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RESEARCH ARTICLE

Effect of magnetic and oxygenated water on growth performance and immune response of broiler chickens

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Abstract

The present work aimed to study the effect of magnetic and oxygenated water on immune response and production performance (body weight, feed intake, and mortality). A total of 270 one-day-old Cobb chickens were randomly divided into three treatment groups (T_1), with chickens drinking natural water as a control without any variations. (T_2) chickens received magnetic water; (T_3) chickens received oxygenated water. Body weight, feed intake, and mortality percentage were determined every week to the end of the experiment. Blood immunological parameters (Gamburo, Newcastle, H5N1, H9N1 and globulin titers), were determined at the 14, 21, 28 days of age and the end of the experiment (35 days). Also, some carcass traits were weighed. The results showed that T_2 and T_3 significantly increased body weight and decreased feed conversion at different ages compared to the control group. The blood analysis obtained that T_2 and T_3 substantially enhance antibody titer response compared to the control group, hence, an improvement in immunity. The improvement was found in carcass traits in the treated groups compared to the control.

***Keywords*:** chicken, magnetic water, growth performance; immunological performance

1. Introduction

Good water quality increases water intake, which naturally leads to improved performance and reduces health problems of the chicken flock. The authors found a noticeable improvement in the absorption of water through animal cells. This process happens when the water is exposed to a magnetic field, which leads to raising the pH and dissolving oxygen, which reduces the size of the water molecules and thus facilitates their passage through the animal cells. When using magnetized water to drink by birds, this leads to an increase in the water consumed and the feed intake, thus increasing the body weight and immunity, decreasing mortality, while reducing the feed conversion of broilers. This is because magnetic water stimulates and dilates blood vessels, and blood circulation improves, which leads to an increase in the flow of nutrients represented by food and oxygen to all cells Figen *et al*. (2023). Sommer *et al*. (2007) noted that the oxidizing water increases the dissolved oxygen in the water from approximately 5–7 mg/l dissolved oxygen in natural water and also 10–12 mg/l dissolved oxygen in fresh fountain water to 30-120 mg/l dissolved oxygen. It has been proven that the consumption of oxygenated water increases the vitality of broilers and improved immunity, and their ability to resist diseases. Gholizadeh *et al*. (2008) noted that the magnetic water improved growth performance and meat quality as well as decreased feed conversion, sick case, and mortality. the water becomes clean, biologically Correct, was found to be well protected from scale active, and all pathogenic bacteria are destroyed, the reason is due to oxygenated and magnetized water could improve antioxidant enzymes, thyroid hormones, intestinal bacterial count, and immunity, which could have reflected in improved nutrient absorption and increased growth rate. Bock *et al*. (2012) noted that receiving oxygenated water improved the immune system in broilers, and enhanced

resistance to S. Gallinarum - infected broilers. Along with pH and temperature, dissolved oxygen concentration is a crucial component of these quality standards. Several methods are currently utilized to increase the quality of water, one of them involves the use of an exogenous supply of oxygen to obtain oxygenated water and the other is magnetic forces to magnetize the water (Dibner and Richards. (2007), El Sabry *et al*. (2018) and Jung *et al*. (2012)) suggested that oxygenated consumed water enhanced immunity in broiler chicks and improved resistance to S. Gallinarum in broiler chickens that were experimentally infected. Shin *et al*. (2016) indicated that oxygen enhancement of drinking water enhances growth performance and immunity by increasing immunoglobulins, mainly IgG and IgM. The enhancement of drinking water supplementation improved blood parameters, including triacylglyceride, total cholesterol, and low-density lipoprotein-cholesterol. It seems that superoxide dismutase refinement was completed due to oxygen enhancement of drinking water. Wafaa. (2022) found that broilers that consumed magnetized water reported an increase in body weight and improved feed conversion ratio. Laying hens showed an increase in egg quantity and quality, and improvement in the fertility and hatchability parameters. Improvement has been observed in carcass traits after providing magnetized water. Moreover, magnetized water may enhance immunity, decrease the pathogenic microbial load, increase the beneficial bacterial populations, and improve in the blood parameters as well, as relieve oxidative stress. Yusuf *et al*. (2022) stated that broiler chickens treated with magnetic water for 33s with single flow through the magnetic treatment unit had the best FCR, with the reduction in feed intake increasing growth rate and high production for broilers. The technology of giving broiler chickens magnetized water is to accelerate the growth rate (as a growth promoter), improve the feed conversion ratio, boost immunity, and reduce the offensive odour from the poultry droppings. El-Deeb *et al*. (2020) pointed out that water is one of the main factors that are essential for the completion of physiological processes inside the tissues of the poultry. Magnetized water could improve the rate of digestion and could enhance the digestibility of the feed that is rich in protein, thereby accelerating the growth rate of the broiler chicken. Abdel-Baky *et al*. (2023) showed that the use of oxygenated water 28 mg/l and magnetized water enhanced growth performance, production traits of broilers, immunity, reduced total colony and coliform counts of broiler chicks, and also improved the antioxidant enzymes and thyroid hormones.

2. Materials and Methods

2.1. Aim of study and the site

At the beginning of the experiment, a total of 270 chicks of the Cobb strain were individually weighed to the nearest gram to determine any significant differences among the treatment groups. Then the chicks were randomly divided into three treatment groups (90 birds for each) with 3 replicates per treatment (30 birds each replicate) and treated as follows: treatment (T_1) chicks received regular water without any other modifications. (T_2) Chicks received magnetic water. (T_3) Chicks received oxygenated water. The birds were given full care including: cleanliness, good ventilation, and a lighting system as the light from one to three days of age chicks provided 24 hours of light, after three days chicks provided 23 hours of light and 1 hour of dark until the end of the experiment, The birds were given a balanced diet. Birds vaccinated against Newcastle disease at the third day of age (using Hitchner B1 in water) also at the nine and fifteen days of birds age (using Lasota B1 strain in drinking water), The sixth day of broiler ages (using a weak incense complaint), twelve days (using a mixed incense), and eighteen days of broilers ages (using strong incense strain vaccine in water). The avian influenza contagion (H5N1) had an outbreak in Egypt, according to Cobb Birds. Accordingly, at Cobb Birds, the sprats entered a seven-day vaccinated against the H5N1 avian influenza contagion (a reasserting avian influenza contagion vaccine, inactivated (H5N1 subtype, Re-1 strain), produced by Harbin

Weaken Biotechnology Development Co., Harbin, China). This was fulfilled by subcutaneous injection with 0.2 ml of the inactivated H5N1 vaccine into the lower reverse of the neck.

2.2. Preparation of oxygenated and magnetic water Magnetic water

The magnetized water was obtained by a magnetizer device from Delta Water Company (14500 Gauss; Alexandria, Egypt) (Website: http://www.deltawater.net/). Water analyzers in the control lobby oratory were used to conduct the study's chemical analysis of the water. The attraction or expulsion of charges is caused by the magnetic field, which is a flood of waves created by the spinning movement of electrons. The magnetic field's influence depends on the material's magnetic susceptibility. The magnetic field affects water molecules. Although water molecules are thought to be neutral and devoid of magnetic susceptibility, they do possess polar bonds in addition to the Zeeman Effect on buttons, which modifies nothing about the button itself but heightens the polarizations of electrons and, consequently, the polarization of bonds—particularly the hydrogen bonds, which are prone to weakening and breaking. Furthermore, because water is consistently found in large clusters because of hydrogen bonds, it becomes smaller, more stable hexagonal clusters, which greatly lower the water's surface tension and viscosity and increase the water's ability to penetrate tissues and cells.

2.3. Oxygenated water

Oxygenated water was obtained by spraying water through fine sprinklers in a medium saturated with oxygen inside a closed cylinder under a pressure of 3 to 4 bar. Oxygen partial pressure in the water was measured using a model ADWA AD630 apparatus (ADWA Instruments, Szeged, Hungary) or by the chemical method according to Benson and Daniel. (1984). Freshly oxygenated water contained up to 28 mg oxygen/L H2O, which was approximately 4-5 times that of non-oxygenated fresh tap water (6 mg/L H2O).

2.4. Measures

2.4.1. Live body weight and carcass traits

Individual body weight (BW) of birds was recorded at 1, 7, 14, 21, 28, and 35 days of age. Feed intake (FI) in each treatment was recorded per week, and then the feed conversion ratio (FCR) was calculated during the whole experimental period (35 days). Mortality rate was recorded on a daily basis (Al- Fayad and Naji. (1989).

2.4.2. Immune response traits

To study the immune responses of broilers, a blood sample was drawn from the birds' vein wings at 14,21 and 28 day of age(where 3 blood samples are drawn randomly from each treatment one from each replication) to estimate ND, H5N1, H9N2, IBDV titers, IGa, IGm and, IGg . At the end of the 35 days of age, the broilers were slaughtered and blood samples were collected, three blood samples for each treatment (one blood sample from each replicate), then the samples were transferred into tubes containing heparin to prevent blood clotting. Blood samples were centrifuged at 2500 rpm for 15 min. Plasma samples were stored in a freezer at approximately -20 ºC until the time of chemical analysis. The chemical analysis of blood samples was carried out by colorimeter method using commercial kits to estimate the same previous tests (ND, H5N1, H9N2, IBDV titers, IGa, IGm and, IGg) at the age of 35 days.,(Hanson and Menkes. 1972), (Swayne and Halvorson. 2003) and also the following parameters were determined: weight of carcass, drumstick, thigh, breast, back, and neck, abdominal fat as described by Hamidi et al. (2022) was determined.

2.5. Statistical analysis

The data were tested with a one-way statistical analysis model using SAS. (2018), and then the means and significances were extracted using Duncan's test. Differences were considered statistically significant at ($P \leq 0.05$), also, standard errors were determined, obtained by Hamidi et al. (2022).

3. Results and Discussion

3.1. Body Wight BW and Mortality percentage

Data concerning the body weight of the experimental groups as affected by the different treatments during the different experimental periods are shown in table 1 During the first, second , third , fourth and fifth period there were significant differences in (BW) among layer groups drink water treatment in comparison to control group in (group 2) whereas the value were significantly (P≤0.05) higher, being 164, kg for the first period, 431kg g for the second period and 843kg for the third period, 1388kg for fourth period and 2020kg for fifth period, respectively.

Table 1. Effect of treatments on body weight (g) at different ages

	Body weight (g) at day				
Treatment	(7days)	(14days)	(21days)	(28days)	(35days)
T1	145^{c} ±0.5	380.5^{c}±0.7	749^{c}±0.6	1200^{c}±3.8	1822.5^{c}±4.2
T2	164^{a}±0.4	431.6^{a}± 0.6	843^{a}±0.6	1388^{a}±3.1	2020^{a}±3.5
T3	155^{b}±0.4	409.6^{b}±0.6	800^{b}±0.6	1301^{b}±3.1	1908.3^{b}±3.5

a, b Means within a column with different superscripts are significantly different (P< 0.01).

Besides, the same trend was noticed with the layer groups' drinking water treatment. In general, the average (BW) of experimental layers was significantly higher (P≤0.05) affected by drink water treatment in layer group 2, tested levels compared to the control group, throughout the whole experiment period. These results showed that magnetic water may be due to increased utilization of food intake and food conversion coefficient for meat production. The results in Table 2 revealed that the mortality percentage (M %) of the different experimental groups during the different experimental periods. The results revealed that M% values were lower (P≤0.05) with the layer during water groups (2) in comparison to the control group. The recorded values were (0.31 and 0.52%), (0.32 and 0.51%), (0.32 and0.51) and (0.13and0.38) for the second, the third the fourth, and the fifth periods, respectively.

Table .2. Effect of treatments on Mortality percentage at different ages

	Mortality %				
Treatment	(7days)	(14days)	(21days)	(28days)	(35days)
T1	0.62^{a}±0.004	0.52^{a}±0.005	0.51^{a}±0.003	0.51^{a}±0.005	0.38^{a}±0.02
T2	0.32^{b}±0.004	0.31^{b}±0.005	0.32^{b}±0.003	0.32^{b}±0.005	0.13^{b}±0.02
T3	0.31^{b}±0.004	0.32^{b}±0.005	0.33^{b}±0.003	0.32^{b}±0.005	0.15^{b}±0.02

$M_{7,14,21,28,35}$ = % mortality at 7,14,21,28,35 days of age . a, b: Means within a column with different superscripts are significantly different (P<0.01).

The same trend was noticed throughout the whole experiment period. Generally, during water, the different experimental periods are shown in groups (2) decreased the mortality rate in comparison to the control group. the water is treated with a magnetic separator may be due to the effectiveness of water in some bacterial, viral, and protozoan diseases that are among the most common poultry diseases. Increased utilization of feed intake and poultry vitality causes reduced mortality. These results showed that magnetic water may be due to the increased vitality of birds and disease resistance to high immunity. These results agree with Wafaa (2022), who reported that broilers treated with magnetized water reported a significant increase in body weight and also enhanced immunity, which reduces the mortality rate. Abdel-Baky et al. (2023) showed that the use of oxygenated water 28 mg/l and magnetized water enhanced growth performance, production traits of broilers, and immunity. (Ali *et al*.(2014). Day-

old broiler chicks that received magnetic water for 5 weeks showed a significant rise in body weight compared to the non-treated control group (Mustafa, 2007). In addition, magnetized water significantly enhanced body weight, weight gain, and feed efficiency during 1-35 days of age (Al-Fadul and Mohammed .2007). El-Hanoun *et al*. (2017) showed that broiler geese receiving magnetized tap water had a better body weight and feed conversion ratio than the group that received well water. Broiler chicks were given magnetized water showed improvement in final body weight, daily weight increase, feed conversion ratio, protein efficiency ratio, and production index (Ahmed *et al*. 2018). Likewise, these results may be due to the reduction of biofilm formation inside the pipeline, as the formation of biofilm by pathogens increases the danger of health problems for the chicks (Gholizadeh *et al*. 2008). Also, when water is magnetized, cations and anions are rearranged in the medium in a way that produces numerous beneficial changes in water quality, such as increasing the oxygen content, accelerating the solubility of minerals, facilitating the movement of nutrients and water throughout the body's cells, and promoting the growth of cells. Magnetized water reduces the surface tension of cell walls, which increases the permeability of water and nutrients into the body's cells. (Nakagawa *et al*. 1999; Olteanu *et al*. 2012 and Hafizi *et al*. 2014). Furthermore, Magnetic water treatment improves birds' immunity by reducing lime deposits and reducing microbes in water pipes (Sargolzehi *et al*. 2009). As the results above, the use of magnetized water can improve the quality of drinking water, and this could positively enhance the birds' health and productive performance. The magnetic field makes a change in water properties, so the characteristic of water turns very fertile and active causing high oxygen content and speeding up the dissolving of amino acids and salts in water (El Sabry et al. 2021) and increasing flexibility and penetration of water (Daviss. 2004). Also, the magnetic field of water improved blood picture (Milewski *et al*. 2001), and improved blood circulation, oxygen, and transport of feed in the blood (Al-Nuemi *et al*. 2015).

3.2. Feed intake and feed conversion ratio

In Tables 3,4, Results showed that the treated groups with magnetized water (T_2) and oxygenated water (T_3), respectively, throughout the whole experiment period, were affected (FI) in comparison to the control group. Consumed a lower ($P \leq 0.05$) amount of feed than those fed the control diet, being 3250, 3250, and 3191 g/day, respectively. The different experimental drink water did not significantly affect on average weekly FCR, except in the group T2, which recorded better ($P \leq 0.05$) values than most of the other experimental groups.

Table 3. Effect of treatments on feed intake (g/birds) at different ages

Treatment	Average Cumulative feed intake (g)				
	(7days)	(14days)	(21days)	(28days)	(35days)
T1	135.0^{C}±0.3	420.0^{b}±0.8	1001^{c}± 0.7	1900^{c}±4.5	3191^{c}±0.7
T2	142.3^{a}±0.3	453.3^{a}±0.7	1063^{a}±0.5	2020^{a}±3.6	3250^{a}±0.6
T3	139.6^{b}±0.3	400.0^{c}±0.7	1021^{b}±0.5	2001^{b}±3.6	3250^{b}±0.6

a, b Means within a column with different superscripts are significantly different (P< 0.01).

Table 4. Effect of treatments on feed conversion ratio (FCR) (g/birds) at different ages

Treatment	Average feed conversion ratio different ages				
	(7 days)	(14 days)	(21 days)	(28 days)	(35days)
T1	0.93^{a}±0.001	1.10^{a}±0.003	1.3^{a}± 0.001	1.58^{a}± 0.02	1.75^{a}± 0.003
T2	0.86^{c}±0.001	1.05^{c}±0.003	1.26^{c}± 0.001	1.44^{c}± 0.02	1.60^{c}± 0.003
T3	0.90^{b}±0.001	0.97^{b}±0.003	1.28^{b}± 0.001	1.50^{b}± 0.02	1.67^{c}± 0.003

a, b Means ± SEM within a column with different superscripts are significantly different (P< 0.01, $CF_{7,14,21,28,35}$feed conversion at 7,14,21,28,35 day of ages .

The results from this trial showed that magnetic water influences feed conversion (1.60, 1.67, and 1.75). Water treatment using either magnetic or oxidized water increases cell permeability, allowing for expansion of the digestive tract and increased feed utilization. This leads to increased water permeability to improve the absorption of nutrients and minerals in the body. In addition, magnetic water improves feed metabolism. This agreement with Al- Kaabi. (2006), who stated that birds given glamorous water had a positive effect on the body weight, weight gain, and feed conversion ratio. Gholizadeh *et al*. (2008) noted that the magnetic water affects growth and poultry meat quality. The magnetic water improved growth performance and meat quality as well as decreased feed conversion ratio and mortality Al- Fadul, 2007 and Al- Hassani and Amin, 2012). Ali *et al*. (2014) noted that birds given drinking glamorous water had a better feed conversion ratio. Also, in this exploration, glamorous water had an impact on the mess input. Water showed improvement in final growth performance, feed conversion ratio, protein efficiency ratio, and production index (Ahmed *et al.* 2018). Showed that the use of oxygenated water 28 mg/l and magnetized water enhanced growth performance and reduced the feed Conversion ratio. Sommer *et al* .(2007) noted that the oxidizing water increases the dissolved oxygen in the water from approximately 5–7 mg/l dissolved oxygen in natural water and also 10–12 mg/l dissolved oxygen in fresh fountain water to 30-120 mg/l dissolved oxygen. Which may increase growth performance, hence decrease the feed conversion ratio.

3.3. Treatments water on immune response

When broilers were given magnetic water and oxidant water (Tables 5, 6), their avian influenza) H9N1 – H5N1), Newcastle (ND), and gamburo titers had significantly improved (P< 0.05) compared to the control group. This indicates improvement in immunity against these diseases when birds consumed magnetic and oxygenated water compared to birds that took natural, untreated water. The respective values were {5.5, 6.6, 7.7 and 8.6 /3.5, 4.4, 5.6 and 6.7 Compared4.2, 5.3, 6.5 and 7.3(Ab ND)}, {8469, 6549, 10987, and 11322 / 8466, 9545, 10981 and 11332 Compared6781, 7788, 8854 and 9559 (IBVD)}, {4.3, 5.5, 6.6 and 7.6 /4.2, 5.5, 6.5 and 7.5 Compared3.5, 4.4, 5.6 and6.7(Ab H5N1)}and {5.6, 6.5, 7.7 and 8.7 /5.5, 6.4, 7.6 and 8.5 Compared4.3, 5.3, 6.2 and 7.4(Ab H9N2) } respectively.

Table 5. Effect of treatments on some immunological blood parameters at different ages

Day	Immunological Blood Parameters					
	Ab ND			IBVD		
	T1	T2	T3	T1	T2	T3
14days	4.2^{b}±0.05	5.5^{a}±0.05	3.5^{b}±0.05	6781^{b}±19.4	8469^{a}±19.4	8466^{a}±19.4
21days	5.3^{b}±0.06	6.6^{a}±0.06	4.4^{b}±0.05	7788^{b}±76.1	6549^{a}±76.1	9545^{a}±76.1
28days	6.5^{b}±0.06	7.7^{a}±0.06	5.6^{b}±0.05	8854^{b}±24.2	10987^{a}±24.2	10981^{a}±24.2
35days	7.3^{b}±0.05	8.6^{a}±0.05	6.7^{b}±0.05	9559^{b}±28.3	11322^{a}±0.0528.3	11332^{a}±28.3

Ab = antibodies, ND = Newcastle disease, IBDV = Infection Bursal diseases (Gamburo), a, b Means within a row with different superscripts are significantly different (P< 0.01).

Table (6): Effect of treatments on some immunological blood parameters at different ages

Day	Immunological Blood Parameters					
	Ab H5N1			Ab H9N2		
	T1	T2	T3	T1	T2	T3
14days	3.5^{b}±0.05	4.3^{a}±0.05	4.2^{a}±0.05	4.3^{b}±0.05	5.6^{a}±0.05	5.5^{a}±0.05
21days	4.4^{b}±0.05	5.5^{a}±0.5	5.5^{a}±0.05	5.3^{b}±0.06	6.5^{a}±0.06	6.4^{a}±0.06
28days	5.6^{b}±0.05	6.6^{a}±0.05	6.5^{a}±0.06	6.2^{b}±0.06	7.7^{a}±0.06	7.6^{a}±0.06
35days	6.7^{b}±0.05	7.6^{a}±0.05	7.5^{a}±0.05	7.4^{b}±0.06	8.7^{a}±0.06	8.5^{a}±0.06

(H5N1&H9N2) = avian influenza. a, b: Means within a row with different superscripts are significantly different (P<0.01).

These results agree with El Sabry *et al*. 2018). Jung *et al*. (2012) suggested that oxygenated drinking water enhanced immunity in broiler chicks and improved resistance to S. Gallinarum in broiler chickens that were experimentally infected. Sommer *et al*. (2007) noted that the oxidizing water increases the dissolved oxygen in the water from approximately 5–7 mg/l dissolved oxygen in natural water and also 10–12 mg/l dissolved oxygen in fresh fountain water to 30-120 mg/l dissolved oxygen. It has been proven that the consumption of oxygenated water increases the vitality of broilers and improves their immunity and ability to resist diseases. Khudiar and Ali. (2012) found that immunity was significantly improved in rabbits treated with magnetic water daily for 60 days. Also, Shin *et al*. (2016) found that oxygenated water consumed significantly enhanced the immunity of broiler chickens. The improvement in immunity, in treatment groups drinking oxygenated and magnetic water, could be considered as a protective system preventing or delaying the onset of oxidative stress. Such antioxidant effects would be expected to improve the bird's health (Newsholme *et al*. 2003). Indeed, several studies reported that magnetized water could effectively influence the oxidant antioxidant balance for instance, the activity of SOD increases in the magnetic water (Buyukuslu *et al*. 2006).

3.4. Treatments water on immune globulin titer (IgG – IgM and IgA)

In Table 7, data obtained significantly ($P \leq 0.05$) improvement in globulin titers (IGm and IGa) when broilers drink magnetic and oxygenated water (T_2, T_3) compared to the control group. The results generally indicated a considerable increase ($P \leq 0.05$) in IGm and IGa among experimental treatments, while the differences in IGg were not significant. The obtained values 121.4 , 135.4 , 145.6and 155.4 /121.3 , 133.3 , 143.2 and 152.3 Compared 96.4 , 115.6 , 121.2and 131.9(IGa)} and{110 , 126 , 143 and 156/ 109 , 123 , 141and 161 Compared 95.3 , 104 , 121 and 134.6 in (IGm) respectively .

Table (7): Effect of treatments on antibody –titers in blood at different ages

Day	Antibody –Titers In Blood								
	IGa mg/dl			IGm mg/dl			IGg mg/dl		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
14days	96.4^{b}	121.4^{a}	121.3^{a}	95.3^{b}	110^{a}	109^{a}	654^{a}	751^{b}	748^{b}
21days	115.6^{b}	135.4^{a}	133.3^{a}	104^{b}	126^{a}	123^{a}	691^{a}	855^{b}	851^{b}
28days	121.2^{b}	145.6^{a}	143.2^{a}	121^{b}	143^{a}	141^{a}	753^{a}	945^{b}	940^{b}
35days	131.9^{b}	155.4^{a}	152.3^{a}	134.6^{b}	165^{a}	161^{a}	881^{a}	1038^{b}	1032^{b}

Immunoglobulin A (IGa), Immunoglobulin M (IGm) Immunoglobulin G(IGg) a, b: Means within a row with different superscripts are significantly different (P<0.01).

The use of magnetic and oxygenated water improves health and the immune system by increasing the immune responses of organisms against harmful bacterial infections and increasing the vitality of birds. These results agree with Abdel-Baky *et al*. (2023) who showed that antibody titer response significantly (P≤0.05) increased in birds that consumed magnetic water

compared with the control group. El-Hanoun *et al*. (2017) noted that serum IgM, IgG, and IGa were significantly increased. When Egyptian male geese had taken magnetized water with a 6000-gauss magnetic field, El-Katcha *et al*. (2017) concluded that phagocytosis was greatly improved in the Peking duckling group that consumed magnetic water compared to the control group. Moreover, Soliman *et al*. (2021) found that treating broiler chickens with magnetic water resulted in a significant improvement in the IGm and IGg antibodies against the live ND virus. Also, magnetic water improved antibody titer against live ND virus vaccine in broilers infected with Salmonella enteritis (El-Katcha *et al*. 2018). Furthermore, according to an in vitro study, the ND virus vaccination titer significantly decreased when administered in water, saline, and magnetized water at levels of 94.13 %, 84.5 %, and 10.31%, respectively (Soliman *et al*. 2021). Kamel et al. (2015) found that the magnetically treated water (MTW) improves health and the immune system, as stated by MTW makers. This study examines the impact of (MTW) consumption on creatures' immunological responses against bacterial infection. El- Hanoun *et al*. (2017) stated that magnetically treated water had a negative impact on the vulnerable system's response to bacterial infection in rabbits, in addition to having no effect on hematological parameters. Noted the impact of glamorous field exposure on blood factors, vulnerable indicators, and Egyptian geese semen in valve and well water. In contrast, magnetic treatment has been claimed to help the body ward off microbial invaders and improve immune system (Lam. 2001, magnetic technologies L.L.C. (2004-2005). Bock-Gie Jung *et al*. (2012) suggested that oxygenated drinking water improve immune system in broiler chicks, and increases survivability against S. Gallinarum in experimentally infected broiler chicks. Along with pH and temperature, dissolved oxygen concentration is a crucial component of these quality standards. Several methods are currently utilized to increase the quality of water, one of them involves the use of an exogenous supply of oxygen to obtain oxygenated water and the other is magnetic forces to magnetize the water (Dibner and Richards .2007 and El Sabry *et al*, 2018). Jung *et al*. (2012) suggested that oxygenated drinking water enhanced immunity in broiler chicks and improved resistance to S. Gallinarum in broiler chickens that were experimentally infected. On the other hand, these results disagreed with those of Al-Mufarrej *et al*. (2005) who showed that the magnetic water did not influence antibody responses to the antigen of sheep red blood cells in broiler chickens.

3.5. Characteristics of the carcass

Table (8) revealed that the broiler chickens that were received magnetized water (T_2) and chickens that were given oxygenated water (T_3) was significantly increasing in weight of carcass, thigh, drumstick, breast back, and neck compared to control group ($P \leq 0.05$) noting that the treated group with magnetized water was superior compared to other treatments. The recorded values were (1393.333, 149.0, 196.4, 342.4, 268 and 79.7).

Table 8. Effect of treatments on some carcass traits at 35 days of age

Treatment	Some Carcass Traits At 35 Days Of Age						
	Carcass	Drumstick	Thigh	Breast	Back	Neck	Abdominal Fat
T1	$1221.967^{c} \pm 0.8$	$132.2^{c} \pm 0.5$	$178.3^{c} \pm 0.6$	$297.3^{c} \pm 0.7$	$234^{c} \pm 0.6$	$69.6^{c} \pm 0.06$	23.3 ± 0.6
T2	$1393.333^{a} \pm 0.8$	$149.0^{a} \pm 0.5$	$196.4^{a} \pm 0.6$	$342.4^{a} \pm 0.7$	$268^{a} \pm 0.6$	$79.7^{a} \pm 0.06$	24.1 ± 0.6
T3	$1296.0^{b} \pm 0.8$	$138.0^{b} \pm 0.5$	$192.2^{b} \pm 0.6$	$297.0^{b} \pm 0.7$	$251^{b} \pm 0.6$	$73.3^{b} \pm 0.06$	23.4 ± 0.6

a, b: Means within a column with different superscripts are significantly different ($P<0.01$).

Magnetized and oxidized water enhanced the growth performance and productive traits of chickens. It also improved antioxidant enzymes and thyroid hormones, resulting in improved carcass qualities. These data indicate that the abdominal fat is not affected by treats. These results are in agreement with Kronenberg. (1993) and Lin. (1995), who reported that the magnetized water improved the performance of animals (chickens, turkeys, cows, calves, pigs, and sheep). Improvement of final body weight of broiler chicken with magnetized water when compared with the control group, which agrees with Alhassani and Amin. (2012), who noted that magnetized water with a longer period increased the body weight of broiler chicken compared with the control group. In addition, the present result agrees with that obtained by Rona. (2004), who stated that using magnetic drinking water for chickens resulted in an increase in growth rate by 5-7% compared with the control group. Also, Abdel-Baky *et al*. (2023) showed that the use of oxygenated water 28 mg/l and magnetized water enhanced growth performance, production traits of broilers, immunity and reduced total colony and coliform counts of broiler chicks. And also improve the antioxidant enzymes, thyroid hormones. On the other hand the present data disagrees with Al-Mufarrej *et al*. (2005) who reported that magnetized water had no significant effect on the broiler growth performance. The difference may be related to the period which passed.

4. Conclusion

Using magnetized and oxygenated water is an effective way to treat water and deliver it to birds in a way that is suitable for life. These methods also provide an alternative strategy for improving the productive and immune performance of poultry by reducing pathogens and inducing physiological changes within the bird's body, enabling it to utilize feed. Therefore, magnetized and oxygenated water can improve all the productivity parameters studied.

Declarations

Authors' Contributions:

All authors are contributed in this research. All authors reviewed and approved the final manuscript.

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Data Availability Statement

Data presented in this study are available upon reasonable request from the corresponding author.

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Not applicable

Conflicts of Interest:

The authors disclosed no conflict of interest.

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