metabolism and some biochemical reactions. In addition to these advantages, Zn importance was documented in growth and development of skeletal system, bones and functional glands [18].

The current study aims to evaluate the efficacy of adding powders of peppermint leaves and organic zinc to broiler chicken Ross 308 diet under conditions of quantitative and temporal feed restrictions and its effects on productivity and economic cost of project during the subsequent compensatory growth of chickens until the termination of the experiment at 35 days of age.

# MATERIALS AND METHODS

## Experimental Plan and Site

In total 420 unsexed broiler chicks Ross 308 (initial weight=42.2±0.5g) were purchased from a commercial hatchery and were transported and reared in Poultry farm where belong to the Technical College of Al-Musaib, Babylon, Iraq from October 30th to December 3rd, 2021. Chicks were randomly divided into 7 equal groups (n=60 per group) with 3 replicates each. All chicks were reared under environmentally controlled conditions with feeding on balanced diet (table 1) according to NRC [19] and meet the nutritional requirements based on broiler chicken guide 308. The chicks were exposed to the feed restriction program at the beginning of 2nd week until 3rd week followed by compensatory growth phase (*ad libitum* feeding) from 4 to 5 weeks (end of the experiment). The experimental groups were distributed as follows:

i. The 1st group (G1): *ad libitum* feeding (control).
ii. The 2nd group (G2): feed quantitative restriction (40%) only.
iii. The 3rd group (G3): quantitative feed restriction (40%) + 1% peppermint leaves (PL) in diet.
iv. The 4th group (G4): quantitative feed restriction (40%) + 50 mg organic zinc per 1 kg of diet.
v. The 5th group (G5): temporal feed restriction (12 hours/day) only.
vi. The 6th group (G6): temporal feed restriction (12 hours/day) + 1% peppermint leaves (PL) in diet.
vii. The 7th group (G7): temporal feed restriction (12 hours/day) + 50 mg organic zinc per 1 kg of diet.

## Dietary Materials

Both of natural PL and synthetic OZ (Availa-Zn 120, ZINPRO) were in powdery form and procured from local market. PL were analysed to their bioactive compounds (table 2) using high performance liquid chromatography (HPLC) technique according to the methods coined by Anhawange *et al.* [20], Trease and Evans [21], Mradu *et al.* [22],, Ghorai *et al*. [23], Abdelkader *et al.* [24], Zare *et al.* [25], Babaa and Malikba [26].

**TABLE 1.** Components of the Experimental Diet and Chemical Composition

| Feed stuff | Starter (%) (1-2 weeks) | Grower (%) (3-4 weeks) | Finisher (%) (5 weeks) |
|---|---|---|---|
| Soybean meal (46%) | 30.0 | 26.5 | 26.5 |
| Wheat | 25.0 | 28.0 | 10.0 |
| Yellow corn | 20.2 | 14.70 | 32.8 |
| Flour | 12.5 | 15.0 | 15.0 |
| Wheat bran | 8.00 | 9.00 | 9.00 |
| Premix* | 2.50 | 2.50 | 2.50 |
| Limestone | 0.80 | 0.90 | 0.90 |
| Sunflower oil | 0.50 | 2.70 | 3.00 |
| Monocalcium phosphate | — | 0.30 | 0.20 |
| Anti-fungal agent (MINZEL PLUS) | 0.10 | 0.10 | — |
| Choline chloride + Sodium | 0.10 | — | — |
| Sodium bicarbonate | 0.10 | 0.10 | — |
| Table salt | — | 0.05 | — |
| Threonine | 0.05 | — | — |
| Emulsifier (APSA MOS) | 0.05 | | — |
| Emulsifier (Lysoforte™ Extend Dry) | 0.04 | 0.04 | 0.04 |
| Allicine | 0.03 | — | — |
| Enzyme mixture (Kemzyme® Plus P Dry) | 0.03 | — | — |
| Total | 100 | 100 | 100 |
| Chemical analysis** | | | |
| Crude protein (%) | 21.84 | 20.55 | 19.46 |
| Metabolizable energy (kcal / kg) | 3025.3 | 3094.05 | 3144.30 |
| Metabolizable energy to crude protein | 138.5 | 150.56 | 161.57 |
| Crude fiber (%) | 2.73 | 2.65 | 2.865 |
| Lysine (%) | 1.342 | 1.248 | 1161 |
| Methionine (%) | 0.21 | 0.519 | 0.470 |
| Methionine + cysteine (%) | 0.880 | 0.862 | 0.796 |
| Calcium (%) | 0.910 | 0.902 | 0.810 |
| Available phosphorous (%) | 0.501 | 0.932 | 0.837 |

*Produced by Provimi 3110 Company (Jordan).
**Calculated by using NRC [19]

**TABLE 2.** Some Bioactive Compounds Present in Peppermint Leaves

| Item | Unit | Amount |
|---|---|---|
| Total phenols* | mg gallic acid / gm | 46.8 |
| Total flavonoids * | mg rutin / gm | 10.7 |
| Total alkaloids* | % | 5.3 |
| Total terpinoids* | % | 18.9 |
| Total tannins* | % | 3.2 |
| Total saponins* | % | 1.8 |
| Menthol** | % | 42.3 |
| Menthone** | % | 16.8 |
| Eucalyptol** | % | 3.5 |
| Linalool** | % | 8.9 |
| Pinene** | % | 2.3 |

*based on powder.
** based on essential oil.

## Traits Studied

### *Productive Performance*

The productive performance of chicks was recorded and presented weekly and accumulatively in each replicate in group. The productive traits involving live body weight, weight gain (difference between initial and final body weight), feed intake, feed conversion ratio (feed intake / body weight gain), periodical mortality, protein efficiency ratio (weigh gain / protein intake), energy efficiency ratio (weight gain/ energy intake) and productive efficiency factor [27]. At age of 35 days, all birds were deprived from feed and water for 3 hours, 1 male and 3 females were chosen from each replicate to obtain their final body weights and slaughtered to calculate carcass yield with giblets (heart, gizzard and liver) or without giblet and calculation ratio of abdominal fat. All the carcasses were dissected and calculated into primary and secondary parts [28].

### *Economic Cost*

The economic cost of project for all groups was evaluated at the end of experiment (35 days) and calculated based on Iraqi dinar (IQD) currency which include the following items:

$$\text{Total Feed cost} = \text{sum of consumed feed per bird (kg)} \times \text{number of birds} \times \text{price of feed} \quad [1]$$

$$\text{Total expenses} = \text{total feed cost, dietary additives, total cost of chicks, litter, gas and medical treatments…etc} \quad [2]$$

$$\text{Selling revenue} = \text{body weight} \times \text{price of kg for live body weight} \quad [3]$$

$$\text{Net revenue} = \text{difference between total expenses and selling revenue} \quad [4]$$

$$\text{Economic efficiency} = \text{net revenue/total expenses cost} \times 100 \quad [5]$$

### *Statistical Analysis*

The statistical analysis system [29] was used in data analysis to study the effect of different treatments on the traits studied according to a completely randomized design (CRD), and the mean differences among the treatments were compared according to Duncan multiple ranges test [30].

## RESULTS AND DISCUSSION

### Feed Intake

Table (3) indicates that was a significant decrease ($p<0.01$) in feed intake at the first period (2-3 weeks) for G5, G6 and G7 followed by G2, G3 and G4 compared to G1 and in the second period of the experiment (4-5 weeks) showed a significant decrease ($p<0.05$) for G5, G6, G7, G2, G3 compared to G1.In total (1-5 week) , there was only decrease ($p<0.01$) in G2, G3 and G4 compared to G1 and other groups.

**TABLE 3.** Effect of Feed Restriction with or Without Dietary Peppermint Leaves and Organic Zinc on Feed Intake (gm) of Broiler Chickens (Mean ± Standard Error)

| Groups | 2-3 week | 4-5 week | 1-5 week |
|---|---|---|---|
| G1 | 1026.74±6.74 a | 2355.70± 25.26 a | 3537.50± 13.16 a |
| G2 | 616.04± 4.04 c | 2164.00± 29.53 b | 2924.30± 23.57 b |
| G3 | 626.31± 4.11 c | 2169.70± 27.92 b | 2944.60± 22.28 b |
| G4 | 616.05± 4.04 c | 2294.70± 20.24 ab | 3063.10± 22.31 b |
| G5 | 859.13± 5.54 b | 2180.00± 11.45 b | 3187.50± 20.24 ab |
| G6 | 867.33± 8.40 b | 2181.30± 25.75 b | 3207.00± 31.23 ab |
| G7 | 879.07±4.73 b | 2166.40± 25.29 b | 3194.30± 23.27 ab |
| Significance level | ** | * | ** |

The different letters within the same column indicate the presence of significant differences, * at the level ($p<0.05$),** at the level ($p<0.01$).

### Live Body Weight and Weight Gain

It is obvious from data presented in table (4) there was a significant superiority ($p<0.01$) in body weight at 3 weeks for G1 and G7 compared to other experiment groups. At 5 weeks, no significant differences in body weight were observed among G1 and G3, G4, G6 and G7. Low weight gain ($p<0.01$) was observed in most of experimental groups compared to G1 except for G7 which did not differ significantly with G1. High weight gain ($p<0.01$) was recorded by G2, G3 and G4 compared to G1 at 4-5 week. At 1-5 week, G3, G4 , G6 and G7 did not differ with G1 and all these groups surpass other experimental groups.

### Feed Conversion Ratio

It is noted from table 5 that all groups were significantly decreased ($p<0.01$) feed conversion ratio compared to G1 at 2-3 weeks whereas only G2, G3 and G4 surpass ($p<0.01$) G1 at 4-5 week. At 1-5 week, there was a significant lowering ($p<0.01$) in G2, G3, G4 and G6 compared to G1 in feed conversion ratio.

### Protein Efficiency Ratio

It is obvious from table 6 that G2, G3, G4 and G7 improved significantly ($p<0.01$) protein efficiency ratio compared to G1 at 2-3 weeks with no difference among groups at 4-5 in this trait. Moreover, at 1-5 week, a high ($p<0.05$) values of protein efficiency ratio were in favor of G3, G4 and G7 compared to G1.

**TABLE 4.** Effect of Feed Restriction With or Without Dietary Peppermint Leaves and Organic Zinc on Body Weight and Weight Gain (gm) of Broiler Chickens (Mean ± Standard Error)

| Groups | 3 weeks | 5 weeks | 2-3 week | 4-5 week | 1-5 week |
|---|---|---|---|---|---|
| G1 | 1104.33± 15.16 a | 2445.00± 28.58 ab | 909.17± 14.93 a | 1340.67± 13.21 cd | 2402.80± 28.58 ab |
| G2 | 860.00± 26.45 e | 2318.33± 29.84 c | 665.67± 26.64 d | 1458.33± 24.93 ab | 2276.13± 29.84 c |
| G3 | 936.67± 21.79 d | 2443.67± 25.24 ab | 748.40± 10.32 c | 1507.00± 21.73 ab | 2401.47± 25.24 ab |
| G4 | 975.00± 13.22 cd | 2518.67± 28.23 a | 786.67± 11.66 bc | 1543.67± 29.73 a | 2476.47± 28.23 a |
| G5 | 1005.33 ± 5.28 c | 2265.67± 16.29 c | 814.41± 7.02 b | 1260.33± 11.39 d | 2223.47± 16.29 c |
| G6 | 1015.67± 3.71 bc | 2446.67± 25.69 ab | 820.12± 4.88 b | 1431.00± 26.50 cd | 2404.47± 25.69 ab |
| G7 | 1068.00± 17.24 ab | 2351.33± 21.17 bc | 875.91± 14.76 a | 1283.33± 4.05 d | 2309.13± 21.17 bc |
| Significance level | ** | ** | ** | ** | * |

The different letters within the same column indicate the presence of significant differences, * at the level ($p<0.05$),** at the level ($p<0.01$).

**TABLE 5.** Effect of Feed Restriction with or Without Dietary Peppermint Leaves and Organic Zinc on Feed Conversion Ratio of Broiler Chickens (Mean ± Standard Error)

| Groups | 2-3 week | 4-5 week | 1-5 week |
|---|---|---|---|
| G1 | 1.12± 0.02 a | 1.76± 0.07 a | 1.47± 0.02 a |
| G2 | 0.92± 0.03 c | 1.48± 0.04 b | 1.28± 0.02 bc |
| G3 | 0.83± 0.03 d | 1.44± 0.05 b | 1.22± 0.01c |
| G4 | 0.78±0.00 d | 1.48± 0.05 b | 1.23± 0.02 c |
| G5 | 1.05±0.01 b | 1.73± 0.01 a | 1.43± 0.01 ab |
| G6 | 1.05±0.01 b | 1.52± 0.02 ab | 1.33± 0.00 bc |
| G7 | 1.00±0.00 b | 1.68± 0.22 a | 1.38± 0.12 abc |
| Significance level | ** | ** | ** |

The different letters within the same column indicate the presence of significant differences, ** at the level ($p<0.01$).

**TABLE 6.** Effect of Feed Restriction With or Without Dietary Peppermint Leaves and Organic Zinc on Protein Efficiency Ratio (gm/gm/day) of Broiler Chickens (Mean ± Standard Error)

| Groups | 2-3 week | 4-5 week | 1-5 week |
|---|---|---|---|
| G1 | 4.17± 0.07 e | 2.84± 0.12 | 3.29± 0.05 b |
| G2 | 5.09± 0.18 c | 3.36± 0.09 | 3.77± 0.07 ab |
| G3 | 5.63± 0.22 b | 3.47± 0.13 | 3.95± 0.04 a |
| G4 | 6.02± 0.06 a | 3.36± 0.12 | 3.92± 0.08 a |
| G5 | 4.47± 0.06 de | 2.88± 0.03 | 3.38± 0.04 ab |
| G6 | 4.46± 0.05 de | 3.27± 0.04 | 3.63± 0.01 ab |
| G7 | 4.70± 0.04 d | 2.96± 0.05 | 3.50± 0.43 a |
| Significance level | ** | N.S | * |

The different letters within the same column indicate the presence of significant differences, * at the level ($p<0.05$),** at the level ($p<0.01$), N.S: non significant.

## Energy Efficiency Ratio

Table (7) shows the effect of groups on energy efficiency ratio, and it is clear that there was superiority ($p<0.01$) for G2, G3, G4 and G7 at 2-3 week compared to G1. However, not significant differences was found in this trait among groups at 4-5 week . In total (1-5 week), high values ($p<0.05$) for this trait was for G2, G3, G4 and G6 compared to G1.

**TABLE 7.** Effect of Feed Restriction With or Without Dietary Peppermint Leaves and Organic Zinc on Energy Efficiency Ratio (gm /100 kcal/day) of Broiler Chickens (Mean ± Standard Error)

| Groups | 2-3 week | 4-5 week | 1-5 week |
|---|---|---|---|
| G1 | 28.94± 0.52 e | 18.29± 0.77 | 21.99± 0.34 b |
| G2 | 35.30± 1.26 c | 21.61± 0.58 | 25.21± 0.52 a |
| G3 | 39.05± 1.52 b | 22.28± 0.84 | 26.41± 0.29 a |
| G4 | 41.73± 0.45 a | 21.60± 0.80 | 26.20± 0.55 a |
| G5 | 30.98± 0.45 de | 18.53± 0.21 | 22.59± 0.29 ab |
| G6 | 30.91± 0.40 de | 21.03± 0.29 | 24.28± 0.09 a |
| G7 | 32.56± 0.29 d | 18.99± 0.19 | 23.41± 0.90 ab |
| Significance level | ** | N.S | * |

The different letters within the same column indicate the presence of significant differences, * at the level ($p<0.05$),** at the level ($p<0.01$), N.S: non significant.

## Mortality and Productive Efficiency Factor

In comparison with G1, the lowest of mortality percentage ($p<0.05$) was in G3, G4, G6 and G7 during 2-3 week. At 4-5 week, G2, G3, G5, G6 and G7 achieved low value ($p<0.05$) whereas G3, G5,G6 and G7 reordered low value ($p<0.05$) at 1-5 week compared to G1. Most of experimental group obtained high averages ($p<0.05$) of productive efficiency factor compared with G1 , however, G5 did not differ significantly from G1 in this parameter (table 8).

**TABLE 8.** Effect of Feed Restriction with or Without Dietary Peppermint Leaves and Organic Zinc on Mortality (%) and Productive Efficiency Factor of Broiler Chickens (Mean ± Standard Error)

| Groups | Mortality | | | Productive efficiency factor |
|---|---|---|---|---|
| | 2-3 week | 4-5 week | 1-5 week | |
| G1 | 5.00± 0.00 a | 3.50± 0.15 a | 8.33± 0.66 a | 435.55± 19.42 c |
| G2 | 5.00± 0.00 a | 1.75± 0.11 b | 6.66± 0.21 ab | 482.13± 16.27 b |
| G3 | 3.33 ± 0.13 b | 1.66± 0.11 b | 5.00± 1.28 b | 540.79± 15.19 a |
| G4 | 3.33± 0.13 b | 3.42± 0.71 a | 6.66± 0.12 ab | 543.19± 11.66 a |
| G5 | 5.08± 0.96 a | 0.00±0.00 c | 5.00± 1.88 b | 428.61± 5.01 c |
| G6 | 0.00±0.00 c | 1.66± 0.36 b | 1.66± 0.36 d | 515.55± 14.04 ab |
| G7 | 3.33 ± 0.13 b | 0.00± 0.00 c | 3.33± 0.21 c | 531.75± 19.93 ab |
| Significance level | * | * | * | * |

The different letters within the same column indicate the presence of significant differences, * at the level ($p<0.05$).

## Carcass Quality

Table (9) refers to effect of the treatments on the of carcass yield and carcass parts. There was a significant increase ($p<0.01$) for G3, G4, G6 in the dressing percentage without giblets compared to G1. With respect of dressing percentage with giblets, there was an increase ($p<0.01$) only for G3 with no differences among G1 and other groups. No significant differences were found among groups regarding to percentage of breast, thighs, drumsticks, back, wings, abdominal fat, liver and heart. Moreover, G1 did not differ from other groups regarding to neck percentage and no clear differences among G1 and G3, G4 , G5 and G7 were obtainable in relative weight of gizzard.

## The Economic Cost of The Study

Table (10) shows the effect of feed restricted groups of birds on the economic cost of the studied project based on IQD currency. It is obvious that all experimental groups lowered the costs of total consumed feed and total expenses with an economic increase in net revenue and economic efficiency compared to G1. The best mass of marketed broilers and selling revenue was in favor of G3, G4, G6 and G7 compared to other groups.

The improved results which were obtained in final body weight (BW) and total weight gain (WG) for feed restricted birds supplemented with OZ and PL powders in diet (G3, G4, G6 and G7) and equivalence in most of the feed restricted groups with control regarding to decreased feed intake (FI), improved feed conversion ratio (FCR) might be due to the role of feed restriction in supporting the growth rate by reducing consumption of additional feed. At at the same time achieving an increase in efficiency of nutrients

**TABLE 9.** Effect of Feed Restriction with or Without Dietary Peppermint Leaves and Organic Zinc on Carcass Yield and Carcass Parts (%) of Broiler Chickens (Mean ± Standard Error)

| Groups | carcass yield without giblets | carcass yield with giblets | Breast | Thighs | Drums-tick | back | Wings | neck | Abdon-inal fat | Liver | Hart | Gizzard |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G1 | 73.54± 0.23 b | 78.42± 0.19 bc | 39.47± 0.49 | 18.61± 0.68 | 12.58± 0.16 | 15.81± 0.35 | 10.67± 0.06 | 2.75± 0.33 ab | 1.76± 0.18 | 2.69± 0.08 | 0.52± 0.04 | 1.32± 0.03 a |
| G2 | 73.41± 0.45 b | 77.53± 0.51 cd | 41.02± 1.74 | 18.61± 0.70 | 12.60± 0.61 | 14.56 ± 0.55 | 10.53± 0.39 | 2.65± 0.08 ab | 2.31± 0.15 | 2.63± 0.44 | 0.55± 0.07 | 0.93± 0.08 b |
| G3 | 74.53± 0.20 a | 80.31± 0.14 a | 39.06± 1.57 | 17.49± 0.22 | 13.71± 0.76 | 16.99± 0.66 | 10.25± 0.40 | 2.34± 0.20 b | 2.06± 0.97 | 2.70± 0.33 | 0.60± 0.06 | 1.12± 0.06 ab |
| G4 | 75.14± 0.22 a | 79.47± 0.32 ab | 40.27± 0.63 | 18.27± 0.41 | 13.48± 0.35 | 15.00± 0.93 | 10.41± 0.33 | 2.55± 0.27 ab | 1.84± 0.36 | 2.71± 0.05 | 0.54± 0.07 | 1.07± 0.10 ab |
| G5 | 72.92± 0.15 b | 77.22± 0.42 d | 37.62± 0.15 | 18.22± 0.22 | 13.41± 0.57 | 17.98± 0.48 | 9.62± 0.27 | 3.31± 0.38 a | 2.01± 0.26 | 2.54± 0.15 | 0.64± 0.08 | 1.10± 0.14 ab |
| G6 | 74.55± 0.21 a | 78.52± 0.34 bc | 39.68± 0.13 | 18.67± 0.20 | 12.58± 0.44 | 16.00± 0.59 | 9.78± 0.25 | 2.99± 0.17 ab | 1.68± 0.16 | 2.47± 0.13 | 0.52± 0.04 | 0.96± 0.08 b |
| G7 | 73.73± 0.19 b | 78.20± 0.44 cd | 40.67± 0.33 | 18.11± 0.55 | 13.33± 0.75 | 14.55± 0.17 | 10.19± 0.48 | 3.12± 0.34 ab | 1.49± 0.19 | 2.85± 0.19 | 0.57± 0.08 | 1.04± 0.07 ab |
| Significance level | ** | ** | N.S | N.S | N.S | N.S | N.S | * | N.S | N.S | N.S | * |

The different letters within the same column indicate the presence of significant differences, * at the level ($p<0.05$), ** at the level ($p<0.01$), N.S: non-significant.

**TABLE 10.** Effect of Feed Restriction with or Without Dietary Peppermint Leaves and Organic Zinc on Economic Cost of the Experiment

| Groups* | total feed cost ($10^3$ IQD) | total expenses ($10^3$ IQD) | mass of marketed broilers (kg) | selling revenue ($10^3$ ID) | net revenue ($10^3$ ID) | economic efficiency |
|---|---|---|---|---|---|---|
| G1 | 178.48 | 261.62 | 134.47 | 403.42 | 141.79 | 54.19 |
| G2 | 147.54 | 230.68 | 129.82 | 389.48 | 158.79 | 68.83 |
| G3 | 148.56 | 231.71 | 139.28 | 417.86 | 186.154 | 80.33 |
| G4 | 154.54 | 237.68 | 141.04 | 423.13 | 185.44 | 78.02 |
| G5 | 160.82 | 243.96 | 129.14 | 387.42 | 143.46 | 58.80 |
| G6 | 161.80 | 244.94 | 144.35 | 433.06 | 188.11 | 76.79 |
| G7 | 146.03 | 229.17 | 136.37 | 409.13 | 179.95 | 78.52 |

*According to the prices of local market in IQD currency, one chick cost is 952.38 IQD, 1 kg of feed cost is 840.90 IQD, total cost of feed additives, litters, medical treatments and gas per group is 26000 IQD.

Utilization during the compensatory growth period and subsequent periods [5], [31]. It was previously noted to role of quantitative and qualitative restriction of feed in improving FCR and public health in poultry [32], [4]. Feed restrictions followed by compensatory growth phase (realimentation) could stimulate the immunity and relieve incidence of some metabolic disorders, sudden death syndrom, lameness and skeletal abnormalities in poultry so that lead to reduce the mortality incidence in comparison with the control one [4], [32], [33], [34]. The same was shown by Boostani *et al.* [34] who reported that temporal feed restriction for 8 hours/ day reduced rate of feed consumed, improved BW and FCR of broilers. The high performance indicators in groups of feed restricted birds is probably to reduce presence harmful microorganisms and encourage the beneficial intestinal microflora in digestive system [35] with an increase digestibility of nutrient through an augment in gut sucrase, amylase, and lipase activities immediately after the restriction period [6], [33]. Identical data were found that broiler fed restricted feed (30%) from 7 to 14 day of age had no effect on WG on 7 weeks [6]. Also, Zubair and Leeson [5] refered that was no alterations in weights of breast part and abdominal fat, although increased BW without changing in FI and carcass weight were found at 49 day of age in broiler males through feeding on dilution starter diet (restricted feed) with 50% oat hulls for 6 days only. The same was reported by Ahmed and Butris [4] that exposition broilers to temporal feed restriction at different periodical intervals and applying skip-a day fasting from 8-21 days of age reduced FI , FCR and total mortality , however, increased BW and no changed weight of carcass yield on 42 days were noticed as well. In line with current results, it was stated that feed restriction by 8 hours daily or in skip-a day program for broiler chickens resulted in increased carcass yield for males with no differences in females BW compared to control at 49 days of age . Moreover, Gonzales *et al.* [36] mentioned that there were no significant differences in the WG at 21, 35 and 49 days for broilers when fed 25% of free feeding for 7–21 days.

The improvement in the productive performance of feed restricted groups which fed PL powder accompanied with the decrease in mortality rate in G3 might be due to the importance of PL which have antioxidant, immune-stimulating properties, antimicrobial activity [9], [37] with enhancing appetite [10] and thus might reduce the oxidative stress to birds exposed to restriction condition which reflected on the preservation of the optimal growth performance. This mainly belongs to fact that powder of PL and its essential oil contain several bioactive compounds (table 2) that might improve the growth performance of broilers in the early stages of life [38], improve egg quality in laying hens [39] and increase the digestion and absorption of nutrients [40], [41]. Khempaka *et al.* [42] also indicated that PL have beneficial effects on antioxidant activity due to the presence of active substance in PL (menthol) which prevent abdominal fat deposition, and reduce ammonia production from broilers . Previous studies documented that adding 5, 10 and 15 mg/kg of PL [39] or the active compound menthol [43] to broiler diet led to a significant increase in BW and daily WG and this could play positive effects on the utilized efficiency of digested feed, amelioration absorption and digestive system disorders [38] and thus resulted in equivalence of the final BW to those in control group. Conflicted results were stated about incorporation of PL in diet, Al-Ankari *et al.* [44] found that there was a significant improvement in BW, daily WG, FI and FCR for birds fed diet equipped with 150 g of PL/ kg whereas Khurshid *et al.* [45] and Isha *et al.* [46] found that 0.5, 1 and 2% PL in diet had no effect on BW under normal feeding conditions.

The similarity in final BW of birds subjected to feed restriction regimes is dependent on gut metabolic capacity during the compensatory growth period, and this might be supported by added OZ to diet. Zinc is important nutrient for the functioning of many enzymes (carbonic anhydrase, dehydrogenase, peptidase, phosphatase) and participates in many other enzymatic activities which involved in metabolic processes in the body [47] and therefore it is very necessary for proteins, lipids and carbohydrates metabolism [48]. Zinc is also a powerful antioxidant, which might reduce the oxidative stress status of birds exposed to starvation and the antioxidant supplemented diets are crucial element in lowering the economic cost in poultry production as well [49]. Moreover, zinc participates in metallothionein synthesis, a protein rich in the amino acid cysteine, which in turn reduces production of harmful free radicals [15] and exerts as cofactor for antioxidants, especially for superoxide dismutase, combines with enzymes that maintain the integrity of the cell membrane with improving the overall immunity [47]. It also proven that synthesis of metalloproteins, insulin-like growth factor (IGF-1), stimulation of thyroxine and triiodothyronine secretion, regulating glucose uptake and cellular processes [50], [51] is one of the zinc functions that contributes to the maintenance of normal body growth and development. This explains the improvement in the productive performance of OZ fed groups under feed restriction conditions (G4 and G7). Our results agreed with Sumiati *et al*. [52] who found that adding 200 mg/kg of dietary organic and inorganic zinc improved BW, WG and FCR. This was similar with Zhang *et al.* [53] that supplementation of zinc at 20, 40, 60, 80, 100 and 120 mg/kg from 1-21 days of age improved BW and WG. This result was agreed with what mentioned by Kumar *et al.* [54] who found recently that adding 55 mg/kg of nano-ZnSO4 to diet improved the productive performance of broiler chickens.

The improvement in dressing percentage without giblets for (G6, G4, G3) and the dressing percentage with giblets for G3 might be basically due to the role of OZ and PL in achieving the positive results of the compensatory growth of birds via obtaining an increase in the carcass weight in these groups and then increasing muscular body weights although there was no change in weights of the carcass cuts. These results were different with Willis and Reid [35] who showed a lower dressing percentage in feed restricted birds compared with those non restricted one. This is because that zinc can increase absorption of amino acids of muscle proteins [55], [56]. The present data agreed with others that was no negative effect of PL added to diet on carcass properties, weight of gizzard abdominal fat [57], relative weight of the crop [58],weight of liver and abdominal fat [59]. However, the present results did not agree with Khempaka *et al.* [42], who found that there was no changes in carcass yield with decrease in the abdominal fat content of broilers at 42 days of age fed 0.5, 1.0, 1.5 and 2.0 % PL. Increased values of production efficiency factor in all feed restricted groups except for G5 is might be related to low averages of mortality rate, FI and FCR and thus an improved production efficiency factor is correlated index to an increase in the financial return [27], [28].

Improved productive traits of feed restricted birds was profitable for monetary savings which resulted in lowering the total expenses cost of the rearing project with an increase in net revenue and overall economic efficiency accounted in IQD currency. Interestingly, feed restriction will maximize the highly mass production, reduce the economic losses with low economic cost especially in case of feed prices which constitutes the most costly requirements in poultry farming.

## CONCLUSION

This study proved the powerful efficiency for both quantitative and temporal feed restriction programs especially with added peppermint leaves and organic zinc powders to diet in maximizing the productive attributes of broiler chickens which led to augment the overall productive efficiency and lowering the economic cost. This allowed in turn to increase financial profits of the rearing project and explore a new idea for understanding the sustainable development perspectives in poultry industry sector.

## REFERENCES


1. Pasternak, H. and Shalev B.A.,"Genetic-economic evaluation of traits in broiler enterprise: reduction of food intake due to increased growth rate", Bri. Poult. Sci., 24, 531-536 (1983).
2. P. Magdelaine, *Egg and egg product production and consumption in Europe and the rest of the world*. In: *Improving the safety and quality of eggs and egg products: egg chemistry production and consumption* (Woodhead Publishing Limited, 2011). pp.1-16.

3. Tolkamp, B. J., Sandilands V., and Kyriazakis I., "Effect of qualitative feed restriction during rearing on the performance of broiler breeders during rearing and lay". Poult. Sci., 84, 1286–1293 (2005)
4. Ahmed, S.K., and Butris G.Y."The off feeding intervals effect on some performance traits of broilers" Iraqi J. Vet. Med., 38, 48 – 55 (2014).
5. Zubair, A.K. and Leeson S., "Effect of varying period of early nutrient restriction on growth compensation and carcass characteristics of male broilers". Poult. Sci., 73,129 – 136 (1994).
6. Pinheiro, D. F., Cruz V.C., Sartori J.R., and Paulino M. L. V.."Effect of early feed restriction and enzyme supplementation on digestive enzyme activities in broilers", Poult. Sci., 83, 1544–1550 (2004).
7. Kaushik, R., Garg G., Sharma G. and Arora C., "Antibacterial activity of plant extracts from Uttaranchal Hills, India", Allelopathy J., 12, 205-213 (2003).
8. Mimica-Dukic, N., Bozin B., Sokoviæ M., Mihajloviæ B. and Matavulj M.,"Antimicrobial and antioxidant activities of three Mentha species essential oils", Planta Med., 69, 413-419 (2003).
9. Schuhmacher, A., Reichling J., and Schnitzler P., "Virucidal effect of peppermint oil on the enveloped viruses herpes simplex virus type 1 and type 2 in vitro" Phytomedicine, 10, 504– 510 ( 2003).
10. Dorman, H.D., Kosar M., Kahlos K., Holm Y. and Hiltunen R., "Antioxidant properties and composition of aqueous extracts from mentha species, hybrids, varieties, and cultivars", J. Agric. Food Chem, 51, 4563-4569 (2003).
11. Lee, K. W., Everts H., Kappert H. J., Frehner M., Losa R., and Beynen A. C., "Effects of dietary essential oil components on growth performance, digestive enzymes and lipid metabolism in female broiler chickens" Br. Poultry Science, 44, 450–457 (2003).
12. Jang, I. S., Ko Y. H., Yang H. Y., Ha J.S., Kim J.Y., Kang S.Y., Yoo D.H., Nam D.S., Kim D.H. and Lee C.Y., "Influence of essential oil components on growth performance and the functional activity of the pancreas and small intestine in broiler chickens", Asian-Australian Journal Animal Science, 17, 394–400 (2004).
13. Amad, A. A., M¨anner K., Wendler, K. R., Neumann K. and Zentek J., "Effects of a phytogenic feed additive on growth performance and ileal nutrient digestibility in broiler chickens", Poult. Sci., 90, 2811–2816 (2011).
14. L.R. Mc Dowell, *Zinc minerals in animal and human nutrition* (Elsevier Sci. Amsterdam, Netherlands, 2003). pp. 357 – 395
15. Zaki, A.N., and Al-jebory H.H.D. "Effect of early feeding with zinc-methionine on improving growth performance and some biochemical characteristics of broilers", IOP Conf. Series: Earth and Environmental Science, 722 (2021) 012035 (2021).
16. Bettger, W.J. "The effect of dietary zinc deficiency on erythrocyte free and membrane bound amino acids in the rats", Nutrition research, 9, 911-919 (1989).
17. Vallee, B.L., and Auld D.S., "Zinc coordination, function, and structure of zinc enzymes and other proteins", Biochemistry, 29, 5647–5659 (1990).
18. Andreini, C., Banci L., Bertini I. and Rosato A. "Counting the zinc-proteins encoded in the human genome", Journal of proteome research, 5, 196-201 (2006).
19. NRC. *Nutrient Requirements of Poultry*, National Research Council, 9th rev. ed, (National Academic Press,Washington, DC, 1994).
20. Anhawange, A.A., Ajibola V.O. and Oniye S.J. "Chemical studies of the Seeds Moringa oleifera (LAM) Detarium mirocarpum (Guill and Perr)", Journal of Biological Sciences, 4:711-715 (2004)
21. G.E Trease and W. C. Evans. *Trease and Evans' Pharmacognosy*. (Philadelphia: WB Saunders, Elsevier Science Limited., p. 336, 2009).
22. Mradu, G., Saumyakanti S., Sohini M. and Arup M., "HPLC profiles of standard phenolic compounds present in medicinal plants", International Journal of Pharmacognosy and Phytochemical Research, 4, 162-167 (2012).
23. Ghorai, N., Chakraborty S., Gucchait S., Saha S.K. and Biswas S., "Estimation of total terpenoids concentration in plant tissues using a monoterpene, linalool as standard reagent, Protocol Exchange, 27(11), 2012
24. Abdelkader, M., Ahcen B., Rachid D. and Hakim H., "Phytochemical study and biological activity of sage (*Salvia officinalis* L.), "International Journal of Bioengineering and Life Sciences, 8, 1253- 1257 (2014).
25. Zare, K., Nazemyeh H., Lotfipour F., Farabi S., Ghiamirad M. and Barzegari A., "Antibacterial activity and total phenolic content of the *Onopordon acanthium* L. Seeds", Pharmaceutical Sciences, 1, 6-11 (2014).

26. Babaa, S.A. and Malikba S.A. "Determination of total phenolic and flavonoid content, antimicrobialand antioxidant activity of a root extract of Arisaema jacquemontii Blume", Journal of Taibah University for Science, 9, 449– 454 (2015).
27. Lemme A., Frackenpohl U., Petri A., Meyer H. "Response of male BUT big 6 turkeys to varying amino acid feeding programs", Poult, Sci., 85, 652-660 (2006).
28. K.I.A Al-Shammari, PhD thesis, University of life Sciences in Lublin, Poland, 2017, The use of chosen plant extracts in various aspects of Japanese quail production.
29. SAS, *SAS/STAT User's Guide for Personal Computers*. Release 9.1 (SAS Institute Inc., Cary, N.C., USA., 2012).
30. Duncan, D.B. "Multiple Rang and Multiple F-test", Biometrics,11, 4-42, (1955).
31. Klein S. A. S., Silva F. A., Kwakkel R. P. and Zuidhof M. J. "The effect of quantitative feed restriction on allometric growth in broilers", Poult. Sci., 96, 118–126 (2017).
32. Sahraei., M. "Feed restriction in broiler chicken's production", Global Veterinaria, 8, 449-458 (2012).
33. Zubair, A.K. and Leeson S., "Compensatory growth in the broiler chicken: a review", World's Poult. Sci., 52,189-201 (1996).
34. Boostani, A., Ashayerizadeh A., Fard M.H.R. and Kamalzadeh A. A., "Comparison of the effects of several feed restriction periods to control ascites on performance, carcass characteristics and hematological indices of broiler chickens", Brazilian Journal of Poultry Science,12, 171 – 177 (2010).
35. Willis, W. L. and Reid L., "Investigating the effects of dietary probiotic feeding regimens on broiler chicken production and Campylobacter jejune presence", Poult. Scie., 87, 606–611(2008).
36. Gonzales, A.J.M., Oporta M.E.S., Pro-Martinez A. and Lopez_C.Y.C "Feed restriction and salbutamol to control ascites syndrome in broilers: 1- Productive performance and carcass traits", Publicado Como Articulo en Agrociencia, 34, 283-292 (2000).
37. Singh, C. S., and R. Agarwal, "Evaluation of antibacterial activity of volatile oil from *Mentha spicata* L.", Journal of Drug Delivery and Therapeutics, 3,120-121(2013).
38. Ocak, N., Erener G., Burak Ak F., Sungu M., Altop A., and Ozmen A., "Performance of broilers fed diets supplemented with dry peppermint (*Mentha piperita* L.) or thyme (*Thymus vulgaris* L.) leaves as growth promoter source", Czech J. Anim. Sci. 53, 169–175 (2008).
39. Abdel-Wareth, A.A.A., and Lohakare J.D. "Effect of dietary supplementation of peppermint on performance, egg quality, and serum metabolic profile of Hy-Line Brown hens during the late laying period". Anim. Feed Sci. Technol., 197, 114–120 (2014).
40. Grigoleit, H. G. and Grigoleit P., Pharmacology and preclinical pharmacokinetics of peppermint oil. Phytomedicine, 12, 612–616 (2005).
41. Bupesh, G., Amutha C., Nandagopal S., Ganeshkumar A., Sureshkumar P., and Saravana K.M., "Antibacterial activity of Mentha piperita L. (peppermint) from leaf extracts – A medicinal plant", Acta. Agric.Slov., 89, 73–79 (2007).
42. Khempaka, S., Pudpila U., and Molee W., "Effect of dried peppermint (Mentha cordifolia) on growth performance, nutrient digestibility, carcass traits, antioxidant properties, and ammonia production in broilers", J. Appl. Poult. Res., 22, 904–912 (2013).
43. Akbari, M., Torki M., and Kaviani K., "Single and combined effects of peppermint and thyme essential oils on productive performance, egg quality traits, and blood parameters of laying hens reared under cold stress condition", International Journal Biometeorology, 60, 447–454 (2016).
44. Al-Ankari, A.S., Zaki M.M. and Al-Sultan S.I., "Use of habek mint (Mentha longifolia) in Broiler Chicken Diets", Int. J. Poult. Sci.,3 (10), 629-634 (2004).
45. Khurshid, A., Banday, M.T., Adil S., Untoo M., and Afzal I., "Mint leaves (*Mentha piperita*) as herbal dietary supplement: Effect of performance and economics for broiler chicken production", Pak. J. Nutr., 15(9), 810-815 (2016).
46. Isha, A.A., Abd El-Hamid A. E., Ziena H. M. and Ahmed H. A., "Effect of spearmint (Mentha spicata ) on productive and physiological parameters of broiler chicks", Egypt. Poult. Sci. J., 38(3), 815-829 (2018).
47. Prasad, A.S. and Kucuk O., "Zinc in cancer prevention", Cancer Metastasis Rev., 21, 291–295 (2002).
48. MacDonald, R.S., "The role of zinc in growth and cell proliferation", J.Nutr., 130(5), 1500-1508 (2000).
49. Salami, S.A., Majoka M.A., Saha S., Garber A., and Gabarrou J.F., "Efficacy of dietary antioxidants on broiler oxidative stress , performance and meat quality : science and market" , Avian . Biol. Res., 8 (2), 65 – 78 (2015).
50. Midilli, M., Salman M., Muglali O. H., Ögretemen T., Cenesiz S. and Ormanci N. "The effects of organic or inorganic zinc and microbial phytase , alone or in combination , on the performance , biochemical

parameters and nutrient utilization of broilers fed a diet low in available phosphorus", J. Sci. Food Agric., 8, 461– 467 (2014).
51. Rouhalamini, S.M., Salarmoini M. and Asadikaram G.H.,"Effect of zinc sulfate and organic chromium supplementation. the performance, meat quality and immune response of japanese quails under heat stress conditions", Poult. Sci. J., 2(2), 165-181 (2014).
52. Sumiati, H.C., Jayanegara A., and Wina E., "Effect of zinc on the immune response and production performance of broilers: a meta-analysis", Asian-Australas J Anim Sci., 33(3), 465-479 (2020).
53. Zhang, T.Y., Liu J.L., Zhang J.L., Yang Z.N, Qu H.X., Xi L. and Han J.C., "Effects of dietary zinc levels on the growth performance, organ zinc content, and zinc retention in broiler chickens", Brazilian Journal of Poultry Science, 20 (1), 127-132 (2018).
54. Kumar, A., Hosseindoust A., Kim M. J., Kim K.Y., Choi Y.H., Lee S.H., Lee S.Y., Lee J.H., Cho H.J., Kang W.S. and Chae B.J. "Nano-sized zinc in broiler chickens: effects on growth performance,zinc concentration in organs, and intestinal morphology", The Journal of Poultry Science, 58, 21-29 (2021).
55. Tronina, W., Kinal S., and Lubojemska B. "Effect of various forms of zinc applied in concentrate mixtures for broiler chickens on its bioavailability as well as meat composition and quality". Pol. J. Food .Nutr. Sci., 57, 577-581 (2007).
56. Saenmahayak , B., Bilgili S.F., Hess J.B., and Singh M. "Live and processing performance of broiler chickens fed diet supplemented with complex zinc", J. Applied . Poult . Res. 19, 334–340 (2010).
57. Adibnezhad, M., Chaharaeen B., Mohammadian-Tabrizi H. R., Pourelmi M. R., and Abadi H. K., "Effect of peppermints and thyme powder on performance and carcass characteristics in broiler", Res. Opin. Anim. Vet. Sci., 4, 385–388 (2014).
58. Durrani, F. R., Sultan A., Latif-marri M., Chand N., and Durrani Z., "Effect of wild mint (*Mentha longifolia*) infusion on the overall performance of broiler chicks", Pak. J. Biol. Sci.,10, 1130–1133 (2007)
59. Gurbuz, Y., and Ismael I. A., "Effect of peppermint and basil as feed additive on broiler performance and carcass characteristics", Iran. J. Appl. Anim. Sci., 6, 149–156 (2016).