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# Productive Response to Manganese Added to the Diet of Broilers Ross (308) Exposed to Feed Restriction

**Mohammed Khalil Ibrahim Al-Saeedi[1], Hashim Hadi Al-Jebory[2], Majeed Ajafar[3], Nihad Abdul-Lateef Ali[4]**
[1] Department of Environment - College of Environmental Science -Al-Qasim Green University- Babylon province, Iraq.
[2] Uruk University/Baghdad/Iraq
[2,3,4] Department of Animal Production- college of agriculture-Al-Qasim Green University- Babylon province, Iraq.

**ABSTRACT:** Manganese sulfate was applied as a feed additive in the diet to show its effect on the productive characteristics of broilers. One hundred eighty broiler chicks were used, divided into four treatments. For each treatment, 45 chicks were divided into three replicates, each replicating 15 chicks. The treatments were 0+ (Free diets), 0+ Feed restriction eight h/day, 75, 100, and 125 mg/ kg feed+ feed restriction eight h/day for treatments T1, T2, T3, T4, and T5, respectively, and were subjected to feed restriction (8 hours/day) for 8-14 days of the experiment. The experiment continued for 35 days. The results of the experiment were: Significant superiority ($P \leq 0.05$) in live body weight at the end of the experiment and the total average weekly weight gain for treatments T3 and T4 compared to the rest of the treatments, and the treatment also increased significantly ($P \leq 0.05$) T1 in the rate of feed consumed, and the treatments T2 and T3 improved significantly ($P \leq 0.05$) in the feed conversion factor, and no significant differences were found in the percentage of chicks' mortality.

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**KEYWORDS:** Broiler, manganese, productive, feed additive, feed restriction.

**Corresponding Author:**
**Hashim Hadi Al-Jebory**

**INTRODUCTION**

Feed restrictions have been resorted to prevent getting rid of the prepared carcass's defects and reduce the abdominal fat content while increasing the sedimentation rate of protein, which leads to improved carcass quality (Pinheiro et al., 2004). Feed restriction in raising broilers is essential in reducing the amount of feed consumed and avoiding the rapid growth rate of modern breeds (Tolkamp et al., 2005). In addition, restricting feed in the early stage of chick growth is beneficial in improving the feed conversion factor and thus reducing the cost of rearing (Ahmed and Butris, 2014). However, Restricting feed at an early age reduces growth performance. Still, compensatory growth will be achieved in the subsequent feeding period to accelerate the growth of chicks to reach the required market weight (Jalal and Zakaria, 2012). Some studies have shown that dietary restriction can reduce metabolic diseases and skeletal disorders that lead to economic losses due to the reduced growth performance of birds, high mortality rates, and rejection of marketed birds at slaughterhouses (Scott, 2002; Jalal and Zakaria, 2012), and birds Previously regulated feed will have the ability to benefit from feed more efficiently after the period of regulated feeding or the so-called compensatory growth period because a better feed conversion ratio will have better compared to unregulated birds (Onderka and Hanson, 2003), especially in the case of adding some nutritional supplements to the diet or Drinking water during the food restriction period. Trace minerals are necessary for the growth and development of chicks and support their immune system, both before and after hatching (Al-Khafaji and Al-Jebory, 2018; Al-Khafaji and Al-jebory 2019; Kadhim et al., 2021; Al-Gburi et al., 2021; Al-Saeedi et al., 2021), manganese is a trace mineral element that is present in all tissues and is necessary for the metabolism within the body of amino acids, fats, proteins and carbohydrates (Zhu and Richards, 2017). Manganese is also a cofactor in many enzymes, such as lyases, oxidoreductases, transferases, isomerases, hydrolases, and ligases. The Mn metalloenzymes include arginase, phosphoenolpyruvate decarboxylase, glutamine synthetase, as well as Mn-superoxide dismutase (Mn-SOD) (Tufarelli and Laudadio, 2017), manganese is absorbed in the intestine and on the other hand, manganese absorption occurs in mucosal cells throughout the small intestine (Kies, 1987), as manganese is essential for many vital functions including supporting the immune system, modulating blood sugar and cellular energy, digestion, reproduction, bone growth, and aiding in defense mechanisms against free radicals (Dominguez, 2013). Also, manganese works with vitamin K to prevent blood sugar and clotting conditions. Manganese deficiency causes growth problems, reduced bone growth, skeletal defects, reduced fertility, and impaired carbohydrate and fat metabolism (Freeland-Graves et al., 2016).

Furthermore, manganese is essential for the formation of mucopolysaccharides that are important for the formation of cell membranes and components of proteoglycans, and these proteins are necessary for the growth of bone layers and the formation of cartilage in poultry bones (Yildiz et al., 2011; Favero et al., 2013). Mwangi et al. (2019) indicated that adding manganese sulfate to the broiler diet improved the body weight, productivity, and physiological status of birds. Therefore, this study aims to study the effect of adding manganese to the diet on the productive performance traits of broilers exposed to feed restriction.

## MATERIALS AND METHODS

This study was conducted on the farm of Jaflawi Poultry Company for the period from 25-2-2020 to 03-24-2020 when 180 day-old chicks were used, which were divided into five treatments, and the experimental parameters were as follows:

T1: control treatment without additives and free diets.

T2: dietary restriction 8 hours/day.

T3: Add 75 mg manganese sulfate/kg feed with a dietary restriction of 8 hours/day.

T4: Add 100 mg manganese sulfate/kg feed with a dietary restriction of 8 hours/day.

T5: Add 125 mg manganese sulfate/kg feed with a dietary restriction of 8 hours/day.

The dietary restriction application is from 8 am to 4 pm for 8 to 14 days of the experiment.

### Feed treatment

The chicks were fed on the starter diet from one day until the third week of the bird's age, containing a protein of 23% and representative energy of 3027 kcal/kg for feed. They were replaced by the final diet until the end of the fifth week, a container containing a protein of 20% and representative energy of 3195.3 kcal/kg; the feed and water were provided free of charge (ad libitum).

### Studied traits

Live body weight, weight gain, feed consumption, feed conversion ratio and, total mortality were measured according to Al-Jebory et al., (2024)

### Statistical analysis

The data were analyzed using a completely random design (CRD) to study the effect of the studied factors on the different traits. Significant differences between the averages were compared using Duncan's Multiple-Range Test (Duncan, 1955). SAS (2012) was used in the statistical analysis according to the following mathematical model: $Yij = \mu + Ti + eij$.

## RESULTS AND DISCUSSION

### Body weight and weight gain

Table (2) shows the effect of the study on live body weight checks for five weeks' age; in the first and third weeks, there was no significant difference between treatments; meanwhile, in the second, fourth, and fifth, Significant superiority ($P \leq 0.05$) was obtained for all manganese addition treatments compared to the control treatment. Table (3) Indicates the effect of the study on the weekly weight gain of broilers; it is noted that there were no significant differences between the treatments during the first week, while in the second week, the control treatment was significantly ($P \leq 0.05$) superior compared to the first treatment. Still, in the third week and the total average weekly weight gain, treatments T3 and T4 were significantly ($P \leq 0.05$) superior to those of T1, T2, and T3. In the fourth week, the treatments improved significantly ($P \leq 0.05$) T3 compared to treatment T1 and T2, and at the end of the experiment, treatments T5 were significantly increased ($P \leq 0.05$) compared to the treatments.

**Table 2: Effect of manganese in Live Body Weight (g / Bird) of broilers**

| Treatments | **Average ± standard error** | | | | |
|---|---|---|---|---|---|
| | First week | Second week | Third week | Fourth week | Fifth week |
| T1 | 131.91 ± 1.94 | 430.55 ± 1.62 a | 754.93 ±1.13 | 1190.65 ± 1.25 d | 1850.19 ±2.08 c |
| T2 | 130.85±1.63 | 409.13± 5.33 c | 740.85±3.09 | 1184.23±1.00 d | 1841.32±2.55 c |
| T3 | 130.71 ± 2.75 | 408.61 ± 1.74 c | 741.33 ±1.47 | 1239.61 ± 1.90 b | 1855.37 ±2.33 b |
| T4 | 132.41 ± 2.55 | 415.13 ± 0.90 b | 751.00 ±1.75 | 1228.93 ±1.14 c | 1867.27 ± 1.17a |
| T5 | 132.10 ± 2.13 | 403.91 ± 1.23 c | 758.68 ±1.50 | 1243.67 ±1.09 a | 1870.91 ± 2.00a |
| Significant | N.S | * | N.S | * | * |

Means with different letters indicate a significant difference in level * ($P \leq 0.05$), N. S: Not significant.

**Table 3: Effect of manganese in the weekly weight gain (g / bird) of broilers**

| Treatments | **Average ± standard error** | | | | | |
|---|---|---|---|---|---|---|
| | First week | Second week | Third week | Fourth week | Fifth week | Total |
| T1 | 92.91± 0.50 | 298.64± 1.52 a | 324.38± 0.60 c | 435.72± 1.14 c | 659.54± 1.71 a | 1811.19± 1.64 c |
| T2 | 91.85± 1.00 | 278.28± 0.91 b | 331.72±0.57 b | 443.38±2.01 c | 657.09±2.37 ab | 1802.32± 3.74 c |
| T3 | 91.71± 0.85 | 277.90± 0.35 b | 332.72± 0.72 b | 498.28± 1.51 a | 615.76± 1.80 c | 1816.37± 1.72 c |
| T4 | 93.41± 1.10 | 282.72± 0.44 b | 335.87± 0.85 b | 477.93± 1.09 bc | 638.34± 1.13 b | 1828.27± 1.30 b |
| T5 | 93.10± 0.75 | 271.81± 0.55 b | 354.77± 0.48 a | 484.99± 1.36 b | 627.24± 0.91 b | 1831.91± 1.81 a |
| Significant | N.S | * | * | * | * | * |

Means with different letters indicate a significant difference in level * (P≤0.05), N. S: Not significant.

**Feed intake**

It is noticed from table (4) the effect of manganese feed addition on the rate of feed consumed, and it appears that there is no significant difference between the treatments in the first and second week. In the third week, there was a substantial increase (P≤0.05) for the first treatment compared to the rest of the treatments, and this superiority withdrew for the fourth week. Treatment T3 came with the lowest feed rate in the fifth week, treatments T1 and T5 outperformed, and the significant decline (P≤0.05) of treatment T2 continued. In the total average of feed consumed, treatment T4 came with the lowest (P≤0.05) amount of feed consumed, followed by treatment T3 and T5 compared to treatment T1 and T2.

**Table 4: Effect of manganese in feed intake (g / bird) for broilers**

| Treatments | **Average ± standard error** | | | | | |
|---|---|---|---|---|---|---|
| | First week | Second week | Third week | Fourth week | Fifth week | Total |
| T1 | 118.00 ± 3.11 | 361.22 ± 3.14 a | 661.19 ± 2.90 a | 871.32 ± 4.12 a | 1095.31 ± 2.15 ab | 3107.04± 4.32 a |
| T2 | 119.98±2.03 | 311.05±1.28 b | 651.09±1.75 b | 863.12±3.14 b | 1098.95± 2.97 ab | 3044.19± 5.41 b |
| T3 | 119.35 ± 2.91 | 319.22 ± 3.19 b | 645.31 ± 2.16 c | 862.00 ± 3.82 b | 1053.21 ± 2.53 c | 2999.09± 3.65 c |
| T4 | 116.97 ± 3.00 | 309.07 ± 2.79 b | 649.33 ± 2.51 b | 839.53 ± 2.61 c | 1064.91 ± 2.70 b | 2979.81± 3.22 d |
| T5 | 119.61 ± 3.21 | 306.15 ± 3.55 b | 650.19 ± 3.57 b | 847.83 ± 3.50 bc | 1100.19 ± 2.87 a | 3023.97±3.17 bc |
| Significant | N. S | * | * | * | * | * |

Means with different letters indicate a significant difference in level * (P≤0.05), N. S: Not significant.

**Feed conversion ratio**

Table (5) shows the effect of the studied treatments on the feed conversion ratio. It significantly improved during the first week for T1, T4, and T5. In the second week, they improved significantly (P≤0.05) for T2, T4, and T5 treatments compared to the rest. In contrast, treatments T3, T4, and T5 improved significantly (P≤0.05) compared to treatments T1 and T2 in the third and fourth weeks; the total average of the feed conversion ratio was significantly improved (P≤0.05) by all. The manganese addition treatments were compared with the control treatment, but in the fifth week, the treatments T1, T2, T3, and T4 improved significantly (P≤0.05) compared to the treatment T5.

**Table 5: effect of manganese on feed conversion efficiency (gm feed/gm meat/bird) for broilers**

| Treatments | **Average ± standard error** | | | | | |
|---|---|---|---|---|---|---|
| | First week | Second week | Third week | Fourth week | Fifth week | Total |
| T1 | 1.27± 0.22 b | 1.20± 0.25 a | 2.03± 0.39 a | 1.99± 0.26 a | 1.66± 0.71 c | 1.71± 0.33 a |
| T2 | 1.30± 0.11 a | 1.11±0.12 c | 1.96±0.81 ab | 1.94±0.72 ab | 1.67±0.29 c | 1.68±0.41 b |
| T3 | 1.30± 0.47 a | 1.14± 0.55 b | 1.93± 0.23 b | 1.72± 0.17 c | 1.71± 0.43 b | 1.65± 0.28 b |
| T4 | 1.25± 0.15 c | 1.10± 0.50 c | 1.92± 0.27 b | 1.75± 0.52 b | 1.64± 0.52 c | 1.62± 0.54 b |
| T5 | 1.28± 0.36 b | 1.12± 0.41 c | 1.83± 0.61 c | 1.74± 0.39 b | 1.75± 0.91 a | 1.66± 0.80 b |
| Significant | * | * | * | * | * | * |

Means with different letters indicate a significant difference in level * (P≤0.05), N. S: Not significant.

**Total mortality percentage**

No significant differences were recorded between the studied treatments in the percentage of total loss (Table 6).

The improvement in live body weight, total weight gain, feed consumption, and feed conversion efficiency in the restriction and manganese addition treatments may be due to the role of dietary restriction, where restriction causes a reduction in feed consumption and, at the same time achieves an increase in the efficiency of its utilization through compensatory growth (Klein et al., 2017). Or, the role may be due to the time restriction, as research indicated that rationing feed improves the efficiency of feeding birds and reduces the percentage of bird mortality (Sahraei, 2012), and this also explains the low percentage of deaths in the restriction treatments, as between Boostani et al., (2010) that Time restriction reduced the rate of bird feed consumption and improved body weight and food conversion factor when exposed to food rationing for 8 hours/day. Compensation for the growth of birds depends on their ability to compensate for body weight during the compensatory growth period, and this may be due to the role of adding manganese to the ration; the manganese supplementation may be due to its role as a potent antioxidant agent that can improve the state of antioxidants inside the body, which is reflected on the productive traits of birds (Li et al., 2011; Fouad & El-Senosey, 2014), or it may be due to The role of manganese in the metabolism of amino acids, fats, proteins and carbohydrates within the body (Zhu and Richards, 2017). Manganese is also a cofactor for many enzymes, such as lyases, oxidoreductases, transferases, isomerases, hydrolases, and ligases. The Mn metalloenzymes include arginase, phosphoenolpyruvate decarboxylase, glutamine synthetase, as well as Mn-superoxide dismutase (Mn-SOD) (Tufarelli and Laudadio, 2017), thus increasing the utilization efficiency of the feed consumed which in turn increases body weight, weight gain, and feed conversion efficiency, manganese is poorly absorbed in the alimentary canal, especially in the intestine, and therefore it must be added to poultry diets to ensure that the bird gets its needs of manganese, and organic sources of manganese are more bioavailable compared to inorganic sources (Li et al., 2008; Yildiz et al., 2011). Manganese is also necessary for phosphorous oxidation processes, in synthesizing fatty acids, and in the metabolism of proteins. It is also an essential component of Mn superoxide dismutase (Mn-SOD) that protects cells from oxidative stress (Li et al., 2011), and manganese deficiency is associated with skeletal and physiological disorders, which include decreased oxidative defense system, and malformation of skeletal and cartilage (Tuormaa, 1996). The National Research Council (NRC, 1994) recommended that the manganese level for standard growth of broilers is 60 mg/kg. However, the commercial broiler industry typically formulates meals to contain higher amounts of trace minerals, including manganese, from inorganic sources (Leeson and Caston, 2008). Manganese also has a vital role as an antioxidant inside the body, as it was found to reduce the gene expression of heat shock proteins due to its antioxidant role (Zhu et al., 2016), which explains the improvement in the productive performance of fowls with Mn supplementation treatments.

**Table 6: Effect of manganese in total mortality % for broilers**

| Treatments | Average ± standard error |
|---|---|
| | total mortality (%) |
| T1 | 0.00 ±0.00 |
| T2 | 0.11±0.02 |
| T3 | 0.00 ± 0.00 |
| T4 | 0.05 ± 0.01 |
| T5 | 0.00 ± 0.00 |
| significance | N.S |

Means with different letters indicate a significant difference in level * (P≤0.05), N. S: Not significant.

## CONCLUSION

The results showed that the addition of manganese to the feed improved the productive characteristics under the conditions of feed restriction. The study also supported the reduction of bird mortality. Therefore, we recommend the addition of manganese to the diets of broilers and laying hens when the feed is restricted.

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