

Magnetized Water and Organic Acids Enhance Weights Gain, Lipid Parameters and Hematology Indices of Broiler Chickens

Khudhair A. M. Abed Al-Ani

Department of Physiology, Biochemistry and Pharmacology, College of Veterinary Medicine,
University Diyala, Diyala, Iraq

Corresponding author: Khudhair, A.M. Abed AL Ani

Email: khudhair.a@uodiyala.edu.iq

ORCID: 0000-0003-4931-0598

Important dates: Received: 17-October-2025; Accepted: 22- March-2026; Published: March-2026

Abstract:

Background: Imbalance of lipid profile and alteration of hematological indices in broilers are attributed to excessively deposition of fat in the tissue which reduces health status and leads to economic losses in poultry production. The intervention of natural products such as magnetized water, apple cider vinegar and date vinegar as alternatives may provide safer improvement of these traits than synthetic drugs.

Aims: Investigating the impact of supplementation of magnetic water Organic Acids, body weight, lipid and hematological profile in broilers chicks.

Results: The synergy of magnetized water with 0.5% date vinegar in G5 was significantly reduced cholesterol, triglycerides, low- and very low-density lipoproteins, while increased high-density lipoprotein, erythrocytes, hemoglobin, packed cell volume, total proteins, platelets, and improved leukocyte balance. In G2, magnetic water has moderately improved the lipid indices and percentages of leukocytes, whereas in G3 and G4, apple cider vinegar and date vinegar, respectively, have mainly lowered cholesterol and low-density lipoproteins.

Conclusions: Intervention of magnetized water plus 0.5% date vinegar to the chickens has effectively improved body weight, lipid profile, and hematological indices in chickens. This treatment strategy may assist in boosting the cardiovascular function and overall productivity of chickens.

Keyword: Chickens, broilers, lipid profile, hematology parameters, apple cider vinegar, date vinegar



This is an open access article licensed under a [Creative Commons Attribution- NonCommercial 4.0 International License](https://creativecommons.org/licenses/by-nc/4.0/).

Introduction:

Excessive deposition of fat in broilers is one of the major areas of interest in poultry production, as it has negative impacts on general health status, growth performance, and meat quality (Couto *et al.*, 2022). High concentration of triglycerides, cholesterol, and low-density lipoproteins in the blood and disturbances in the blood parameters are linked to atherosclerosis and cardiovascular diseases that predispose most animals (including chickens) to irreversible heart attacks (Streicher *et al.*, 2018; Malheiros *et al.*, 2019). Thus, interventions by using natural products (e.g., magnetized water and vinegar) that can improve weight gain, lipid profiles and blood indices are required for both general animal health and growth performance that ultimately led to high productivity.

The metabolism of lipid in chickens can be affected by the quality of water and supplementation of diet. It has been proposed that treatment with magnetized water can improve nutrient and lipid absorption by the intestine, potentially reduces very low-density lipoprotein cholesterol (VLDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), and total cholesterol (TC) levels. However, it increases high density lipoprotein cholesterol (HDL-C) concentration in the blood (Mohan *et al.*, 2021). Also, it has been reported that the use of organic acids (e.g., date vinegar and apple cider vinegar) enhance lipid metabolism, modulate erythropoiesis process, augment hematology parameters such as red blood cells (RBC), hemoglobin (Hb), packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular hemoglobin (MCH) and boost immune function by balancing the white blood cell (WBC) numbers and leukocyte percentages (e.g., basophils, eosinophils, heterophils, monocytes, and lymphocytes) (Tayyab *et al.*, 2021; Haldar *et al.*, 2022).

While the impacts of individual treatment such as magnetic water, apple cider vinegar or date vinegar have previously been investigated, limited studies have examined their combined effects on body weight gain, lipid profile or comprehensive hematology indices in broiler chickens. Therefore, the current study aimed to assess the impacts of magnetic water, apple cider vinegar, and the combination of magnetic water plus date vinegar on body weights and lipid profile such as cholesterol (TC), triglycerides (TG), high-density lipoprotein (HDL), low- (LDL) and very low-density lipoproteins (VLDL). In addition, hematology indices, which include red blood cells (RBC), hemoglobin (Hb), packed cell volume (PCV), total proteins (TP), platelets, mean corpuscular indices (MCV, MCHC, MCH), white blood cells (WBC) and differential leukocyte (basophils, eosinophils, heterophils, lymphocytes and monocytes), were also analyzed in this study. Overall, the current study provides applicable insights into poultry nutrition strategies for augmenting weight gain and limiting the lipid-associated cardiovascular diseases and comprehensive health status.

Materials and Methods:

Animals Management and Experimental Design

Broiler chicks (*Gallus domesticus*, one-day-old, n=50) were randomly divided into five distinct groups (10 chicks/group). Chicks were reared in controlled ambient conditions (controlled temperature, 16-hour light and 8-hour dark cycle). These chicks were managed with a standard program of feeding consisted of starter, grower, and finisher rations, respectively, which has been supplied *ad libitum*. The experiment endured for 42 days and the experimental groups were divided and treated as followings:

- **G1 (Control):** This group provided with tap water.
- **G2 (Magnetized Water):** Freshly prepared magnetized water was given to this group. The magnetized water was prepared daily (fresh) as described previously by Elwasife and co-authors (Elwasife *et al.*, 2019).
- **G3 (0.5% Apple Cider Vinegar):** This group supplied with tap water containing 0.5% **apple cider vinegar**
- **G4 (0.5% Date Vinegar):** Chicks of this group given tap water containing 0.5% date vinegar.
- **G5 (Magnetized Water + 0.5% Date vinegar):** This group was supplied with magnetized water plus 0.5% date vinegar.

Body Weight Measurement

The whole-body weight of the experimentally manipulated hens was measured at predetermined times to evaluate the growth metrics. At the beginning of the trial, initial body weight was measured on Day 1 of the experiment (prior to the start of any treatment) and subsequent weekly measurements (from week 1 to the end of week 6) were performed. To ensure accuracy of the measurements, a calibrated digital scale (Kunshan Scale Electronic Technology Co., Ltd., China) was used to weigh each chick individually. Weights values were presented as mean data in addition to their corresponding standard error of the mean (Figure 1).

Feed Intake Measurement

Feed consumption of the experimental birds was assessed daily throughout the study period. Standard ration was provided to all birds *ad libitum* (all birds fed with the same ration). Each day, any leftover feed was gathered and weighed to compute the daily feed intake per chick. Ration weight quantifications were performed using a scale with appropriate sensitivity (Kunshan Scale Electronic Technology Co., Ltd., China). For visualization of data analysis, feed consumption was averaged at weekly intervals and plotted in a line graph (Figure 2) to show the feed intake progression in the trial groups over the time.

Blood Collection and Serum Preparation

At 42 days of age (post-hatching), blood was collected from chickens by wing vein punctures and transferred immediately into two kinds of tubes: The first, tubes containing anticoagulant (sodium ethylenediaminetetradate vinegar, LABOAO, China; used to prevent blood coagulation), were used for hematological analysis. These tubes were inverted (gently) to ensure that the blood has thoroughly mixed with the anticoagulant and cellular integrity has been preserved. Then, the tubes were transported to the laboratory in an ice box for later analysis. Second, sterile plastic test tubes (Agarwal Closures, India) without anticoagulant were used for serum extraction. The sample tubes were maintained at room temperature for 30 minutes to allow the blood to be clotted and then the tubes were centrifuged (3,000×g, 10 minutes) to obtain serum. The serum was then frozen (−20°C) until used for lipid analysis (Gerasopoulos *et al.*, 2021; Al-Muslehi, 2013).

Lipid Profile Analysis

Triglycerides (TG) and Total Cholesterol (TC): The levels of serum TG and TC were assessed using colorimetric enzymatic assays. Lipase hydrolyzed TG and converted it to glycerol and then the glycerol was processed to produce hydrogen peroxide. Cholesterol esterase was used to hydrolyze cholesterol esters, and cholesterol oxidase was also used to oxidize free cholesterol to yield hydrogen peroxide. The produced hydrogen peroxide from TG or TC reactions was then reacted with chromogenic substrates and produced a color relative to the TG or TC concentrations that was then detected by spectrophotometer (Tayyab *et al.*, 2021; Al-Muslehi, 2013).

High-Density Lipoprotein Cholesterol (HDL-C): Quantification of HDL-C was performed with the use of a precipitation method. In this method, lipoproteins (other than HDL-C) were precipitated by magnesium chloride and phosphotungstic acid. Then, the supernatant particles (containing HDL-C) were enzymatically analyzed to measure the cholesterol contents (Gerasopoulos *et al.*, 2021).

Low-Density Lipoprotein Cholesterol (LDL-C) and Very Low-Density Lipoprotein Cholesterol (VLDL-C): Friedewald equation (11) was used to estimate the LDL-C as follows:

$$LDL (mg/dL) = TC - HDL - \frac{TG}{5}$$

VLDL-C was calculated by dividing TG by 5. This calculation is appropriate when TG concentration is lower than 400 mg/dL (Birtcher, 2004; Friedewald *et al.*, 1972).

Hematological Analyses

Packed Cell Volume (PCV): PCV was measured by hematocrit capillary tubes. These tubes were filled with blood by capillary action and sealed from one end. Then, they were centrifuged for 5 minutes (3000 rpm). Finally, hematocrit reader was used to read the percentage of PCV (Coles, 1967).

Red Blood Cell Count (RBC): Standard pipette of red blood cell was used to dilute whole blood (1:200). The diluted blood was then mounted onto the specified area on hemocytometer. Then, RBCs were counted in five squares in the centre of the hemocytometer using oil immersion lens of a light

microscope (Carl Zeiss AG, Germany). Total RBC number/microliter (μ) was determined by multiplying the RBCs number by 10,000 (Coles, 1967).

Hemoglobin (Hb) Concentration: The concentration of hemoglobin was determined by the acid-hematin method. 0.1 N hydrochloric acid was added to the whole blood samples to convert the hemoglobin of the blood into acid hematin stain (brown in color). The solution was continually diluted to match the color of a standard block tubes. Then, the intensity of color of the solution was compared to the color of the standard block tubes and the final concentration was measured in gram per deciliter (g/dL) (Coles, 1967; Humadi and Minnat, 2023).

Total Protein (TP): Total plasma protein concentration was measured by biuret method. In this method, copper ions react with the plasma protein in alkaline solution. This reaction forms a colored solution that can be measured by the spectrophotometer (Doumas *et al.*, 1981).

Platelet Count: Whole blood was diluted to count the platelets number. Then, the diluted blood was loaded on the hemocytometer and the platelets (per microliter) were counted based on the dilution factor (Kralova *et al.*, 2018).

Erythrocyte Indices: MCV, MCH, MCHC were calculated mathematically with the use of standard equations based on Hb, RBC, and PCV measures (Coles, 1967).

White Blood Cell (WBC) Count

Hemocytometer method was used to determine the total leukocyte number. In this method, whole blood was diluted (1:100 ratio) and all WBCs within the specified squares on the hemocytometer were counted. Then, the number of WBCs (per cubic millimeter) was computed using the following formula (Bjorner *et al.*, 2019):

Total WBCs = (WBCs in 4 squares) \times 50

Differential Leukocyte Count

Immediately after collection of the blood samples, blood smears were prepared to determine the differential WBCs. These smears were dried, fixed (using methanol), and stained with Wright-Giemsa stain. For each smear, at least one hundred leukocytes were identified in each smear as basophils, eosinophils, heterophils, lymphocytes, or monocytes based on the cellular characteristics and nuclear morphology. The percentages of each type of WBC were determined relative to the total number of leukocytes (Halder *et al.*, 2022; Fife *et al.*, 2021).

Statistical Analysis

Data in the tables and figures were presented as mean \pm standard error of the mean (M \pm SEM). Differences between the experimental groups (G2 - G5) and control group (G1) were assessed using One-Way Analysis of Variance (ANOVA). To compare each individual treatment group with the control group, Dunnett post-hoc test was used following the ANOVA analysis. The statistical significance criterion was set at $p < 0.05$ (Couto *et al.*, 2022). Version 8.3 GraphPad Prism software

(GraphPad Software, USA) was used for the statistical analysis of the experimental data (Almuslehi *et al.*, 2022; Sen *et al.*, 2021; Almuslehi *et al.*, 2020). Graphs of the results were also designed by the GraphPad Prism software. The effects of significant interaction among the experimental groups relative to the controls were described in the legends of the figures.

Ethics approval: All experimental protocols involving animals were undertaken according to the institutional standard guidelines for the animal care and the use of animals in experimental research. The experimental design was critically valuated and approved by the Animal Ethics Committee of the College of Veterinary Medicine, University of Diyala, Iraq (Approval No.: VM,219, February, 2025, M K M and T).

Results:

Body weight gain

Chickens weight has been progressively increased in all treatment groups throughout the whole period of the experiment. Relative to the controls chickens (G1), there were no significant changes were observed in treatment groups G2 and G4, which displayed comparable patterns of growth progressions. In contrast, G3 group (in the last week of the experiment) exhibited significantly greater body weight in comparison to the control group. The greatest weight improvement was evident in G5 group, which showed a significantly higher weight gain than control and all other treatment groups.

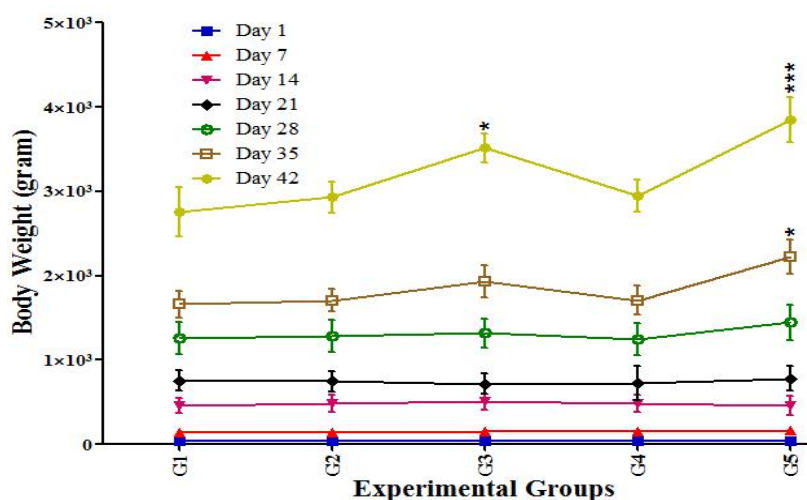


Figure 1: Body weight values (gram) of differently treated experimental groups during six weeks. G1: Control (water only); G2: Magnetized Water; G3: 0.5% Apple Cider Vinegar; G4: 0.5% Date Vinegar; G5: Magnetized Water with 0.5% Date Vinegar. Data are presented as mean \pm SEM (standard error of the mean). Lines represent the data recorded weekly from Day 1 of the experiment to the day 42. Asterisks on the lines are indicative of P value (* $P < 0.05$ and *** $P < 0.001$); no asterisk on the lines mean no significant change between treatment group(s) and the control (G1).

Feed consumption

Feed intake by chickens rose gradually with the age progression across all groups (Figure 2). Group G2 revealed a broadly consistent pattern of feed intake throughout the treatment period compared to the controls (G1). Chickens of G3 group consumed a slightly lower ration during the first 4 weeks of the experiment but demonstrated superiority over the control during the last week; however, this demonstration was not significant in comparison with control group. G4 revealed a moderately greater feed consumption than the control group, particularly the last week, but this consumption has not reached to the significant level. The greatest overall intake was reported in the G5 group, which was consistently exceeding all of the experimental groups during the last week of the trial.

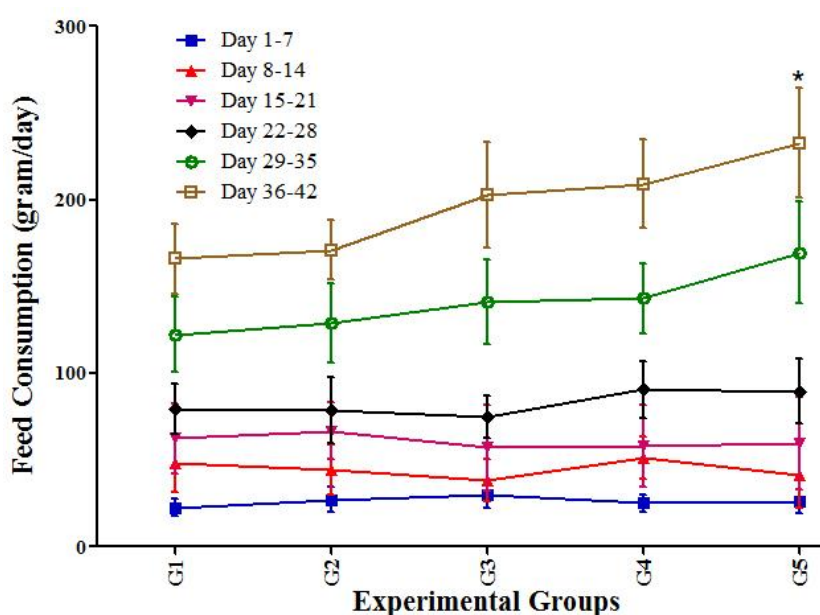


Figure 2: Daily chickens feed intake (gram/day) of five experimentally treated groups during six weeks. G1: Control (tap water only); G2: Magnetized Water; G3: 0.5% Apple Cider Vinegar; G4: 0.5% Date Vinegar; G5: Magnetic Water with 0.5% Date Vinegar. Results are expressed as mean \pm SEM. Lines represent weekly measurements: Days 1–7, 8–14, 15–21, 22–28, 29–35, and 36–42. Asterisk on the line is indicative of P value ($*P < 0.05$); no asterisk on the lines mean no significant change between treatment group(s) and the control (G1).

Lipid profile

Across all experimental groups (G1 - G5), lipid parameters of broilers were explored in Table 1; and data trends and significant values indications were illustrated in Figure 3. In general, the use of different treatments in this study resulted in a positive change in lipid profile, indicating improved lipid metabolism. Total cholesterol and triglyceride levels demonstrated a gradual decrease with the increased intensity of the treatments. In contrast, there was a progressive elevation in the HDL-C across the treatment groups compared to control group except G3 group. The levels of LDL-C were decreased consistently in all experimental groups relative to controls. Also, VLDL-C (calculated from triglyceride levels) revealed a marked gradual decline with the increase of the treatments intensity. Collectively, the treatments provided a recommended effect on lipid profile which was distinguished

by marked decrease in levels of total cholesterol, triglycerides, LDL-C, and VLDL-C; and, the most importantly, marked and elevation in the levels of HDL-C. These results indicate an overall improvement of lipid parameters which reflect an enhanced lipid metabolism include a decreased levels of atherogenic lipids (TC and TG) and lipoproteins (LDL-C and VLDL-C) and an increased levels of in cardiovascular protective lipoprotein (HDL-C), suggesting enhanced cardiovascular system health in broilers.

Table 1: Values of Serum Lipid Profile (mg/dL) in Different Treatment Groups (G1 - G5).

Test (mg/dL)	Experimental groups				
	G1	G2	G3	G4	G5
TC	179.6±10.09	160.8±7.87	164.7±8.65	133.5±11.57	127.02±11.67
TG	148.8±5.17	138.6±4.05	129.4±10.08	119.4±9.59	121.4±7.18
HDL-C	47.4±3.21	56.9±2.61	50.2±2.01	55.3±2.03	55.6±2.07
LDL-C	102.2±7.2	86.0 ± 5.1	88.7 ± 5.01	54.1 ± 14.5	47.1 ± 12.4
VLDL-C	29.8±1.03	27.9 ± 0.96	25.2 ± 2.04	23.9 ± 1.07	24.3 ± 1.08

Table's key: Values are presented as mean ± standard error of the mean (M±SEM). TC (Total Cholesterol); TG (Triglycerides); HDL-C (High-Density Lipoprotein Cholesterol); LDL-C (Low-Density Lipoprotein Cholesterol); VLDL-C (Very Low-Density Lipoprotein Cholesterol). G1-G5 represent the treatments groups as follows: Control (G1), Magnetized water (G2), 0.5% Apple Cider Vinegar (G3), 0.5% Date Vinegar (G4), Magnetic Water Plus 0.5% Date Vinegar (G5).

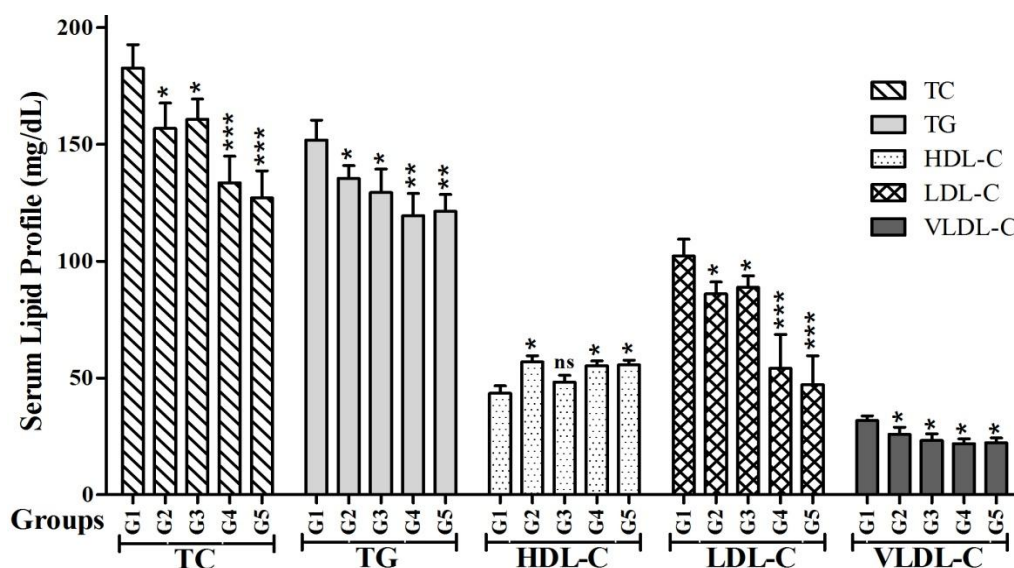


Figure 3: Effect of various treatments interventions on lipid parameters in broilers. Bars of the graph represent the mean of the experimental data ± standard error of the mean (SEM) for each experimental group (G1-G5). Total Cholesterol (TC) concentration, Triglycerides (TG), High-Density Lipoprotein-Cholesterol (HDL-C), Low Density Lipoprotein-Cholesterol (LDL-C), and Very Low Density Lipoprotein-Cholesterol (VLDL-C). G1-G5 represent the treatments groups as follows: Control (G1), Magnetized Water (G2), 0.5% Apple Cider Vinegar (G3), 0.5% Date Vinegar (G4), Magnetic Water Plus 0.5% Date Vinegar (G5). All treatment groups are compared to the control group. Asterisks above bars indicate significant differences (*p<0.05, **p<0.01, ***p<0.001) between the asterisk marked group and control group and ns indicate no significant change.

Hematological parameters

Hematological indices were shown in Table 2. This table included excessively complicated information; and thus, for convenience and better understanding, data were illustrated in Figure 4 to simplify these data. The concentrations of RBC, Hb, and PCV revealed a significant decrease in all experimental groups relative to the controls, whereas the levels of the parameters were significantly increased in the G5 group. Total protein concentrations were decreased in the treatment groups (G2, G3, and G4), but significantly increased in the G5 group compared to the controls. Platelet numbers were markedly increased in the G2 group. In G3 and G4 groups the platelets count was non-significant relative to the control group. However, G5 group revealed a significant elevation when compared to the control group. MCV declined in group G2 but significantly increased in the G4 and G5 groups. MCH exhibited a mild decline in G2 group; whereas the MCH demonstrated a progressive increase in the G4 and G5 groups, while G3 has not been changed. However, the MCH values of the G3, G4 and G5 groups were relatively constant across the treatment groups and no significant differences were observed when compared to the control. In addition, the MCHC values were also constant with no significant change relative to the control group. Collectively, these results indicate that treatments, the combination of organic acids that were used in G5 in particular, have effectively enhanced the blood parameters (and probably the erythropoiesis), total protein level, and platelets count, and contributed to the improvement of hematology-related health matter in broiler chickens.

Table 2: Hematology parameters (RBC Count, Hb concentration, PCV percentages, MCV, MCH and MCHC) across different treatments groups (G1- G5).

Test	Experimental groups				
	G1	G2	G3	G4	G5
RBC	4156250±223815	2736750±307765	3381250±157610	3206875±193539	4866250±210705
PVC	33.5±1.75	25.6±0.73	24.2±0.60	24.5±1.23	36.75±2.01
Hb	10.75±0.81	8.7±0.27	8.27±0.14	7.9±0.35	12.02±0.80
TP	5.925±0.36	4.825±0.07	4.8±0.11	4.5±0.12	6.525±0.20
Platelet	140087.5±7134.5	214073.3±23539.6	119775±12430.5	154993.8±11561.1	158962.5±8055.8
MCV	57.19±1.32	52.61±2.68	56.81±1.48	59.66±0.31	59.62±0.34
MCH	18.32±0.60	15.74±0.71	17.03±1.50	18.05±0.20	19.51±0.40
MCHC	32.01±2.38	30.06±1.28	29.78±2.27	30.25±1.26	32.64±2.60

Table's key: Values are presented as mean ± standard error of the mean (M±SEM). RBC (Red Blood Cell count, per µl); PCV (Packed Cell Volume, %); Hb (Hemoglobin, g/dL); TP (Total Protein, g/dL); Platelet count (per µl); MCV (Mean Corpuscular Volume, fl); MCH (Mean Corpuscular Hemoglobin, pg); MCHC (Mean Corpuscular Hemoglobin Concentration, g/dL). G1- G5 represent the treatments groups as follows: Control (G1), Magnetized Water (G2), 0.5% Apple Cider Vinegar (G3), 0.5% Date Vinegar (G4), Magnetic Water Plus 0.5% Date Vinegar (G5).

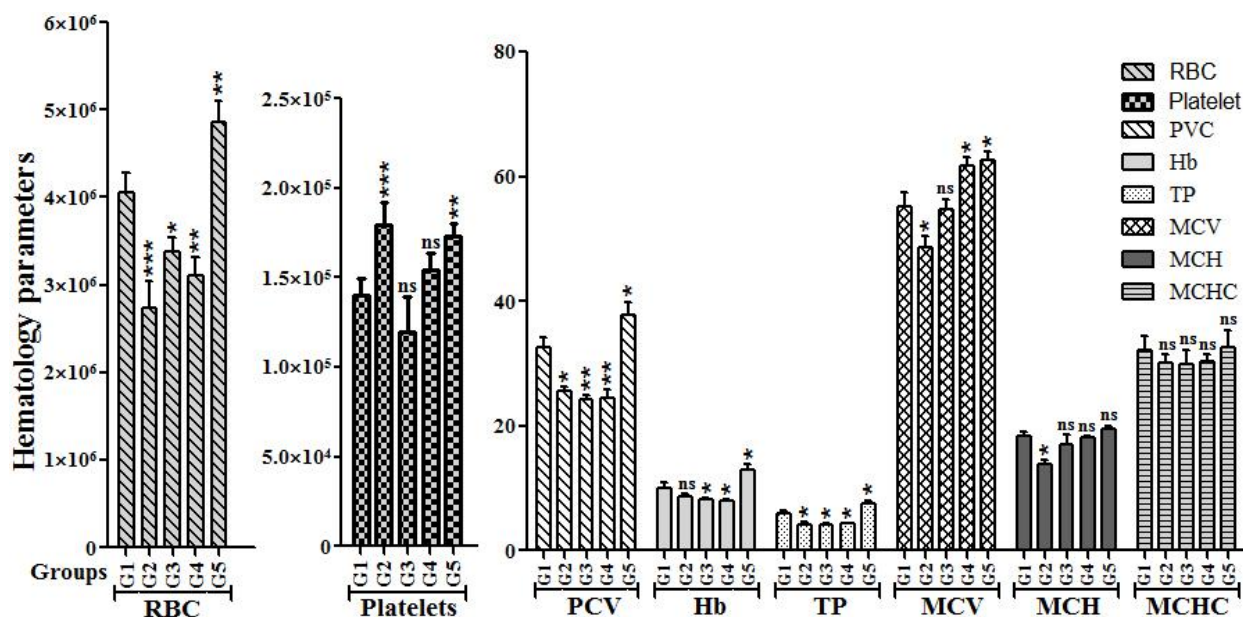


Figure 4: Hematologic indices of broiler chickens subjected to various treatments in the water. The left side graph of Red Blood Cell (RBC) count (millions/ μL) and Platelet count ($\times 10^3/\mu\text{L}$) are presented separately to emphasize the differences in the numbers of Y axis in all bar graphs (left and right side graphs). The next grouped bar graph (on right side) is revealing Packed Cell Volume (PCV) percentage, Hemoglobin (Hb) concentration (g/dL), Total Protein (TP) concentration (g/dL), Mean Corpuscular Volume (MCV, fL), Mean Corpuscular Hemoglobin (MCH, pg/cell), and Mean Corpuscular Hemoglobin Concentration (MCHC, g/dL). Values are presented as mean \pm standard error of the mean (SEM) for each treatment group: Control (G1), Magnetized Water (G2), 0.5% Apple Cider Vinegar (G3), 0.5% Date Vinegar (G4), Magnetic Water Plus 0.5% Date Vinegar (G5). All treatment groups are compared to the control group. Asterisks above bars indicate significant differences (* $p < 0.05$, ** $p < 0.01$, * $p < 0.001$) between the asterisk marked group and control group and ns indicate no significant change.**

The impacts of different interventions or treatments on the leukocyte indices were presented in Table 3 and also these data were graphed in Figure 5 to be conveniently interpreted. The total number of WBCs was reduced in the G2, G3 and G4 groups relative to the controls, whereas it was increased in G5 group in comparison with control group too. The percentage of heterophil was higher in the G2, G3 and G4 groups in comparison with the control group, while in the G5 group it did not differ significantly from the control. Eosinophil percentage elevated in the treatment groups (G3, G4 and G5), whereas there were no significant differences among controls and the treatment groups in terms of basophil percentage. On the other hand, the percentages of monocyte were decreased in the G4 and G5 groups compared to the controls and this change was more prominent in the G4 group. The percentages of lymphocyte were decreased in the G2, G3 and G4 groups relative to the controls, whereas the G5 group demonstrated no significant effect. These findings indicate that the treatment with magnetic water and 0.5% date vinegars in the G2 and G4 groups are generally reduced the total WBCs numbers and lymphocytes percentages, while increased eosinophils and heterophils. Moreover, the treatment with the combination of organic acids (date vinegar plus apple cider vinegar) in the G5 group has enhanced the overall leukocyte counts.

Table 3: Leucocytes Parameters (total WBCs count) of Different Experimental Groups (G1- G5).

Test	Experimental groups				
	G1	G2	G3	G4	G5
WBC	17215±222.14	14788.5±198.08	14983.7±184.20	16011.2±204.42	20147.25±230.28
Hetrophils	39.62±1.04	52.12±1.78	48.73±1.47	50.5±2.53	38.62±1.47
Eosinophil	3±0.33	3.75±0.46	4.9±0.53	5±0.41	4.57±0.50
Basophil	0.36±0.23	0.5±0.23	0.5±0.23	0.31±0.23	0.29±0.23
Monocyte	5.65±0.58	5.51±0.86	4.82±1.26	4.25±0.37	4.72±0.32
Lymphocyte	51.37±0.86	38.12±1.38	41.05±2.34	40.39±1.93	51.8±2.20

Table's key: Values are presented as mean ± standard error o the mean (M±SEM). WBC (White Blood Cell count, per µl); Hetrophils, Eosinophils, Basophils, Monocytes, and Lymphocytes are expressed as percentages (%).

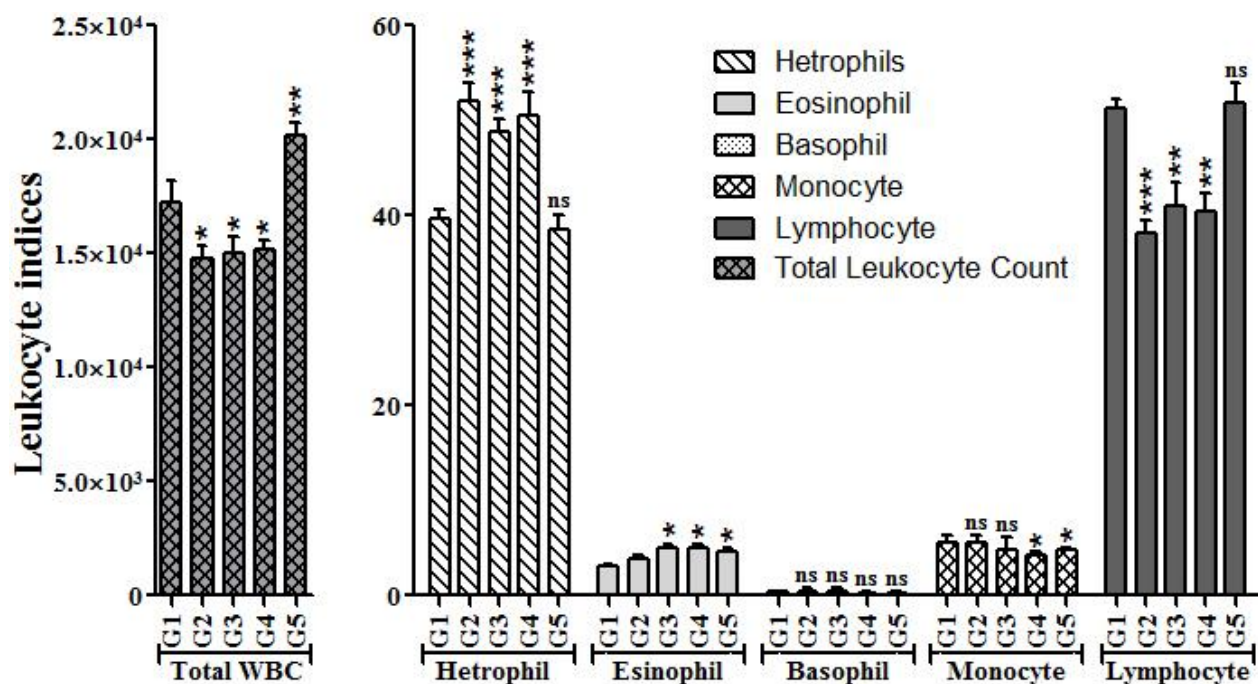


Figure 5: Leukocyte indices of broilers exposed different treatments paradigm. Total White Blood Cell count (WBC; cells/µL) is illustrated separately on the left side of the figure to emphasize the differences in the numbers of Y axis in both bar graphs (left and right side graphs). The next grouped graph exhibits percentages of the differential leukocyte including heterophils, eosinophils, basophils, monocytes, and lymphocytes. Data are expressed as mean ± standard error of the mean for each treatment group: Control (G1), Magnetized water (G2), 0.5% Apple Cider Vinegar (G3), 0.5% Date Vinegar (G4), Magnetic Water Plus 0.5% Date Vinegar (G5). All treatment groups are compared to the control group. Asterisks above bars indicate significant differences (*p<0.05, **p<0.01, ***p<0.001) between the asterisk marked group and control group and ns indicate no significant change.

DISCUSSION

The current study assessed the impacts of magnetic water, apple cider vinegar and the combination of magnetized water and date vinegar on body weights and lipid profile parameters as well as hematological indices of broiler chickens. The results of this study demonstrated that the use of apple cider vinegar (G2 group) and magnetic water plus 0.5% date vinegar (G5 group) produced the greatest comprehensive weight gain, attaining nearly 3,350g and 3,749 grams, respectively, at the day 42. These results suggest that the combined treatment may synergistically enhance growth performance. In addition, the records of daily feed consumption across six time points (Days 1-7 through Days 36-42) exhibited a progressive elevation in daily feed intake in all experimental groups, with G5 persistently presenting the highest feed consumption value (e.g., ~230.6 gram/day at Days 36–42). Increased feed consumption, especially G5, suggests that feed digestion efficiency or appetite of these birds may have had increased.

The weight gain results aligned with prior observations revealing that supplementation with apple cider vinegar tends to increase body weight in broiler chickens (Jahantigh and Kalantari, 2019). In parallel, a study on magnetic water has reported enhancements of the ratio of feed conversion and weight gain in chickens (Mitre, 2018). The findings of the current study provide evidence that magnetic water and organic acids, particularly when used in combination, have a favorable impact on growth performance, likely by improving the absorption of nutrients and increasing metabolic efficiency. Regarding feed intake results, previously published studies using organic acids (e.g., vinegar) in chickens have observed similar findings such as augmented microbiome balance, which may improve feed intake and nutrients uptake by intestine (Jahantigh and Kalantari, 2019; Tasharofi *et al.*, 2017). Moreover, it has been demonstrated that organic acids (including apple cider vinegar and date vinegar) increased villi heights and crypt depth in the intestinal walls, thereby augmenting digestive functionality (Al-Khalidi, 2023; Manswr *et al.*, 2023). Notably, the potential benefits of magnetic water to feed consumption remains poorly understood; yet, enhanced body weights reported in some studies be somewhat linked to the increased feed intake (Mitre, 2018).

The results of the current study have also revealed that the use of magnetized water in combination with 0.5% date vinegar in the treatment group (G5) was significantly enhanced lipid parameters. This effect can be eventually attributed to the improvement of lipid metabolism. Furthermore, the hematological indices were also improved when the combination of magnetized water and 0.5% date vinegar was used (G5) as compared to the control group (G1). Collectively, these findings highlighted the potential of using the combination of magnetized water and 0.5% date vinegar together rather than using them individually as a practical intervention in the poultry nutritional programs.

In the treated broiler chickens, the values of TC, TG, LDL-C and VLDL-C (known as ‘bad cholesterol’) were pronouncedly reduced in G3, G4 and G5 groups. However, this reduction in the bad cholesterol parameters was accompanied with a dramatic elevation in ‘good cholesterol’ (the HDL-C). These findings suggest that the lipid metabolism and clearance was enhanced and the overall cardiovascular system health was improved in the experimental hens. Similar findings have been noticed in previously published studies where the individual supplementation of date vinegar or apple cider vinegar decreased the TC and LDL-C while increased the HDL-C in chickens (Tayyab *et al.*, 2021; Gerasopoulos *et al.*, 2021). The results of this study were also revealed a moderate enhancement

of the lipid profile parameters in the magnetic water treated group (G2). This observation was aligned with the previously published report by Mohan and co-authors who stated that the magnetic water can induce positive impacts on lipid metabolism (Mohan *et al.*, 2021). Mohan and colleagues were also attributed this positive impact of the magnetized water to the enhancement of minerals bioavailability in cells and the improvements of activity of the enzymes involved in the catabolism of fat and adipose tissue.

The combination magnetized water and 0.5% date vinegar group (G5) exhibited a significant increase in RBC numbers, Hb and TP concentrations, PCV percentages, and platelet counts. These positive results indicate improvements of erythropoiesis and overall health of hematological parameters. The elevation in the platelet count suggests better clotting potential, which maybe contributed to the augmented physiological resilience. Far more similar impacts of organic acids on RBC count, Hb concentrations and PCV percentages have been observed in broiler chickens (Haldar *et al.*, 2022). These observations were potentially attributed to the strengthened nutrients absorption in the intestine and minimized oxidative stress (Fife *et al.*, 2021). Chickens of the G5 group also demonstrated normalized WBCs count and differential WBCs percentage, including eosinophils, heterophils, lymphocytes and monocytes, reflecting optimized immune performance. The increased heterophils percentages in the experimental groups (G2, G3 and G4) maybe reflected mild inflammation due to stress responses, while the G5 group maintained the immune cells distribution. The results of the current study were in line with other previously published studies (Haldar *et al.*, 2022; Samanya and Yamauchi, 2002). These studies demonstrated that organic acids supplementation can augment immune system and improve the function of WBCs in broiler chickens.

The enhancement of body weight gain, reduction in 'bad' lipids and the improvements of hematological parameters observed in the combined treatment of magnetized water and 0.5% date vinegar group (G5) maybe resulted from the synergistic impact of magnetized water and 0.5% date vinegar on the intestinal microbiota, metabolism of bile acids, and systemic utilization of nutrients (Elwasife *et al.*, 2019). Also, the use of magnetized water in broiler chickens may further improve the absorption efficiency by the intestinal cells (Mohan *et al.*, 2021). Enhanced lipid parameters are specifically relevant in broiler chickens, as excessive deposition of lipids and elevated level of LDL-C predispose chickens to atherosclerosis, myocardial fat deposition, and reduced efficiency of the cardiovascular system (Streicher *et al.*, 2018; Malheiros *et al.* 2019). The increased HDL-C and reduced LDL-C and VLDL-C, in the combined treatment group (G5) may potentially relieve cardiovascular problems and promote overall health and growth performance in broiler chickens.

Despite the prospective findings outcome, several limitations have been recorded in this study that should be taken into considerations. First, the effects of combined treatment of magnetized water plus apple cider vinegar had not been explored in the current study to be compared with the apple cider vinegar treated group (G2). Second, the relatively small sample size (only 10 chicks per experimental group) may limit the generalization of the findings. Third, the current study has explored a single broilers breed only under controlled environmental conditions but ignored strains variation, or other environmental variables that could affect the chicken responses to such treatments intervention. Fourth, while enhancements of hematological indices and lipid profile parameters were prominent, the mechanisms underlying these findings such as changes of the intestinal microbiota, metabolism of bile

acids and oxidative stress, have not been investigated in the current study. Additionally, the potential dietary components interactions with specific treatments in this study as well as the long-term impact of the treatment beyond rearing period (42 days), remain ambiguous. Future studies should consider greater sample size, multiple chickens' strains and mechanistic investigation studies to warrant the validation of these findings.

Conclusions:

The findings of this study suggest that the combined treatment of **magnetic water and date vinegar** yields the highest enhancements in both weight gain and feed consumption. Also, the treatment of G5 group has effectively improved serum lipid profile, erythropoiesis and immune cells competence in broilers. Magnetic water, date vinegar or apple cider vinegar alone were also exhibited advantageous impacts but to a limited extent. These results indicate that the use of the combination of magnetized water with organic acids enhanced both lipid metabolism and hematological parameters in broiler chickens. Finally, this combined treatment can be used as a practical strategy in the poultry nutritional program to boost the overall health and production of broilers.

Acknowledgment: The author expresses their sincere gratitude to Prof. Abdul-Lateef Molan, College of Sciences, University of Diyala, for his valuable support and guidance. Appreciation is also extended to the Department of Physiology, Biochemistry and Pharmacology, College of Veterinary Medicine, University of Diyala, for providing the necessary facilities to conduct this research.

Conflict of Interest: The author declares that they do not have any competing financial or personal interests that might influence the work of this manuscript.

Funding Sources: This work did not receive any grant from funding commercial or non-profit sectors agencies.

References:

- Couto, A., Santos, J. A., & Faria, R. (2022). Lipid metabolism and serum lipid profile in broiler chickens: Effects of diet and age. *Poultry Science*, 101(4), 101859. <https://doi.org/10.1016/j.psj.2021.101859>
- Streicher, K., Schedle, K., & Applegate, T. J. (2018). Cardiovascular health and lipid metabolism in poultry: Pathophysiology and nutritional interventions. *Animal Feed Science and Technology*, 241, 1–12. <https://doi.org/10.1016/j.anifeedsci.2018.06.004>
- Malheiros, R. D., Pelícia, K., & Bressan, M. C. (2019). Lipid deposition and cardiovascular health in broiler chickens: Implications for production. *Poultry Science*, 98(12), 6501–6512. <https://doi.org/10.3382/ps/pez398>
- Mohan, P., Jain, S., & Kumar, R. (2021). Effect of magnetized water on growth performance, nutrient digestibility, and blood profile in broiler chickens. *Journal of Applied Animal Research*, 49(1), 64–72. <https://doi.org/10.1080/09712119.2020.1836041>

- Tayyab, U., Mahmood, S., & Khan, R. U. (2021). Evaluation of lipid profile in broilers under different nutritional treatments. *Veterinary World*, 14(7), 1724–1731. <https://doi.org/10.14202/vetworld.2021.1724-1731>
- Haldar, S., Bhattacharya, S., & Roy, S. (2022). Comparative evaluation of differential leukocyte counts in broilers under different management systems. *Veterinary World*, 15(7), 1803–1810. <https://doi.org/10.14202/vetworld.2022.1803-1810>
- Elwasife, K. Y., Alattar, E., Radwan, E. S., & Abuassi, W. A. (2019). Influence of magnetized water on the growth of corn (*Zea mays*) seedlings. *Scientific Reports*, 9(1), 1–10. <https://doi.org/10.1038/s41598-019-46498-1>
- Gerasopoulos, D., Tsiouris, V., & Kapsalis, J. (2021). Effects of dietary supplements on serum lipid levels in broilers. *Animal Nutrition*, 7(4), 1201–1209. <https://doi.org/10.1016/j.aninu.2021.05.006>
- Al-Muslehi, M. S. M. (2013). *Clinical use of estradiol benzoate to inhibit aggressive behavior in male calves*. Iraqi Journal of Veterinary Sciences, 27(4), 45–52. <https://iasj.rdd.edu.iq/journals/uploads/2024/12/14/b195404a4eb268b2467ca4d840ee33f0>
- Al-Muslehi, M. S. M. (2013). *Effect of powder of pomegranate (Punica granatum) peels on lipid profile in hypercholesterolemic rats*. Kufa Journal for Veterinary Sciences, 4(2), 95–104. <https://journal.uokufa.edu.iq/index.php/kjvs/article/view/3915>
- Birtcher, K. K. (2004). Measurement of cholesterol. *Circulation*, 110(6), e15–e17. <https://doi.org/10.1161/01.CIR.0000141564.89465.4E>
- Friedewald, W. T., Levy, R. I., & Fredrickson, D. S. (1972). Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clinical Chemistry*, 18(6), 499–502. <https://doi.org/10.1093/clinchem/18.6.499>
- Coles, E. H. (1967). *Veterinary clinical pathology* (1st ed.). W.B. Saunders.
- Humadi, A. A., & Minnat, T. R. (2023). The hematological and histopathological changes of *Giardia duodenalis* on the intestine in Diyala Government. *Diyala Journal for Veterinary Sciences*, 1(1), 66–84. <https://doi.org/10.71375/djvs.2023.01107>
- Doumas, B. T., Watson, W. A., & Biggs, H. G. (1981). Albumin standards and the measurement of serum albumin with bromocresol green. *Clinica Chimica Acta*, 31(1), 87–96. [https://doi.org/10.1016/0009-8981\(81\)90043-1](https://doi.org/10.1016/0009-8981(81)90043-1)
- Kralova, J., Hloucalova, M., & Kosina, P. (2018). Platelet count and morphology in healthy chickens. *Avian Pathology*, 47(6), 626–632. <https://doi.org/10.1080/03079457.2018.1491652>
- Bjorner, M., Madsen, M., & Jensen, T. (2019). A minimally invasive, low-stress method for serial blood sampling in mice. *Journal of the American Association for Laboratory Animal Science*, 58(3), 271–277. <https://doi.org/10.30802/AALAS-JAALAS-18-000062>
- Fife, B., Gous, R. M., & Du Preez, J. (2021). Hematological reference ranges for broiler chickens under commercial conditions. *Poultry Science*, 100(12), 101485. <https://doi.org/10.1016/j.psj.2021.101485>
- Almuslehi, M. S. M., Sen, M. K., Shortland, P. J., Mahns, D. A., & Coorsen, J. R. (2022). Histological and top-down proteomic analyses of the visual pathway in the cuprizone demyelination model.

- Journal of Molecular Neuroscience*, 72(6), 1374-1401. <https://doi.org/10.1007/s12031-022-01997-w>
- Sen, M. K., Almuslehi, M. S. M., Shortland, P. J., Mahns, D. A., & Coorsen, J. R. (2021). *Proteomics of Multiple Sclerosis: Inherent Issues in Defining the Pathoetiology and Identifying (Early) Biomarkers*. *International Journal of Molecular Sciences*, 22(14), Article 7377. <https://doi.org/10.3390/ijms22147377>
- Almuslehi, M. S. M., Sen, M. K., Shortland, P. J., Mahns, D. A., & Coorsen, J. R. (2020). *CD8 T-cell Recruitment Into the Central Nervous System of Cuprizone-Fed Mice: Relevance to Modeling the Etiology of Multiple Sclerosis*. *Frontiers in Cellular Neuroscience*, 14, Article 43. <https://doi.org/10.3389/fncel.2020.00043>
- Jahantigh, M., & Kalantari, S. (2019). Effects of dietary vinegar on performance, immune response, and small intestine histomorphology in 1- to 28-day broiler chickens. *Veterinary Medicine and Science*, 5(4), 576–584. <https://doi.org/10.1002/vms3.408>
- Mitre, K. (2018). The effect of magnetic water on feed conversion ratio, body weight gain, feed intake, and livability of male broiler chickens. *Poultry Science Undergraduate Honors Theses*, 5. University of Arkansas. <https://scholarworks.uark.edu/poscuht/5>
- Tasharofi, A., Torki, M., & Tasharofi, S. (2017). Effects of dietary vinegar on performance, immune response, and small intestine histomorphology in 1- to 28-day broiler chickens. *Veterinary Medicine and Science*, 5(4), 576–584. <https://doi.org/10.1002/vms3.408>
- Al-Khalidi, A. A. H. (2023). Histopathological, metabolic and performance changes in laying hens affected by fatty liver haemorrhagic syndrome. *Diyala Journal for Veterinary Sciences*, 1(3), 45–59. <https://doi.org/10.71375/djvs.2023.01304>
- Manswr, B. M., Al-Khalidi, A. A. H., & Ali, A. E.-M. H. (2023). Molecular detection of IBV from backyard chickens in Diyala province. *Diyala Journal for Veterinary Sciences*, 1(4), 99–114. <https://doi.org/10.71375/djvs.2023.01408>
- Samanya, M., & Yamauchi, K. (2002). Effects of dietary fiber on digestive organs and intestinal microflora in broilers. *Journal of Poultry Science*, 39(3), 135–143. <https://doi.org/10.2141/jpsa.39.135>