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THE RESPONSE OF PRODUCTIVE BROILER CHICKENS FOR ADDING NANO-ZINC TO DRINKING WATER UNDER HIGH TEMPERATURES IN IRAQ

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Abstract

This experiment was conducted in the field of poultry research belonging to the Department of Animal Production, College of Agriculture, Al-Qasim Green University for the period from 24/7/2018 to 28/8/2018, in order to investigate the effect of adding nano-zinc to drinking water in some of the productive traits for broiler chickens (ROSS 308) exposed to thermal stress. The experiment was started from one day to five weeks and 300 birds were used in the experiment. The birds were randomly divided into 5 treatments with 3 replicates per treatment and 20 birds for each replicate. The birds of the experiment were subjected to periodic temperatures (28 - 35 - 28)°C. The T_1 treatment was control treatment (without addition), while the treatments (T_2, T_3, T_4, T_5) included the adding of nano-zinc to drinking water at concentrations of (0.1, 0.2, 0.3, 0.4 ppm.L^{-1}), respectively. The results were as follows: A significant excelling ($P < 0.05$) was obtained in the T5 treatment compared to other treatments, as well as a significant excelling in the T_2 treatment on the treatments (T_1, T_3, T_4) in the average of live body weight and the average of weight gain for broiler chickens at 35 days. In addition, a significant increase was obtained in the amount of total feed consumption for weeks (1-5) in the T_5 treatment compared to the treatments (T_1, T_3, T_4), as well as a significant increase was obtained in the amount of total feed consumption for the T_2 treatment compared to the T_4 treatment. A significant improvement was observed in the feed conversion ratio for broilers chickens at weeks (1 - 5) in the adding treatment of nano - zinc (T_2, T_3, T_4, T_5) compared to the control treatment T_1 (without addition).

Keywords : Broilers chicken, nano-zinc, thermal stress.

Introduction

Poultry breeding in Iraq is experiencing the problem of rising temperatures during the long summer months, where the rise of temperatures from normal rates expose the bird for physiologic stress, which is responsible for bird immunity in birds, productive performance, Increasing the infection with disease, percentage of bird mortality (Gharib *et al.,* 2005). Thermal stress causes an increase in the formation of free radicals for reactive oxygen species (ROS), which causes oxidative damage in cells through the formation of lipid peroxidation, which leads to several disorders such as programmed cells death and several other diseases, The negative impact on the safety of muscle membranes (Saleh, 2014; El-Deep *et al.,* 2016). Recently, the poultry industry has seen the use of new technology, which is the nanotechnology for used materials at nano-scale with a size of (1-100 nm) (Albanese *et al.,* 2012). In recent years, nanomaterials have been used in the poultry industry because the use of antibiotics to treating pathogenicity for birds has become ineffective in order to increase the types of bacteria resistant to these antibiotics (Schwarz *et al.,* 2001). Where suitable substitutes (nanoparticles) were used as an antimicrobial, which improved growth in birds (Emily *et al.,* 2017). Zinc is considered one of the most important trace minerals of living systems in microorganisms, plants, and animals, where It plays an important role in various phylogenies, especially the rapid growth of poultry (Liu *et al.,* 2011). Zinc is considered an essential element in its effect on immune function, gene expression, cell reproduction, growth, and fertility, as well as being an essential part in the activity of more than 300 known enzymes. It is directly involved in metabolic pathways, a key component of cytoskeletal resistance against oxidative stress as an essential part of the superoxide dismutase (Zago and Oteiza, 2001; Mc

Dowell, 2003). Zinc has a positive effect on food utilization through its involvement in the metabolism of carbohydrates, proteins, and fats (Mac Donald, 2000). Through mentioned above from the importance of the zinc element in general and Nano zinc, especially as modern technology in the field of the poultry industry and to treating the problem of poultry exposure to thermal stress and what is caused by negative effects on the productive traits, This study was conducted to know the effectiveness of nano-zinc in the treating and mitigation of thermal stress and determining the best obtained concentrations.

Materials and Methods

This experiment was conducted in the field of poultry research belonging to the Department of Animal Production, College of Agriculture, Al-Qasim Green University for the period from 24/7/2018 to 28/8/2018. The chicks (ROSS 308) were prepared from Al-Anwar hatchery in Babylon province, with an average weight of (40 g ± 1). After the arrival of the chicks to the breeding hall, which their number is 300 chicks, they were distributed on five treatments and each treatment contains 60 chicks, with a rate of 3 replicates per treatment and each replicate contains 20 chicks. It was randomly distributed within pens, with dimensions of (1 x 1.5 m). The temperature of the hall was periodic (28, 35, 28 °C) and the treatments of the experiment were as follows:

1) First treatment: control treatment (without adding).
2) Second treatment: Adding nano-zinc to drinking water with a concentration of (0.1 ppm.L^{-1}).
3) Third treatment: Adding nano-zinc to drinking water with a concentration of (0.2 ppm.L^{-1}).
4) Fourth treatment: Adding nano-zinc to drinking water with a concentration of (0.3 ppm.L^{-1}).
5) Fifth treatment: Adding nano-zinc to drinking water with a concentration of (0.3 ppm.L^{-1}).

The chicks were fed on initiator diet (23% protein content and energy 3027 kcal/kg feed) from one day to the third week of the birds' life. They were then replaced by the growth diet (20% protein content and energy 3195.3 kcal/kg feed) until the end of the fifth-week, feed and water were provided free (ad libitum) and the used diet as shown in Table 1.

Table 1: Shows the percentage of used ingredients in the experiment and their chemical composition.

Feed materials	Initiator diet (%) 1-21 days	Growth diet (%) 22-35 days
yellow corn	30	40
wheat	28.25	24
Soybeans meal (48% protein)	31.75	24.8
The Concentrated Proteins	5	5
Sunflower oil	2.9	4.4
limestone	0.9	0.6
Dicalcium phosphate (DCP)	0.7	0.9
salt	0.3	0.1
A mixture of vitamins and minerals	0.2	0.2
Total	100	100
The Calculated chemical analysis		
Crude protein (%)	23	20
The calculated metabolic energy (kcal/kg feed)	3027	3195.3
Lysine (%)	1.2	1.1
Methionine (%)	0.49	0.46
Cysteine (%)	0.36	0.32
Methionine + Cysteine (%)	0.85	0.76
Available phosphorus (%)	0.45	0.49
C / P Energy: Protein ratio (%)	131.61	159.77

* The concentrated Protein (BROCON-5 Special W) from Chinese origin, each 1 kg of it contains: 40% curde protein, 3.5% fat, 1% fiber, 6% calcium, 3% phosphorus available, 3.25% lysine, 3.90% methionine + Cysteine, 2.2% sodium, 2,100 kcal / kg metabolic energy, 20000 IU Vitamin A, 40000 IU Vitamin D3, 500 mg Vitamin E, 30 mg vitamin K3, 15 mg vitamin B1 + B2, 150 mg B3, 20 mg B6, 300 mg B12, 10 mg folic acid, 100 ìg biotin, 1 mg iron, 100 mg copper, 1.2 mg manganese, 800 mg zinc, 15 mg iodine, 2 mg selenium, 6 mg cobalt, 900 mg anti-oxidant (BHT).
** The chemical analysis for the ingredients was calculated according to NRC (1994).

The liquid nano-zinc was obtained from Nanosany Corporation company in Iran, its size (10-30 nm), solution density (25 g.cm-3) and purity (99%).

The following health and safety program was used:

The temperature inside the hall was recorded daily in the hours of (600 AM, 1200 PM, 1800 PM and 2400 PM by 3 thermometers distributed inside the hall, where birds were exposed to periodic temperatures (28, 35, 28 °C) as shown in Table 3.

The following productive traits were studied

The average of live body weight for each treatment was calculated at the end of each week and for weeks (1 - 5) by weighing all birds of the replicate by a sensitive balance. The average of live weight

Table 2: The used health and safety program in the experiment.

Age (day)	The used vaccine or vitamin
1	Oily vaccine (Newcastle + IB + Infectious bursal disease)
2-5	B-Complex Vitamins + Antibiotics
14	Newcastle vaccine + IB (dropping in the eye)

Table 3: Average periodic temperature for the period (1-5 weeks).

Age (week)	Time			
	The temperature at 600 (°C)	The temperature at 1200 (°C)	The temperature at 1800 (°C)	The temperature at 2400 (°C)
1	33.76	35.14	35.21	33.24
2	29.94	35.38	35.55	29.38
3	28.81	35.62	36.08	28.07
4	29.42	36.67	36.28	28.33
5	27.65	36.85	36.44	29.38

for the bird was calculated according to the formula indicated by (Fayyad and Naji, 1989).

The average of live body weight (g/bird) =

(Total live weights for the birds of the replicate at the end of the week (g)) / (Number of the birds of the replicate at the end of the week (g))

As for the weekly average weight gain (g/bird) was calculated as following (Fayadh and Naji, 1989):

The weekly average weight gain (g/bird) = The average of live body weight at the end of the week (g) - The average of live body weight at the beginning of the week (g).

The weekly average feed consumption for the birds of single replicate and for weeks (1 - 5) was calculated by weighing the given feed for them at beginning of the week minus the remaining feed at the end of the week.

The feed conversion ratio was calculated according to the equation indicated by (Al-Zubaidi, 1986).

The weekly feed conversion ratio (g feed/g weight gain)=

$$\frac{\text{The average amount of consumed feed (g) per pack}}{\text{Average weight gain (g) within a week}}$$

Statistical Analysis System (SAS) (2012) was used in data analysis to study the effect of different treatments in the studied traits according to the completely randomized design (CRD) and The significant differences between the averages were compared with the Duncan's Multiple Range Test (Duncan, 1955).

Results

The average body weight and the average weight gain (g)

Tables 4, 5 shows the effect of the studied treatments on the average of live body weight (g) and the average weight gain for weeks (1-5 weeks). Table 4 shows that a highly significant excelling (p<0.01) was obtained for the average of live body weight in the first week for the T_5 treatment (Adding nano-zinc to drinking water with a concentration of (0.3 ppm.L^{-1})) on the T_1 treatment (without addition), T_2, T_3, T_3, and T_4. The T_2 treatment was also excelled on the treatments (T_1, T_4). The T_3 treatment was excelled on the T_1 treatment while no significant differences were found between the two treatments (T_1, T_4), between the two treatments (T_2, T_3) and between the two treatments (T_3, T_4). In the second week, the T_2 treatment was significantly excelled (P <0.01) on the treatments (T_1, T_3, T_5). The treatments (T_4, T_5) were also excelled on the treatments (T_1, T_3). The T_3 treatment was excelled on the T_1 treatment but there were no significant differences between the two treatments (T_2, T_4) and between the two treatments (T_4, T_5). As for the third week from age, the T_5 treatment recorded a significant excelling (P <0.01) on the treatments (T_1, T_2, T_3, T_4). The two treatments (T_2, T_4) were also excelled on the two treatments (T_1, T_3). At the fourth week, a highly significant excelling (p<0.01) was observed for the T_5 treatment on the treatments (T_1, T_2, T_3, T_4). The birds of the T_2 treatment were also excelled on the treatments (T_1, T_3, T_4), as well as the excelling of the T_4 treatment on the two treatments (T_1, T_3) and the T_3 treatment on the T_1 treatment. In the fifth week, the results of the statistical analysis showed a significant superiority (0.01> P) for the treatments (T_2, T_4, T_5) on the two treatments (T_1, T_3). The T_5 treatment was excelled on the treatments (T_1, T_2, T_3, T_4). The T_2 treatment was also excelled on the treatments (T1, T3, T_4). The T_4 treatment was excelled on the two treatments (T_1, T_3). Table 5 shows the effect of the studied treatments on the average weight gain for weeks (1-5 weeks). In the first week, the T_5 treatment was significantly excelled (p<0.01) on the rest of the treatments. The T_2 treatment was also excelled on the two treatment (T_1, T_4). The T_3 treatment excelled on the control treatment (T_1). while no significant differences were found between the two treatments (T_1, T_4) and between the two treatments (T_3, T_4). In the second week, the two treatments (T_2, T_4) was significantly excelled (P <0.01) on the treatments (T_1, T_3, T_4). The T_3 treatment was excelled on the T_1 treatment but there were no significant differences between the two treatments (T_1,

T_3) and between the two treatments (T_1, T_5). As for the third week from age, the T_5 treatment recorded a significant excelling (P <0.01) on the treatments (T_1, T_2, T_3, T_4). The T_4 treatment was also excelled on the two treatments (T_1, T_2, T_3). The two treatments (T_1, T_2) were also significantly excelled on the T_3 treatment. The table shows a high significant excelling (p<0.01) for the T_5 treatment on the treatments (T_1, T_2, T_3, T_4). At the fourth week, a highly significant excelling (p<0.01) was observed for the T_2 treatment on the treatments (T_1, T_3, T_4). The two treatments (T_3, T_4) were also excelled on the T_1 treatments. In the fifth week, the results of the statistical analysis showed a significant superiority (0.01> P) for the T_2 treatment on the treatments (T_1, T_2, T_3, T_5). The treatments (T_1, T_4, T_5) were excelled on the T_3 treatment. The T_5 treatment was also excelled on the T_4 treatment and it did not show significant differences between the two treatments (T_1, T_4) and between the two treatments (T_1, T_5). As for the total weight gain (g), the data of the table show a highly significant superiority (0.01> p) for the T_5 treatment on the treatments (T_1, T_2, T_3, T_4). the T_2 treatment was also excelled on the treatments (T_1, T_3, T_4). The T_4 treatment was excelled on the two treatments (T_1, T_3).

The average feed consumption (g/bird)

Table 6 shows the effect of the studied treatments on the average of feed consumption (g/bird) for weeks (1-5 weeks). in the first week, it was found significant excelling in the T_5 treatment on the treatments (T_1, T_2, T_3, T_3, T_4). The two treatment (T_2, T_3) was also excelled on the treatments (T_1, T_4). In the second week, the T_1 treatment was significantly excelled on the rest of the treatments. In the second week, the T1 treatment showed a significant excelling (p<0.01) on the rest of the treatments. In the third week, the results of the table showed a significant superiority (p<0.01) for the T_5 treatment on the treatment (T_1, T_3, T_4). while no significant differences were found between the treatments (T_1, T_2, T_3, T_4) and between the two treatments (T_2, T_5). In the fourth week, there were significant differences (P

Table 4: Effect of adding different concentrations of nano-zinc to the drinking water of broiler chickens exposed to thermal stress in the average of live body weight (g) for weeks (1-5).

Treatments	Average ± standard error (g)					
	One day-age	First week	Second week	Third week	Fourth week	Fifth week
T_1	39.91 ± 0.36	136.67 ± 1.20 d	446.72 ± 1.16 d	755.45 ± 5.46 c	1289.48 ± 7.74 e	1765.42 ± 18.21 d
T_2	40.16 ± 0.54	143.17 ± 1.76 b	461.41 ± 0.58 a	774.75 ± 1.52 b	1385.75 ± 3.41 b	1905.39 ± 3.99 b
T_3	39.75 ± 0.25	140.91 ± 0.98 bc	452.55 ± 1.47 c	748.71 ± 1.49 c	1313.92 ± 2.39 d	1747.46 ± 2.92 d
T_4	39.75 ± 0.14	138.97 ± 0.39 cd	458.09 ± 1.31 ab	782.41 ± 3.77 b	1338.00 ± 4.71 c	1798.36 ± 3.99 c
T_5	40.83 ± 0.08	150.41 ± 1.15 a	456.75 ± 0.66 b	808.75 ± 3.47 a	1452.00 ± 4.18 a	1936.88 ± 3.10 a
Significant level	NS	**	**	**	**	**

The averages with different letters within the same column vary significantly between them.
** (P <0.01), NS: Not significant.
The treatments (T_1, T_2, T_3, T_4, T_5) represent the adding of nano-zinc to drinking water at a concentration of (0, 0.1, 0.2, 0.3, 0.4 ppm / L water), respectively.

Table 5: Effect of adding different concentrations of nano-zinc to the drinking water of broiler chickens exposed to thermal stress in the average weight gain (g) for weeks (1-5).

Treatments	Average ± standard error (g)						
	One day-age	First week	Second week	Third week	Fourth week	Fifth week	Average weight gain (g)
T_1	96.75 ± 1.50 d	310.05 ± 2.27 bc	308.73 ± 4.37 c	534.02 ± 6.94 d	475.94 ± 10.75 bc	1725.50 ± 17.92 d	96.75 ± 1.50 d
T_2	103.00 ± 1.23 b	318.25 ± 1.37 a	313.33 ± 3.00 c	611.00 ± 3.00 b	519.64 ± 6.58 a	1865.22 ± 4.44 b	103.00 ± 1.23 b
T_3	101.16 ± 0.74 bc	311.63 ± 0.56 b	296.16 ± 1.15 d	565.20 ± 3.61 c	433.54 ± 4.67 d	1707.71 ± 2.71 d	101.16 ± 0.74 bc
T_4	99.22 ± 0.26 cd	319.11 ± 1.61 a	324.32 ± 3.29 b	555.58 ± 0.94 c	460.35 ± 3.29 c	1758.61 ± 4.02 c	99.22 ± 0.26 cd
T_5	109.58 ± 1.08 a	306.33 ± 0.92 c	352.00 ± 3.78 a	643.24 ± 6.87 a	484.88 ± 7.28 b	1896.05 ± 3.10 a	109.58 ± 1.08 a
Significant level	**	**	**	**	**	**	**

The averages with different letters within the same column vary significantly between them.
** (P <0.01), NS: Not significant.
The treatments (T_1, T_2, T_3, T_4, T_5) represent the adding of nano-zinc to drinking water at a concentration of (0, 0.1, 0.2, 0.3, 0.4 ppm / L water), respectively.

Table 6: Effect of adding different concentrations of nano-zinc to the drinking water of broiler chickens exposed to thermal stress in the average of feed consumption (g/bird) for weeks (1-5).

Treatments	Average ± standard error (g)						
	One day-age	First week	Second week	Third week	Fourth week	Fifth week	Total feed consumption
T_1	98.25 ± 1.04 c	366.29 ± 3.97 a	521.46 ± 11.44 b	809.33 ± 10.80 ab	895.58 ± 11.18	2690.93 ± 23.04 bc	98.25 ± 1.04 c
T_2	105.50 ± 0.66 b	356.75 ± 0.43 b	532.75 ± 6.08 ab	827.58 ± 9.56 a	924.91 ± 5.20	2747.50 ± 20.17 ab	105.50 ± 0.66 b
T_3	104.16 ± 1.34 b	350.58 ± 1.08 b	513.58 ± 0.71 b	808.91 ± 10.80 ab	905.41 ± 11.81	2682.67 ± 22.35 bc	104.16 ± 1.34 b
T_4	99.70 ± 0.33 c	355.75 ± 3.13 b	519.41 ± 3.84 b	787.83 ± 13.54 b	893.83 ± 11.99	2656.53 ± 22.40 c	99.70 ± 0.33 c
T_5	111.25 ± 1.37 a	352.00 ± 2.89 b	546.66 ± 3.44 a	836.67 ± 7.92 a	917.83 ± 8.29	2764.58 ± 12.91 a	111.25 ± 1.37 a
Significant level	**	**	*	*	NS	**	**

The averages with different letters within the same column vary significantly between them.
** (P <0.01), NS: Not significant.
The treatments (T_1, T_2, T_3, T_4, T_5) represent the adding of nano-zinc to drinking water at a concentration of (0, 0.1, 0.2, 0.3, 0.4 ppm / L water), respectively.

Table 7: Effect of adding different concentrations of nano-zinc to the drinking water of broiler chickens exposed to thermal stress in the feed conversion ratio (g feed/ g weight gain) for weeks (1-5).

Treatments	Average ± standard error (g)						
	One day-age	First week	Second week	Third week	Fourth week	Fifth week	Average
T_1	1.015 ± 0.005 ab	1.181 ± 0.020 a	1.688 ± 0.029 a	1.515 ± 0.022 a	1.883 ± 0.043 bc	1.456 ± 0.014 a	1.015 ± 0.005 ab
T_2	1.024 ± 0.006 ab	1.139 ± 0.024 ab	1.700 ± 0.022 a	1.354 ± 0.009 bc	1.804 ± 0.010 c	1.404 ± 0.011 b	1.024 ± 0.006 ab
T_3	1.029 ± 0.011 a	1.124 ± 0.005 ab	1.733 ± 0.004 a	1.431 ± 0.022 b	2.088 ± 0.028 a	1.481 ± 0.005 b	1.029 ± 0.011 a
T_4	1.004 ± 0.002 b	1.114 ± 0.015 b	1.571 ± 0.005 b	1.417 ± 0.026 b	1.941 ± 0.039 b	1.409 ± 0.013 b	1.004 ± 0.002 b
T_5	1.015 ± 0.006 ab	1.148 ± 0.012 ab	1.553 ± 0.026 b	1.301 ± 0.025 c	1.892 ± 0.015 bc	1.382 ± 0.003 b	1.015 ± 0.006 ab
Significant level	*	*	**	**	**	**	*

The averages with different letters within the same column vary significantly between them.
** (P <0.01), NS: Not significant.
The treatments (T_1, T_2, T_3, T_4, T_5) represent the adding of nano-zinc to drinking water at a concentration of (0, 0.1, 0.2, 0.3, 0.4 ppm / L water), respectively.

<0.05) for the two treatments (T_2, T_5) on the T_4 treatment and it was not observed significant differences between the treatments (T_1, T_2, T_3, T_5) and the treatments (T_1, T_3, T_4). In the fifth week, it was not observed significant differences between the different treatments. The total amount of feed consumption for weeks 1-5. Table 6 shows a significant superiority (0.01> p) for the T_5 treatment on the (T_1, T_3, T_4). The T_2 treatment was also excelled on the T4 treatment but there were no significant differences between the treatments (T_1, T_2, T_3) and between the treatments (T_1, T_3, T_4) and between the two treatments (T_2, T_5).

Feed conversion ratio (g feed/ g weight gain)

Table 7 shows the effect of adding nano-zinc to drinking water in the feed conversion ratio for the different weeks (1-5) of the bird's age. The first week showed significant improvement (P <0.05) for the T_4 treatment compared to the T_3 treatment, while did not show significant differences between the treatments (T_1, T_2, T_3, T_5) and between the treatments (T_1, T_2, T_4, T_5). In the second week, there was a significant improvement (P <0.05) in the T_4 treatment compared to the T_1 treatment, while did not show significant differences between the treatments (T_1, T_2, T_3, T_5) and between the treatments (T_2, T_3, T_4, T_5). A significant improvement (0.01% p) for the two treatments (T_4, T_5) was found in the third week compared to the treatments (T_1, T_2, T_3). The results of the table showed a significant improvement (P <0.01) for the T_5 treatment compared to the treatments (T_1, T_3, T_4). There was also a significant improvement in the treatments (T_2, T_3, T_4) compared to the T_1 treatment, while did not show significant differences between the treatments (T_2, T_3, T_4) and between the treatments (T_2, T_5). In the fifth week, there was a significant improvement (p<0.01) in the T_2 treatment compared to the two treatments (T_3, T_4), As well as a significant improvement in the treatments (T_1, T_4, T_5) compared to the T_3 treatment, while did not show significant differences between the treatments (T_1, T_2, T_5) and between the treatments (T_1, T_4, T_5). As for the general average for a feed conversion ratio, the results of the statistical analysis for the table showed a significant improvement ($p<0.01$) for the adding treatments (T_2, T_3, T_4, T_5) compared to the control treatment (T_1).

Discussion

The reason for the significant improvement for the productive traits for the broiler chickens which represented by the live body weight (g), the weight gain (g), the amount of feed consumption (g/bird) and the feed conversion ratio in the treatments (T_2, T_4, T_5), which added to it nano-zinc with concentrations of (0.1, 0.3, 0.4 ppm) to drinking water compared to the control treatment (without adding). The reason may be due to the role of nano-zinc in improving the productive performance for the broiler chickens to achieve optimal performance in conditions of thermal stress through its role in the mitigation of oxidative damage where the antioxidants are necessary to prevent economic losses in poultry (Salami *et al.,* 2015). Zinc works to increase the production of metallothionein, a cysteine-rich protein that works on reduce the free radicals (Oteiza *et al.,* 1996). Zinc is also absorbed in the intestines and it is combined with the protein metallothionein intestinal or it can be transferred by albumin to the liver (Prasad, 1993; Oteiza *et al.,* 1996). Zinc can replace some mineral elements such as iron Fe and copper Cu in their union places, combine with cellular membranes and reduce free radicals production, thereby acting directly to oxidative stress in thermal stress (Powell, 2000; Prasad and Kucuk, 2002). Thermal stress increases the formation of free radicals of active oxygen in the body, leading directly to the oxidation of fatty membranes, such as the membranes surrounding fatty phospholipids, which are a component of the plasma membrane in cells (Surai, 2000). Thus free radicals damage the body cells, Zinc works to prevent this condition in the body by preventing lipid peroxidation by inhibiting the depletion of glutathione (Prasad, 1997). The significant improvement in the treatments that added to it nano-zinc to the role of zinc in enhancing the resistance of birds to thermal stress, which directly affected the improvement in the productive performance for the birds in these treatments compared to the control treatment that achieved the lowest growth rate and the lowest feed conversion ratio. This is due to the role played by zinc, which is necessary for the activity of more than 300 enzymes and is involved in many of the enzymatic activities that enter the metabolic processes in the body (Prasad and Kucuk, 2002). Zinc also increases the resistance of birds to thermal stress through increasing the use of food intake through its involvement in the metabolism of carbohydrates, fats, and proteins (MacDonald, 2000), because the digestion of protein and fat and starch decreases when the birds are exposed to high temperatures (Bounet and others, 1997). In addition, the decrease in the activity of Trypsin, Chymotrypsin, and Amylase enzymes at high temperature is more than 32 °C (Hai *et al.,* 2000). This result agrees with the results of our experiment, in which we observed an increase in body weight and feed consumption and an improvement in the feed conversion ratio compared to the control treatment. The reason for the increase in body weight, the average weight gain, and the improvement of the feed conversion ratio in adding treatments compared to the control treatment may be due to the role of zinc in maintaining the structure of metalloproteins such as growth hormone (GH), Insulin-like growth factor 1 (IGF-1) and insulin. This role contributes to maintaining the natural growth and development of the body because these hormones regulate the absorption of glucose and regulation of cellular processes (Midilli *et al.,* 2014; Khan *et al.,* 2014; Rouhalmini *et al.,* 2014). It may also be due to the role of zinc in improving the health of birds when exposed to thermal stress by increasing the effectiveness of the metabolic rate in the body as a result of increasing the level of thyroxine (T4) when adding zinc, Morley *et al.,* (1980) found that zinc reduction in serum was accompanied by reducing the levels of TSH that secreted from the pituitary gland and then decreases in thyroid hormones T_3 and T_4, which shows that zinc has a role in contributing the building of body tissues by increasing the level of thyroid hormones.

Conclusion

It was observed that adding nano- nano-zinc to drinking water with a concentration of (0.4 $ppm.L^{-1}$) for broiler chickens exposed to the thermal stress led to improvements in the average of live body weight and the amount of feed consumption as well as an improvement in the feed conversion ratio compared to the control treatment (without adding).

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