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Effects of turmeric addition to broiler starter on growth performance, nutrient digestibility, and production economics

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Abstract: The research aimed to assess how feeding broiler chicks' diets supplemented with turmeric meal affected their growth performance, nutrient digestibility, and production economics. A four-week feeding trial was conducted with 120 unsexed day-old Arbor Acres Plus broiler chicks, which were randomly assigned to four dietary groups, each containing three replicates of ten chicks. The dietary treatments included T1 (control), T2, T3, T4, and T5, with turmeric inclusion levels of 0%, 0.25%, 0.50%, 0.75%, and 1.0%, respectively. Data were gathered on growth performance, nutrient utilization, and production costs. Significant differences ($p<0.05$) were noted in average daily feed intake (ADFI), ranging from 37.64 to 52.22 g, and feed conversion ratio (FCR), varying from 1.98 to 2.61. However, dietary turmeric did not significantly impact nutrient utilization across the groups. The cost of feed per kilogram increased with higher inclusion levels, while T5 demonstrated the lowest feed cost per chick, as well as for feed cost per weight gain and total production cost. The study concluded that incorporating turmeric up to 1.0% in broiler diets significantly enhanced feed efficiency without adversely affecting nutrient utilization. Thus, using turmeric at this level is a beneficial strategy for optimizing production costs related to feed expenditure per weight gain.

Keywords: broiler chicks; phytogenic; turmeric; growth; digestibility; production cost

INTRODUCTION

The European Union's ban on the use of antimicrobial growth promoters in 2006, prompted the search for alternative growth enhancers that can support animal health and productivity. These alternatives are typically natural, less toxic, and residue-free, making them suitable feed additives in animal agriculture (Hashemi et al. 2008).

Feed additives are substances incorporated in small amounts into animal feed to improve its nutritional value, increase feed intake, and promote overall health, ultimately enhancing both productive and reproductive performance (Hashemi and Davoodi, 2010). Common examples of these additives include probiotics, prebiotics, enzymes, organic acids, and phytogenic compounds (Stanaćev et al. 2011).

While phytogenic feed additives may face challenges, such as variability in composition and lack of standardization, many herbs are both photo-stable and thermo-stable. Their biological benefits stem from specific chemical compounds that exert physiological effects in animals (Sunmola et al. 2023). Key bioactive components include alkaloids, tannins, flavonoids, saponins, and phenolic compounds (Hashemi and Davoodi, 2010). One notable phytogenic additive is turmeric (Curcuma longa).

Turmeric has long been recognized for its use as a spice and for its therapeutic properties (Tapsell et al. 2006). The root of turmeric contains several biologically active compounds with antioxidant, antimicrobial, and pharmacological effects (Sunmola et al. 2021). These compounds are particularly effective in preventing carcinogenesis by mitigating oxidative stress (Osawa et al. 1995).

Research has demonstrated the positive effects of turmeric in poultry production. For instance, Al-Kassie et al. (2011) found that adding a mixture of turmeric and cumin at 0.5 g/kg to broiler diets, resulted in increased body weight gain and improved feed conversion ratios. Similarly, Al-Sultan and Gameel (2004) highlighted turmeric's effectiveness in enhancing broiler performance, while Sunmola et al. (2022) noted that a 0.30% inclusion of turmeric positively affected feed conversion without adversely impacting nutrient utilization.

Despite several studies on turmeric's effects on broiler chickens, findings have been inconsistent. Thus, there is a pressing need to identify the optimal inclusion level of turmeric powder in poultry and livestock diets. This study aims to investigate the impact of turmeric meal supplementation on the growth performance, nutrient digestibility, and economic viability of broiler chicks.

MATERIALS AND METHODS

Experimental site

The research was carried out at the Poultry House, within the Livestock unit of the Teaching and Research Farm, at Joseph Sarwuan Tarka University in Makurdi, Benue State, Nigeria. Makurdi is situated at latitude of 7°44′N and a longitude of 80°21′E in the Guinea Savanna Zone of West Africa. The region experiences an annual rainy season lasting between six to eight months (from March to October), with rainfall varying from 508 to 1016 mm. Temperature averages range from a minimum of 22.8°C to a maximum of 40.0°C, and relative humidity levels fluctuate between 37.3% and 59.2% (Audu et al. 2022).

Purchasing and processing of turmeric

Fresh turmeric rhizomes were obtained from a local market in Makurdi, Benue State, Nigeria. The rhizomes were thoroughly washed with clean water to eliminate any foreign materials, such as soil and mold. They were then cut into smaller pieces using sharp knives. The chopped rhizomes were sun-dried on a clean, flat concrete surface for five days during February, which is part of the dry season, with temperatures ranging from 35°C to 40.03°C. After drying, the samples were ground into a fine powder (0.05 mm) using a Eurolex Mixer/Grinder model MG1153, a household blender, and stored in an airtight container for future chemical analysis and feed mixing purposes.

Management and disease control

The poultry house and all associated equipment were thoroughly cleaned and disinfected ten days prior to the chicks' arrival. Mold-free litter material, consisting of wood shavings, was placed in the experimental pen ahead of time, and the entire poultry house was fumigated to prevent contamination. To ensure a suitable environment, the pen was heated for 24 hours before the chicks arrived, maintaining a temperature of 85 to 90°F. The brooder temperature was adjusted based on the chicks' needs and behavior. The birds were kept in an intensive system and fed a specially formulated starter diet designed for the first four weeks. Feed and water were provided ad libitum throughout the duration of the trial.

Experimental design and diets formulation

One hundred and twenty (120) unsexed day-old Abor Acre Plus broiler chicks were sourced from a reputable hatchery in Ibadan, Oyo State, Nigeria. The chicks were weight-balanced and assigned to four dietary groups, each consisting of three replicates with ten birds per replicate, housed in deep litter compartments. The diets were isonitrogenous and isocaloric, formulated to meet the standard nutrient requirements for broiler chicks as outlined by the NRC (1994) for the starter phase (days 1 to 28), as detailed in Table 1. The diets were labeled T1 (control), T2, T3, T4, and T5, with respective inclusion levels of 0%, 0.25%, 0.50%, 0.75%, and 1.0%. A previous study by Sunmola et al. (2022) indicated improved performance of broiler chicks at a dietary turmeric inclusion level of up to 0.30%, which informed the levels used in this study.

Growth data collection

Data were collected weekly on feed intake, body weight, and weight gain. Feed intake was calculated by determining the difference between the amount of feed offered and the leftover feed at the end of each week. Weight gain was assessed as the change in the birds' weight over the 28-day period. The feed-to-weight gain ratio was calculated by dividing total feed intake by the total weight gain.

Production cost

The cost of feed per kilogram was determined by dividing the total cost of the ingredients used in feed preparation by the total weight of the feed in kilograms. The feed cost per unit of weight gain was calculated by multiplying the cost of feed per kilogram by the total feed intake and then dividing by the total weight gain. The feed cost per chick was calculated by multiplying the feed intake by the cost of feed per kilogram. The operational cost per bird was determined by summing all other expenses, excluding feed and broiler chick costs. The total production cost

Table 1. Gross composition of the experimental starter broiler diets

Ingredients (kg/100kg)	T1	T2	T3	T4	T5
Yellow maize	54.00	54.00	54.00	54.00	54.00
Soya bean meal	30.30	30.30	30.30	30.30	30.30
Groundnut cake	6.00	6.00	6.00	6.00	6.00
Rice bran	3.50	3.50	3.50	3.50	3.50
Bone meal	3.00	3.00	3.00	3.00	3.00
Blood meal	2.00	2.00	2.00	2.00	2.00
Palm oil	1.00	1.00	1.00	1.00	1.00
L-Lysine	0.15	0.15	0.15	0.15	0.15
Herbo-Methionine	0.20	0.20	0.20	0.20	0.20
Vitamin/mineral premix*	0.25	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Turmeric	0.00	0.25	0.50	0.75	1.00
Calculated analysis					
ME (Kcal/kg)	2914	2914	2941	2941	2941
Crude protein (%)	22.47	22.47	23.24	23.24	23.24
Crude fibre (%)	4.35	4.35	4.00	4.00	4.00
Ether extract (%)	4.66	4.66	4.83	4.83	4.83
Lysine (%)	1.49	1.49	1.48	1.48	1.48
Methionine (%)	0.58	0.58	0.54	0.54	0.54
Calcium (%)	1.32	1.32	1.29	1.29	1.29
Available Ph (%)	0.71	0.71	0.71	0.71	0.71

**To provide the following per kg of diet vitamin A – 15,000.00IU, Vitamin D3 - 3, 000,000IU, Vitamin E- 30,000IU, Vitamin K3,000mg, Vitamin B1 3000,mg Vitamin B2-6000mg, Vitamin B6- 5,000mg, Vitamin B12-40mg, Biotin 200mg, Niacin-40,000mg, Pantothenic acid 15,000mg, Folic acid 2,000mg, choline 300,000mg, Iron 60,000mg, manganese 80,000mg, copper 25,000mg, Zinc 80,000mg cobalt 150mg, Iodine 500mg. (feed formulation was done using the feedwin software application) ME – metabolizable energy; BDG - Brewer dried grain; Ph - Phosphorus* was calculated by adding the cost of the day-old chicks, the feed cost per chick, and the operational cost. Finally, the feed cost as a percentage of total production cost was calculated by dividing the cost of feed per kilogram by the total production cost and multiplying by one hundred.

Nutrient digestibility

Nutrient digestibility assessments were conducted at the conclusion of the third week and wrapped up by the end of the fourth week. For this purpose, two birds from each replicate were chosen and placed in metabolic cages. The birds underwent a three-day adaptation period, during which they received their specific diets. Daily feed intake and fecal output were recorded over four days. Feces were collected from each replicate once a day, weighed, and then dried in an oven at 70°C until a constant weight was achieved. The dried fecal matter was weighed, combined, and ground for each replicate. Both the experimental diets and fecal samples were analyzed for their proximate composition following the AOAC (2006) guidelines.

Statistical analysis

All collected data were analyzed using one-way Analysis of Variance (ANOVA) with the SAS (2018) software package. For parameters that showed significant differences ($p<0.05$), means were separated using Duncan's Multiple Range Test (DMRT).

RESULT

The study evaluated the effects of dietary turmeric meal on the growth performance of broiler chicks, as detailed in Table 2. All chicks started with a standardized initial body weight of 39.00 grams. The findings indicated that the average final body weight and average daily weight gain were not significantly impacted by the inclusion of turmeric in their diets. This suggests that turmeric, at the tested inclusion levels, does not adversely affect the overall growth rates of the birds. However, notable changes were observed in the average daily feed intake and feed conversion ratio due to the supplementation of turmeric. Specifically, a significant reduction in feed intake occurred with a turmeric inclusion of up to 1.0%. This decrease might imply that the chicks were more selective in their feeding when turmeric was part of their diet, potentially due to changes in flavor, or palatability introduced by the spice. Regarding the feed conversion ratio, which is a crucial metric in poultry production, indicating how efficiently feed is converted into body mass, the results showed that the ratio for chicks fed turmeric diets was comparable to the control group at inclusion levels up to 0.75%. However, at the 1.0% inclusion level, the feed conversion ratio improved, suggesting that this higher level of turmeric may have had beneficial effects on feed efficiency, allowing the birds to gain weight more effectively relative to their feed intake.

Table 3 further explores the effects of dietary turmeric meal on nutrient digestibility in broiler chicks. The analysis revealed that all parameters evaluated, such as digestibility coefficients remained statistically unchanged with turmeric inclusion levels up to 1.0 %. This finding indicates that turmeric does not negatively impact the digestibility of nutrients, which is essential for the overall health and growth of the birds.

The economic aspect of feeding turmeric meal to broiler chicks is presented in Table 4, where production costs are expressed in naira (₦). The cost of day-old chicks was uniform across all treatment groups, remaining constant at ₦750.00. When examining the feed cost per kilogram, it ranged from ₦521.90 to ₦556.90, with a noticeable increase in costs correlating with higher inclusion levels of turmeric. This suggests that while turmeric may have certain benefits, it also contributes to higher feed expenses at elevated levels. Furthermore, the analysis of feed cost per weight gain revealed a range from ₦1,104 to ₦1,392, with the most economical option being treatment T5 and the highest cost associated with treatment T2. This variability underscores the importance of selecting an optimal level of turmeric to balance both cost and performance. Additionally, the feed cost per bird and total production costs varied between ₦587 (T5) and ₦778.20 (T2) for individual costs, and from ₦1,417 (T5) to ₦1,608 (T2) for total production costs. These figures highlight the financial implications of dietary choices in broiler production, emphasizing the need for a careful evaluation of both growth performance and cost-effectiveness when considering turmeric as a dietary supplement.

DISCUSSION

The findings of this study highlight the significant effects of dietary turmeric meal on the growth performance and economic aspects of broiler chicks. Notably, the group receiving 1.0% turmeric (T5) exhibited a substantial decrease in average daily feed intake, while achieving a supe-

Table 2. Effect of dietary turmeric on growth performance of starter broiler chicks (28days old)

Parameters	T1	T2	T3	T4	T5	SEM	p-value
AIW	39.00	39.00	39.00	39.00	40.00	0.00	0.00
AFBW	673.02	598.21	588.89	586.39	570.00	15.56	0.20
ADWG	22.64	19.97	19.64	19.55	18.99	0.53	0.20
ADFI	52.22^{a}	52.37^{a}	42.50^{ab}	43.84^{ab}	37.64^{b}	2.04	0.05
FCR	2.31^{ab}	2.61^{a}	2.16^{ab}	2.24^{ab}	1.98^{b}	0.08	0.04

[ab]Means within each row with different superscripts are significantly different (P< 0.05). SEM = standard error of mean AIW = average initial weight; AFBW = average final body weight; ADWG = average daily weight gain; ADFI = average daily feed intake; FCR = feed conversion ratio; SEM = standard error of mean; T1= 0.0 % turmeric; T2= 0.25 % turmeric; T3= 0.50 % turmeric; T4= 0.75 % turmeric; T5 = 1. 0 % turmeric

Table 3. Effect of dietary turmeric on nutrient digestibility of starter broiler chicks (28days old)

Parameters	T1	T2	T3	T4	T5	SEM	p-value
DM	77.79	76.33	71.38	73.93	75.64	0.97	0.30
CP	65.61	66.33	53.72	60.75	62.69	1.68	0.09
CF	61.35	68.71	62.40\	73.12	65.41	1.58	0.08
EE	66.34	71.93	61.62	63.26	66.95	1.31	0.09
NFE	80.35	76.94	74.58	75.21	78.53	1.01	0.39

DM = Dry Matter; CP = Crude protein; CF = Crude Fibre; EE = Ether Extract; NFE = Nitrogen Free Extract

Table 4. Effect of dietary turmeric on production cost of broiler chicks (28days old)

Parameters	T1	T2	T3	T4	T5	SEM	p-value
C of DOC (₦)	750.00	750.00	750.00	750.00	750.00	-	-
FC/kg (₦)	521.90^{e}	530.70^{d}	539.40^{c}	548.20^{b}	556.90^{a}	3.30	0.07
FC/bird (₦/kg)	763.20^{b}	778.20^{a}	641.90^{d}	672.90^{c}	587.00^{e}	19.39	0.28
FC/WG (₦/kg)	1204^{c}	1392^{a}	1167^{d}	1229^{b}	1104^{e}	25.65	0.92
OPC (₦)	80.00	80.00	80.00	80.00	80.00	0.00	0.00
TPC (₦)	1593^{b}	1608^{a}	1472^{d}	1503^{c}	1417^{e}	19.39	0.92

DOC= Day old chicks; FC= feed cost; FC/WG= feed cost per weight gain; TPC= Total production cost; OP = Operational cost rior feed conversion ratio. This improvement can be attributed to the beneficial biochemical compounds found in turmeric, particularly flavonoids, which act as antioxidants. These compounds are known to enhance gut health by increasing digestive fluids, improving nutrient absorption, and neutralizing toxins within the gastrointestinal tract (Rajput et al. 2012). Sunmola and Tuleun (2023) noted that the improved feed conversion ratio observed in the turmeric-supplemented diets is likely due to the growth-promoting properties of turmeric, which inhibit the growth of pathogenic bacteria in the gastrointestinal tract. Such findings align with previous research indicating that turmeric can have a positive impact on gut flora, thereby promoting better health and growth in poultry. Emadi and Kermanshahi (2007) similarly reported enhanced performance in chickens fed diets supplemented with turmeric powder. Interestingly, the significant reduction in average daily feed intake observed in this study contrasts with the findings of Sunmola et al. (2022), who reported no significant effect on feed intake when broiler chicks were given diets containing turmeric powder at a maximum level of 0.30%. This discrepancy highlights the complexity of dietary influences on feed consumption and suggests that the effects of turmeric may vary based on inclusion levels and other dietary components.

Regarding weight gain and final body weight, the non-significant effects recorded in this study align with Sherif et al. (2022), who also found no significant differences in body weight among broiler chickens fed diets with added turmeric powder. However, Ekine et al. (2020) reported significant effects at inclusion levels of up to 0.75%, indicating that the impact of turmeric on growth metrics can be variable and may depend on the specific context of the study.

The lack of significant differences in nutrient utilization among the various dietary treatments suggests that turmeric does not negatively affect nutrient absorption. In fact, its bioactive compounds may stimulate digestive enzymes, thereby enhancing overall nutrient digestion. According to Platel and Srinivasan (2000), phytogenic compounds can improve the activity of digestive enzymes such as amylase, protease, and lipase, which are crucial for effective nutrient utilization. Turmeric has been shown to boost the activity of pancreatic and intestinal lipases, as well as disaccharidases like sucrose and maltase, contributing positively to gastrointestinal function - an essential mechanism for growth-promoting feed additives (Windisch et al. 2008).

The observed increase in feed cost per kilogram with higher turmeric inclusion levels can be attributed to the additional expense associated with the turmeric itself. Despite this, a decrease in feed cost per bird at inclusion levels above 0.25% (T2) indicates that the presence of turmeric improved feed acceptability among the birds compared to the control group. The lowest feed cost per weight gain at the 1.0% inclusion level (T5) further illustrates that these birds efficiently utilized the feed consumed, outperforming those in other dietary groups.

Moreover, the findings align with observations made by Sunmola et al. (2023), who noted similar trends with increased feed costs per kilogram and reduced feed costs per weight gain as inclusion levels of both white and yellow ginger increased. The decreased total cost of production at inclusion levels above 0.25% (T2) relative to the control can be attributed to the linear increase in feed consumption, highlighting the economic benefits of turmeric supplementation.

CONCLUSION

While turmeric meal did not significantly impact growth metrics, it influenced feed intake and conversion efficiency, and its economic implications warrant consideration for poultry producers. Therefore, supplementation of dietary turmeric up to 1.0 % of the total diet is recommended.

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