Impact of turmeric rhizome powder (*Curcuma longa* Linn) on the growth performance and economic indices of broiler chickens

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Abstract

Recent ban on antibiotics has necessitated the use of alternatives in phytobiotics such as turmeric. A total of 120 Ross 308 strain of broiler chickens were divided into four treatment groups, which were further replicated three times with 10 birds each per replicate in a Completely Randomized Experimental Design. The experimental groups were made up of the birds fed turmeric rhizome powder (TRP) at 0, 200, 400 and 600g/100kg of feed for treatments 1, 2, 3 and 4, respectively. The experiment lasted 8 weeks, during which data on weight gain, feed efficiency and cost efficiency were collected. Analysis of Variance (ANOVA) was adopted to detect significant differences in the treatment means while post hoc analysis using Duncan Multiple Range Test further differentiated the means. The results revealed that the birds on T3 diets (400g TRP) exhibited the highest weight gain (1508.33g), demonstrating the potential of TRP supplementation at that level of inclusion to enhance broiler growth performance. Furthermore, the cost analysis reveals that the cost per kilogram weight gain was least in the treatment fed 400g of TRP (₦959.00). Equally, the revenue and the gross margin was also highest in the treatment fed 400g of TRP (₦1885.00, ₦439.00). In contrast, exceeding 400g level of supplementation, as observed in the T4 group (600g TRP), led to an increase in production costs without any proportional improvement in body weight gain.

Keywords: broilers, additives, turmeric, curcumin and broiler economics.

Impact de la poudre de rhizome de curcuma (*Curcuma longa Linn*) sur la performance de croissance et les indices économiques des poulets de chair

Résumé

L'interdiction récente des antibiotiques a nécessité l'utilisation d'alternatives dans les phytobiotiques, tels que le curcuma. Un total de 120 poulets de chair de la souche Ross 308 a été divisé en quatre groupes de traitement, lesquels ont été reproduits trois fois avec 10 oiseaux par réplique dans un plan expérimental complètement randomisé. Les groupes expérimentaux étaient constitués des oiseaux nourris avec de la poudre de rhizome de curcuma (PRC) à des doses de 0, 200, 400 et 600g/100kg d'aliment pour les traitements 1, 2, 3 et 4, respectivement. L'expérience a duré 8 semaines, durant lesquelles des données sur le gain de poids, l'efficacité alimentaire et l'efficacité des coûts ont été collectées. Une analyse de variance (ANOVA) a été adoptée pour détecter les différences significatives entre les moyennes des traitements, tandis qu'une analyse post hoc utilisant le test de Duncan a permis de différencier davantage les moyennes. Les résultats ont révélé que les oiseaux du groupe T3 (400g de PRC) ont montré le plus grand gain de poids (1508,33g), démontrant le potentiel de la supplémentation en PRC à ce niveau d'inclusion pour améliorer la performance de croissance des poulets de chair. De plus, l'analyse des coûts révèle que le coût par kilogramme de gain de poids était le plus bas dans le traitement nourri avec 400g de PRC (₦ 959,00). De même, les revenus et la marge brute étaient également les plus élevés dans le traitement nourri avec 400g de PRC (₦ 1885,00, N439,00). En revanche, dépasser le niveau de 400g de supplémentation, comme observé dans le groupe T4 (600g de PRC), a conduit à une augmentation des coûts de production sans amélioration proportionnelle du gain de poids corporel.

Mots-clés : poulets de chair, additifs, curcuma, curcumine, et économie des poulets de chair.

Introduction

High population growth and urbanization is driving the demand for meat and other high protein foods of animal origin in Nigeria and the rest of the developing world. As a means of achieving sufficient protein intake, broiler meat remains one of the chief sources that Nigerians rely on because of its availability as well as its popularity as a component of the menu of the generality of the populace (Anyanwu *et al.*, 2015). The poultry industry value chain in Nigeria had experienced a boom in recent time but currently challenged by several factors including cost of production (Mondal *et al.*, 2015). Average feed prices have at least doubled within the last one-year and a half, which has not only put many farmers out of business but has also reduced profit margins considerably for the resilient ones (Ettah *et al.*, 2021). High feed costs are driven by many factors; notable amongst them is the reduced supply of major conventional feed ingredients such as maize and soya bean due to insecurity and insurgency ravaging the major grain producing areas of northeast and north central Nigeria (Anyanwu *et al.*, 2015). In these areas, farmers are unable to access their farms, as a result, there appears to be more industrial demand for the little quantity of grains and pulses available (Ettah *et al.*, 2021). Consequently, the high cost of feed has necessitated the need for research to discover alternative feed ingredients and for discovering means of improving the feed conversion ratio. This has led to the emergence of numerous unconventional feedstuff and increased demand for organic feed additives in the market, in the form of probiotics, antibiotics and growth promoters. Growth promoters are chemical and biological substances, which are added to livestock feeds to improve feed utilization and growth for better production and financial results (Mondal *et al.*, 2015). Their mode of action could be through improved appetite, improved feed conversion, stimulation of the immune system and increased vitality (Malik *et al*., 2022).

Under intensive chicken production systems, feed additives and or growth promoters are often used to suppress or eliminate harmful microorganisms in the intestines and to improve performance. However, synthetic growth promoters and hormones have disadvantages of high cost, adverse side effects on health of birds and residues in meat and development of antibiotic resistance in microbes (Mondal *et al.*, 2015). In view of the recent increase in the demand for organically produced food free from antibiotics, research on the use of natural plant ingredients to replace the synthetic products has received more attention. Alternative substances and strategies for animal growth promotion and disease prevention have been and are being investigated. Some phytogenic and herbal products which have received high acceptability among consumers in recent times have been targeted (Nouzarian *et al.*, 2011).

Amongst these lists of natural supplements capable of eliciting physiological responses when added to the broiler diets, include members of the Zingiberaceae family such as ginger and turmeric. Other researchers have reported on other additives such as *Moringa oleifera* (Anyanwu *et al.*, 2020), garlic, and scent leaf (Odoemelam *et al.*, 2017). Turmeric (*Curcuma longa*) is a food spice used mainly for its human nutritional and medicinal potentials. It is a rhizomatous herbaceous perennial plant of the Zingiberaceae family and has its native origin in southeastern India where it is known as golden spice of India and has a very long history of medicinal use, dating back nearly 4000 years (Akaberi *et al.*, 2021). Turmeric is used not only as a principal spice but also as a component in religious ceremonies (Samarasinghe *et al.*, 2003). Its brilliant yellow colour gives it the name. "Indian saffron." (Prasad and Aggrawal, 2011). According to Prasad and Aggrawal (2011), India

is the largest producer of turmeric and supplies 94% of the world's demand. The main active substance of turmeric extract is identified as curcumin, a strong antioxidant and a peptide named turmerin (Samarasinghe *et al.,* 2003). Turmeric has been shown to have several biological effects in humans, exhibiting anti-inflammatory (Holt *et al.,* 2005), antioxidant (Iqbal *et al.,* 2003) and hypolipidaemic (Ramirez-Tortosa *et al.,* 1999) activities. It has also been suggested that turmeric possess hepato-protective, anti-tumor, antiviral and anticancer activities (Polasa *et al.,* 1991). Reports also exist indicating that it has been used for the treatment of gastrointestinal and respiratory disorders in humans (Anwarul *et al.,* 2005). However, its effect on broiler chickens up to 600g/kg diet inclusion in the diet has not been widely reported. It is in the light of these physiological effects and economic importance of turmeric (*Curcuma longa*), that this study was conducted to evaluate the performance of raw powder turmeric (*Curcuma longa*) rhizome supplemented diet meal on broiler chickens.

Materials and Methods

Experimental site

The experiment was carried out at the Animal Unit of the University of Uyo Teaching and Research Farm. The area falls within the tropical rainforest zone of Nigeria, with two distinct seasons, rainy season (March – Mid November) and dry season (November - March) it has an average rainfall of 2200mm to 3500mm. The temperature of the area ranges from 26℃ to 28℃(University of Uyo Meteorological station, 2018).

Procurement and processing of Experimental Materials

Turmeric rhizomes were purchased from a vendor in a local market in Uyo metropolis. The rhizomes were washed, peeled and slice into smaller sizes and washed and then sun dried until constant weight was attained not more than seven days. When they were dried enough, the rhizomes were ground into fine powder using mechanical blenders. The powder was then stored in tightly sealed containers.

Experimental birds and Management

A total of 120 unsexed Ross 308 broiler strain day old chicks were used for the experiment. The experimental birds were purchased from a vendor in Uyo Metropolis. The birds were managed in a deep litter system with wood shavings as the litter material during the brooding and rearing phases. The experiment lasted for 56 days. Water and feed were provided for the experimental birds *ad libitum*. The birds were fed daily during the early hours of the day and in the evening while leftovers were weighed every day to ascertain the daily feed intake of each replicate. Routine vaccination and drugs were administered.

Experimental Diet

Four experimental broiler diets were formulated for the whole period of the experiment. The diets were formulated with the supplementation of Turmeric rhizome Powder (TRP) that was locally prepared and included in the diets at different levels. Treatment 1 representing the control had no TRP while T2, T3, and T4 contained 200, 400 and 600g/100kg of the formulated feed respectively. The other feed ingredients were adjusted to meet the nutrient requirement of the broilers at all the ages of the experiment. The comprehensive ingredient composition and the calculated chemical composition of the formulated diets are presented in Table 1.

Table 1: Composition of experimental diets (Straight diet) containing varying levels of turmeric rhizome powder

Ingredients	T_1 (0g)	T_2 (200g)	T_3 (400g)	T_4 (600g)
Maize	52.00	52.00	52.00	52.00
Full fat soya	20.00	20.00	20.00	20.00

Groundnut cake	11.00	11.00	11.00	11.00
Fish meal	3.00	3.00	3.00	3.00
Wheat offals	5.20	5.20	5.20	6.20
Palm kernel meal	5.00	5.00	5.00	5.00
Bone meal	3.00	3.00	3.00	3.00
Common Salt	0.25	0.25	0.25	0.25
Vitamin /mineral premix	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20
Methionine	0.10	0.10	0.10	0.10
Turmeric rhizone powder	0.00	0.02	0.04	0.06
Total	**100.00**	**100.0**	**100.0**	**100.0**
Calculated Analysis				
Crude protein (%)	22.13	22.13	22.13	22.13
Metabolizable Energy ME (kcal/kg)	2985.2	2985.22	2985.22	2985.22
Crude fat (%)	26.85	6.85	6.85	6.85
Crude fibre (%)	3.76	3.76	3.76	3.76
Calcium (%)	1.10	1.10	1.10	1.10
Phosphorus (%)	0.45	0.45	0.45	0.45

Vitamin premix = vitamin A, D_3, E,K, B_1, B_2,B_6, B_{12}, Nacin, Pantotenic acid, Folic acid, Biotin, Choline Chloride, Manganese, Zinc, iron, Copper, iodine, selenium, cobalt and antioxidants.

Experimental birds and Design

A total of 120 unsexed Ross 308 broiler strain were used for the experiment. The experimental birds were purchased from a vendor in Uyo Metropolis. The birds were managed in a deep litter system with wood shavings as the litter material during the brooding and rearing phases. The experiment lasted for 56 days. The chicks were randomly divided into four (4) treatment groups (T1, T2, T3, and T4), with thirty (30) birds each per treatment. Each of the four treatments was further divided into three replicates with ten (10) per replicate and the birds were randomly assigned to each of the formulated diets in a Completely Randomized Design (CRD).

Data Collection

The data collected for these experiments were initial weight, total feed intake, daily feed intake, daily weight gain, final weight and FCR. The experimental birds were fed ad libitum on daily basis. Daily feed intake was calculated by subtracting the daily leftover from the quantity of feed given the previous day. The total feed intake therefore was calculated by summing all the daily feed intake from the first to the last day of the experiment. On the first day of the experiment, the initial weight of the experimental birds was taken by weighing them individually according to their replicates. This same process was carried out weekly to obtain their weekly weight and weekly weight gain. On the last day of the experiment, the final weight of the experimental birds was recorded, and total weight gain was obtained by subtracting the initial weight from the final weight.

Feed conversion ratio is the measure of the ratio of the total feed intake that was used by the chicken to gain weight. It was calculated by dividing the total feed intake by the total weight gained by the chicken. Where:

$$\text{FCR} = \frac{\text{Total feed intake}}{\text{Total weight gain}}$$

The data for analysis of cost for this experiment was obtained using standard economic principles. The following data were collected: cost of feed consumed, cost/kg weight gain, total cost of

production, revenue, and gross margin. The cost of feed consumed per chicken was calculated by calculating the total cost of the total feed intake per chicken for all the replicates and treatments.
The cost per kilogram weight was obtained by dividing the cost of production per chicken by the total weight gain in kilogram.

$$\text{Cost per Kilogram Weight Gain} = \frac{\text{Total Production Cost}}{\text{Weight Gain}}$$

Revenue was calculated by multiplying the price per kilogram of chicken by the quantity of chicken produced.
The gross margin was calculated by subtracting the cost of producing the broiler chicken from the revenue generated from the sales of the broiler chickens.

Data Analysis

Data generated from the experiment were subjected to analysis of variance (ANOVA) according to Steel and Torrie (1980). ANOVA detected the treatment effects while means were separated using the Duncan Multiple Range Test.

Results and Discussion

Effect of dietary supplementation of TRP on the growth performance of broiler chickens.

The effect of supplementing broiler diets with turmeric rhizome powder (TRP) on their growth performance is presented in Table 2. The table shows that TRP supplementation on broiler diets had a significant effect ($P<0.05$) on the growth parameters measured beginning from initial weight up to the FCR except feed intake. The findings showed that weight gain for the chickens diet with 400g/kg supplementation with turmeric powder recorded the highest weight gain (1508.33g), followed by the T2 (200g) group (1390.92g), the T1 (control) group (1375.00g). However, those on T4 (600g) group recorded the lowest weight gain (1225.00g). While the highest weight was recorded in T3, it was statistically different ($p<0.05$) from the T4 but was statistically similar ($p>0.05$) with those of the T1 and T2.
Equally, the same trend was observed in the daily weight gain of the broiler chickens where the T3 (400g) group was also the highest (35.91g), followed by the T2 (200g) group (33.12g), the T1 (control) group (32.74g), and then the T4 (600g) group (29.16g). Just like in total and daily weight gain, the final weight gain of the experimental birds was found to also be highest in T3 which is significantly different from T4 but was similar to T1 and T2.
The feed conversion ratio (FCR) is a measure of how much a bird converts the consumed feed into flesh and in this present study, the best FCR (1.92), was recorded in the broiler chickens in the T3 (400g) group followed by the T2 (200g) group (2.01), the T1 (control) group (2.18), and the T4 (600g) group (2.43). The difference that existed between the groups in the FCR also follows the trend which is reported in the daily, total weight and final weight. The T3 was highest and statistically different ($p<0.05$) from T4 but was statistically similar ($p>0.05$) to T1 and T2.
Findings from this study suggests that supplementing broiler chicken diets with turmeric rhizome powder at a level up to 400g/100kg can improve their growth performance and feed utilization. From these figures, it can be inferred that feeding TRP as a dietary supplement to broilers is a beneficial practice that can be adopted in practical farming and chicken production. However, the study also showed that feeding TRP beyond this threshold of 400g/100kg was not beneficial probably due to high concentrations of the additive not exerting a positive effects on growth performance.
The positive outcome achieved in this study is similar to the outcomes observed by Samarasinghe *et al.* (2003); Riasi *et al.* (2012); Hussien (2013); Kafi *et al.* (2017); Guil-Guererro *et al.* (2017); and Oke (2018) except that some reported an optimal ratio of supplementation that are higher than 400g/100kg of feed. In the study of Samarasinghe *et al.*, (2003), two bioassays

were conducted to assess the effectiveness of turmeric root powder and mannan-oligosaccharides (MOS) as antibiotic alternatives for broilers, and it was found turmeric (1g/kg) in the first trial generally improved broiler weight gain by 5.3%, In the second trial, it also significantly increased weight gain by 15.1%, respectively. In another study where ginger and turmeric powders were fed to broiler chickens at the rate of 0.50% and 0.75% of the diet, respectively, both were found to exert positive impact on the weight gain and FCR conversion Ratio, however, garlic was reported to have performed better than the turmeric (Kafi *et al.*, 2017).

Riasi *et al.* (2012), also found that turmeric rhizome powder improved the Feed Conversion Ratio of older laying hens, supplementing broiler diets with 7 g/kg of Turmeric powder have also positively influenced growth performance, reduced abdominal fat, and lowered serum cholesterol and triglyceride levels in broiler chickens (Hussien, 2013). This study differs from the present study because 7 g/kg is higher than the 4 g/kg which we found optimal.

The positive effect of turmeric rhizome powder on the physiological responses of broiler chickens was also consistent in the study of Oke (2018), as the supplementation of 8g turmeric per kilogram of diet was found to improve the final weight, weight gain and feed conversion ratio, all of which are key indices of a broiler's performance. But once again this study differs from our findings as the amount which Oke (2018) reported to be optimal is double of ours and higher than 600/100kg which had a negative impact in our present study.

Table 2: Growth Performance of broiler chickens fed diets supplemented with TRP

Parameters	T1 (Control)	T2 (200g)	T3 (400g)	T4 (600g)	SEM
Initial Weight (g/bird)	30.83	27.57	29.17	27.30	5.60
Daily Feed intake (g/bird)	71.68	65.88	69.02	70.89	2.80
Total weight gain (g/bird)	1375.00^{ab}	1390.92^{ab}	1508.33^{a}	1225.00^{b}	64.66
Daily weight gain (g/bird)	32.74^{ab}	33.12^{ab}	35.91^{a}	29.16^{b}	1.54
Final Weight (g/bird)	1683.33^{ab}	1666.67^{ab}	1800.00^{a}	1583.33^{b}	64.55
Feed conversion ratio	2.18^{ab}	2.01^{ab}	1.92^{b}	2.43^{a}	0.13

^{ab} Means with different letters on the same row are significantly different from each other.

Cost of producing broiler chickens fed diets supplemented with Levels of TRP

The result for the analysis of the cost of production for this study is presented in Table 3. The result from this study, showed that supplementing broiler diets with graded levels of turmeric rhizome powder had a significant effect ($P<0.05$) on the cost of producing broiler chicken as well as on the revenue and gross margin generated from the production. The result showed that the control; T1 (0g) had the highest cost per kilogram weight gain (N1013.00), while T2 (200g) and T3 (400g) had the lowest cost per kilogram weight gain (N960.00 and N959.00, respectively) while T4 (600g) had a higher cost per kilogram weight gain than T2 and T3, but it was still lower than T1.

In the analysis for Gross margin, TRP had a significant effect ($P<0.05$), and it was found that T3 (400g) had the highest gross margin

(N439.00), followed by T2 (200g) with N413.00, and T1 (0g) with N337.00. However, it was found that T4 (600g) had the lowest gross margin (N127.00). Additionally, the data for the revenue generated revealed a significant effect ($P<0.05$) of supplementing broiler diets with TRP. It was found that T3 (400g) had the highest revenue (N1885.00), followed by T2 (200g) with N1739.00, and T1 (0g) with N1719.00. Equally, just like in the gross margin, the T4 (600g) also generated the lowest revenue N1531.00).

From these figures, it can be inferred that feeding TRP as a dietary supplement to broilers is a beneficial practice that can be adopted in practical farming and chicken production. However, the study also showed that feeding TRP beyond a certain threshold may instill a negative economic impact. In this case, it was shown that 600g of TRP per 100kg of feeds does more economic harm than good to a farmer whose main aim is to maximize profit.

Scholarly, there is scarcity of literature that have studied the economic impact of turmeric rhizome powder supplementation on broiler production, but our study agreed to those of Kafi *et al.* (2017) who found that turmeric supplementation at 0.75% improved the economic viability of broiler chicken as well as their growth performance. Given that the growth performance and physiologic performance of broilers correlates positively with their profitability, this study agrees with some past literature including Oke (2018) who found that TRP positively influences the physiological response and growth performance of broiler chickens. In a similar study conducted by Hussein *et al.* (2013), it was found that growth performance of broilers was higher in birds fed 7g TRP per kilogram feed.

Table 3: Cost analysis of producing chickens fed diets supplemented with TRP

Parameters	T1 (0g)	T2 (200g)	T3 (400g)	T4 (600g)	SEM
Cost per kg feed (₦)	459.11	479.11	499.11	519.11	60.11
Cost per kg weight gain (₦)	1013.00^{ab}	960.00^{b}	959.00^{b}	1146^{a}	50.40
Cost of feed consumed (₦)	1382.00	1325.00	1447.00	1404.00	35.50
Cost of Production (₦)	1382.00	1325.00	1447.00	1404.00	35.50
Gross Margin (₦)	337.00^{ab}	413.00^{a}	439.00^{a}	127.00^{b}	82.60
Revenue (₦)	1719.00^{ab}	1739.00^{ab}	1885.00^{a}	1531.00^{b}	80.80

^{ab} Means with different letters on the same row are significantly different from each other. FCR = Feed Conversion Ratio

Conclusion

Supplementing broiler diet with turmeric rhizome powder (TRP) improved their growth and feed efficiency, especially at a level of 400 grams per 100kg of feed. This amount of TRP also reduced production costs and increased profits, but higher levels had negative economic effects.

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