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Research Article

EFFECT OF SHRIMP MEAL ON GROWTH PERFORMANCE, DIGESTIBILITY, CARCASS CHARACTERISTICS, INTESTINAL MORPHOLOGY, AND IMMUNOLOGICAL RESPONSES OF BROILER CHICKEN

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ABSTRACT: The purpose of the study was to assess the impact of varying levels of shrimp meal incorporation on the growth performance, nutrient digestibility, carcass traits and immunological responses of broiler chickens. Three groups of 56 chicks each were randomly selected from a total of 168 day-old mixed-sex broiler chicks and divided into seven replicates of eight chicks. There were three experimental groups: SM1 (2.5 percent shrimp meal), SM2 (five percent shrimp meal), and a control group that was given a diet devoid of shrimp meal. Weight gain, intake of feed, and feed conversion ratio were measured on days 0, 7, 14, 21, 28, and 35. At the completion of the trial, carcass characteristics, gut morphology, and antibody titre were assessed. The study found that in SM2 group, final body weights and average daily gain were significantly higher compared to control group and FCR showed better in SM2 group compare to SM1 and control groups. SM2 showed significantly higher DM digestibility compared to SM1 and control. There were no significant effects on carcass traits.The height of duodenal villi (VH), crypt depth (CD), and the ratio of villi height to crypt depth (VH/CD) were not significantly different from each other. The jejunal VH in the SM2 group was significantly higher than that of the control groups (P<0.05). The ileum's VH/CD ratio was significantly higher (P<0.05) in the SM2 and SM1 groups in compare to control group. The results of the study show that shrimp meal can be included at the rate of 5% in a broiler diet without compromising performance.

Keywords: Broiler chickens, Shrimp meal, Growth performance, Gut morphology, Immune response.

INTRODUCTION

The broiler sector is the leading industry in animal output. With the global population expanding and more land allocated to cash crop cultivation, traditional chicken feed ingredients like maize and soybean meal are in short supply. The quality and cost of chicken feed are essential to meet the rising demand. The number of broilers processed annually is increasing, and it is projected that over 73 billion chickens will be processed globally by 2021 [1]. Animal feed is a crucial component of the global food and agriculture industry. It is important to supply animals with clean, high-quality feed to ensure efficient livestock production. High-quality feed provides essential minerals and energy for chicken growth, bone development, and feather production. With the increasing cost of raw materials, attempts are in vogue to identify the potential of several agro-industrial byproducts and bioconverting the community waste to animal wealth in terms of boosting production and health [2, 3, 4]. Kumari [5] reported that shrimp waste meal supplemented diets showed significantly higher body weight gain (P<0.01) compared to those on the control diet throughout the growth phases. Rahman and Koh [6] found that increasing the amount of SM in the diet led to a significant decrease in feed intake. Onbasılar *et al*. [7] suggested that the VH/CD ratio in the jejunum was significantly affected by the addition of shrimp waste to the diet, with the control group showing a lower ratio. Okonkwo *et al*. [8] observed no significant differences

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(P>0.05) in the weights of various body parts across the SWM incorporated groups.Traditional chicken diets often rely on costly and sporadically scarce ingredients like soybean meal (SBM). To deal with this problem, farmers might utilize farm waste and agro-industrial by-products as alternative protein sources. Shrimp meal (SM) is a cost-effective and viable substitute for SBM in poultry diets [9]. SM can be used in poultry feed to reduce reliance on soybean meal, a key protein source with fluctuating prices [10]. SM is a dry, powdered feed ingredient with approximately 40%-62% protein, 3%-8% ether extract, 4%-13% crude fiber, 11%-14% chitin, and 12%-23% minerals [11]. The study aims to investigate the potential use of shrimp meal as a source of protein in broiler diets to reduce environmental pollution. Limited research exists on shrimp meal inclusion in broiler diets. This trial evaluates the effect of shrimp meal on the growth, digestibility, intestinal structure, immunological responses, and carcass characteristics of broiler chickens.

MATERIALS AND METHODS

Experimental design and diets

The experiment was conducted in compliance with the guidelines established by the Institutional Animal Ethics Committee of West Bengal University of Animal & Fishery Sciences under approval no: 763/GO/Re-S/ReRc-L/03/CCSEA/77/2024-25, dated: 12.02.2025. Total 168 one-day-old broiler chicks of mixed sex (Vencobb 400, Venkys, Pune, India) were used in the study. They were divided into three groups based on the shrimp meal content in their diet: 1) basal diet without any shrimp meal (CON), 2) basal diet containing 2.5 % Shrimp meal (SM1), and 3) basal diet containing 5 % Shrimp meal (SM2). Shrimp meal was collected from local markets in West Bengal. Each group of treatment consists of seven replicates of eight birds. The birds included in the treatment were statistically homogeneous in weight and were housed in twenty-one pens. The chicks were housed in pens measuring 90 × 76 cm with litter, following standard management practices.The basal diet, in mash form, was formulated using maize and soybeans to meet the nutritional requirements of Vencobb 400 broiler chicks at different growth stages (starter, grower, and finisher) (Table 1). Experimental birds were given *ad libitum* access to water. The chick starter feed was given from 0–14 days of the 35-day trial period, followed by grower feed from 15–28 days and finisher feed from 29–35 days. From each replicate, two birds were housed for five consecutive days in metabolic cages and fed the respective experimental finisher feed.

Measurement of growth performance, digestibility and carcass traits of experimental birds.

At 0 day, prior to feeding and watering, the birds' body weight was measured, and then weekly throughout the experiment. The feed intake, feed conversion ratio and body weight gain of each replicate were recorded. Two randomly selected broilers were slaughtered following standard protocols from each group at 35 days of age for carcass evaluation. Weight ofabdominal fat, internal organs and the carcass were measured. The different parts of birds' namely prime cuts, edible visceral organs, and lymphoid organs were weighed separately as per standard procedures. For digestibility trial thefecal samples of birds were collected and weighed, along with the total feed given.Digestibility and retention of dry matter, nitrogen, and ash in the feces were analyzed using daily samples stored at -20°C [12].

Determination of intestinal morphology

On the 35th day, broilers were slaughtered for intestinal morphology assessment. Tissue samples from the duodenum, jejunum, and ileum were fixed in 10% buffered formalin for 24-48 hours, processed, and embedded in paraffin. Sections were stained with hematoxylin and eosin, and then examined under a light microscope (Cilika BTE 100 benchtop, MedPrime Technology). Villi with a complete lamina propria and twelve villi per slice were selected. Villus height (VH) and crypt depth (CD) were measured in micrometers (µm). Each sample was analyzed using 10 observations and at least three sections to establish a single observation in micrometers (µm).

Determination of immunological responses

All birds were vaccinated with Newcastle disease (ND) at 5 and 21 days and infectious bursal disease (IBD) at 14 days. Blood was collected from two randomly selected birds from each pen on days 28 and 35. The anti-NDV and anti-AIV antibody response was assessed using the hemagglutination inhibition assay following the methods described by Moghaddam and Jahanian [13]. ELISA was used to detect anti-IBD or anti-IBV responses using machine IDEXX Laboratories Inc., USA.

Statistical analysis

The data was analyzed using SPSS's one-way analysis of variance (ANOVA) in a completely randomized manner [14]. The pen was considered the experimental unit for feed intake, body weight gain, and FCR, while a single bird was the experimental unit for other parameters. At a significance level of P < 0.05, and differences between treatment means were identified using Duncan's test when a significant treatment effect was observed.

RESULTS AND DISCUSSION

Average daily gain, feed intake, feed efficiency and digestibility of nutrients

The SM2 group exhibited a significantly higher (P<0.05) average daily gain (ADG) compared to the CON group throughout the 35-day experiment, while the SM1 group did not show significant differences with either the SM2 or CON group (Table 2). However, during the starter (days 1-14), grower (day 15-28), and finisher (day 29-35) phases of the experiment, there were no differences (P>0.05) in ADG among the treatment groups. Bird's final body weight was significantly higher in the SM2 group in comparison to the CON group, with no significant difference with SM1 group. The SM1 group exhibited a significantly higher (P<0.05) average daily feed intake (ADFI) compared to the CON group, although no significant variation was observed with the SM2 group during the grower period of the broilers. There were no significant variations (P>0.05) in ADFI among the treatment groups for the remains of the experiment period or over the entire 35-day experiment period. The feed conversion ratio (FCR) was significantly (P<0.05) improved in the SM2 group comparing with the CON group, while the SM1 group did not show any difference with either the SM2 or CON group during the starter phase (day 1-14). Additionally, a significant (P<0.05) improvement in

Table 1: Ingredients and composition (%) of the experimental diets.

Ingredients	Starter			Grower			Finisher		
	CON	SM1	SM2	CON	SM1	SM2	CON	SM1	SM2
Maize	61.809	60.634	59.459	64.386	63.215	62.043	66.994	65.819	64.642
Soya DOC Hypro	33.491	32.116	30.741	29.983	28.608	27.232	26.364	24.989	23.617
Shrimp Meal	0	2.500	5.000	0	2.500	5.000	0	2.500	5.000
Oil-veg	0.790	0.963	1.137	2.026	2.198	2.370	3.216	3.389	3.564
Dicalcium phosphate	1.658	1.507	1.356	1.526	1.375	1.224	1.395	1.244	1.093
Limestone powder	0.932	0.962	0.993	0.951	0.982	1.013	0.943	0.974	1.005
Common salt (Nacl)	0.322	0.325	0.328	0.313	0.314	0.315	0.326	0.328	0.331
DL-methionine	0.328	0.322	0.316	0.258	0.252	0.246	0.230	0.224	0.216
L-lysine HCL	0.262	0.264	0.266	0.171	0.173	0.175	0.148	0.149	0.151
L-threonine	0.088	0.086	0.084	0.066	0.064	0.062	0.065	0.064	0.062
Toxin binder	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Sodium bi-carbonate	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Mineral premix[1]	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Vitamin premix[2]	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Antioxidant	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Phytase 5000	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Analysed values (%)									
ME (kcal/kg)*	3000.00	3000.00	3000.00	3100.00	3100.00	3100.00	3200.00	3200.00	3200.00
Crude protein*	22.50	22.50	22.50	20.83	20.83	20.83	19.20	19.20	19.20
Ether extract	3.17	3.50	3.71	1.94	4.23	4.30	4.93	4.60	4.45
Crude fiber	2.23	2.37	2.84	1.99	2.15	2.43	2.12	2.52	2.69
Dry matter	89.09	87.88	87.04	88.56	88.24	87.96	86.55	87.99	87.75
Lysine*	1.25	1.25	1.25	1.09	1.09	1.09	0.98	0.98	0.98
Methionine+Cysteine*	0.90	0.90	0.89	0.80	0.80	0.80	0.74	0.74	0.74
Threonine*	0.77	0.77	0.77	0.70	0.70	0.70	0.65	0.65	0.65
Total ash	6.32	9.09	7.57	6.92	7.19	7.04	6.97	6.93	6.41
Acid insoluble ash	0.31	1.14	1.36	0.44	0.77	0.79	0.51	0.66	0.57
Calcium*	0.94	0.94	0.94	0.91	0.91	0.91	0.87	0.87	0.87

[1]Contains Zn 4.0%, Mn 4.0%, Fe 1.5%, Cu 0.8%, I 0.4%, Se 300ppm, Cr 200ppm;
[2]Contains vitamin E100g, vitamin A 40000000 IU, vitamin D_3 12000000IU, pantothenic acid 60g, vitamin K 8g, vitamin $B_1$120g, vitamin B_2 24g, vitamin B_6 10g, vitamin B_{12} 0.10g, biotin 0.40g, folic acid 4g, niacin 100g

Table 2: Effect of shrimp meal on final body weight (BW), average daily gain (ADG), average daily feed intake (ADFI) and FCR of broiler chickens.

Parameter	Attribute	Treatment			SEM (n=7)	P-Value
		CON	SM1	SM2		
ADG (g/d)	D1-14	27.89	28.52	29.61	0.329	0.091
	D15-28	68.01	72.66	73.05	0.998	0.063
	D29-35	73.14	72.55	76.78	2.122	0.700
	D1-35	52.99[b]	54.98[ab]	56.42[a]	0.503	0.011
	Final BW	1901.15[b]	1970.36[ab]	2020.57[a]	17.625	0.012
ADFI (g/d)	D1-14	32.58	32.58	31.82	0.306	0.533
	D15-28	93.48[b]	99.86[a]	96.38[ab]	0.995	0.023
	D29-35	135.25	135.68	135.53	1.189	0.990
	D1-35	77.47	80.11	78.39	0.489	0.074
FCR (g intake/g gain)	D1-14	1.166[a]	1.143[ab]	1.081[b]	0.015	0.041
	D15-28	1.374	1.376	1.323	0.012	0.137
	D29-35	1.883	1.881	1.806	0.055	0.824
	D1-35	1.464[a]	1.457[a]	1.390[b]	0.013	0.028

[ab] means bearing different superscripts in the same row differ significantly ($p \leq 0.05$). CON- control diet, SM1- control diet containing 2.5 % Shrimp meal, SM2- control diet containing 5 % Shrimp meal

Table 3: Effect of supplementation of shrimp meal on digestibility of nutrients.

Digestibility %	Treatment			SEM (n=7)	P-Value
	CON	SM1	SM2		
DM	71.83[c]	74.17[b]	76.88[a]	0.761	0.001
CP	77.66[b]	84.76[a]	87.16[a]	1.596	0.008
CF	29.59	26.39	23.76	1.064	0.052
EE	77.06[c]	82.21[b]	85.04[a]	1.170	0.000

[ab] means bearing different superscripts in the same row differ significantly ($p \leq 0.05$). CON- control diet, SM1- diet containing 2.5 % Shrimp meal, SM2- diet containing 5 % Shrimp meal.

Table 4: Effect of shrimp meal on carcass characteristics of broiler chickens at day 35.

Attributes	Treatment			SEM(n=7)	P-Value
	CON	SM1	SM2		
Final BW (g)	1901.57[b]	1969.14[ab]	2020.57[a]	16.815	0.007
Eviscerated BW (g)	1229.46[b]	1305.88[a]	1338.88[a]	14.469	0.002
Dressing Percentage (%)	64.65	66.27	66.34	0.409	0.165
Breast (g)	484.56	495.28	521.82	6.696	0.056
Frame (g)	238.28	254.59	255.42	3.711	0.100
Thigh (g)	153.10[b]	166.21[a]	177.01[a]	3.029	0.001
Drumstick (g)	178.66	179.34	190.49	2.302	0.053
Wing (g)	104.21	114.75	115.37	2.231	0.064
Neck (g)	49.68[b]	48.77[b]	54.30[a]	0.807	0.005
Gizzard (g)	43.91	47.76	49.64	1.703	0.395
Liver (g)	45.79[a]	37.59[b]	39.02[b]	1.144	0.002
Heart (g)	9.07	9.24	9.30	0.275	0.944
Spleen (g)	1.89	1.76	1.92	0.063	0.554
Bursa (g)	1.29	1.50	1.28	0.090	0.561
Abdominal Fat (g)	32.64	35.17	38.75	1.216	0.117

[ab] means bearing different superscripts in the same row differ significantly ($p \leq 0.05$). CON- control diet, SM1- diet containing 2.5 % Shrimp meal, SM2- diet containing 5 % Shrimp meal.

Table 5: Effect of shrimp meal on gut morphology of broiler chickens at day 35.

Gut part	Attribute	Treatment			SEM(n=7)	P-Value
		CON	SM1	SM2		
Duodenum	Villi height (VH; µm)	1496.77	1506.55	1541.22	32.147	0.864
	Crypt depth (CD; µm)	212.48	186.72	170.25	7.772	0.065
	VH/CD ratio	7.10	8.09	9.22	0.385	0.061
Jejunum	Villi height (VH; µm)	1006.88^{b}	1089.98^{ab}	1235.85^{a}	37.528	0.021
	Crypt depth (CD; µm)	263.32	259.85	257.48	9.952	0.976
	VH/CD ratio	3.84	4.25	4.90	0.208	0.102
Ileum	Villi height (VH; µm)	687.09	805.03	854.56	34.212	0.114
	Crypt depth (CD; µm)	188.15	179.50	172.28	3.866	0.264
	VH/CD ratio	3.66^{b}	4.48^{a}	4.95^{a}	0.190	0.003

^{ab} means bearing different superscripts in the same row differ significantly ($p \leq 0.05$). CON- control diet, SM1- diet containing 2.5 % Shrimp meal, SM2- diet containing 5 % Shrimp meal

Table 6: Effect of shrimp meal on antibody titre (log_{10}) against infectious bursal disease vaccine (IBDV) and New castle disease vaccine (NDV) of broiler chickens at day 28 & 35.

Disease	Attribute	Treatment			SEM(n=7)	P-Value
		CON	SM1	SM2		
IBDV	d28	2.60^{b}	2.87^{ab}	3.08^{a}	0.063	0.005
	d35	2.52	2.74	2.98	0.083	0.072
NDV	d28	2.71^{b}	2.79^{ab}	2.92^{a}	0.032	0.027
	d35	2.38	2.50	2.59	0.067	0.470

^{ab} means bearing different superscripts in the same row differ significantly ($p \leq 0.05$). CON- control diet, SM1- diet containing 2.5 % Shrimp meal, SM2- diet containing 5 % Shrimp meal.

FCR was seen in the SM2 group when compare with the SM1 and CON groups throughout the experiment (day 1-35). However, during the grower phase (days 15–28) and finisher phase (days 29–35), no significant impact on FCR was noted.

In our study, the group supplemented with 5% shrimp meal showed a significant increase in final body weight in the fifth week and ADG throughout the trial compared to the other groups.There were variations in the average daily weight gain among the groups over the 35-day study period. Previous research [9, 15] has shown that broiler feed containing 5% shrimp waste meal resulted in a significant increase in growth rate ($P < 0.01$). Researcher [5] found that 0.5 g/kg of cricket chitin was more effective in improving broiler growth compared to chitosan. In contrary to researchers' observations [16, 7, 17], which indicated a decrease in broiler growth performance with increased consumption of shrimp waste meal, Okoye et al. [18] observed only minor changes in broiler weight when fed shrimp waste feed during the finisher period. Several experiments have used various shrimp species [19] and segments [20] in experiments, leading to variations in shrimp waste quality. The nutritional composition of shrimp waste varies significantly based on the shrimp species, shell content and processing and storage methods employed [21]. Though the feed intake level did not varied significantly but the lower level of addition of shrimp meal may have increased palatability so birds had a higher intake, but that intake did not translate to proportionally higher weight gain may be due to the nutrient balance at that inclusion was not optimal for growth (limiting amino acids, or the palatability effect increased intake without improving the efficiency than that of SM2 level).

Table 3 shows the impact of an experimental diet on nutrient digestibility after a 35-day trial. Dry matter (DM) digestibility was significantly ($P<0.05$) higher in SM2 compared to SM1 and CON. Crude protein (CP) digestibility was higher ($P<0.058$) in SM2 and SM1 than CON. The ether extract (EE) digestibility of the 5% SM diet was significantly ($P<0.05$) higher than the 2.5% SM diet and the control diet.

Kumar [22] found that nutrients were more digestible during the finisher phase, except for ether extract. According to Birto et al. [23], the inclusion of SWM in broiler diets led to a significant improvement in protein digestibility (P=0.001). Oduguwa et al. [11] found that adding fishmeal and shrimp waste meal to broiler diets slightly improved ether extract, ash, and dry matter digestibility. They also noted that nutrient digestibility increased as birds matured, with finisher broilers exhibiting higher values than starter broilers and that might be the reasons of showing comparatively better FCR and ADG in finisher period.

Carcass characteristics

Eviscerated weights in the SM1 and SM2 groups were significantly higher (P<0.05) than CON group (Table 4). Significant differences (P<0.05) were also observed in liver, thigh, and neck weights. The results were consistent with researcher [25], showing that broilers fed high amino acid density diets at 35 and 55 days had improvements in various parameters such as fillet weight, tender weight, tender yield, total breast weight, drumstick weight, saddle weight, wing weight, and carcass weight. Likewise, investigator [26] found that increasing lysine content in the diet of 20-week-old pullets to 110% during the rearing phase resulted in higher breast meat production and lower belly fat deposition.The genetic potential of current broiler strains for breast meat production was highlighted by Vieira et al. [24], who found that a high-protein diet increased breast meat yield in broiler carcasses. In a study by Premathilaka et al. [27], broilers fed a diet with 4% FM had higher internal organ weights compared to those on a diet with 2% FM and 3% fortified SBM. The 5% SM incorporated group showed significantly higher slaughter weight, possibly due to increased abdominal fat deposition. However, there were no significant differences (P>0.05) in dressed weight, wing, drumstick, breast, gizzard, spleen, and heart in the group supplemented with SWM [9]. The gizzard, spleen, and heart were not affected, indicating no significant toxicity threat with all the SM incorporated diets [28].

Gut morphology

There were no variations in villi height (VH), crypt depth (CD), or the VH/CD ratio of duodenum among the CON, SM1, and SM2 groups (Table 5). The jejunal VH in the 5% inclusion group was similar to the SM1 group but significantly higher (P<0.05) than the CON group. The VH and CD of the ileum showed no noticeable changes, but the ileum's VH/CD ratio was significantly higher (P<0.05) in both the SM1 and SM2 groups in comparison with the CON group. Overall, the gut morphology of the SM2 group was superior to that of the other groups. According to Li et al. [29], supplementation with chitosan oligosaccharide (COS) may have a beneficial effect on intestinal morphology by increasing villus height and the VH/CD ratio, while decreasing crypt depth. In contrast to the current study, investigator [8] found that adding shrimp waste to the diet significantly affected the VH/CD ratio in the jejunum. Ibitoye et al. [30] found that adding shrimp and cricket chitosan to the diet significantly reduced crypt depth and increased jejunal villus height without affecting body weight.However, the current study did not provide an explanation for the significant improvement in the ileum VH: CD ratio and jejunal VH of broilers fed the 5% SWM-incorporated diet compared to the basal diet. Shrimp meal contains bioactive substances such chitin, chitosan, and astaxanthin, broilers given the 5% SWM diet showed improvements in their ileal VH:CD ratio and jejunal villus height. Through modifying intestinal microbiota, lowering inflammation, and promoting villus growth, these substances are known to improve gut health. By inhibiting harmful bacteria and encouraging advantageous species like *Lactobacillus* spp., chitosan and its oligosaccharides can alter the intestinal microbiota and lower intestinal inflammation and epithelial turnover [29]. A larger VH:CD ratio is a result of the extension of villi and shallower crypts made possible by the decrease in mucosal damage and the need for cellular regeneration.This group's increased growth performance and feed efficiency were likely due to the greater inclusion level (5%) providing enough functional nutrients and antioxidants to enable improved intestinal morphology and nutrient absorption.

Immune response

Our study showed that on day 28, the antibody titers for both IBDV and NDV vaccinations were significantly better in the SM2 group compared to the CON group (P<0.05) (Table 6). But between SM1 and SM2, there was no difference. By day 35, the antibody titers for both IBDV and NDV were comparatively higher (P>0.05) in the SM2 group than other the treatment groups. The post-vaccination antibody levels in broilers increased more with higher doses of shrimp extract, indicating a stronger immune response and overall health. Broiler immune systems can be strengthened with an amino acid-rich diet. Amino acids supplementation has been shown to improve immunological function [31, 32]. Rapidly growing animals like pigs and broilers require arginine, an essential amino acid present in animal cells, for processes such as immune regulation, protein synthesis, and ammonia detoxification. A deficiency in arginine in broiler diets can lead to reduced spleen and thymus weight, lower antibody levels against NDV, and a decrease in blood heterophil percentage. Research by Tayade *et al*. [32] suggests that arginine enhances the specific immune response against IBD in chickens. Broilers fed the 5% shrimp meal (SM2) diet showed better antibody titers against IBDV and NDV, indicating that shrimp meal boosted immunological competence. High-quality proteins, vital amino acids (particularly arginine), and bioactive substances including chitin, chitosan, and astaxanthin-all of which are known to enhance immunological modulation-are abundant in prawn meal. Arginine is essential for the formation of nitric oxide, antibodies, and lymphocytes, all of which boost immunological responses. Additionally, astaxanthin and chitosan have immunostimulatory and antioxidant qualities that support the integrity of immune organs and improve vaccine response. Therefore, the increased incorporation of shrimp meal in the SM2 group is linked to enhanced nutritional and immunological health, which is reflected in the elevated antibody levels in that group.

CONCLUSION

Recycling animal waste is essential for promoting environmental sustainability. Diet containing 5% shrimp meal has been shown to have positive effects on broiler performance, carcass quality, intestinal morphology, and immunological responses in broiler chickens without any adverse effects. This approach can also help protect the environment by utilizing a waste product. This method utilizes a waste product and contributes to environmental protection.

CONFLICT OF INTEREST

The Authors declares that there is no conflict of interest.

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