International Journal of Bio-resource and Stress Management https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM May 2025, 16(5): 01-06

Article AR6100

Research Article

Stress Management

DOI: HTTPS://DOI.ORG/10.23910/1.2025.6100

Effect of Blue Green Algae (*Spirulina platensis*) as Feed Additive on Productive Performance of Broiler Chicks

Sanjay Kumar Dhaker[1], Mahendar Singh Meel[1], Monika Joshi[1], Kavita A. Shende[1], and Harendra S. Rajoriya[2]

[1]Dept. of Animal Nutrition, College of Veterinary and Animal Science, Navania, Vallabhnagar, Udaipur, Rajasthan (313 601), India
[2]Animal Nutrition Division, ICAR-NDRI, Karnal, Haryana (132 001), India

Open Access

Corresponding skdhaker009@gmail.com

0009-0002-1433-5074

ABSTRACT

This study was carried out in August and September of 2024 at the Department of Animal Nutrition, C.V.A.S., Navania, Udaipur, Rajasthan, India, to evaluate the effect of blue green algae (*Spirulina platensis*) as feed additive on productive performance of broiler chicks. A six-week feeding trial was conducted using 120-day-old (Cobb-400) broiler chicks. Five treatment groups, each consisting of eight chicks and three replicates. A basal diet was given to the T_1 control group, while the T_2, T_3, T_4 and T_5 treatment groups received supplements of 0.25, 0.50, 0.75 and 1.00 g kg^{-1} *Spirulina platensis* powder in their respective basal broiler pre-starter, starter and finisher rations. The findings demonstrated that the T_5 group had the greatest impact on growth characteristics, with the T_1 group showing the lowest feed intake, body weight, weekly body weight gain, average daily body weight gain, and performance index (all significantly higher; (p<0.01). Supplementing with *Spirulina* had no observable impact on haemato-biological indicators such as TEC, PCV, and Hb. However, significantly (p<0.01) increased TLC, serum albumin, globulin, total protein, and the A/G ratio. The results of the subsequent study showed a significant reduction in the blood lipid profile as well as significant changes in the levels of serum creatinine, serum glucose, ALT and AST. Therefore, based on the development and feed intake of broilers, it may be possible to increase the growth performance and profitability of broiler farming by supplementing with up to 1.00 g kg^{-1} of *Spirulina* powder.

KEYWORDS: *Spirulina*, broiler, performance

***Citation* (VANCOUVER):** Dhaker et al., Effect of Blue Green Algae (*Spirulina platensis*) as Feed Additive on Productive Performance of Broiler Chicks. *International Journal of Bio-resource and Stress Management,* 2025; 16(5), 01-06. HTTPS://DOI.ORG/10.23910/1.2025.6100.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 24th January 2025 RECEIVED in revised form on 13th April 2025 ACCEPTED in final form on 25th April 2025 PUBLISHED on 01st May 2025

1. INTRODUCTION

The growth of global poultry industry is driven by escalating global protein demand, increasing consumer awareness of nutritional benefits, and an expanding global population. Poultry meat is favoured for its affordability, high protein content, low fat levels and minimal environmental impact compared to other livestock products. However, despite these achievements, the poultry industry faces significant challenges, including increasing disease prevalence, suboptimal nutrition, rising production costs and growing consumer demands for food safety, sustainability and animal welfare (Hafez and Attia, 2020). The industry's reliance on antibiotics as growth promoters has diminished significantly due to global efforts to combat antimicrobial resistance and concerns about antibiotic residues in meat. This transition necessitates alternative strategies to maintain and enhance productivity, health and sustainability. Feed additives such as probiotics, prebiotics, organic acids and phytogenic compounds have emerged as promising substitutes, offering functional benefits that address modern poultry production challenges (Ricke et al., 2020; Abdelli et al., 2021). Addition of prebiotic in broiler ration improve growth performance (Rajoriya et al., 2024). The Phytogenic feed additives, derived from bioactive compounds in plants, are increasingly recognized for their multifunctional benefits, including antimicrobial, antioxidative, immunomodulatory and gut health-promoting effects. These compounds include essential oils, flavonoids, tannins, saponins and phenolic acids, which improve nutrient absorption, reduce oxidative stress and enhance immunity (Abdelli et al., 2021). *Spirulina* is rich in Protein (55–70%) contains all essential amino acids with high digestibility and bioavailability, making it superior to conventional protein sources like soybean meal and fishmeal (Kulshreshtha et al., 2008). Essential fatty acids, includes gamma-linolenic acid (GLA) and polyunsaturated fatty acids (PUFAs), which are crucial for lipid metabolism, anti-inflammatory activity and immune modulation. Micronutrients, abundant in vitamins (e.g., B-complex, β-carotene, tocopherols) and trace minerals such as selenium, iron and zinc, which are vital for metabolic and immune functions (Jung et al., 2019). *Spirulina's* broad-spectrum benefits are attributed to its bioactive compounds and functional mechanism, which influence multiple physiological pathways. Phycocyanin, a blue pigment and photosynthetic protein with potent antioxidant properties. Phycocyanin scavenges reactive oxygen species (ROS), reduces lipid peroxidation and protects cellular structures from oxidative damage. It also exhibits anti-inflammatory activity by modulating cytokine production and inhibiting pro-inflammatory mediators (Lupatini et al., 2017). Polysaccharides function as prebiotics, stimulating beneficial gut microbiota, enhancing nutrient absorption and supporting gut barrier integrity (El-Shall et al., 2023). *Spirulina* has been extensively studied for its potential to address key challenges in poultry production. Such as growth performance of broiler chicks. Its bioactive compounds promote villi development and intestinal morphology, leading to improved nutrient absorption (Swiatkiewicz et al., 2015). The soluble fiber in *Spirulina* may form a viscous layer in the intestine promoting a stable environment for beneficial microbial colonization and supporting the integrity of the gut barrier (Grosshagauer et al., 2020; Pestana et al., 2020). *Spirulina* also reduces oxidative stress. This protects cells from oxidative damage and improves overall health and productivity (Kumar et al., 2022). Similarly, *Spirulina* enhances immune responses by stimulating lymphocyte and macrophage activity, increasing antibody production and modulating cytokine expression. These effects improve disease resilience and systemic immunity (El-shall et al., 2023). *Spirulina's* also have hypocholesterolemic effects lower serum cholesterol and triglycerides while increasing high-density lipoprotein (HDL) levels. This aligns with consumer demand for healthier meat products (Farag et al., 2016). The inclusion of *Spirulina* in broiler diets has been associated with improved growth performance, feed efficiency and health status. Abdelfatah et al. (2024) found that supplementing broiler diets with *Spirulina* significantly increased body weight gain and feed conversion ratio, while also enhancing antioxidant status and gut health. Similarly, Abdel-Wareth et al. (2024) reported that integrating *Spirulina* into poultry diets offers a promising avenue for enhancing nutrition, boosting sustainability efforts and potentially stimulating disease resistance.

2. MATERIALS AND METHODS

2.1. Treatments and experimental designs

The experiment was conducted during August and September of 2024 at the department of animal nutrition, C.V.A.S., Navania, Udaipur, Rajasthan, India. The Institutional Animal Ethics Committee (Approved No. IAEC/RES/04/06) at the Department of Animal Nutrition, C.V.A.S., Navania, Vallabhnagar, Udaipur, Rajasthan University of Veterinary and Animal Sciences, Bikaner, Rajasthan, India, gave its prior approval for this experiment, which was carried out in August and September of 2024. The study was done on 120 unsexed, apparently healthy broiler chicks of the same hatch (VENCOBB-400Y strain) that were purchased from Kewal Ramani Hatchery Pvt. Ltd. in Ajmer. The chicks were raised for 42 days at the Poultry Unit in the Livestock Farm Complex of the College of Veterinary and Animal Science in Navania, Vallabhnagar, Udaipur (Rajasthan) in 2024. To prevent any initial bias, the purchased chicks were weighed individually and then randomly assigned to one of five dietary treatment groups

(T_1, T_2, T_3, T_4 and T_5) using a totally randomized block design. A total of 15 experimental units (three repetitions per treatment) were produced by further dividing each treatment group into three replicates (R_1, R_2, R_3), each containing eight chicks. Diets Organics (SK Groups, 64 Mettu St, Korattur, Chennai-76) provided the necessary quantity of *Spirulina platensis* powder. To maintain nutritional integrity until usage, the powder was kept in a controlled environment at 4°C and out of direct sunlight. With special focus on ensuring uniformity across all treatment groups, the necessary quantity of the ISO-certified basal feed in the form of broiler starter and finisher was purchased from feed distributor "Udaipur Kukkut Utpadak Sahkari Samiti Ltd.," Udaipur, Rajasthan. To guarantee safety before usage, the feed was also examined for microbial contamination using accepted microbiological procedures. Table 1 shows the proximate composition of the basal feed and *Spirulina platensis* powder, which were assessed in accordance with Anonymous (2016). The following were the treatment groups: However, the T_2, T_3, T_4 and T_5 treatment groups were supplemented with 0.25, 0.50, 0.75 and 1.00 g-kg^{-1} *Spirulina platensis* powder in the basal broiler pre-starter, starter, and finisher rations, respectively, whereas T_1 (control) was fed the conventional broiler mash diet (Anonymous, 2007). They have unlimited access to clean water and food. In separate pens, each chick was housed hygienically on a deep litter system under consistent management settings. Electric bulbs were used for the first two weeks of the brooding process. The usual immunization protocol was adhered to. At the conclusion of each week of the six-week trial, each bird was weighed separately. The weight at 42 days of age and on the first day (when the experiment began) were recorded. To determine the average weekly feed consumption and feed conversion ratio (FCR), feed intake per pen was observed every week.

2.2. *Blood and faecal sample collection*

Blood samples were taken from the randomly selected birds in each treatment group replicate (six birds per treatment group) on the 42nd day of the experimental trial by puncturing the brachial vein in the wing. These samples were placed in two sets of tubes: one set of sterile tubes labelled "EDTA" for haematology and another set of tubes without anticoagulant for serology. An automatic haematology analyzer (Rescholar RM-303-03) was used to measure haemoglobin, red blood corpuscle count, and packed cell volume in tubes containing EDTA. Used commercially available kits to evaluate serum total protein, creatinine, cholesterol, glucose and antioxidant in accordance with the methods stated.

Table 1: proximate composition of broiler pre-starter, starter, finisher feed and *Spirulina* powder (% DM basis)

Sl. No.	Proximate principle	Broiler pre-starter	Broiler starter	Broiler finisher	*Spirulina*
1.	Dry matter	90.42	91.14	91.28	89.00
2.	Crude protein	23.22	22.14	20.12	52.40
3.	Ether extract	3.11	3.72	4.25	0.67
4.	Crude fibre	4.28	4.43	4.71	31.25
5.	Total ash	5.88	6.17	6.25	10.45
6.	Nitrogen free extract	63.51	63.54	64.67	5.23

2.3. *Statistical analysis*

To assess the primary impacts and interplay between variables, data from the experiment on how dried spirulina powder affected several performance indicators were statistically analyzed using a factorial design. Snedecor and Cochran's (1994) approaches were followed in the statistical processes to make sure the right statistical assumptions were made. To account for the treatment groups' structure, a fully randomized design (CRD) was used in the study. For accuracy and consistency, statistical software (such as SPSS) was used to perform the ANOVA. The mean changes between treatments were compared using the Duncan's New Multiple Range Test (DNMRT), which was invented by Kramer (1957), for post-hoc analysis. Superscripts "*" and "**" indicate significant (p<0.05) and extremely significant (p<0.01) differences between treatments, respectively.

3. RESULTS AND DISCUSSION

3.1. *Growth performance*

The effect of blue green algae *(Spirulina platensis)* as feed additive on growth performance of broiler chicks is presented in Table 2. The results revelled that *Spirulina* powder supplementation had significant effect on growth performance in broiler chicks. Significantly higher (p<0.01) feed intake, body weight, weekly body weight gain, average daily body weight gain and performance index was noticed in T_5 group and lowest was observed in T_1 group. However, the overall FCR for the trial period showed significant differences (p<0.05) with T_5 demonstrating the most efficient feed conversion ratio, reflecting *Spirulina* 's impact on improving nutrient utilization and metabolic efficiency over the entire growth cycle. These findings are consistent with previous studies, such as Fathi (2018) and Hanafy (2022), which reported that *Spirulina* supplementation enhances feed intake in broilers by engaging multiple pathways including sensory appeal, gut health support, antioxidant activity, and hormonal stimulation. Similarly, Hosseini et al. (2022) reported that *Spirulina* supplementation significantly increased feed intake in broilers, primarily due to its amino acid profile particularly glutamic acid which provides an

Table 2: Supplemental effect of *Spirulina platensis* as feed additive on growth performance of broiler chicks

Parameters	Treatment groups					SEm±
	T_1	T_2	T_3	T_4	T_5	
Initial weight (g bird^{-1})	50.04	49.04	47.42	48.21	49.21	0.332
Final weight (g bird^{-1})	2335.09^{e}	2382.69^{d}	2542.62^{c}	2605.96^{b}	2698.75^{a}	36.537
Total body weight gain (g bird^{-1})	2285.05^{e}	2329.86^{d}	2495.20^{c}	2557.76^{b}	2649.54^{a}	36.839
Average daily weight gain (g bird^{-1})	54.41^{e}	55.47^{d}	59.41^{c}	60.90^{b}	63.08^{a}	1.633
Total feed consumption (g bird^{-1})	4056.98^{d}	4088.03^{cd}	4155.10^{c}	4244.28^{b}	4358.97^{a}	30.514

All values are represented as mean, SEm±; n=24 in each group; means bearing different superscript in the same row differ highly significantly between groups at p<0.01

umami flavor that enhances palatability. Furthermore, bioactive peptides and aromatic compounds in *Spirulina* are known to improve sensory perception making feed more appealing to broilers despite their limited taste receptor diversity (Abdel-Moneim et al., 2022).

The significant body weight observed in this study align with previous findings. For instance, Shanmugapriya and Saravana Babu (2015) also reported enhanced growth with *Spirulina* supplementation. Moreover, recent studies by Abbass et al. (2018) and Hosseini et al. (2022) confirm the growth-promoting effects of *Spirulina*, particularly when administered at optimal dosages.

The enhancement in feed conversion ratio (FCR) observed in this study is consistent with findings from various research. Shanmugapriya and Saravana Babu (2015) reported that incorporating *Spirulina* into broiler diets significantly improved FCR. Similarly, Jamil et al. (2015) found that feeding broilers with *Spirulina* enhanced both body weight and FCR. In a more recent study, Khan et al. (2020) evaluated the impact of *Spirulina* inclusion levels in broiler rations and observed improvements in growth performance and FCR. Furthermore, Abdelfatah et al. (2024) demonstrated that *Spirulina* supplementation led to significant increases in body weight gain and improved FCR, highlighting its potential as a growth booster in broiler diets.

3.2. Haemato-biochemical parameters

The effect of supplemental effect of *Spirulina platensis* as feed additive on haemato-biochemical parameters of broiler chicks has been presented in Table 3. The non-significant effect of *Spirulina* supplementation on Hb, PCV, and TEC indicates that its inclusion at varying levels does not adversely impact red blood cell parameters in broiler chicks. Conversely, the significant (p<0.01) increase in TLC with higher *Spirulina* inclusion levels. However, serum albumin, globulin, total protein, A/G ratio, glucose, triglycerides,

Table 3: Supplemental effect of *Spirulina platensis* on haemato-biochemical parameters of broiler chicks

Parameters	Treatment groups					SEm±
	T_1	T_2	T_3	T_4	T_5	
Hb (g %)	11.223	11.913	11.487	11.673	11.627	0.114
PCV (%)	30.02	28.15	26.92	27.74	27.50	0.53
TEC (10^6 cumm^{-1})	3.080	2.883	3.093	3.160	3.103	0.047
TLC (10^3 cumm^{-1})	24.127^{e}	27.410^{d}	29.017^{c}	30.883^{b}	32.187^{a}	1.407
Serum total protein	2.670^{d}	2.950^{c}	3.190^{b}	3.727^{a}	3.710^{a}	0.208
Glucose (mg dl^{-1})	192.387^{d}	203.937^{c}	225.867^{b}	232.950^{ab}	240.967^{a}	9.108
Triglyceride (mg dl^{-1})	102.993^{a}	106.330^{a}	94.670^{c}	101.603^{ab}	97.000^{bc}	2.094
Cholesterol (mg dl^{-1})	177.030^{a}	169.413^{b}	163.963^{c}	157.377^{d}	159.723^{cd}	3.535
Creatinine (mg dl^{-1})	0.500^{d}	0.527^{c}	0.543^{bc}	0.560^{ab}	0.577^{a}	0.013
ALT (U l^{-1})	33.450^{a}	25.140^{b}	24.037^{bc}	22.387^{bc}	20.873^{c}	2.191
AST (U l^{-1})	165.773^{a}	156.243^{b}	145.460^{c}	141.613^{cd}	136.713^{d}	5.252

All values are represented as mean, SEm±; n=24 in each group; means bearing different superscript in the same row differ highly significantly between groups at p<0.01

cholesterol and antioxidant revealed highly significant ($p<0.01$) effect of *Spirulina* powder supplementation. Similarly, serum creatinine levels increased significantly ($p<0.05$) across treatment groups. Whereas, ALT and AST levels decreased significantly ($p<0.05$) across *Spirulina* powder supplementation groups.

The results observed in this study are consistent with findings reported in previous studies evaluating the effects of *Spirulina* supplementation on blood parameters in poultry. For haematological parameters, Fathi (2018) and Hassan et al. (2022) demonstrated significant improvements in TLC and immune parameters with *Spirulina* supplementation, supporting the immune boosting effects observed in the current study. Similarly, neutral effects on Hb, PCV, and TEC at lower *Spirulina* doses were reported by Abaza et al. (2021).

The results observed in this study are consistent with findings reported in previous studies evaluating the effects of *Spirulina* supplementation on serum protein profile, studies by Abd El-Dayem et al. (2021) and Sherif et al. (2022) consistently showed dose-dependent increases in total protein and globulin levels with *Spirulina* supplementation. Lastly, the immunomodulatory effects, including increased TLC and globulin levels, are supported by studies by Abaza et al. (2021), Abed et al. (2023), and Fathi (2018), highlighting *Spirulina*'s antioxidant and immune-boosting properties. Similarly, Fathi (2018) also found that the level of serum ALT, AST, triglycerides and total cholesterol had decreased significantly ($p\leq0.05$) in chicks fed diets supplemented with *Spirulina platensis*. Furthermore, Jamil et al. (2015) concluded that, ALT and AST decreased significantly ($p<0.05$) when fed with *S. platensis* compared with the control group.

The observed increase in glucose levels in this study aligns with findings by Alghamdi et al. (2024) and Hassan et al. (2022), who reported enhanced energy metabolism in *Spirulina* fed broilers and quails.

Similarly, the increased creatinine levels noted in the present study are consistent with results from Abd Elzaher et al. (2023) indicating improved renal function without adverse effects. All around, these studies emphasize the physiological and metabolic benefits of *Spirulina* supplementation, validating the findings of the present study.

4. CONCLUSION

Addition of *Spirulina platensis* supplementations to broiler diets improved the growth performance, haemato-biochemical parameter like TLC, total protein and decreased serum cholesterol, triglyceride level of the broilers at 42 days of age.

5. ACKNOWLEDGMENT

We thank Assistant Professor, Department of Animal Nutrition, College of Veterinary and Animal Science, Navania, Vallabhnagar, Udaipur, Rajasthan-313601, and their staff for kind permission, help and cooperation extended in taking up this research work.

6. REFERENCES

Abaza, I., Helal, A.M., Sherif, E.Y., 2021. Antioxidant statues, growth and some physiological performances of the gimmizah male chickens supplemented by dietary *Spirulina platensis* under chronic heat stress. Journal of Desert and Environmental Agriculture 1(1), 35–49.

Abbass, M.A., Mahfouz, M.E. Zaki, M.M., 2018. Impact of *Spirulina platensis* on growth, biochemical, and antioxidant parameters of broiler chickens. Veterinary World 11(10), 1492–1498.

Abed, H.A., Ahmed, A.M.H., Abdel-Azeem, F., Shourrap, M.I., 2023. Effect of *Spirulina platensis* algae supplementation on growth performance, physiological status of broilers during summer season. Egyptian Journal of Nutrition and Feeds 26(1), 101–107.

Abd EL-Dayem, G., Saleh, G. Abd EL-Elwahab, R.A.E.R., 2021. Impact of dietary *Spirulina* (*Arthrospira platensis*) on growth performance, gene 16 expression and antioxidant status of quail challenged with *salmonella enteritidis*. Mansoura Veterinary Medical Journal 22(2), 38–47.

Abd Elzaher, H.A., Ibrahim, Z.A., Ahmed, S.A., Salah, A.S., Osman, A., Swelum, A.A., Abd El-Hack, M.E., 2023. Growth, carcass criteria, and blood biochemical parameters of growing quails fed *Arthrospira platensis* as a feed additive. Poultry Science 102(12), 103–205.

Abdelfatah, S.H., Yassin, A.M., Khattab, M.S., Abdel-Razek, A.S., Saad, A.H., 2024. *Spirulina platensis* as a growth booster for broiler; insights into their nutritional, molecular, immunohistopathological, and microbiota modulating effects. BMC Veterinary Research 20(1), 11.

Abdelli, N., Solà-Oriol, D., Pérez, J.F., 2021. Phytogenic feed additives in poultry: Achievements, prospective and challenges. Animals 11(12), 3471.

Abdel-Moneim, A.M.E., Shehata, A.M., Mohamed, N.G., Elbaz, A.M., Ibrahim, N.S., 2022. Synergistic effect of *Spirulina platensis* and selenium nanoparticles on growth performance, serum metabolites, immune responses, and antioxidant capacity of heat-stressed broiler chickens. Biological Trace Element Research 1–12.

Abdel-Wareth, A.A.A., Williams, A.N., Salahuddin, M., Gadekar, S., 2024. Algae as an alternative source of protein in poultry diets for sustainable production: A comprehensive review. Frontiers in Veterinary Science

11(2), 1382163
Alghamdi, A.R., Al-Sagheer, A.A., El-Masry, T.A., 2024. Enhanced antioxidant profiles and growth performance in Japanese quail supplemented with *Spirulina*. Poultry Science Journal 12(1), 1–10.
Anonymous, 2016. Association of Official Analytical Chemists, Official Methods of Analysis. 20th Edition, Washington, D.C, USA. Available at: https://www.aoac.org/official-methods-of-analysis/ and accessed on: 15/11/2024.
Anonymous, 2007. Bureau of Indian Standards, Poultry Feeds Specification. (5th Revision), Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi-11. Available at: https://law.resource.org/pub/in/bis/S06/is.1374.2007.pdf and accessed on: 11/11/2024.
El-Shall, N.A., Jiang, S., Farag, M.R., Azzam, M., Al-Abdullatif, A.A., Alhotan, R., Alagawany, M., 2023. Potential of *Spirulina platensis* as a feed supplement for poultry to enhance growth performance and immune modulation. Frontiers in Immunology 14, 1072787.
Farag, M.R., Alagawany, M., El-Hack, M.E.A., Kuldeep, D., 2016. Nutritional and healthical aspects of *Spirulina* (*Arthrospira platensis)* for poultry, animals and human. International Journal of Pharmacology 12(1), 36–51.
Fathi, M.A., 2018. Effect of dietary supplementation of algae meal (*Spirulina platensis*) as growth promoter on performance of broiler chickens. Egyptian Poultry Science Journal 38(2), 375–389.
Grosshagauer, S., Kraemer, K., Somoza, V., 2020. The true value of *Spirulina*. Journal of Agricultural and Food Chemistry 68(14), 4109–4115.
Hafez, H.M., Attia, Y.A., 2020. Challenges to the poultry industry: Current perspectives and strategic future after the covid-19 outbreak. Frontiers in Veterinary Science 7, 516.
Hanafy, A., 2022. *Spirulina platensis* a promising growth promoter for poultry industry. Asian Journal of Research in Animal and Veterinary Sciences 10(1), 27–33.
Hassan, R.I., Refaie, M.S., El-Shoukary, R.D., Rehan, I.F., Zigo, F., Karaffová, V., Amer, H.Y., 2022. Effect of dietary microalgae (*Spirulina platensis*) on growth performance, ingestive behavior, hemato-biochemical parameters, and economic efficiency of fayoumi broilers. Life 12(11), 1892.
Hosseini, S.M., Khosravi, A., Hosseini, S.A., 2022. Dietary *Spirulina* supplementation improves growth performance, intestinal health, and oxidative status in broiler chickens. Poultry Science 101(8), 101743.
Jamil, A., Qureshi, S., Khan, S.H., 2015. Effect of *Spirulina platensis* as a feed supplement on growth performance and feed conversion ratio in broilers. Pakistan Journal of Zoology 47(4), 1003–1008.
Jung, F., Kruger-Genge, A., Waldeck, P., Kupper, J.H., 2019. *Spirulina platensis*, a super food?. Journal of Cellular Biotechnology 5(1), 43–54.
Khan, S., Mobashar, M., Mahsood, F.K., Javaid, S., Abdel-Wareth, A.A., Ammanullah, H., Mahmood, A., 2020. *Spirulina* inclusion levels in a broiler ration: Evaluation of growth performance, gut integrity, and immunity. Tropical Animal Health and Production 52(6), 3233–3240.
Kramer, C.Y., 1957. Extension of multiple range tests to group correlation adjusted means. Biometrics 13(1), 13–18.
Kulshreshtha, A., Jarouliya, U., Bhadauriya, P., Prasad, G.B.K.S., Bisen, P.S., 2008. *Spirulina* in health care management. Current Pharmaceutical Biotechnology 9(5), 400–405.
Kumar, A., Ramamoorthy, D., Verma, D.K., Kumar, A., Kumar, N., Kanak, K.R., Mohan, K., 2022. Antioxidant and phytonutrient activities of *Spirulina platensis*. Energy Nexus 6(8), 100070.
Lupatini, A.L., Colla, L.M., Canan, C., Colla, E., 2017. Potential application of microalga *Spirulina platensis* as a protein source. Journal of the Science of Food and Agriculture 97(3), 724–732.
Pestana, J.M., Puerta, B., Santos, H., Madeira, M.S., Alfaia, C.M., Lopes, P.A., Prates, J.A.M., 2020. Impact of dietary incorporation of *Spirulina* (*Arthrospira platensis*) and exogenous enzymes on broiler performance, carcass traits and meat quality. Poultry Science 99(5), 2519–2532.
Rajoriya, H.S., Shende, K.A., Chavhan, D.M., Meel, M.S., Joshi, M., 2024. Effect of dietary supplementation of prebiotic and acidifier powder on growth performance and haemato-biochemical parameters in broilers. International Journal of Bio-resource and Stress Management 5(4), 01–07.
Ricke, S.C., Dittoe, D.K., Richardson, K.E., 2020. Formic acid as an antimicrobial for poultry production. Frontiers in Veterinary Science 7, 563.
Shanmugapriya, B., Saravana Babu, S., 2015. Effect of *Spirulina platensis* supplementation on the growth performance of broiler chickens. International Journal of Current Microbiology and Applied Sciences 4(1), 1030–1038.
Sherif, K.E., Dorra, T.M., Hassan, I.E.E., Mahmoud, A.K., 2022. Effect of dietary Azolla and *Spirulina* on performance of Japanese quails. Journal of Animal and Poultry Production 13(4), 51–57.
Snedecor, G.W., Cochran, W.C., 1994. Statistical methods 8th edition. Oxford and IBH Publishing Co. New Delhi, India.
Swiatkiewicz, S., Arczewska-Wlosek, A., Józeflak, D., 2015. Application of microalgae biomass in poultry nutrition. World's Poultry Science Journal 71(4), 663–672.