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Effect of supplementation of modified lignin on growth performance in broilers

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Abstract
An experiment was conducted using 180 day-old Cobb broiler chicks to study the effect of modified lignin on growth performance. The chicks were randomly divided into six treatment groups with three replicates of ten birds each for 42 days. Treatment groups included a control diet (T_1) as per BIS (2007) [4], a reformulated diet with 2% reduction in metabolizable energy and crude protein of control diet (T_2), and experimental diets T_3 and T_4 supplemented with 0.2% modified lignin in both control and reformulated diets, respectively and similarly, the treatments T_5 and T_6 supplemented with 0.3% modified lignin in both control and reformulated diets, respectively. The results showed that birds supplemented with 0.2 and 0.3% modified lignin in both control and reformulated diets showed significantly improved body weight, feed intake and better feed conversion ratio compared to both the control and reformulated diets fed groups and no significant difference was noticed in survivability among all the groups. It was concluded that supplementing modified lignin improved growth performance in broilers.

Keywords: Modified lignin, reformulated diet, body weight, feed intake, feed conversion ratio, survivability

Introduction

The poultry industry in India has evolved from backyard farming to a modern organized sector, significantly contributing to the agro-livestock economy. It provides livelihood opportunities, especially in rural areas, due to its low capital requirements and high employment generation. As per BAHS (2024), India recorded a 3.17% increase in egg production, 4.95% rise in meat production, and 8.1% annual growth in poultry population, making it the second-largest egg producer and fifth-largest chicken meat producer globally. However, per capita availability remains below ICMR recommendations, highlighting the need for expansion to meet nutritional demands. With FAO projecting a 70% surge in demand for animal protein, sustainable intensification is necessary, especially as feed costs remain the major limiting factor. The focus is shifting towards alternative feed resources that improve nutritional quality and sustainability. Concerns over antimicrobial resistance have driven research on prebiotics, particularly lignocellulosic derivatives, which stimulate beneficial gut bacteria and improve digestive health (Gibson *et al*., 2017) [7]. Dietary fibers, once regarded as anti-nutritional, are now valued for promoting gut development, with lignin recognized for its natural prebiotic properties (Baurhoo *et al*., 2009) [2].

Lignin, a complex polyphenolic polymer and key component of lignocellulose, accounts for 20-35% of dry biomass weight. It strengthens plant cell walls, resists microbial degradation, and provides antioxidant, flame-retardant, and UV-protective functions. Structurally, it is composed of syringyl (S), guaiacyl (G), and p-hydroxyphenyl (H) monomers, whose proportions vary among plant types (Norgren and Edlund, 2014) [11]. Softwood lignin is rich in guaiacyl, while hardwood lignin contains more syringyl units. Agricultural residues like sugarcane bagasse, wheat straw, and rice husk represent rich lignin sources. Extraction methods produce sulfur-containing types such as kraft lignin and lignosulfonates (Mahmood *et al*., 2018) [9] and sulfur-free types like soda and organosolv lignins. Since native lignin is chemically inert, modifications such as sulfonation, oxidation, graft copolymerization, and alkylation are applied to enhance reactivity and expand applications (Mahmood *et al*., 2018) [9]. Lignin and its derivatives have found diverse industrial and biomedical applications. They are used in dye adsorption (Silva *et al*., 2011) [6], dispersants, plasticizers, and catalysts (Zhu *et al*., 2019) [15]. In healthcare, lignin exh ibits anticancer, antibacterial, antioxidant, and antimicrobial (Alzagameem *et al*., 2018) [1] activities.

Recent research highlights applications in surfactants, UV protection, composites (Klimek *et al*., 2017) [8] and drug delivery systems (Cauley and Wilson, 2017) [5]. These multifunctional roles make lignin a promising candidate for sustainable livestock feed formulations and value-added industrial products.

Materials and Methods

Venkateshwara Hatcheries Pvt. Ltd. provided 180 day-old commercial broiler chicks for this investigation, and modified lignin was procured from Phytaxis SA, Rueschlikon, Switzerland. The chicks were first evaluated based on their weight upon acquisition and then randomly divided into six experimental groups. Each group had three replicates, with 10 chicks in each replicate. Following the Bureau of Indian Standards (BIS) 2007 [4] guidelines, the control group (T_1) was fed a basal diet, while group T_2 was fed with reformulated diet [2% reduction in ME and CP in the basal diet] and the experimental groups T_3 and T_4 supplemented with 0.2% modified lignin in both basal and reformulated diets, respectively and similarly, the treatment groups T_5 and T_6 supplemented with 0.3% modified lignin in both basal and reformulated diets, respectively. The chicks were reared under standard management practices in a deep litter system until six weeks of age. The birds were vaccinated as per a standard vaccination schedule, and food and water were provided *ad libitum* throughout the trial. The study was approved by the Institutional Animal Ethics Committee, KVAFSU, Bidar, Karnataka.

The data on weekly body weight, feed intake, feed conversion ratio, and survivability were recorded throughout the experiment and subjected to statistical analysis.

Results

1. Body weight

The results of the experiment on cumulative body weight are presented in Table 1. Statistical analysis revealed a significant difference ($p \leq 0.05$) among the treatment groups. The treatment groups T_3 and T_5 consistently showed significantly higher average body weights compared to T_1, T_2, T_4, and T_6, with no significant difference between T_3 and T_5 and the groups T_1, T_4, and T_6 exhibited significantly higher body weights than T_2, while no significant differences were found among T_1, T_4, and T_6. These results indicate that treatments T_3 and T_5 were the most effective in enhancing the growth performance of chicks.

2. Feed intake

The results of the experiment on cumulative feed intake are presented in Table 2. Statistical analysis revealed a significant difference ($p \leq 0.05$) among the treatment groups during first, fourth, fifth, and sixth weeks. In the first week, treatment T_2 showed significantly higher feed intake compared to T_1, T_4, T_5, and T_6 and no significant difference between T_2 and T_3. During the fourth week, treatments T_1, T_3, and T_4 had significantly higher feed intake than T_2 and T_6 no significant difference between T_1, T_3, T_4 and T_5. During fifth and sixth weeks, treatments T_1, T_3, T_4, T_5, and T_6 exhibited significantly higher feed intake compared to T_2, with no significant difference between T_1, T_3, T_4, T_5, and T_6 groups. However, during the second and third weeks, no significant differences ($p > 0.05$) were observed in cumulative feed intake among treatment groups. Overall, feed intake during the later weeks was lower in the T_2 group.

3. Feed conversion ratio

The results of the experiment on cumulative feed conversion ratio (FCR) are presented in Table 3. Statistical analysis revealed a significant difference ($p \leq 0.05$) among the treatment groups from second week to sixth week, except during the first week there was no significant difference was observed. However, the treatments T_3 and T_5 consistently exhibited significantly better FCR compared to T_1, T_2, T_4 and T_6, while no significant differences between T_3 and T_5 groups. Additionally, the treatments T_1, T_4, and T_6 showed significantly better FCR than T_2, while no significant differences were observed among T_1, T_4 and T_6. Overall, treatments T_3 and T_5 proved to be most effective in improving feed conversion ratio in broiler chicks across the study period.

4. Survivability

The survivability or livability (%) values at the end of the experiment were 96.67, 93.33, 96.67, 93.33, 100 and 100 in all groups T_1, T_2, T_3, T_4, T_5 and T_6 respectively. Statistical analysis revealed no significant difference in survivability among different treatment groups.

Discussion

There was a significant difference ($p \leq 0.05$) in body weight of the birds supplemented with modified lignin compared to the control group from first week to sixth week.

The results of the present study were in agreement with Sozcu (2019) [13] who observed significantly higher body weight in broilers supplemented with 1 kg of processed lignocellulose per ton of feed compared to the control group. They attributed the increase in body weight due to improved gizzard function through a reduction in pH, as well as enhanced activity of proteolytic enzymes in digestive organs such as the proventriculus and pancreas.

The results of the present study were in disagreement with Rohe *et al*. (2020) [12] who studied the effect of dietary lignocellulose in broilers. Their findings indicated that supplementation of lignocellulose at different levels had no significant effect on body weight compared to control group.

There was a significant difference ($p \leq 0.05$) in feed intake of the birds supplemented with modified lignin compared to the control group in first week and from fourth week to sixth week.

The results of the present study were in agreement with Makivic *et al*. (2019) [10] who conducted a trail by supplementing lignocellulose at different levels in broilers and reported that the supplementation of 0.6 percent lignocellulose significantly increased their feed intake compared to control group. They attributed this result to the low pH in the gizzard, as well as increased gizzard function and enhanced proteolytic digestive enzyme activities in the proventriculus and pancreas due to lignocellulose supplementation.

The results of the present study were in disagreement with Zeitz *et al*. (2020) [14] who conducted a trial supplemented with different forms of lignocellulose and reported that there was no significant difference in feed intake in comparison to control group.

There was a significant ($p \leq 0.05$) difference in feed conversion ratio of the birds supplemented with modified lignin compared to the control group from second week to till the end of the experiment.

The results of the present study were in agreement with Sozcu (2019) [13] who observed significantly lower feed conversion ratio in broilers supplemented with 1 kg of processed lignocellulose per ton of feed compared to the control group. They attributed the decrease in feed conversion ratio is due to improved gizzard function through a reduction in pH, as well as enhanced activity of proteolytic enzymes in digestive organs such as the proventriculus and pancreas.

The results of the present study were in disagreement with Baurhoo *et al*. (2007) [3] they reported that supplementation of Alcell lignin at different levels in broilers showed no significant difference in feed conversion ratio compared to control group.

There was no significant difference ($p > 0.05$) in survivability of the birds supplemented with modified lignin in comparison to control from first week to till the end of the experiment.

The results of the present study were in agreement with Makivic *et al.* (2019) [10] who observed no significant difference in mortality in broilers fed diet with different levels of lignocellulose compared to those on a control diet.

Table 1: Effect of supplementing modified lignin on weekly cumulative body weight (g / bird / week) (Mean ± SE) in broilers.\

Experimental group	Weeks					
	I	II	III	IV	V	VI
T_1	176.48 ± 2.01^{ab}	462.73 ± 4.48^{b}	874.47 ± 6.73^{b}	1426.1 ± 18.46^{b}	1975.39 ± 26.02^{b}	2372.07 ± 23.74^{b}
T_2	173.91 ± 1.74^{ab}	450.69 ± 3.51^{a}	836.16 ± 9.22^{a}	1371.09 ± 12.40^{a}	1771.03 ± 10.78^{a}	2187.12 ± 21.53^{a}
T_3	182.52 ± 1.56^{c}	484.36 ± 4.7^{c}	901.17 ± 7.99^{c}	1481.61 ± 18.44^{c}	2067.10 ± 17.68^{c}	2492.76 ± 24.47^{c}
T_4	175.17 ± 1.57^{ab}	465.13 ± 3.82^{b}	868.47 ± 5.53^{b}	1418.47 ± 17.13^{b}	1984.49 ± 18.46^{b}	2379.53 ± 22.6^{b}
T_5	178.71 ± 1.72^{bc}	482.37 ± 3.74^{c}	902.27 ± 7.14^{c}	1478.71 ± 16.51^{c}	2080.71 ± 23.62^{c}	2495.67 ± 19.38^{c}
T_6	173.31 ± 1.83^{a}	463.31 ± 3.3^{b}	870.49 ± 10.01^{b}	1412.05 ± 8.18^{b}	1936.24 ± 17.8^{b}	2373.81 ± 18.98^{b}

^{a,b,c}Means in the same column with no common superscript differ significantly (P ≤ 0.05)

Table 2: Effect of supplementing modified lignin on weekly cumulative feed intake (g / bird / week) (Mean ± SE) in broilers.

Experimental group	Weeks					
	I	II	III	IV	V	VI
T_1	142.11 ± 2.24^{a}	530.46 ± 5.45	1214.32 ± 7.17	2173.27 ± 25.08^{b}	3445.54 ± 15.74^{b}	4250.59 ± 21.38^{b}
T_2	150.31 ± 1.75^{b}	528.19 ± 2.26	1195.97 ± 2.62	2111.24 ± 8.31^{a}	3176.83 ± 21.08^{a}	4042.25 ± 14.98^{a}
T_3	145.93 ± 1.1^{ab}	520.64 ± 2.31	1199.85 ± 3.42	2165.55 ± 15.75^{b}	3405.64 ± 30.62^{b}	4213.38 ± 17.26^{b}
T_4	141.15 ± 0.62^{a}	527.26 ± 2.08	1194.79 ± 3.85	2171.58 ± 10.64^{b}	3452.60 ± 13.37^{b}	4244.40 ± 20.53^{b}
T_5	144.20 ± 3.04^{a}	519.77 ± 4.79	1201.92 ± 9.11	2152.47 ± 9.42^{ab}	3449.73 ± 7.93^{b}	4245.95 ± 15.98^{b}
T_6	142.01 ± 1.62^{a}	530.80 ± 2.19	1212.70 ± 6.35	2105.27 ± 14.73^{a}	3431.91 ± 12.6^{b}	4268.40 ± 13.49^{b}

^{a,b}Means in the same column with no common superscript differ significantly (P ≤ 0.05)

Table 3: Effect of supplementing modified lignin on weekly cumulative feed conversion ratio (Mean ± SE) in broilers.

Experimental group	Weeks					
	I	II	III	IV	V	VI
T_1	1.104 ± 0.001	1.278 ± 0.001^{b}	1.454 ± 0.003^{b}	1.545 ± 0.015^{b}	1.787 ± 0.003^{b}	1.829 ± 0.001^{b}
T_2	1.105 ± 0.002	1.279 ± 0.018^{b}	1.461 ± 0.005^{b}	1.583 ± 0.011^{c}	1.844 ± 0.003^{c}	1.890 ± 0.003^{c}
T_3	1.104 ± 0.004	1.228 ± 0.002^{a}	1.408 ± 0.002^{a}	1.511 ± 0.003^{a}	1.712 ± 0.004^{a}	1.724 ± 0.003^{a}
T_4	1.107 ± 0.006	1.267 ± 0.003^{b}	1.456 ± 0.002^{b}	1.543 ± 0.01^{b}	1.783 ± 0.007^{b}	1.820 ± 0.005^{b}
T_5	1.102 ± 0.003	1.234 ± 0.003^{a}	1.402 ± 0.002^{a}	1.519 ± 0.003^{ab}	1.697 ± 0.01^{a}	1.726 ± 0.003^{a}
T_6	1.108 ± 000	1.288 ± 0.004^{b}	1.456 ± 0.003^{b}	1.546 ± 0.007^{b}	1.788 ± 0.005^{b}	1.823 ± 0.004^{b}

^{a,b,c}Means in the same column with no common superscript differ significantly (P ≤ 0.05)

Conclusion

Based on the results, it was concluded that the addition of 0.2 and 0.3% modified lignin to the basal diet improved growth performance in broilers. However, the supplementation of 0.2 and 0.3% modified lignin in reformulated diet showed similar results like that of control diet. Hence, it was concluded that supplementing 0.2% modified lignin in both control and reformulated diets (2% reduction in ME and CP) was beneficial in improving growth performance.

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