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The Effect of Artemisia on Immune Response and Productive Performance Against Newcastle Disease in Broiler Chickens

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ABSTRACT

Prevention of Newcastle disease has received a lot of interest across the world. The high productivity performance of the commercial chickens' breeds has negative effects on the immune system and animal welfare. As a result, the current study aimed to investigate the benefits of adding Artemisia powder at levels of 0.5% and 1% to broilers' feed as a growth and health promoter. A total of 120 commercial broiler chickens were grown on the floor in a chicken house and separated into three groups, including one control and two treatment groups. Each group contained 40 chickens subdivided into two replicates. The three groups, namely G1 (chickens without Artemisia powder, as a control group), G2, and G3 in which chickens were fed with basal diet plus 0.5% and 1% Artemisia powder, respectively, were differentiated based on their diet throughout 35 days of the experiment. The measured parameters included the immune response to Newcastle disease vaccine, blood biochemical parameters, and growth performance as well as relative weight for the spleen and bursa of Fabricius. A diet containing 1% Artemisia powder significantly improved antibody titer against Newcastle disease, body weight, and weight gain. Thus, the addition of 1% of Artemisia powder to the broiler's diet can improve immune response against Newcastle disease and growth performance.

Keywords: Artemisia, Broiler chicken, Newcastle disease, Productive traits

INTRODUCTION

Considering the poultry diet, feed additives, including antibiotics, enzymes, diet dyes, flavors additives, probiotics, (Vahdatpour and Babazadeh, 2016), phytobiotics (Saeed et at., 2018), and antioxidants (Pirgozliev et al., 2019) are added to enhance poultry production performance although they are not nutritious. These substances are added to a diet mainly for the improvement of feed intake and growth rate in chickens (Bali et al., 2011; Abouelfetouh and Moussa, 2012; Ahsan et al., 2018). Most growth promoter antibiotics were banned by the European Union countries in 2006 due to their remains in body tissues and the development of pathogen resistance (Millet and Maertens, 2011). Researchers have investigated the use of aromatic plants as an alternative to antibiotics. Aromatic plants or herbs as feed additives are used widely in the Middle East for a long time ago helping to enhance food taste (Saeed et al., 2017; Daramola, 2019; Christaki et al., 2020). Medical plants supplementation in the broiler chicken diet could affect performance characteristics, serum metabolites, and antioxidant status (Kostadinović et al., 2015; Jin et al., 2020). According to the World Health Organization, about 80% of medical plants in humans are used for disease prevention and treatment particularly in developing countries (Deniz et al., 2021).

Chicken production is mainly correlated to gastrointestinal tract (GIT) efficiency, where its main role is feed digestion and metabolism (Ravindran and Abdollahi, 2021). Thus, GIT health is playing a substantial role in productivity as it affects the utilization of energy, proteins, and consequently disease resistance. Phytogenic feed additives (PFAs) are substances of plant origin used as diet additives in the poultry industry for the improvement of performance characteristics (Noonan,

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2018). In modern animal production, PFAs are used for their antimicrobial effect, digestibility enhancement, and performance improvement (Hafeez et al., 2016; Ahsan et al., 2018). Artemisia is a class of plant that belongs to the Asteraceae family and is used as human and animal medicine. The nutrition contents of Artemisia are presented by Iqbal et al. (2012) which includes carbohydrates, fibers, fat, protein, phytate, tannin, and tocopherol. Artemisia has been utilized in poultry production as an enhancer of weight gain, feed conversion ratio (Gholamrezaie et al., 2013), and gut microbiota (Saracila et al., 2018; Song et al., 2018; Panaite et al., 2019). Abdullah and Al-Barwary (2020) indicated that the addition of Artemisia to the broilers' diet can lead to improved performance, gut morphology, and serum biochemical parameters during a coccidiosis challenge. Saracila et al. (2018) found that intestinal microflora improved in broilers reared under heat stress after the administration of Artemisia in the diet. Guo et al. (2020) found that Artemisia could improve growth performance and antioxidant function in broilers. Liu et al. (2009) demonstrated that Artemisia inhibited the proliferation of Newcastle disease virus in chicken embryos in an *in vivo* study. In Iraq, the commercial poultry industry aims to reach the highest body weight gain from feed intake. However, productivity and immune response for diseases are adversely correlated (Lwelamira et al., 2009; Sahib, 2021).

Many countries have tended to minimize or prohibit the chemical components because of their deleterious side effects on both animals and humans (Hao et al., 2014; Osman et al., 2018). Therefore, the aim of the current research was to investigate the effects of adding Artemisia powder at levels of 0.5% and 1% to the basal diet on immune response against Newcastle disease and the productive performance of broiler chickens.

MATERIALS AND METHODS

Ethical approval

All the procedures involved in the current study were confirmed by the scientific and animal care committee at the University of Kufa, Iraq (Certificate number: 100821.139).

Chickens

This experiment was conducted at the poultry farm of the University of Kufa, Iraq. A total of 120 Cobb 500 broiler chickens aged one day old were purchased from a local hatchery in Najaf, Iraq. One-day-old chickens with an average weight of 39.8 g were randomly split into three nutritional groups with two replicates (20 birds per replicate). All the management requirements (temperature, light, and ventilation) were met based on the Cobb 500 production guide management (2021). Chicks were raised on wood shaving floor pens. The first group (G1) was provided with a basal diet as a control group. While the second group (G2) and the third group (G3) were daily fed on a basal diet plus 0.5% and 1% Artemisia powder respectively. Feed and water were available *ad libitum*. Two formulas of diets (starter and finisher) were utilized during 35 days of the experiment (Table 1). All birds received a companied Newcastle disease (ND) (B1 strain, (Poulvac®, USA)) and infectious bronchitis vaccine (Poulvac®, USA) by spraying each of them on the first day at the hatchery.

On the other hand, booster dose was administered orally in water, these vaccines included ND (Lasota strain Poulvac®, USA) on day 10 as well as Gumboro (IBD2, Bursine®, USA) on days 14 and 23 (Lasota strain of ND, Poulvac®, USA). Moreover, Vitamin C was administered (1 gm/liter) orally for 3 days after each vaccination. The chickens cared in accordance with animal welfare principles and with attention to ethics committee roles.

Table 1. Composition of diet in broiler chickens during 5 weeks of rearing

Ingredient (%)	Initial diet (1- 20 day)	Closer diet (21-35 day)
Corn (yellow)	53	44
Soybean meal (48% protein)	30	21
Wheat	10	26
Protein concentrate	5	5
Oil	1	3
Premix (VAPCO®, Jordan)	0.2	0.2
Limestone	0.5	0.5
Salt	0.2	0.2
Dicalcium phosphate	0.1	0.1
Overall	100	100
Chemical analysis		
Energy (kcal/kg)	2951.5	3128.5
Crude protein (%)	22	19

The balanced diet based on the NRC (1994). Premix is a mixture of vitamins and minerals.

Production traits

The electronic balance was used to measure live body weight and feed consumption to calculate body weight gain and feed conversion ratio at weekly intervals (Aguilar et al., 2013). However, the mortality rate was recorded daily as it occurred.

Blood collection and analysis of cells count and enzymes

About 1 ml blood sample from brachial vine was collected from all chickens at age of 20 and 35 days by one-use syringe then transferred to test blank tubes to separate sera after clotting blood by centrifuge (10 minutes at 3000 rpm). In the next step, serum was frozen at -20°C according to Mitchell and Johns (2008). Antibodies of Newcastle disease were measured in serum by utilizing a specific ELISA Kit (Proflok®, USA) run by following the instructions of the manufacturer. Blood components (WBCs and RBCs) measures were conducted using counter medionic cells. Blood biochemistry analyses of total protein, albumin, Hb, and AST were achieved by Micro Lab 300 analyzer (Merck®, France) and using kits from Merck (France). By following the instructions of the manufacturer after mixing the sample with provided reagents with the kits, and then the mixture was brought up to 37°C by incubation for 5 minutes. Measurement was achieved with equivalent wavelength to the designated parameters.

Measurement of lymphatic organs

On day 35 of age, three chicks were randomly taken from each replicate and slaughtered after a cervical dislocation to avoid pain. The weight of each chick was measured using a digital balance. The internal organs, such as the spleen, bursa of Fabricious were weighted after collection by digital balance to calculate the ratio between them. Remove feather, head, legs, and viscera and kept only the carcass.

Statistical analysis

The obtained data were analyzed in a complete randomized design (Steel and Torrie, 1980). These data were analyzed by one way ANOVA test following the procedure of the general linear model (SAS, system-version 9.1). Duncan's multiple range tests were employed to determine the differences among group means at a significance level of $p < 0.05$. The following is the model: $Y_{ij} = \mu + T_i + e_{ijk}$, where, Y_{ij} represents individual observation, μ is the overall mean, T_i indicates the effect of treatment (i = 1, 2, 3), and e_{ijk} signifies a random error.

RESULTS

The effects of Artemisia powder additive during the experimental period on immune response (antibodies titer)against Newcastle disease are shown in Figure 1. The antibody titers increased significantly in the chickens fed with Artemisia 1% at 35 days of age, compared to other groups ($p < 0.05$). On the other hand, 0.5% of Artemisia did not lead to a significant increase regarding antibody titers ($p < 0.05$).

The results of Artemisia's effects on the blood cells count and some biochemical tests are presented in Figure 2. There was a significant difference among treatment groups in terms of red blood cells (RBC) counts with the peak (3.2 ± 0.04) in the group fed 1% Artemisia ($p < 0.05$). The Hb significantly increased in diet plus Artemisia with 0.5% and 1%, compared to the diet without Artemisia additive ($p < 0.05$). White blood cells (WBC) count was significantly higher (32 ± 0.7) in the control group, compared to other groups (Artemisia 0.5% and 1%). Aspartate aminotransferase (AST) measurements revealed significant differences ($p < 0.05$) and recorded a peak in the basal diet without Artemisia (242.5 ± 2.02), compared to chickens fed 0.5% Artemisia (218.5 ± 4.47). There were no significant differences among groups regarding both albumin and total blood protein.

The final body weight at 35 days of age enhanced significantly in G3 and G2 respectively, compared with G1 ($p < 0.05$, Figure 3). Weight gain of broiler chickens for all-treatments groups are presented in Table 2 and the total gain at the end of the experiment (day 35) is presented in Figure 4. The body weight gain was significantly different at week 5 when the highest was in G3 (764.9 ± 32.9 gm). The second highest record for body weight gain was for G2 (679.40 ± 33.09) and then the least was for G1 (556.20 ± 12.85). There were no significant differences among the three groups in terms of feed consumption and feed conversion (Tables 3 and 4). The same trend was true for the relative weight of lymphatic organs (bursa of Fabricious and spleen) among the three groups ($p > 0.05$, Table 5).

Table 2. Weight gain (g) of broiler chickens after dietary supplementation with different levels of Artimasia during 5 weeks of growing

Treatment \ Age	First week	Second week	Third week	Fourth week	Fifth week	Total
G1 (control)	130.50±2.12[a]	218.50±5.70[a]	417.10±6.54[b]	469.60±7.73[a]	556.20±12.85[c]	1791.90±8.30[b]
G2 (Artemisia 0.5%)	127.70±1.54[a]	217.30±3.30[a]	424.50±4.06[ab]	469.40±6.51[a]	679.40±33.09[b]	1918.30±40.90[ab]
G3 (Artemisia 1%)	127.70±1.15[a]	214.20±1.91[a]	436.60±3.85[a]	466.40±9.78[a]	764.90±32.95[a]	2009.80±40.60[a]

Mean (gm) ± standard errors, Alteration in superscript letters in each column refers to a significant difference between treatments at $p < 0.05$.

Table 3. Feed intake (g) of broiler chickens after dietary supplementation with different levels of Artimasia during 5 weeks of growing

Treatment \ Age	First week	Second week	Third week	Fourth week	Fifth week	Total
G1 (control)	157.50± 4.50[a]	352± 9[a]	666.90± 15[a]	821± 20[a]	1081± 25[a]	3078.40± 73.50[a]
G2 (Artemisia 0.5%)	156.40± 2.50[a]	371± 8[a]	657.10± 13[a]	813.50± 19.50[a]	1082.50± 24.50[a]	3080.50± 67.50[a]
G3 (Artemisia 1%)	157.40± 4.50[a]	362± 9[a]	673.70± 13[a]	814± 18[a]	1052.50± 24.50[a]	3059.60± 69[a]

Mean ± standard errors, Alteration in superscript letters in each column refers to a significant difference between treatments at $p < 0.05$.

Table 4. Feed conversion ratio of broiler chickens after dietary supplementation with different levels of Artimasia for 5 weeks

Treatment \ Age	First week	Second week	Third week	Fourth week	Fifth week	Total
G1 (control)	1.206± 0.022[a]	1.610± 0.021[a]	1.598± 0.001[a]	1.751± 0.100[a]	1.944± 0.067[b]	1.622± 0.042[a]
G2 (Artemisia 0.5%)	1.224± 0.016[a]	1.707± 0.034[a]	1.548± 0.057[a]	1.733± 0.005[a]	1.595± 0.045[a]	1.561± 0.011[a]
G3 (Artemisia 1%)	1.233± 0.049[a]	1.689± 0.024[a]	1.543± 0.026[a]	1.745± 0.048[a]	1.378± 0.043[a]	1.517± 0.021[a]

Mean ± standard errors, Alteration in superscript letters in each column refers to a significant difference between treatments at $p < 0.05$.

Table 5. The relative weight of lymphatic organs of broiler chickens at age 35 days after dietary supplementation with different levels of Artemisia

Treatment \ Lymphatic organ (%)	Spleen	Bursa of Fabricius
G1 (control)	0.06 ± 0.006[a]	0.08 ± 0.014[a]
G2 (Artemisia 0.5%)	0.07 ± 0.006[a]	0.09 ± 0.012[a]
G3 (Artemisia 1%)	0.07 ± 0.007[a]	0.10 ± 0.012[a]

Mean ± standard errors, Alteration in superscript letters in each column refers to a significant difference between treatments at $p < 0.05$.

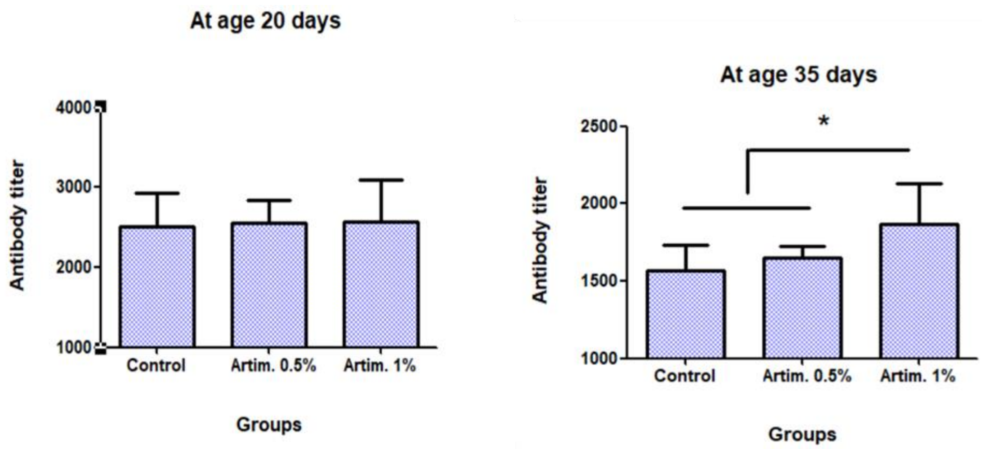

Figure 1. The level of antibody titer against Newcastle disease vaccine in broiler chickens aged 35 days after dietary supplementation of different levels of Artemisia

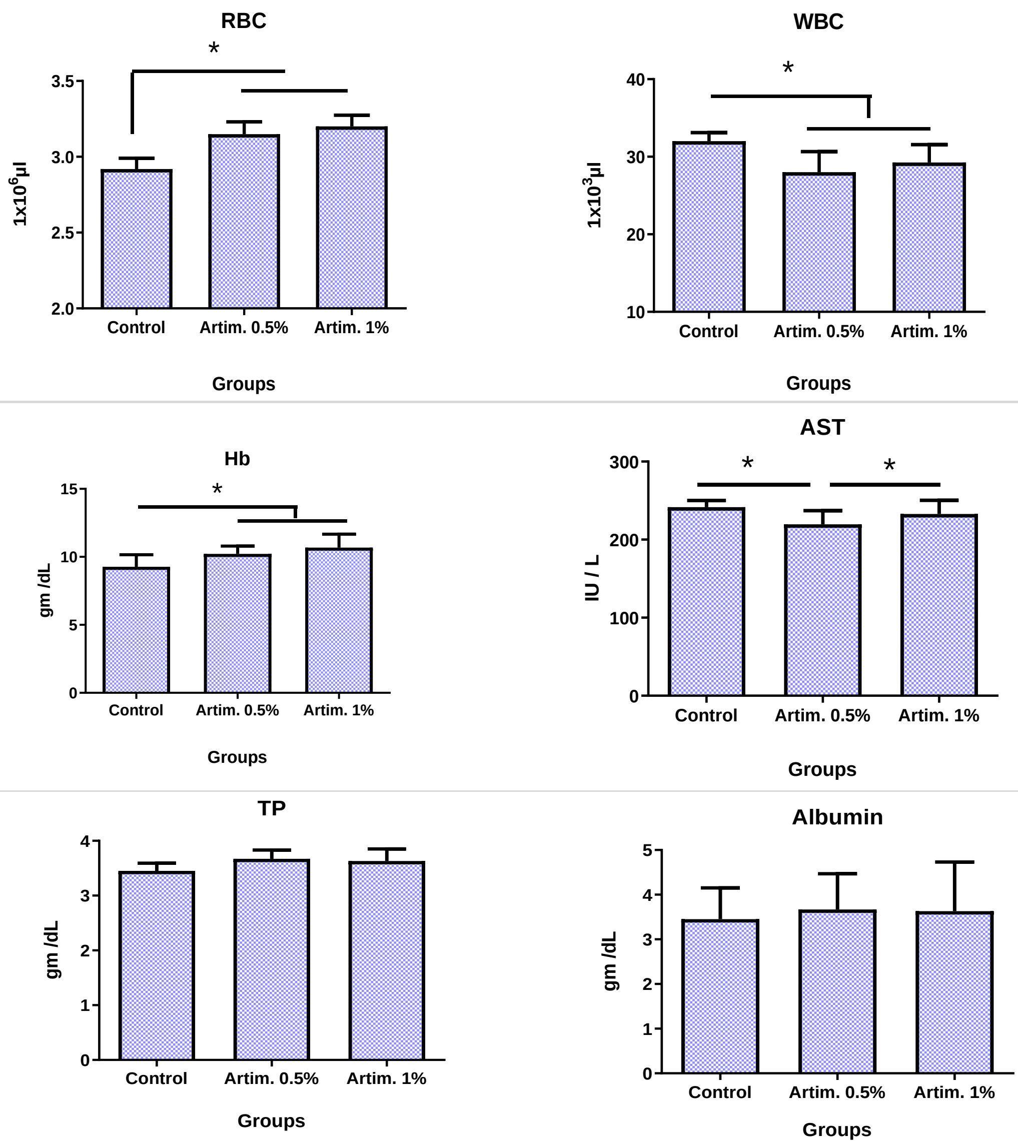

Figure 2. The responses of physiological parameters to dietary supplementation of Artimasia in broiler chickens aged 35 days. These are RBCs, WBCS, Hb and AST, TP, and Albumin

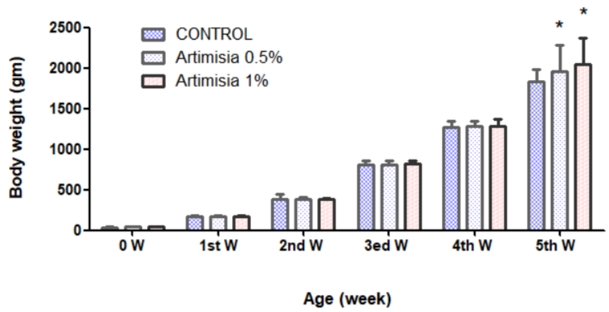

Figure 3. Body weight of broiler chickens from first to fifth week age after dietary supplementation of different levels of Artemisia.

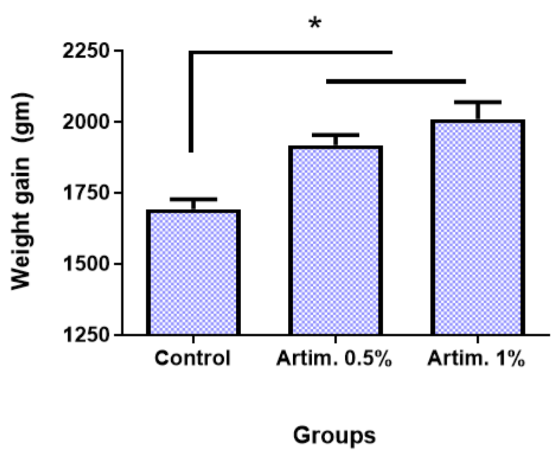

Figure 4. The body weight gain of broiler chickens at 35 days old after dietary supplementation with different levels of Artemisia

DISCUSSION

The immune response was estimated by measuring antibody titer which was significantly higher in G3, compared to other groups (Figure 1). This significant improvement of antibody titer could be due to the promotion of the dendritic cells and their maturation as a result of increased expression of CD86 and CD40. Consequently, antigen phagocytosis decreases, and the function of T-cells is improved (Wang et al., 2019). Other researchers have reported the enhancement of antibody levels after influenza vaccination, in addition to the improvement in lymphocyte proliferation and cytokine secretion (Zhang et al., 2017). This finding was in line with the one reported by AL-Saeedi et al. (2018) indicating an increased level of antibody titer in vaccinated laying hens with Newcastle and Infectious bronchitis diseases vaccine when fed with Artemisia additive.

The mean of the body weight gains of chickens fed diets supplemented with Artemisia 0.5% and 1% in the current study differed significantly from the control group. This finding indicated that the chickens of the current study could positively benefit from the diet containing Artemisia. Ration containing Artemisia has enhanced the broiler productivity performance throughout the experiment period. The increment of body weight and immunity as a result of a diet containing Artemisia additive could lead to promoting the digestion and absorption of nutrients in the intestine. According to previous studies, Artemisia has abundant bioactive composites, such as coumarin, flavonoids, purines, and phenols (Carrà et al., 2014). The polyphenol substances act as numerous biological activities, among which are anti-inflammatory, antipyretic, anti-cancer, anti-fungal, antiparasitic, and cytotoxic activities (Ćavar et al., 2012). Moreover, it improves gut integrity by increasing villous height and villous to crypt depth (Abdullah and Al-Barwary, 2020). Therefore, dietary supplementation of Artemisia leads to an increased concentration of serum globulin. Liu et al. (2019) have reported that Artemisia enhances IgA levels, and decreases IL-2 and IL-6 in the intestine). Furthermore, it reduces the colonization of pathogenic microbes, such as coccidia, Enterobacteriaceae, *Escherichia coli*, and *Staphylococcus aureus* and improves the viable counts of bacteria-produced lactic acid (Lactobacilli, Saracila et al., 2018; Panaite et al., 2019; Abdullah and Al-Barwary, 2020). All these positive properties of Artemisia have consequently enhanced the immune status and performance.

Moreover, Artemisia enhances the activity of catalase, superoxide dismutase, glutathione peroxidase, and total antioxidant capacity, while reducing the concentration of malondialdehyde in serum, liver, and spleen (Guo et al., 2020). Therefore, improved liver enzymes activities lead to better health conditions.

The results of blood biochemical parameters and cells count of the experiment groups at age of 35 days are in agreement with other studies, such as those conducted by El-Latif et al. (2013) and Oleforuh-Okoleh et al. (2015). As the studies suggested the increment of both RBCs and Hb in broiler chickens as a result of different phytogenic feed additives. The measurement of blood components could be employed for interpreting the health status (Maxwell et al., 1990). In the current study, it has been noticed that the levels of blood parameters were in normal ranges which could be interpreted as better health and immune status of the experimental chickens. Nevertheless, the clinical investigations indicated no abnormalities in broiler chickens. The results showed an increase in WBCs count in the control group, compared to the other two experimental groups. On the other hand, the results indicated that the feed additive of 0.5% reduced the level of aspartate aminotransferase, compared to the control group indicating the viability role of Artemisia in enhancing liver activities. Reduced activities of the liver enzyme in the current study confirm the appropriate doses of the investigated herbal additive (Sohail et al., 2012; Ali et al., 2014). No significant differences were recorded in both total serum protein and albumin. These findings were similar to those reported in previous studies (Bhaisare and Thyagarajan, 2014). However, enhancements have been noticed in total protein, which could refer to a better immune state of the chickens fed with Artemisia additives (Kapelański et al., 2004).

CONCLUSION

In conclusion, broiler chickens fed a diet containing Artemisia powder at a level of 1% for 35 days indicated an improved growth rate and immune response. It is suggested to investigate the effect of adding Artemisia to broiler chickens' diet on the immune responses against Gumboro and infectious bronchitis vaccines in extensive research.

DECLARATION

Authors' contribution

Haider Kaab wrote the paper and corresponded to complete further requirements of writing. Samer and Ali conducted the experiment. All authors confirmed the statistical results and the final version of the article.

Acknowledgment

The researchers offer their gratitude to the University of Kufa, Faculty of Veterinary Medicine to help with providing animal houses to conduct the experiment.

Competing interest

No conflict of interest for this manuscript has been stated by the authors.

Ethical considerations

The results (or any part of them) used in the manuscript have not been sent for publication to any other journal nor have they already been published. The authors declare that they have checked the manuscript for plagiarism and there is no data fabrication or redundancy. The performed experiment complied with current laws and written consent of the Scientific Ethnic Committee in the department of the pathology and poultry diseases in the College of Veterinary Medicine University of Kufa and Baghdad.

REFERENCES

Abdullah LN, and Al-Barwary LTO (2020). Effect of *Artemisia* splendens powder and extract on broiler chicken's performance, lymphoid organ weight, gut morphology and serum biochemicals during coccidiosis challenge. The Iraqi Journal of Agricultural Science, 51(2): 611-618. DOI: https://www.doi.org/10.36103/ijas.v51i2.988

Abouelfetouh AY, and Moussa NK (2012). Enhancement of antimicrobial activity of four classes of antibiotics combined with garlic. Asian Journal of Plant Sciences, 11: 148-152. DOI: https://www.doi.org/10.3923/ajps.2012.148.152

Aguilar YM, Becerra JC, Bertot RR, Peláez JC, Liu G, and Hurtado CB (2013). Growth performance, carcass traits and lipid profile of broiler chicks fed with an exogenous emulsifier and increasing levels of energy provided by palm oil. Journal of Food, Agriculture and Environment, 11(1): 629-633. Available at: https://www.scielo.br/j/rbca/a/rjmVRVJqKCrqxK3DzRFsfKK/?lang=en&format=html

Ahsan U, Kuter E, Raza I, Köksal BH, Cengiz Ö, Yıldız M., Kızanlık PK, Kaya M, Tatlı O, and Sevim Ö (2018). Dietary supplementation of different levels of phytogenic feed additive in broiler diets: The dynamics of growth performance, caecal microbiota, and intestinal morphometry. Brazilian Journal of Poultry Science, 20: 737-746. DOI: https://www.doi.org/10.1590/1806-9061-2017-0698

Ali N, Shah SWA, Ahmed G, Shah I, Shoaib M, Junaid M, and Ali W (2014). Acute toxicity and antispasmodic activities of *Achillea* wilhelmsii C. Koch. Pakistan Journal of Pharmaceutical Sciences., 27: 309-315. Available at: https://pubmed.ncbi.nlm.nih.gov/24577920/

AL-Saeedi TA, Mahmood FA, and Hamad WA (2018). Evaluation of humoral immunity to infectious Bronchitis and Newcastle disease vaccines and received *Artemisia herba-alba* Extract in layer hens. Kufa Journal for Veterinary Medical Sciences, 9: 8-12. Available at: https://www.iasj.net/iasj/pdf/f3f269f6cc6f1cea

Bali A, Das SK, Khan A, Patra D, Biswas S, and Bhattacharyya D (2011). A comparative study on the antioxidant and antimicrobial properties of garlic and coriander on chicken sausage. International Journal of Meat Science, 1(2): 108-116. DOI: https://www.dx.doi.org/10.3923/ijmeat.2011.108.116

Bhaisare DB, and Thyagarajan D (2014). Effect of four herbal seeds on blood parameters in turkey poults. International Journal Science Research, 3: 235-240. Available at: https://www.ijsr.net/archive/v3i8/MDIwMTUyNTA=.pdf

Carrà A, Bagnati R, Fanelli R, and Bonati M (2014). Fast and reliable artemisinin determination from different *Artemisia annua* leaves based alimentary products by high performance liquid chromatography–tandem mass spectrometry. Food Chemistry, 142: 114-120. DOI: https://www.doi.org/10.1016/j.foodchem.2013.07.052

Ćavar S, Maksimović M, Vidic D, and Parić A (2012). Chemical composition and antioxidant and antimicrobial activity of essential oil of *Artemisia annua* L. from Bosnia. Industrial Crops and Products, 37(1): 479-485. DOI: https://www.doi.org/10.1016/j.indcrop.2011.07.024

Christaki E, Giannenas I, Bonos E, and Florou-Paneri P (2020). Innovative uses of aromatic plants as natural supplements in nutrition. Feed Additives, Academic Press, pp. 19-34. DOI: https://www.doi.org/10.1016/B978-0-12-814700-9.00002-9

Cobbe guide manageemt (2021). https://www.cobb-vantress.com/assets/Cobb-Files/4d0dd628b7/Broiler-Guide_English-2021-min.pdf

Daramola OT (2019). Medicinal plants leaf meal supplementation in broiler chicken diet: Effects on performance characteristics, serum metabolite and antioxidant status. Animal Research International, 16(2): 3334-3342. Available at: https://www.ajol.info/index.php/ari/article/view/189520

Deniz D, Sevimli E, and Ünlü TN (2021). An overview of traditional and complementary medicine initiatives and strategies. Sağlık Akademisyenleri Dergisi, 8(1): 85-89. Available at: https://dergipark.org.tr/en/pub/sagakaderg/issue/60517/730463

El-Latif ASA, Saleh NS, Allam TS, and Ghazy EW (2013). The effects of rosemary (*Rosemarinu afficinalis*) and garlic (*Allium sativum*) essential oils on performance, hematological, biochemical and immunological parameters of broiler chickens. British Journal Poultry Science, 2: 16-24. DOI: https://www.doi.org/10.5829/idosi.bjps.2013.2.2.74145

Gholamrezaie SL, Mohammadi M, Jalali SJ, Abolghasemi SA, and Roostaei AM (2013). Extract and leaf powder effect of *Artemisia annua* on performance, cellular and humoral immunity in broilers. Iranian Journal of Veterinary Research, 14(1): 15-20. Available at: https://www.sid.ir/en/journal/ViewPaper.aspx?id=308485

Guo S, Ma J, Xing Y, Xu Y, Jin X, Yan S, and Shi B (2020). *Artemisia annua* L. aqueous extract as an alternative to antibiotics improving growth performance and antioxidant function in broilers. Italian Journal of Animal Science, 19(1): 399-409. DOI: https://www.doi.org/10.1080/1828051X.2020.1745696

Hafeez A, Männer K, Schieder C, and Zentek J (2016). Effect of supplementation of phytogenic feed additives (powdered vs. encapsulated) on performance and nutrient digestibility in broiler chickens. Poultry Science, 95(3): 622-629. DOI: https://www.doi.org/10.3382/ps/pev368

Hao H, Cheng G, Iqbal Z, Ai X, Hussain HI, Huang L, Dai M, Wang Y, Liu Z, and Yuan Z (2014). Benefits and risks of antimicrobial use in food-producing animals. Frontiers in Microbiology, 5: 288. DOI: https://www.doi.org/10.3389/fmicb.2014.00288

Iqbal S, Younas U, Chan KW, Zia-Ul-Haq M, and Ismail M (2012). Chemical composition of Artemisia annua L. leaves and antioxidant potential of extracts as a function of extraction solvents. Molecules, 17(5): 6020-6032. DOI: https://www.doi.org/10.3390/molecules17056020

Jin LZ, Dersjant-Li Y, and Giannenas I (2020). Application of aromatic plants and their extracts in diets of broiler chickens. Feed Additives, pp. 159-185. DOI: https://www.doi.org/10.1016/B978-0-12-814700-9.00010-8

Kapelański W, Grajewska S, Bocian M, Dybała J, Jankowiak H, and Wiśniewska J (2004). Changes in blood biochemical indicators during fattening of the high-lean pigs. Animal Science Paper Report, 22: 443-449. Available at: https://api.semanticscholar.org/CorpusID:6595048

Kostadinović L, Lević J, Popović ST, Čabarkapa I, Puvača N, Djuragic O, and Kormanjoš S (2015). Dietary inclusion of *Artemisia absinthium* for management of growth performance, antioxidative status and quality of chicken meat. Poultry Science, 79: 1612-9199. DOI: https://www.doi.org/10.12681/jhvms.22229

Liu L, Zuo W, and Li F (2019). Dietary addition of Artemisia argyi reduces diarrhea and modulates the gut immune function without affecting growth performances of rabbits after weaning. Journal of Animal Science, 97(4): 1693-1700. DOI: https://www.doi.org/10.1093/jas/skz047

Liu Y, Yan G, Chen G, and Zhang J (2009). Efficacy trials of crude extraction from *Artemisia Annua* L. against Newcastle disease virus *in vivo* in Xinjiang. Modern Applied Science, 3(5): 176-178. DOI: https://www.doi.org/10.5539/mas.v3n5p176

Lwelamira J, Kifaro GC, and Gwakisa PS (2009). Genetic parameters for body weights, egg traits and antibody response against Newcastle Disease Virus (NDV) vaccine among two Tanzania chicken ecotypes. Tropical Animal Health and Production, 41(1): 51-59. DOI: https://www.doi.org/10.1007/s11250-008-9153-2

Maxwell M, Spence S, Robertson G, and Mitchell M (1990). Haematological and morphological responses of broiler chicks to hypoxia. Avian Patholology, 19: 23-40. DOI: https://www.doi.org/10.1080/03079459008418653

Millet S, and Maertens L (2011). The European ban on antibiotic growth promoters in animal feed: from challenges to opportunities. Veterinary Journal, 187(2): 143-144. DOI: https://www.doi.org/10.1016/j.tvjl.2010.05.001

Mitchell EB, and Johns J (2008). Avian hematology and related disorders. Veterinary Clinics of North America: Exotic Animal Practice, 11(3): 501-522. DOI: https://www.doi.org/10.1016/j.cvex.2008.03.004

National Research Council (NRC) (1994). Nutrient requirements of poultry. 9th edition. National Academy Press. Washington. DC. USA. Available at: https://www.nap.edu/read/2114

Noonan M (2018). What is a phytogenic feed additive?. AFMA Matrix, 27(3): 46-47. DOI: https://www.doi.org/10.10520/EJC-f617defe4

Oleforuh-Okoleh VU, Ndofor-Foleng HM, Olorunleke SO, and Uguru JO (2015). Evaluation of growth performance, haematological and serum biochemical response of broiler chickens to aqueous extract of ginger and garlic. Journal of Agricultural Science, 7: 167-173. DOI: https://www.doi.org/10.5539/jas.v7n4p167

Osman KM, Kappell AD, Orabi A, Al-Maary KS, Mubarak AS, Dawoud TM, Hemeg HA, Moussa IM, Hessain AM, Yousef HM et al. (2018). Poultry and beef meat as potential seedbeds for antimicrobial resistant enterotoxigenic Bacillus species: A materializing epidemiological and potential severe health hazard. Scientific Reports, 8(1): 1-15. Available at: https://pubmed.ncbi.nlm.nih.gov/30072706/

Panaite TD, Criste RD, Vlaicu PA, Saracila M, Tabuc C, Olteanu M, Turcu RP, and Buleandră M (2019). Influence of *Artemisia annua* on broiler performance and intestinal microflora. Brazilian Journal of Poultry Science, 2(4): 1-10. DOI: https://www.scielo.br/j/rbca/a/cYxSsqtBcpCNqTFz4xnZNvr/?lang=en

Pirgozliev V, Rose SP, and Ivanova S (2019). Feed additives in poultry nutrition. Bulgarian Journal of Agricultural Science, 25(1): 8-11. Available at: https://www.agrojournal.org/25/01s-02.pdf

Ravindran V, and Abdollahi MR (2021). Nutrition and digestive physiology of the broiler chick: State of the art and outlook. Animals, 11(10): 2795. DOI: https://www.doi.org/10.3390/ani11102795

Saeed M, Babazadeh D, Arain MA, Naveed M, Shah QA, Kamboh AA, Moshaveri A, Modarresi-Ghazani F, Hejazi V, and Chao S (2017). The use of chicoric acid from Echinacea purpurea as a feed additive in poultry nutrition. World's Poultry Science Journal, 74(1): 69-78. DOI: https://www.doi.org/10.1017/S0043933917001027

Saeed M, Kamboh AA, Syes SF, Babazadeh D, Suheryani I, Shah QA, Umar M, Kakar I, Naveed M, Abd El-Hack ME et al. (2018). Phytochemistry and beneficial impacts of cinnamon (*Cinnamomum zeylanicum*) as a dietary supplement in poultry diets. World's Poultry Science Journal, 74(2): 331-346. DOI: https://www.doi.org/10.1017/S0043933918000235

Sahib AM (2021). The Association of genetic polymorphism of transforming growth factor β2 and β3 with some productive and physiological traits in local chickens. Ph.D. A Dissertation in Veterinary Public Health. University of Baghdad. Iraq. Available at: https://jcovm.uobaghdad.edu.iq/index.php/Iraqijvm/article/view/1034

Saracila M, Criste RD, Panaite TD, Vlaicu PA, Tabuc C, Turcu RP, and Olteanu M (2018). *Artemisia annua* as phytogenic feed additive in the diet of broilers (14-35 days) reared under heat stress (32 ºC). Brazilian Journal of Poultry Science, 20: 825-832 DOI: https://www.doi.org/10.1590/1806-9061-2018-0772

Song ZH, Cheng K, Zheng XC, Ahmad H, Zhang LL, and Wang T (2018). Effects of dietary supplementation with enzymatically treated *Artemisia annua* on growth performance, intestinal morphology, digestive enzyme activities, immunity, and antioxidant capacity of heat-stressed broilers. Poultry Science, 97(2): 430-437. DOI: https://www.doi.org/10.3382/ps/pex312

Sohail MU, Hume ME, Byrd JA, Nisbet DJ, Ijaz A, Sohail A, Shabbir MZ, and Rehman H (2012). Effect of supplementation of prebiotic mannan-oligosaccharides and probiotic mixture on growth performance of broilers subjected to chronic heat stress. Poultry Science, 91: 2235-2240. DOI: https://www.doi.org/10.3382/ps.2012-02182

Steel RGD, and Torrie JH (1980). Principle and procedures of statistics. 2nd edition. McGraw-Hill Book Co. Inc. New York. USA, pp. 183-193. Available at: https://www.scirp.org/(S(oyulxb452alnt1aej1nfow45))/reference/ReferencesPapers.aspx?ReferenceID=1855584

Vahdatpour T, and Babazadeh D (2016). The effects of Kefir rich in probiotic administration on serum enzymes and performance in male Japanese quails. Journal of Animal and Plant Sciences, 26(1): 34-39. Available at: http://thejaps.org.pk/docs/v-26-01/05.pdf

Wang DY, Cao H, Li JY, Zhao B, Wang Y, Zhang AL, and Huang J (2019). Adjuvanticity of aqueous extracts of Artemisia rupestris L. for inactivated foot-and-mouth disease vaccine in mice. Research in Veterinary Science, 124: 191-199. DOI: https://www.doi.org/10.1016/j.rvsc.2019.03.016

Zhang A, Wang D, Li J, Gao F, and Fan X (2017). The effect of aqueous extract of *Xinjiang Artemisia* rupestris L. (an influenza virus vaccine adjuvant) on enhancing immune responses and reducing antigen dose required for immunity. PLoS One, 12: e183720. DOI: https://www.doi.org/10.1371/journal.pone.0183720