Effects of Disinfectants in Drinking Water on Productive Performance, Bacterial Counts, and Sensory Evaluation of Broiler Chickens

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Received:21/5/2026 **Accepted:** 19/6/2026 **Published:** 6/9/2026

***Abstract*—** This study aimed to evaluate the effect of different disinfectants, including iodine, quaternary ammonium compounds (QACs) with glutaraldehyde, and Virkon administered through drinking water, on broiler chickens' performance traits (body weight, weight gain, feed intake, and feed conversion ratio), bacterial count (*E. coli* and *Lactobacillus*), and sensory evaluation. A total of 120 one-day-old Ross 308 broiler chicks were randomly allocated into four groups: a control group and three treatment groups receiving iodine (1 mL/L), QAC (1mL/L), and Virkon (1 g/L) in drinking water over 35-day experimental period. Bacterial counts were determined using standard microbiological culturing methods. The results demonstrated that disinfectant application significantly affected productive performance, microbial load, and sensory quality. The Virkon group consistently showed the best performance in terms of final body weight, weight gain, feed conversion efficiency, and sensory evaluation parameters compared with the other groups. In contrast, the QAC group showed the poorest growth performance and the highest cumulative FCR values. Both Virkon and QAC treatments were effective in reducing harmful bacteria (*E. coli* counts) and improving intestinal microbial balance by increasing beneficial bacteria (*Lactobacillus* counts).Overall, the findings indicate that appropriate use of disinfectants, particularly Virkon, can improve broiler health status, enhance biosecurity, reduce microbial contamination, and improve production efficiency and meat quality without compromising product safety. These results support the application of disinfectants as an effective strategy in poultry production systems.

***Keywords* —** Broiler chickens, disinfectants, iodine, Virkon, Quaternary ammonium compounds, bacterial count, sensory evaluation.

INTRODUCTION

Broiler chicken production plays an important role in increasing global demand for poultry meat, which is necessary for feeding the growing human population. In addition, Chickens production provides income and employment opportunities, Additionally, the industry has seen advancements improved productivity and reduced the occurrence of diseases in broiler production systems (1).

Industry of poultry supports the economy of many countries, especially those in developing areas, and provides good source of animal protein (2). Poultry production contribution to human nutrition and food safety, by Providing energy,and characterized by short cycles of production and high feed conversion efficiency, creating it one of Agriculture's fastest-growing in the world , particularly in developed worlds (1).

Poultry production increased lead to increased of disease Outbreaks in chicken farms in particular viral illnesses cause a significant financial setback. One of the viruses that is most contagious and infectious in domestic chickens and Newcastle disease in birds is seriously hurting the poultry industry worldwide and for diseases control and prevention must used disinfection programs to prevent viral infections. (3).

Disinfection defined as the process of eliminating or controlling by using chemical, biological, or physical agents to prevent different infections, the antimicrobial agents or disinfectants are used to sterilize, , sanitize, or anticipate, long-lasting antimicrobial chemicals that help remove or control microbes (4).

Disinfection can help stop the spread of pathogenic microorganisms between production cycles and reduce or eliminate any potentially harmful microorganisms. The incidence of infectious illnesses in chickens houses can be effectively controlled by selecting the right disinfectants as well as methods and procedures for disinfection, as different disinfection techniques yield different results. (5).

It is now crucial to disinfect chicken houses and livestock.The Several chemical disinfectants are commonly used in broiler houses, including iodine disinfectants, quaternary ammonium compounds, glutaraldehyde and Virkon (6, 7).The effectiveness of different disinfectants when applied to broiler houses on a

large scale may vary based on the type of microorganism and environmental conditions because they operate via different mechanisms. (8).

Objective: 1. To evaluate The effects of various disinfectants on productive Performance traits in broiler chickens, including body weight, weight gain, feed intake, and feed conversion ratio. 2. To investigate the effects of various disinfectants on bacterial count and sensory evaluation in broiler chickens.

MATERIALS AND METHODS

Ethical Approval

University of kerbala College of Veterinary Medicine's Research Ethics Committee (ethics number UOK.VET.AN 2025.147) accepted the experimental design and techniques used in this work in compliance with animal welfare ethics

Experimental design

The study was conducted in a private broiler house at Karbala Governorate over 35 days, from November 13 to December 17, 2025. Ross 308 broiler chicks bought from a commercial hatchery (Barakat Al-Hussein Hatchery).

Poultry house preparation

The floor, walls, manual drinkers, and feeders were cleaned with fresh water and disinfected with formalin. Ventilation was activated, and all windows were opened to ensure that any harmful fumes were completely removed before the chicks were admitted and distributed among the experimental groups. Brooders were operated before chick placement, and the temperature was adjusted to 37°C to simulate the thermal conditions experienced by chicks inside the egg during incubation. Thereafter, the brooding temperature was gradually reduced by 2°C each week according to the age of the birds. Appropriate litter (wood sawdust) was provided for each group. LED lighting lamps and ventilation were adjusted, and the ambient temperature was measured using a thermometer and monitored daily. All chicks were reared according to the recommendations of the Aviagen Management Manual.

Four experimental groups of thirty birds each were randomly selected each group was further divided into two replicates of fifteen birds each.

The following were the experimental treatments:

T1: Control group basal feed + normal drinking water.

T2: Basal feed + iodine disinfectant (Germ-Iod®) manufactured by Cenavisa S.L., Spain (1 ml/L of water to drink).

T3: basal feed + Quaternary ammonium compounds with glutaraldehyde disinfectant (Manufactured by THESEO**,** France) (1 ml/L of water to drink).

T4: Basal feed + Virkon disinfectant (Dexon super Interchemie werken "De Adelaar" B.V, Holland / The Netherlands) (1 g/L of water to drink).

The experiment was conducted with *ad libitum* access to food and water. Standard management were applied according to broiler management guidelines. Body weight, feed intake, and other performance parameters were recorded weekly. Samples collection took place at the end of the experiment.

Parameters of the study

1.Production performance of broiler chickens

Productive Performance

Weekly Productive performance, such as body weight, weight gain feed intake, feed conversion ratio (9).

Average body weight (BW) (g /birds). Each chick was weighed using a careful balance on the first day of life and at the conclusion of every week to determine the weight. The total weight of chicks divided through the number of chicks on the mean body weight.

Weight gain (WG) (g/birds) Weekly mean body weight gain for each replicate was calculated by recording the Body weight gain at the end of each week and depending on the following equation

Mean body weight at the end of the week minus mean body weight at the start of the week equals mean weekly weight gain.

Feed intake (FI) (g /bird). Feed intake was calculated weekly using the equation provided by this was accomplished by weighing the feed at the conclusion of each week and deducting it from the total amount provided at the beginning of each week.

Feed Conversion Ratio (F.C.R) Feed conversion ratio was determined using the following equation **FCR= mean weekly feed intake (gm) ÷ mean weekly body weight gain (gm)**

2.Bacteriological Analysis

Sample Collection Swab Sample were randomly collected from vent from all groups at 35 days of age. The sterile swab were carefully inserted into the vent and rotated gently to ensure adequate sample collection. Each swab was then immediately transferred into sterile tubes containing nutrient broth . (10, 11).

Preparation of Nutrient Broth Nutrient broth was prepared by dissolving 13 g of the broth medium in 1000 ml of distilled water. After thoroughly mixing the medium, it was autoclaved for 15 minutes at 121°C to sterilize it then place it inside the tube (10,12).

Materials Needed vent samples**,**Sterile saline or broth (e.g., phosphate-buffered saline) **,**Sterile plates for culturing (*E. coli* and *Lactobacillus*) (11,13,14).

1. Prepare Dilution Series

Label a series of sterile tubes:

Tube 1: Original sample (1:1)

Tube 2: 10^{-1} dilution

Tube 3: 10^{-2} dilution

Tube 4: 10^{-3} dilution

Continue as needed for additional dilutions (e.g., 10^{-4}, 10^{-5}, etc.).

2.Initial Sample Preparation: Take a known volume of the intestinal content (e.g., 1 mL) and add it to tube 1 containing 9 mL of sterile saline or broth. This creates your 1:10 dilution (10^{-1})

3.Perform Serial Dilutions:From Tube 1 to Tube 2

Mix Tube 1 thoroughly by vortexing or pipetting up and down. Take 1 mL from Tube 1 and add it to Tube 2 (which contains 9 mL of sterile saline or broth). This gives you a 10^{-2} dilution. From Tube 2 to Tube 3,Mix Tube 2 thoroughly.

Take 1 mL from Tube 2 and add it to Tube 3 to create a 10^{-3} dilution.Repeat this process for as many dilutions as needed we used 6 tubes.

4.Plating the Dilutions:

1. Inoculate PlatesFor each dilution, take a small volume (e.g., 100 µL) and spread it evenly on selective media plates

(MacConkey for E. coli and MRS for Lactobacillus).use a sterile spreader or glass beads to ensure even distribution.
2. Incubation: Incubate the plates under appropriate conditions: *E. coli*: 37°C for 24 hours,*Lactobacillus*: 30–37°C for 48 hours.
5.Counting CFUs: 1. Count Colonies
After incubation, count the number of colonies on each plate. Select plates with 30–300 colonies for accurate counting. (15, 16).2. Calculate CFUs: Use the formula:

CFU/mL = (Number of colonies×Dilution factor)/ Volume plated (mL)

3.Sensory evaluation Slices of breast meat in 2 to 3 cm in size and placed in an electric oven and roasted in 180°C, internal temperature of 80°C:°C before being lowered to the sensory assessment. According to the scores shown in the table (3-2), the sensory evaluation of five trained panelists was conducted for flavor, tenderness, juiciness, color, and palatability (17) .

STATISTICAL ANALYSIS

Data were analyzed using SAS and GraphPad Prism software. The mean ± standard deviation (SD) was used to express the results. One-way ANOVA and suitable Post hoc analyses were employed to evaluate statistical differences between groups, with significance set at $P < 0.05$.

RESULT AND DISCUSSION

Table 1. Effect of disinfectants on Body weight(BW) in broiler chickens (mean ± standard error).

Groups	Body weight (g)			
Week Periods	Control T1	Iodine T2	QAC T3	Virkon T4
Week 1	189.7±3.699 A	201.7±2.788 A	186.7±2.446 A	183.3±2.586 A
Week 2	444.8±10.40 A	456.7±7.458 A	386.9±9.321 B	385.5±13.26 B
Week 3	877.1±17.34 A	864±13.94 A	689.3±10.01 B	870.5±24.45 A
Week 4	1478±31.74 A	1364±26.01 B	1167±15.23 C	1552±26.82 A
Week 5	1997±39.62 B	1800±36.99 C	1600±29.78 D	2194±41.35 A

Different letters among groups in the same row indicate significant differences at ($P \leq 0.05$).

The findings of table (1) indicated that there were no significant differences ($P > 0.05$) among the experimental groups during the first week of age. During the second week, significant differences ($P \leq 0.05$) were observed, with the control (T1) and iodine (T2) groups recording higher body weight values than the QAC (T3) and Virkon (T4) groups. during the third week, the control (T1), iodine (T2), and Virkon (T4) groups showed significantly higher body weight values than the QAC group (T3). During the fourth week, the Virkon (T4) and control (T1) groups recorded the highest body weight values and did not differ significantly from each other, whereas the iodine group (T2) and QAC group (T3) showed lower values. In the fifth week, the Virkon group (T4) recorded the highest body weight value, followed by the control (T1), iodine (T2), and QAC (T3) groups.

Table 2. Effect of disinfectants on Weight gain **(**WG **)**in broiler chickens **(**mean ± standard error**)**

Groups	Weight gain (g)			
Week Periods	Control T1	Iodine T2	QAC T3	Virkon T4
Week 1	150.0±5.774 B	161.8±1.010 A	146.5±2.021 B	143.3±1.905 B
Week 2	255.1±10.36 A	255±6.091 A	200.2±8.429 B	202.2±7.015 B
Week 3	432.3±3.118 B	407.3±1.905 C	302.4±1.241 D	485.0±1.588 A
Week 4	600.9±7.563 B	500±5.110 C	477.7±11.26 D	681.5±12.99 A
Week 5	519±9.382 B	436±25.40 C	433±27.60 C	642±56.44 A
Cumulative	1957.3±29.76 B	1760.1±42.29 C	1559.8±27.89 D	2154±38.86 A

Different letters among groups in the same row indicate significant differences at ($P \leq 0.05$).

The findings showed that there were significant differences ($P \leq 0.05$) among the experimental groups during the first week of age. The iodine group (T2) recorded the highest weight gain value, whereas the control (T1), QAC (T3), and Virkon (T4) groups recorded lower values without significant differences among them.

During the second week of age, significant differences ($P \leq 0.05$) were observed. The control group (T1) and iodine group (T2) recorded the highest weight gain values compared with the QAC group (T3) and Virkon group (T4).

In the third week, significant differences ($P \leq 0.05$) were observed among the treatments. The Virkon group (T4) recorded the highest weight gain value, followed by the control group (T1), iodine group (T2), and QAC group (T3), respectively.

During the fourth week, the Virkon group (T4) recorded the highest weight gain value, followed by the control group (T1), iodine group (T2), and QAC group (T3), with significant differences among all groups.

In the fifth week, the Virkon group (T4) recorded the highest weight gain value with significant differences ($P \leq 0.05$) compared with all other groups, followed by the control group (T1), whereas the iodine (T2) and QAC (T3) groups recorded the lowest values without significant differences between them.

Overall, the cumulative results demonstrated that the Virkon group (T4) recorded the highest cumulative weight gain value, followed by the control group (T1), iodine group (T2), and QAC group (T3), with significant differences among all groups.

Table 3. Effect of disinfectants on feed Intake **(**FI**)** in broiler chickens (mean ± standard error**)**

Groups	Feed intake (g)			
Week Periods	Control T1	Iodine T2	QAC T3	Virkon T4
Week 1	165.7 ±6.380 B	178.3 ±0.981 A	172.5 ±1.443 A	165.0 ±2.887 B

Week 2	296.9 ±5.918 A	309.0 ±7.159 A	246.5 ±7.794 B	244 ±13.45 B
Week 3	584.7 ±6.755 B	545.1 ±6.969 B	403.0 ±1.732 C	634.6 ±2.223 A
Week 4	876.4 ±9.469 B	747.0 ±7.910 C	680 ±13.48 D	969.2 ±17.78 A
Week 5	790.4 ±13.74 B	660.2 ±27.08 C	655.0 ±41.37 C	970 ±94.37 A
Cumulative	2714.1 ±45.55 A	2439.6 ±49.80 B	2157 ±47.34 C	2709 ±95.03 A

Different letters among groups in the same row indicate significant differences at (*P*≤0.05).

The findings of table (3) showed that there were significant differences ($P \leq 0.05$) among the experimental groups during the first week of age. The iodine group (T2) and QAC group (T3) recorded the highest feed intake values. During the second week of age, significant differences ($P \leq 0.05$) appeared, and the control group (T1) and iodine group (T2) recorded the highest feed intake values.

At the third week of age, significant differences ($P \leq 0.05$) were observed among the treatments. The Virkon group (T4) recorded significantly higher feed intake values compared with the other groups, whereas the QAC group (T3) showed the lowest feed intake value.

During the fourth week, the same trend continued, where the Virkon group (T4) and control group (T1) showed significantly higher feed intake values than the iodine (T2) and QAC (T3) groups. The iodine group (T2) also recorded significantly higher values than the QAC group (T3).

In the fifth week, the Virkon group (T4) recorded the highest feed intake value with significant differences ($P \leq 0.05$) compared with all other groups, followed by the control group (T1), whereas the iodine group (T2) and QAC group (T3) recorded the lowest values without significant differences between them.

Overall, the cumulative results demonstrated that the control group (T1) and Virkon group (T4) recorded the highest cumulative feed intake values without significant differences between them, whereas the QAC group (T3) showed the lowest cumulative feed intake. The iodine group (T2) recorded intermediate values and differed significantly from the other groups.

Table 4. Effect of disinfectants on Feed conversion ratio **(**FCR) in broiler chickens **(** mean ± standard error**)**

Groups	**Feed conversion ratio**			
Week Periods	**Control T1**	**Iodine T2**	**QAC T3**	**Virkon T4**
Week 1	1.104±0.000 B	1.101±0.028 B	1.177±0.006 A	1.151±0.049 AB
Week 2	1.163±0.023 C	1.211±0.000 B	1.231±0.012 A	1.206±0.021 B
Week 3	1.352±0.025 A	1.338±0.020 B	1.332±0.000 B	1.308±0.000 C
Week 4	1.458±0.003 B	1.494±0.000 A	1.416±0.005 C	1.422±0.000C
Week 5	1.522±0.001 A	1.514±0.028 B	1.512±0.000 B	1.510±0.008 B
Accumulative	1.386±0.043 A	1.386±0.000 A	1.383±0.005 A	1.257±0.020 B

Different letters among groups in the same row indicate significant differences at (*P*≤0.05).

The findings of feed conversion ratio (FCR) showed significant differences ($P \leq 0.05$) among the experimental groups during the first week of age. The QAC (T3) group recorded the highest FCR value (A), while the control (T1) and iodine (T2) groups recorded the lowest values (B). The Virkon (T4) group showed intermediate values (AB).

During the second week of age, significant differences ($P \leq 0.05$) were also observed among the experimental groups. The QAC (T3) group recorded the highest FCR value (A), whereas the control group (T1) recorded the lowest value (C). The iodine (T2) and Virkon (T4) groups showed intermediate values (B).

In the third week, significant differences ($P \leq 0.05$) were observed among the experimental groups. The control group (T1) recorded the highest FCR value (A), followed by the iodine (T2) and QAC (T3) groups, which showed similar values (B), whereas the Virkon group (T4) recorded the lowest value (C).

During the fourth week, significant differences ($P \leq 0.05$) were observed among the groups. The iodine group (T2) recorded the highest FCR value (A), followed by the control group (T1) with intermediate values (B), whereas the QAC (T3) and Virkon (T4) groups recorded the lowest values (C).

In the fifth week, significant differences ($P \leq 0.05$) were also observed among the experimental groups. The control group (T1) recorded the highest FCR value (A), whereas the iodine (T2), QAC (T3), and Virkon (T4) groups recorded lower values (B).

Regarding the accumulative FCR, significant differences ($P \leq 0.05$) were observed among the experimental groups. The control (T1), iodine (T2), and QAC (T3) groups recorded the highest accumulative FCR values without significant differences among them (A), whereas the Virkon group (T4) recorded the lowest value (B).

Overall, the results indicate that the effect of disinfectants on FCR varied according to the age period, with significant differences observed during all experimental periods as well as in the accumulative FCR.

Table 5. Effect of disinfectants on *Lactobacillus* and *E. coli* counts in broiler chickens (CFU /ml) at 35 days (mean ± standard error)

Groups\ Parameters	Control T1	Iodine T2	QAC T3	Virkon T4
E.coli	6.163±0.026 A	5.816±0.129 AB	5.872±0.120 AB	5.720±0.073 B
Lactobacillus	5.734±0.065 B	5.700±0.130 B	6.081±0.021 A	6.122±0.024 A

Different letters among groups in the same row indicate significant differences at ($P \leq 0.05$).

The results showed that disinfectants had a significant effect ($P \leq 0.05$) on intestinal bacterial counts in broiler chickens at 35 days of age.

For *E. coli* count, the control group (T1) recorded the highest value (A), whereas the Virkon group (T4) showed the lowest value (B). The iodine group (T2) and QAC group (T3) recorded intermediate values (AB), indicating partial reduction in *E. coli* counts compared with the control group.

Regarding *Lactobacillus* count, the virkon group (T4) and QAC group (T3) recorded significantly higher values (A), while the control group (T1) and iodine group (T2) showed lower values (B).

Overall, the results indicate that Virkon and QAC treatments improved intestinal microbial balance by reducing *E.coli* harmful bacteria and maintaining higher populations of beneficial *Lactobacillus* bacteria in broiler chickens.

Table 6. Effect of disinfectants on Sensory evaluation in broiler chickens at 35 days (mean ± standard error)

Groups/ parameter	T1 control	T2 Iodine	T3 QAC	T4 Virkon
Tenderness	4.3±0.2000 A	3.2±0.1225 B	2.2±0.1225 C	4.400±0.1871 A
Color	3.8±0.1225 B	3.4±0.1871 B	2.0±0.2236 C	4.7 ±0.1225 A
Flavor	4.0±0.1581 B	3.6±0.1871 B	2.5±0.1581 C	4.7±0.1225 A
Palatability	4.0±0.1581 AB	3.4±0.1871 B	2.6±0.1000 C	4.6 ±0.1871 A
Juiciness	3.4±0.1871 B	3.8±0.1225 B	2.0±0.2236 C	4.7±0.1225 A

Different letters among groups in the same row indicate significant differences at ($P \leq 0.05$).

The findings showed a significant effect ($P \leq 0.05$) of disinfectants on the sensory evaluation parameters of broiler meat at 35 days of age.

For tenderness, the Virkon group (T4) and control group (T1) recorded significantly higher values compared with the iodine group (T2) and QAC group (T3), while T3 showed the lowest tenderness value among all groups.

Regarding color, the Virkon group (T4) recorded the highest value with significant differences ($P \leq 0.05$) compared with the other groups. The control (T1) and iodine (T2) groups showed intermediate and comparable values, whereas the QAC group (T3) recorded the lowest color score.

For flavor, the Virkon group (T4) showed the highest flavor score, followed by the control (T1) and iodine (T2) groups, which did not differ significantly from each other, while the QAC group (T3) recorded the lowest value.

As for palatability, the QAC group (T3) received the lowest score, followed by the iodine group (T2) and the Virkon group (T4) which had the highest score, and then the control group (T1).

The juiciness value of QAC group (T3) was found to be the lowest, while moderate and comparable value was obtained from control (T1) and iodine (T2) groups, while the Virkon group (T4) showed significantly higher value than all other groups.

The Virkon group (T4) had the highest overall scores in all sensory evaluation parameters and the QAC group (T3) consistently had the lowest scores. Overall, T2 (iodine) and T1 (control) groups had intermediate values.

DISCUSSION

The present study indicated that disinfectants significantly affected production traits, bacterial count, sensory evaluation and performance characteristics of broilers. In the last weeks of the experiment, Virkon consistently improved growth parameters of the disinfectants tested in terms of body weight and weight gain. This improvement could be attributed to its wide range of antimicrobial activity, which helps to lower the microbial load in the environment and, consequently, improve the health conditions of the flock as a whole (18, 19).

However, birds in the QAC group (T3) showed lower body weight and weight gain values compared with the other treated groups. This reduction in performance may be associated with differences in microbial control efficiency and their subsequent effects on gut health, nutrient utilization, and growth performance. Variations in environmental and physiological conditions may also have contributed to the observed differences among treatment groups (20, 21).

The feed conversion ratio (FCR) results showed variations according to the age period. The cumulative feed conversion ratio (FCR) results revealed that the Virkon group (T4) recorded the lowest value, indicating superior feed utilization efficiency compared with the other experimental groups. In contrast, the control (T1), iodine (T2), and QAC (T3) groups showed higher cumulative FCR values without significant differences among them. Variations in FCR may be associated with differences in intestinal microbial balance and nutrient utilization efficiency, as improved gut health can enhance feed conversion and growth performance. In general, lower FCR values indicate better feed efficiency (19).

From a microbiological point of view, the difference between the *E. coli* numbers of groups that received disinfectants (especially Virkon and QAC) and the untreated control group shows that there is effective control of harmful bacteria. At the same time, the increase of the *Lactobacillus* count in the QAC and Virkon groups indicates that there is a healthier gut microbiome balance (22, 23).

Further, the tenderness, colour, flavour, palatability and juiciness values for broilers fed Virkon were higher than the other groups, which confirmed the productive and microbiological results. These improvements may be attributed to the antimicrobial effectiveness of Virkon, which contributes to the improvement of environmental hygiene, reduction of physiological stress and maintenance of meat quality characteristics (24, 25). Moreover, with better hygienic conditions, there is less oxidative damage to meat pigments such as myoglobin, resulting in better meat colour and consumer acceptability (26).

The iodine group (T2) showed intermediate sensory responses (27) as it is an oxidative group and its presence may cause mild physiological stress leading to effects on meat quality traits.

The results indicated that application of efficient disinfectants helps to achieve microbial balance, better growth performance and improved sensory quality of broiler meat by reducing the level of microbial contamination and improving environmental conditions.

Conclusion

The present study demonstrated that the application of disinfectants in drinking water significantly influenced productive performance, intestinal bacterial counts, and sensory characteristics of broiler chickens. The Virkon group (T4) achieved the highest body weight, weight gain, and feed intake values, together with the lowest cumulative feed conversion ratio, indicating superior feed efficiency. In addition, Virkon reduced E. coli counts and increased beneficial Lactobacillus populations compared with the other groups. Sensory evaluation also showed that the Virkon group achieved the highest scores for tenderness, colour, flavour, palatability, and juiciness. Overall, Virkon proved to be the most effective disinfectant among the tested treatments for improving broiler performance, intestinal microbial balance, and meat quality.

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