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Research Paper

Improving Chicken Growth Performance with Nano Silver Added to Drinking Water

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Abstract— Silver nanoparticles (Silver NPs) are among the most potent nanoparticles used in nanoscience. Through a five-week feeding trial, this study examined the effects of various concentrations of (Silver NPs) added to water on broiler chicken growth performance. From 21-3-2019 to 24-4-2019, 225-day-old (Ross 308) broiler chicks were allocated into five random groups, each being replicated three times with 15 birds in each replication. Silver nanoparticles were supplemented to drinking water at 0.0, 20, 30, 40, and 50 ppm/L for groups G1 (control group), G2, G3, G4, and G5, respectively. Our findings showed that the group that received drinking water with 20 ppm/L had a significant advantage over the other groups in terms of body weight at the 4th and 5th weeks and total weight gain throughout the experiment. The overall food conversion ratio of groups that received drinking water containing up to 30 ppm/L significantly improved in groups supplemented with greater concentrations in terms of kg weight growth per kilogram feed intake. The G2 group is the only group that achieved zero mortality compared to the other groups. It was also found that the levels of Nanosilver increased the number of red and white blood cells, hematocrit, and hemoglobin at 14 and 35 days of the age of the broilers. It also increased glucose levels, triglycerides, malondialdehyde (MDA), and the glutathione enzyme at 35 days of the age of the broilers the groups G4 and G5 were the highest.

Keywords— Nano metallic, growth performance, broiler, silver nano-particles.

1. Introduction

One of the most promising metallic nanoparticles used in nanoscience and nanotechnology, notably in healthcare applications, is silver nanoparticles (SilverNPs) due to its multifunctional bio-applications such as antibacterial, antiviral, anti-inflammatory, antifungal, and anti-angiogenic [1،2،3] More recently, solutions have been discovered via nanotechnology for using these compounds at the nanoscale (1–100 nm), as occur in metals of silver, platinum, palladium, and gold [4]. Some bacteria have developed antibiotic resistance to become 'superbugs' [5]. Several studies have demonstrated the powerful impact of silver nanoparticles on a wide range of gram-positive and gram-negative bacteria, for example, Escherichia coli, Staphylococcus aureus, Bacillus subtilis, and Campylobacter jejuni [7،6] especially against multi-drug resistant bacteria [8] and common fungi (*Saccharomyces*, *Candida*, and *Aspergillus*) [8،9] besides to antioxidant and anticancer effect [8] which suggests the potential medicinal use of these nanoparticles [10]. The superior antimicrobial characteristics of silver and its derivatives have been exploited because of its oxidative properties that cause cellular respiration failure in microorganisms [11] as well as it is highly effective in neutralizing organisms that destroy the inner walls of their cells as soon as microorganisms ingest the silver ions as shown in treated E. coli cells with silver nanoparticles that form “pits” in the cell wall of the bacteria [12]. Owning to their nanoscale size and high specific colossal surface area that the microorganism may be exposed to, its penetration is facilitated into the bacterial cell walls and, as a consequence, changes the cell membrane structure, leading to cell growth inhibition or even cell death [13]. As proven by [6], in B. subtilis cells treated with 10–50 ppm of Silver NPs, the expression of cytosolic proteins decreased while reductase activity increased at doses of 25 ppm and higher.

Additionally, silver nanoparticles boost the antibacterial effects of many drugs, such as amoxicillin, penicillin G, erythromycin, clindamycin, and vancomycin, with a diameter of 22.5 nm [14]. In addition, it exhibits low toxicity to mammalian cells and tissues and excellent thermal stability [15]. Currently, silver NPs surpassed other types of nanoparticles because of their superior performance in enhancing the health and productivity of chickens, besides their contribution to the decreased feed intake for every kg body weight gain that makes it a valuable feed source from an economical and productive point of view for poultry [16،17]. The superior antimicrobial characteristics of silver nanoparticles are well-reported, but there is still much controversy around the amount of silver NPs that can be hazardous. This study aimed to demonstrate the effect of different concentrations of silver nanoparticles on the growth performance of Ross 308 broiler chickens with particular reference to the safe concentration that achieves the best growth performance.

2. Related Work

Previous studies have reviewed the effect of nano-silver on broilers, its effect on the performance of hatching chicks, the growth performance of chickens, and the extent of its ability to resist heat stress [17،35،،57]**.**

3. Materials and methods

Ethical consideration
This study was conducted under the recommendations of research ethics for scientific researchers involving animal subjects. The animals used were handled according to the Animal Experimentation Ethics Committee principles at Al-Qasim Green University (Research Ethics Committee Recommendations, 2019).

Sampling
This research was conducted in the Department of Animal Production - Faculty of Agriculture / Al Qasim Green University's poultry farm. Nanosilver with a diameter of 20 nm was obtained from the Nanosany company.

Animal
Two hundred twenty-five one-day-old unsexed broiler chicks (Ross 308) were randomly divided into five groups of 45 birds. Each group was distributed over three replicates with 15 birds per each one. Birds were reared in a 1x1.5 m cage under similar management conditions till the end of the study (35 days of age).

Experimental design
Silver nanoparticles were added to the experimental groups' drinking water at concentrations of 0.0, 20, 30, 40, and 50 ppm/L for groups G1 (control group), G2, G3, G4, and G5, respectively. Diets (The composition and nutrient content) were designed to meet the nutrient requirements for the birds during stages of growth (starter, grower, and finisher) based on [18]. For the first three days, the temperature was kept at 32°C. After that, it was gradually decreased by three °C weekly until it reached 24°C, where it remained till the end of the study.

Performance Traits Measurement

Live body weight and weight gain
The body weight and weight gain were calculated according to [19].

Relative growth rate
The relative growth rate was measured according to [20] where RGR = ((W2-W1) / (0.5 (W2+W1)*100 as W1 = initial weight and W2 = final weight.

Feed intake
Feed intake per week was indicated according to [19].

Feed conversion ratio
The feed conversion ratio was indicated according to [19].

Mortality %
The mortality was indicated throughout the whole study and calculated as follows.
Total mortality percent

$$= \frac{\text{The number of mortality birds during the experiment period}}{\text{the total number of birds}} X100$$

Physiological traits
The volume of packed blood cells (PCV) and the number of red and white blood cells (RBC & WBS) were calculated by taking blood samples in tubes containing an anticoagulant that included one male and one female from each replicate at the age of 14 and 35 days from the wing vein. The PCV was calculated according to the method of [21] and the number of (RBC & WBS) according to [22], and hemoglobin (Hb) was extracted according to what was mentioned by [23].

Blood samples were taken from chicks exposed to different groups, and certain physiological traits were assessed. The levels of glucose, cholesterol, and the enzyme glutathione peroxidase (GSH) and (MDA) were measured in the chicks' blood serum. The German business Roche provided the measuring instrument (Kit), which was used to assess the glucose levels according to [24] in the method [25], The concentration of the enzyme GSH and MDA was estimated its concentration was measured using a kit from Roche company, based on [26].

Statistical analysis
The Statistical Analysis System -SAS [27] was used in data analysis with Completely Randomized Design (CRD), and the mean differences between the averages were compared to the [28] polynomial test.

4. Results and Discussion

Body weight (g/bird)
The effect of merging different silver nanoparticle concentrations in drinking water on live body weight is seen in Table 1. The body weight of a 1-day-old chick of Ross-308

breeds did not reveal a significant difference among the different group groups, while later weeks showed significant differences. There was no significant difference between different groups on day one that reflected the homogeneity of treated groups at the beginning of the experiment. In the first week, the G2, G4, and G5 groups had a significant superiority level (P< 0.05) above the G3 groups. There was no significant difference between the G2, G4, G5, and G1 groups, thus the G1 and G3 Groups; however, the second week didn't reveal any significant difference between the studied groups. On the other hand, the G1 group was significantly superior (P< 0.01) to the rest of the trial groups in the third week without significant differences between G2, G3, G4, and G5 groups. The lowest body weight of the fourth and final week was related to groups that received the highest dose of silver nanoparticles at 30 ppm and 40 ppm. G2 was considerably superior to G3, G4, and G5 groups by 3 %, 8%, and 8%, respectively in the fourth week. Also, in the final week of the study, the G2 group showed significant improvement (P< 0.01) compared to the control group, G3, G4, and G5 by 1%, 5%, 7%, and 6%, respectively.

Weight gain and relative growth rate

The effect of silver nanoparticles supplement to drinking water on weight gain (g/bird) was shown in Table 2, noting a significant superiority (P < 0.05) for G2, G4, and G5 groups over group G3 in the first week of the trial. Group effect didn't show significant differences between studied groups between 1-2 weeks. There was a more significant rise (P < 0.01) for the G1 group compared to the rest groups in the third week, but there was no significant difference between G2, G3, G4, and G5 groups. In the 4th week, the G2 group was associated with the most effective weight gain. G1, G4, and G5 groups were considerably superior (P< 0.01), and G1 G3 increased when compared to G4 and G5 groups, and there were no significant differences between G1 and G3 group, G2 group, and G3 group. Statistical analysis did not show significant differences between groups in the final week of the experiment. The data showed that the supplementation of Silver NPs in drinking water significantly increased (p<0.01) total weight gain of G2 by 1% compared to the control group and by 5 %, 7 %, and 6% as compared to G3, G4, and G5, respectively.

Moreover, from our study of the relative growth rate, it was found that there was significant (p>0.05) improvement in treated groups compared to the control group in all levels of Silver NPs for all periods studied (Table 4). G2, G4, and G5 showed the best results compared to G1 and G5 in the first week, while G3 surpassed other groups in the second week. On the other hand, the control group gave the highest value compared to the other groups in the 3rd week. In contrast, G2 and G3 showed significant improvement on the 4th week. G5 recorded a positive value only at the end of the experiment.

Table 1: Effect of Nanosilver added to drinking water on live body weight (g / bird) in broiler chicken.

Groups	Mean ± standard error (g / bird)					
	Day 1	1st week	2nd week	3rd week	4th week	5th week
G1	44.00 ± 3.11	160.77 ^{ab} ± 3.17	457.79 ± 5.39	939.06 ^{a} ± 5.15	1491.47 ^{ab} ± 7.62	2120.40 ^{b} ± 4.76
G2	44.00 ±2.15	165.55 ^{a} ± 3.58	448.66 ± 4.33	903.33 ^{b} ± 1.85	1515.55 ^{a} ± 4.57	2141.28 ^{a} ± 5.73
G3	43.11±1.89	153.99 ^{b} ± 2.03	± 3.44 450.88	892.10 ^{b} ± 3.25	1472.93 ^{b} ± 7.52	2035.57 ^{bc} ± 4.94
G4	43.34 ±4.16	164.44 ^{a} ± 2.47	± 3.71 460.66	904.45 ^{b} ± 3.28	1399.96 ^{c} ± 4.65	1999.45 ^{c} ±6.31
G5	43.55±1.57	166.10 ^{a} ± 3.27	± 3.56 461.11	909.95 ^{b} ± 6.68	1402.06 ^{c} ±4.99	2021.90^{c} ± 3.22
significance	NS	*	NS	**	**	**

*: Significant at a level (P< 0.05). ** : Significant at a level (P< 0.01). NS: Non-significant. G1: control group while G2, G3, G4, and G5 add 20, 30, 40, and 50 ppm nano- silver/ respectively.

Table 2. Effect of adding Nanosilver to drinking water on weight gain (g / bird) in broiler chicken.

Groups	Mean ± standard error (g / bird)					
	0-1 wk	1-2 wk	2-3 wk	3-4 wk	4- 5 wk	0 – 5 wk
G1	116.77 ^{ab}±3.37	297.01± 5.49	481.27^{a} ± 3.85	552.41^{b} ± 3.08	628.82 ± 5.17	2076.40 ^{ab} ± 4.82
G2	122.55^{a} ± 3.27	± 7.58 283.11	454.67^{b} ± 3.40	612.21^{a} ± 6.42	625.73 ± 4.31	2098.28 ^{a} ± 3.71
G3	110.88 ^{b} ± 2.21	± 4.47 297.00	441.22^{b} ± 9.84	580.82^{ab} ± 5.06	562.63 ± 4.12	1992.57 ^{bc} ± 4.98
G4	121.10^{a} ± 2.61	± 4.01 296.22	443.78^{b} ± 6.67	486.50^{c} ± 5.61	599.49 ± 4.51	1956.01 ^{c} ± 6.31
G5	122.55^{a} ± 2.88	± 5.48 295.00	439.84^{b} ± 5.41	492.54^{c} ± 9.51	619.84 ± 7.46	1978.35 ^{c} ± 2.70
significance	*	NS	**	**	NS	**

*: Significant at a level (P< 0.05). ** : Significant at a level (P< 0.01). NS: Non-significant. G1: control group while G2, G3, G4, and G5 add 20, 30, 40, and 50 ppm nano- silver/ respectively.

Table 3. Effect of adding Nanosilver to drinking water on relative growth rate in broiler chicken.

Groups	Mean ± standard error (g / bird)				
	1st week	2nd week	3rd week	4th week	5th week
G1	114.04 ^{b}±0.24	96.03^{b} ±0.09	68.90^{a} ±0.25	45.45^{b}±1. 03	34.82^{b}± 0.04
G2	116.01 ^{a}±0.32	92.18^{d} ±0.17	67.25^{ab} ±0.11	50.62^{a}±0. 61	34.22^{b}± 0.07
G3	112.51^{c} ±0.15	98.16^{a} ±0.13	65.70^{b} ±0.47	49.11^{ab}±0 .10	32.07^{c}± 0.12
G4	116.56 ^{a}±0.91	94.77^{b}± 0.06	65.01^{b} ±0.31	43.00^{c}±0. 36	35.27^{ab}± 0.08
G5	116.90 ^{a}±0.12	94.07^{b}± 0.017	65.47^{b} ±0.55	42.57^{c}±1. 25	36.20^{a}± 0.28
Significant	*	*	*	*	*

*: Significant at a level (P< 0.05). NS: Non-significant. G1: control group while G2, G3, G4, and G5 add 20, 30, 40, and 50 ppm nano- silver/ respectively.

Feed intake (g/bird)

The effect of adding silver nanoparticles in drinking water on the feed intake of birds is shown in Table (4) with no significant differences between groups in the first week but a superior significant (P < 0.05) effect for G1, G2, G3, and G4

groups was observed compared to the G5 group in the second week. In contrast, a significant difference wasn't detected between G1, G2, G3, and G4 groups in the third week. Feed consumption did not change significantly among the groups investigated in the fourth and fifth weeks, as well as total feed intake.

Feed conversion ratio (kg feed/kg meat/chicken)

Table (5) shows the effect of combining silver nanoparticles with drinking water on feed conversion ratio. The first trial week revealed no significant differences between the groups, but a significant improvement (P< 0.05) was shown for the G5 group compared to the G2 group in the 2nd week. At the same time, G3 and G4 groups improved significantly (P<0.05) compared to G5 groups in the 3rd week. Meanwhile, the final week showed no significant difference between the studied groups. On the other hand, there was a significant improvement (P< 0.05) for the total FCR of G1, G2, and G3 groups when compared to G4 without significant differences between G5 and G1, G2, G3, and G4 groups. This indicated that feed intake increased per kg weight gain with increasing silver nanoparticle concentration.

Table 4: Effect of Nanosilver added to drinking water on feed intake (g / bird) in broiler chicken.

Groups	Mean± standard error (g / bird)					
	1st week	2nd week	3rd week	4th week	5th week	Total FI
G1	115.33 ± 2.77	363.44 ^{a}± 4.30	534.00^{ab} ± 4.32	757.0 0 3.46 ±	981.33 ± 3.81	2751.11 ± 4.80
G2	115.85 ± 3.27	362.88 ^{a} ±5.76	535.55^{ab} ± 3.35	765.5 5 ± 5.68	937.33 ± 2.33	2717.18 ± 4.82
G3	109.88 ±2.21	362.92 ^{a} ± 4.63	499.66^{b} ± 1.00	747.9 7 ± 4.99	988.52 ± 5.05	2708.97 ± 2.85
G4	110.11 ±1.45	362.73 ^{a} ± 4.60	515.77^{b} ± 3.61	744.0 8 ± 3.49	950.44 ± 1.10	2683.15 ± 4.28
G5	113.77 ±1.33	343.08 ^{b} ± 7.80	573.69^{a} ± 4.85	759.5 2 2.11 ±	980.35 ± 2.85	2770.43 ± 3.46
significance	NS	*	*	NS	NS	NS

*: Significant at a level (P< 0.05). NS: Non-significant. G1: control group while G2, G3, G4, and G5 add 20, 30, 40, and 50 ppm nano- silver/ respectively.

Table 5: Effect of adding silver nanoparticles with drinking water on feed conversion ratio

Groups	Mean ± standard error (g / bird)					
	1st week	2nd week	3rd week	4th week	5th week	Total FCR
G1	0.988. ± 0.01	1.223^{ab} ± 0.01	1.090 ^{ab} ± 0.03	1.368^{ab} ± 0.02	1.566 ± 0.10	1.255 ^{b}± 0.02
G2	0.945 ± 0.02	1.283 ^{a} ± 0.03	1.178 ^{ab} ± 0.04	1.251^{b} ± 0.03	1.533 ± 0.19	1.260 ^{b}± 0.03
G3	0.990 ± 0.04	1.221 ^{ab}± 0.02	1.131 ^{b} ± 0.02	1.289^{b} ± 0.04	1.766 ± 0.08	1.283 ^{b}± 0.02
G4	0.909 ± 0.03	1.225 ^{ab} ± 0.03	1.164 ^{b} ± 0.07	1.504^{a} ± 0.06	1.587 ± 0.03	1.349 ^{a}± 0.03
G5	0.928 ± 0.02	1.162^{b} ± 0.02	1.278 ^{a} ±0.02	1.545^{a} ±0.08	1.585 ± 0.09	1.329 ^{ab}± 0.03
significance	NS	*	*	*	NS	*

*: Significant at a level (P< 0.05). NS: Non-significant. G1: control group while G2, G3, G4, and G5 add 20, 30, 40, and 50 ppm nano- silver/ respectively.

Mortality %

The effect of silver nanoparticles supplement in drinking water on the mortality percentage via the trial period was shown in Table 6; group G5 led a higher rate of mortality percent (P< 0.05) than G2 without a significant difference between the G2, G5, and G1, G3, and G4 groups that indicate the safety of group concentration at 20 ppm/L drinking water.

Table 6: Effect of adding silver nanoparticles with different concentrations in drinking water on the total mortality percentage of broiler chicken.

Groups	Mean ± standard error
G1	11.11^{a} ± 0.21
G2	0.00^{e} ± 0.00
G3	6.66^{b} ± 0.08
G4	2.22^{d} ± 0.03
G5	4.44^{c} ± 0.07
significance	*

*: Significant at a level (P< 0.05). NS: Non-significant. G1: control group while G2, G3, G4, and G5 add 20, 30, 40, and 50 ppm nano- silver/ respectively.

Physiological traits

Table 7 shows the effect of the study on blood fresh traits at 14 days of chicks, with a significant increase (P< 0.05) in RBC for G2 and G4 groups compared to other groups, while a significant increase (P< 0.01) in WBC for G1, G2, G3, and, G5 groups reached G4 group, as well considerable increase (P< 0.05) in PCV for G4 group compared G1, G2, and, G5 groups.

At 35 days old chicks, noted a significant increase (P< 0.05) in RBC for G3, G4, and G5 groups, as well as a significant increase (P< 0.01) in WBC for G2, G4, and G5 groups, in PCV and HB the G4 and, G5 groups improved significantly (P<0.05) compared others.

Table 7: Effect of adding silver nanoparticles with drinking water in some blood parameters at 14 days of broiler (Ross 308)

Groups	Mean ± standard error			
	RBC ($X*10^{6}$)	WBC ($X*10^{3}$)	PCV %	HB (gm/L)
G1	2.23^{b} ±0.12	30.25^{b} ±0.25	26.50^{b} ± 0.50	8.83^{b} ± 0.17
G2	2.09^{b} ±0.01	31.25^{ab} ±0.50	25.50^{b} ± 0.50	8.49^{b} ± 0.16
G3	2.83^{a} ±0.07	28.50^{c} ±0.50	26.00^{b} ± 1.00	8.66^{b} ± 0.33
G4	2.99^{a} ±0.01	31.75^{a} ±0.25	29.50^{a} ± 0.50	9.83^{a} ± 0.15
G5	3.01^{a} ±0.14	32.50^{a} ± 0.50	30.50^{a} ± 0.50	10.16^{a} ± 0.10
significance	**	**	**	**

*: Significant at a level (P< 0.05). ** : Significant at a level (P< 0.01). NS: Non-significant. G1: control group while G2, G3, G4, and G5 add 20, 30, 40, and 50 ppm nano- silver/ respectively.

Biochemical traits

The biochemical traits shown in (Table 9), noted a significant increase (P<0.05) for nano-silver supplementation groups in glucose and triglyceride, while in GSH, there was a significant increase (P< 0.01) for G4 and G5 groups compared to others, in MDA level significant decrease (P< 0.01) in G2 group and G1, G3, and, G4 groups respectively reached G5 group.

Table 8: Effect of adding silver nanoparticles with drinking water in some blood parameters at 35 days of broiler (Ross308)

Groups	Mean ± standard error			
	RBC (X*10⁶)	WBC (X*10³)	PCV %	HB (gm/L)
G1	1.52^{bc} ±0.16	30.50^{a} ±0.50	24.50^{abc} ±1.25	8.16±0.83
G2	1.88^{a} ±0.03	29.25^{a} ±0.25	25.00^{ab} ±1.00	8.33±0.33
G3	1.62^{ab} ±0.06	29.50^{a} ±0.50	26.00^{ab} ±0.50	8.66±0.00
G4	1.87^{a} ±0.05	26.50^{b} ±0.50	27.00^{a} ±1.00	8.99±0.33
G5	1.72^{ab} ±0.05	29.50^{a} ±0.50	25.00^{ab} ±1.00	8.33±0.33
significance	*	**	*	NS

Table 9: Effect of adding silver nanoparticles with drinking water in some blood parameters at 35 days of broiler (Ross 308)

Groups	Mean ± standard error			
	Glucose (mg/100 ml)	Triglyceride (mg/dl)	GSH (U/L)	MDA (U/L)
G1	238.38^{c} ± 0.68	174.30^{c} ± 1.30	416.64^{c} ± 5.78	6.64^{b} ± 0.47
G2	266.16^{a} ± 0.54	178.60^{bc} ± 3.60	313.16^{d} ± 6.35	5.15^{c} ± 0.23
G3	249.30^{b} ± 0.39	192.55^{b} ± 1.25	389.08^{c} ± 5.62	6.28^{b} ± 0.15
G4	247.37^{b} ± 0.32	189.75^{b} ± 3.25	456.89^{b} ± 4.56	7.05^{b} ± 0.07
G5	264.99^{a} ± 0.97	211.50^{a} ± 1.50	501.28^{a} ± 4.26	9.05^{a} ± 0.56
significance	*	**	**	*

*: Significant at a level (P< 0.05). ** : Significant at a level (P< 0.01). G1: control group while G2, G3, G4, and G5 add 20, 30, 40, and 50 ppm nano-silver/ respectively.

Recently, Silver nanoparticles (AgNP) have obtained much consideration due to their potent effect as antimicrobial or anti-inflammatory agents and as a promising antibiotic growth promoter (Vadalasetty et al., 2018). The feature that distinguishes silver NPs is represented by their inhibition of the growth of pathogenic microorganisms like Salmonella, E. coli, and Streptococcus apps in food and water with no effect on beneficial Lactobacillus spp in the microflora that is present inside the intestine [29،30], hence preventing diseases and improving animal performance, therefore, the Incorporation of NPs as possible feed supplements for poultry is currently evolving as a way to decrease the numbers of harmful bacteria in the chicken microbiota, stimulate the growth of beneficial bacteria, and hence can potentially improve feed conversion ratio, growth performance, and overall health [31،32]. The present study found that the supplementation of 20 ppm dosed Silver NPs in broilers' drinking water positively affected the growth performance of the broilers compared to the other treated groups. The group that received 20 ppm/L showed superiority in living body weight and weight gain over the control group, especially toward the end of the experiment could be attributable to the antibacterial characteristics of Nanosilver as reported by [6] They discovered that bacterial chromosomal DNA loosened at Ag-NP concentrations greater than ten ppm, indicating that chromosomal DNA integrity and cell shape may be negatively impacted by Ag-NP concentrations as low as ten ppm. On the other hand, [33] showed that feeding nano silver at a concentration of 5 mg/kg resulted in an 11% increase in villi length and a 7% increase in pore depth, as well as a decrease in hazardous E-coli bacteria and an increase in helpful lactobacilli bacteria. Consecutively, the gut environment improved, and nutritional absorption increased, as evidenced by previous studies [34،35], which validated that Nanosilver benefited bird growth as a powerful antibacterial, with restricted higher quantities as shown in the present study that decreasing body weight was associated with increasing silver NPs concentration which is compatible with the findings of [7] who investigated that the application of silver nanoparticles in the concentration of 50 ppm via the drinking water not only reduced broiler growth but also impaired immune functions beside to antibacterial effect due to excessive cellular stress resulting from interactions with Silver-Nano intake or either inhibition the absorption of sugars and amino acids beside to protein enzymatic digestibility inhibition [36]. Moreover., [37] reported that the best body weight of Japanese quail was obtained at 25 ppm/kg and increased lactic acid bacteria compared to other groups supplemented with 5 and 15 mg Silver NPs/liter in drinking water. [29] obtained the heaviest final body weight and the highest body weight gain in the group receiving 4 ppm /kg compared to the control group or those receiving 2, 6.8, and 10 ppm Silver NPs/kg. Also, the results agreed with the finding of [38], who reported that daily feed intake, daily feed conversion ratio, and body weight gain were enhanced by adding Silver NPs at 4 mg/kg on one day Ross 308 chicks due to it can reduce symptoms of digestive disorders, which strengthened the digestive system and improved feed efficiency that reflects on body weight While, [39،40] found no significant effect of using different concentration of Nanosilver at 5, 15, and 25 ppm and thus [41] at 2.5, 5.0, 7.5 and 10 ppm in drinking water on body weight and weight gain when compared to the control group. The same result was reported by [36] (at concentrations of 2.5, 5, 10, and 20 mg/kg feed); [42،43] who investigated that silver nanoparticles do not affect growth, development in chicken embryos. The current study did not show any significant difference in feed intake. These results are in agreement with [36،41] but inconsistent with [16], who found a significantly increased feed intake of the case group supplemented with 50 ppm compared to control one. According to FCR, the G2 group showed significantly improved weight gain per kg feed intake along the whole experimental period compared to the studied groups, which is compatible with the findings of [16،36], which attributed to an increase in the weight of the small intestine and fat in the abdominal area of the meat furs [44]. However, contrasted results were revealed by [40], who found no significant effect of different silver nanoparticle concentrations in drinking water (5, 15, and 25 ppm) on the FCR of Ross 308 broiler

chickens. The hypothesis behind the improved growth performance with mineral nanoparticles is related to an enhanced absorption rate of nutrients because the increased surface area and reduced size of mineral nanoparticles improve certain physicochemical properties [45]**.** The low death rate in group G2 could be related to nano silver's ability to limit pathological microbiology's growth and diminish activity, therefore successfully minimizing the incidence of pathological disease. [35،46]. The higher rate of death and negative consequence of higher dose of silver nanoparticles on BW, WG, and FCR may be attributed either to the cytotoxicity to the mitochondrial activity [40] or oxidative stress, apoptosis, and decreased cell viability in fibroblasts [47]. As a result, we could conclude that high concentrations of silver nano supplementation may be unsafe and cause their production abilities to deteriorate. Our findings were in contrast with the outcome of previous studies, which demonstrated that administering silver nanoparticles at 50 ppm in drinking water [49،48] or 300–900 ppm in a solid feed [50] was found to be safe for consumption as well as growth enhancement. This contrast may result from using smaller size particles (15nm) than those used in our study.

The higher numbers of red blood cells in AgNP groups compared to control groups may be due to the role of AgNP in improving the state of antioxidants, which increases the number of red blood cells due to the position of red blood cells in transporting oxygen and carbon dioxide, which exposes them to oxidation significantly. The number of red blood cells, in turn, increases the percentage of PCV; [51] reported that AgNP stimulated the phagocytosis process in chickens, which explains the higher number of white blood cells. The improvement in the level of the enzyme glutathione peroxidase in birds treated with AgNP explains the influential role of silver nanoparticles in supporting antioxidant status [52]. Still, at the same time, the increase in glucose and triglycerides in birds treated with AgNP may be due to a decrease in thyroid activity and thus reduced production rates, T3 and T4 hormones, thus reducing protein synthesis and increasing the level of glucose and cholesterol. This is a result of the lack of effect of silver nanoparticles on the activity of the thyroid gland [53], or this may be a result of the high concentration of AgNP used in the group. Fifth, which causes the birds to be exposed to stress, and the reason for this increase may be a decrease in the secretion rate of the thyroid hormones thyroxine, triiodine, T3, and thyroxine, T4.

In contrast, birds are exposed to any stress, as the decrease in the activity of the thyroid glands generally leads to an increase in the level of cholesterol in the blood through a reduction. In both the rate of cholesterol formation and the rate of its excretion in bile, the cause of high cholesterol may be an increase in the rate of secretion of the hormone corticosterone in response to stress, which leads to a chronic rise in the level of cholesterol in the blood [54،55]. Likewise, stress hormones others, such as epinephrine, norepinephrine, and glucagon, may be at high levels in the blood of birds when they are exposed to stress, and this leads to an increase in blood fat due to the decomposition of the adipose tissue storing it and the occurrence of a state of hyperlipidemia; Also, the concentration of glucose in the blood of birds increases when they are exposed to stress, and this increase in the concentration of glucose may be resulting from the increase in the breakdown of glycogen as a result of the rise in the secretion of hormones that stimulate glycolytic enzymes (epinephrine, norepinephrine, and glucagon) and the increase in the rate of sugar formation from non-carbohydrate sources in the gluconeogenesis process as a result of the rise in the rate of secretion of corticosterone, which is mainly responsible for this process, as these hormones are released in response to stress, this is to maintain a relatively high level of glucose in the blood, which is the primary source for supplying the brain and nervous system with energy, as well as meeting the body's energy needs while it is exposed to stress [56،57].

5. Conclusion and Future Scope

The findings revealed that Nanosilver could be considered a promising and safe nano-growth promoter in broilers when added up to a dose level of 20 ppm/ L in drinking water, improving birds' growth performance. On the other hand, higher concentrations could produce negative results. That indicates toxicity in birds. More research is needed to determine the extent of the effect of silver nanoparticles and any concentration that could cause toxicity in birds.

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Conflict of Interest
The authors declare that they do not have any conflict of interest.

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Authors' Contributions
Author 1 researched the literature, conceived the study, and prepared the manuscript. Author 2 researched literature and was involved in protocol development, and collection of the needed samples. Authors 3 and 4 made data analysis. Authors 5,6,7,8; and 9 were involved in drafting the results and data analysis. All authors have contributed to editing and finalizing the manuscript.

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