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RESPONSE OF BROILER CHICKENS TO DIETS CONTAINING VARYING MIXTURES OF BLACK PEPPER AND TURMERIC AS PHYTOGENIC FEED ADDITIVES

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ABSTRACT

This study investigated the effect of diets containing mixtures of black pepper and turmeric (phytogenic feed additives) on the performance of broiler chickens. Two hundred and forty Ross 308 broiler chicks were randomly assigned to four treatments with five replicates in a completely randomised design. Treatment 1 was the control diet without spices. Treatment 2 contained 0.075 % black pepper plus 0.225 % turmeric, Treatment 3 contained 0.150 % black pepper and 0.150 % turmeric, while Treatment 4 contained 0.225 % black pepper and 0.075 % turmeric. All diets were isocaloric and isonitrogenous. Phytochemical analysis revealed that turmeric contained higher levels of bioactive compounds, including flavonoids (16.80 %), tannins (30.05 mg/100 g), total phenols (25.30 %), and alkaloids (25.43 %), compared to black pepper. Conversely, black pepper contained higher concentrations of anti-nutritional factors, including oxalate (28.60 %) and phytate (162.25 mg/100 g). Saponin and cyanide levels were low in both spices. Growth performance evaluation revealed that treatments significantly affected only feed intake ($p \leq 0.05$), while other growth parameters were not. Apparent nutrient digestibility showed significant ($p \leq 0.05$) differences across treatments, except for ether extract. Carcass characteristics and internal organ weights were unaffected, except for wing yield, which differed significantly ($p \leq 0.05$). Meat quality parameters were significantly ($p \leq 0.05$) affected, except for meat pH ($p > 0.05$). Most meat organoleptic attributes were not significantly ($p > 0.05$) influenced by treatments, except for meat flavour and tenderness. Based on these findings, adding 0.150 % black pepper and 0.150 % turmeric (Treatment 3) to broiler diets is recommended, as it produced the most favourable overall outcomes.

Keywords: Black pepper, Broiler chickens, Phytogenic feed additives, Turmeric

INTRODUCTION

Nigeria is abundant in herbs, spices, and numerous medicinal plants possessing beneficial pharmacological properties yet to be exploited scientifically in poultry nutrition (Obakanurhe and Unukevwere, 2018). Therefore, it is a matter of great interest to research some of our indigenous spices, medicinal plants or herbs as growth promoters in poultry diets. Herbal agents could serve as safer alternatives as growth stimulants due to their suitability and preference, lower production cost, reduced toxicity risks and minimum health hazards. Interestingly, recent biological trials of specific herbal formulations as growth promoters have shown encouraging results. Some reports have demonstrated improvement in weight gain, feed efficiency, lowered mortality, increased immunity and increased life ability in poultry birds (Kumar, 1991).

However, for this research, the phytogenic feed additives used in broiler chicken diets are turmeric (*Curcuma longa*) and black pepper (*Piper guineense*). Turmeric is a natural plant material (yellow spice). Turmeric is a tropical medicinal herb prized for its antioxidant, antifungal, immunomodulatory, and antimutagenic qualities (Nisar *et al.,* 2015). According to Phan *et al*. (2001), the prominent yellow colour of turmeric arises from the bioactive compound curcumin, comprising three primary curcuminoid compounds: curcumin I, curcumin II, and curcumin III. About 8 % of curcumin is present in the dried root portion of turmeric (Ruby *et al*., 2010). For these reasons, they are best used as dietary supplements in animal feed. Using black pepper (*Piper guineense*) as a feed additive in broiler production will likely provide a natural and effective method for promoting growth (Aikpitanyi *et al.,* 2019). Its bioactive compounds, particularly piperine, enhance digestive efficiency, nutrient absorption, and immune function. These benefits lead to improved growth performance and overall health in broilers, making black pepper a promising alternative to synthetic growth promoters in the poultry industry (Platel and Srinivasan, 2000; Alagawany *et al*., 2017). Black pepper and turmeric are readily available, and they have several beneficial properties and may be capable of boosting poultry production. This research aimed to assess the potential of using photobiotic (black pepper and turmeric) as natural feed additives to improve nutrient digestibility and utilisation and stimulate growth performance.

METHODOLOGY

Experimental location

The research was conducted at the Poultry Research Farm of the Federal University of Technology Minna, Niger State. Minna is between latitude 90° 37’, North and longitude 6° 33’, East of the equator. Minna has a mean annual rainfall of 1,200 mm, with the average highest temperature in March and the lowest in August. The mean annual temperature is between 22 °C and 40 °C. Minna is in Nigeria's Southern Guinea Savanna vegetation belt and has two distinct seasons: wet season from March to October and dry season from November to March (Weather Spark, 2019).

Source of experimental birds and test material

Fresh turmeric rhizomes were purchased from the Kure ultra-modern market in Minna, Niger State. The turmeric rhizomes were thoroughly washed with clean water, sliced into pieces, and sun-dried for four days. After drying, they were ground using a blender. Dried black pepper was procured from Kafin Koro Market in Niger State. The black pepper was ground using a blender.

One-day-old Ross 308 broiler chicks used for this experiment were procured from Agritech Farm Limited, Ibadan, Oyo State.

Laboratory analyses

Proximate analyses

Proximate analysis of the spices and the experimental diets was carried out according to the methods described by AOAC (2006). This involved determining the moisture content, crude protein, crude fibre, ether extract, and ash, while nitrogen-free extracts were calculated by difference.

Phytochemical analyses

Phytochemical analyses of the spices were conducted as outlined.

Alkaloids: the total content of alkaloids was determined according to the method described by Biradar and Racheti (2013) with minor modifications.

Phytate was determined using the method Yahaya *et al*. (2013) outlined.

Flavonoids: content of the test ingredients was carried out by the method of Krishnaiah *et al*. (2009).

Tannin: The tannin content of the samples was determined using the procedure of AOAC (1980).

Cyanogenetic glycosides (cyanide) were analysed by the alkaline titration method as described by AOAC (2006).

Saponin: total saponin content (per cent yield) was determined by the gravimetric method as described by Kaur *et al*. (2015).

Oxalate: The titration method described by Mishra *et al*. (2017) was used in the determination of the oxalate content of samples.

Phenols: the estimation of total phenols in the samples was analysed according to the method of Santhi and Sengottuvel (2016) with slight modifications.

Determination of antioxidant activity of test samples using the free radical scavenging assay

In the determination of the antioxidant activity of the photobiotic, 2, 2-diphenyl-1. Picrylhydrazyl (DPPH) was used as the standard free radical according to the method outlined by Mukherjee *et al*. (2011) with minor modifications, Ascorbic acid (vitamin C) was used as the standard control antioxidant.

Experimental birds and the experimental design

The experiment was carried out for 8 weeks using two hundred and forty (240) Ross 308 one-day-old broiler chicks. The experiment used two indigenous and locally available spices: black pepper and turmeric. These spices were used in various combinations. Treatment 1 was the control without the black pepper and turmeric. Treatment 2 was a diet containing 0.075 % black pepper plus 0.225 % turmeric. Treatment 3 was a diet containing a combination of 0.150 % black pepper and 0.150 % turmeric, and Treatment 4 was a diet containing a combination of 0.225 % black pepper and 0.075 % turmeric. The diets formulated were isocaloric and isonitrogenous (Table 1). The birds were weighed and randomly allocated to 4 treatments, replicated 5 times, with 12 birds per replicate using the Completely Randomised Design model. Feed intake was measured daily, while birds were weighed weekly. At the end of the eighth week of the feeding trial, an evaluation of carcass characteristics, internal organ weights, meat quality and organoleptic assessment of broiler chicken meat was conducted. The single-phase feeding regime was used during the experiment.

Table 1: Composition of Experimental Diets

Ingredients (%)	**(T1)**	**(T2)**	**(T3)**	**(T4)**
Maize	45.85	45.85	45.85	45.85
Soybeans (full fat)	40.00	40.00	40.00	40.00
Maize offal	6.00	5.70	5.70	5.70
Black pepper	0.00	0.075	0.15	0.225
Turmeric	0.00	0.225	0.15	0.075
Fish meal	4.00	4.00	4.00	4.00
Bone meal	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
*Vitamin/mineral premix	0.25	0.25	0.25	0.25
Toxin binder	0.15	0.15	0.15	0.15
Total	100	100	100	100
Calculated				
Phosphorus (available) %	0.51	0.51	0.50	0.50
Calcium %	1.19	1.20	1.20	1.20
Crude fibre %	4.38	4.36	4.35	4.33
Crude protein %	22.42	22.41	22.41	22.42
ME (kcal /kg)	3044.22	3042.69	3042.15	3041.62
Proximate Analysis (%)				
Crude protein	22.44	22.00	22.06	21.60
Crude fibre	5.52	5.10	6.42	5.77
Ash	8.99	8.25	7.08	7.97
Ether extract	4.11	5.79	4.71	4.72
Nitrogen-free extract	52.24	51.67	54.17	53.11
Moisture	6.70	7.19	5.56	6.83

ME= Metabolizable energy

*Supplied per 1kg diet is the following:-Vitamin A (30,000.00 IU), Vitamin D3 (6,000.00 IU), Vitamin E (30.00 IU), vitamin K (2.00mg), Vitamin B2 (5.00mg), Vitamin C (20.00mg), Niacin (40.00mg), Pantothenic Acid (12.00mg), Vitamin B6 (1.50mg), Vitamin B12 (10.00mg), Folic acid (1.00mg), Biotin (0.40mg), Choline Chloride (300.00mg), Cobalt (0.20mg), Copper (1.20mg), Iodine (20.00mg), Iron (40.00mg), Manganese (100.00mg), Selenium (1.50mg), Zinc (30.00mg).

Management of the experimental birds

Experimental birds were raised on deep litter. The pens were washed and disinfected. Drinkers and feeders were thoroughly cleaned and made ready for use. Before the arrival of the birds, wood shavings were spread on the floor; a heat source was made available for brooding the chicks, and a foot dip was provided at the entrance of the poultry house. On arrival of the chicks, they were weighed to obtain their initial weights, after which the chicks were randomly distributed to the various treatment groups. The birds were vaccinated against the prevailing diseases; the first dose of the Gumboro vaccine was administered at week one against the Gumboro disease, and at week two, the first dose of the Lasota vaccine was administered to the birds against Newcastle disease. When the birds were three weeks old, the second dose of Gumboro vaccine was given. The last dose of the Lasota vaccine was administered in the fourth week.

Apparent nutrient digestibility trial

An apparent nutrient digestibility trial was conducted. One bird was taken from each replicate group between the 7th and 8th weeks. The birds were housed in metabolic cages for a week adjustment period before faecal collection. Daily faeces was collected separately from each replicate for seven days. The faecal samples from each treatment group were bulked, oven-dried, weighed, and analysed for proximate analysis as recommended by AOAC (2005).

Evaluation of carcass characteristics and internal organ weights of broiler chickens

At the end of the eighth week of the experiment, five birds from each treatment were slaughtered to evaluate carcass characteristics and measurements of the internal organs. The birds were fasted overnight to ensure gut clearance but were provided with *ad libitum* access to water. The slaughtering of broilers was done by cutting the jugular vein.

Meat quality evaluation

The pH of the cold carcass was determined using a pH meter. The water-holding capacity was measured according to the procedures described by Kauffman *et al*. (1992). The difference between the pre- and post-cooked weight was the cooking loss. The cooking yield percentage was calculated as: Cooking yield% % = (Cooked weight/ Thawed weight) × 100

Sensory evaluation of broiler meat

The frozen meat samples of the broiler breast portion were thawed at room temperature for sensory evaluation. The meat samples were cut into smaller pieces according to their treatments and replicates. The meat samples were boiled in a pot containing 150 ml of water for ten minutes, and one gram of salt was added. Thirty semi-trained taste panellists from the Federal University of Technology, Minna Gidan Kwano Campus community were used for the meat sensory evaluation. The evaluation was performed according to the method Grunert *et al*. (2004) described, using a 9-point hedonic scale. The meat samples were evaluated for sensory attributes such as colour, appearance, juiciness, tenderness, taste, aroma, texture and overall acceptability. After every evaluation, oral rinsing with water was mandatory for the panellist to prevent flavour carryover between samples.

RESULTS AND DISCUSSION

Proximate composition of black pepper and turmeric

Table 2 shows the proximate composition of the black pepper and turmeric used as feed additives. The analysis revealed distinct nutritional profiles for each spice. Turmeric was observed to have a higher content of crude protein (13.29 %), ash (11.88 %), and moisture (4.20 %) compared to black pepper. Conversely, black pepper contained considerably more crude fat (12.18 %) and slightly more crude fibre (10.73 %) and nitrogen-free extract (56.08%). The high percentage of nitrogen-free extract in both spices indicates they are rich in carbohydrates, which serve as an energy source. Black pepper in this study had a higher fat content (12.18%), suggesting it is a potential energy source.

Table 2: Proximate composition of black pepper and turmeric

Parameters	Black pepper (DM%)	Turmeric (DM%)
Crude protein	10.29	13.29
Fat	12.18	6.50
Ash	7.87	11.88
Crude fibre	10.73	9.25
Moisture	2.85	4.20
Nitrogen free extract	56.08	54.88

Phytochemical composition and bioactivity of black pepper and turmeric

The phytochemical composition of black pepper and turmeric is presented in Table 3, showing a diverse array of bioactive and anti-nutritional compounds. Turmeric exhibits a higher concentration of bioactive compounds, including flavonoids (16.80 %), tannins (30.05 mg/100 g), and total phenols (25.30 %), compared to black pepper. Alkaloid levels are considerable in both spices, with a slight elevation in turmeric (25.43 %). Conversely, black pepper contains elevated levels of anti-nutritional factors, specifically oxalate (28.60 %) and phytate (162.25 mg/100 g). Saponin and cyanide levels are low in both spices.

The phytochemical profile explains the potential mechanisms behind these spices' bioactivity. The considerable alkaloids in both spices, including piperine in black pepper, contribute to their physiological effects and distinct tastes (Gorgani *et al*., 2018).

Antioxidant activity of black pepper and turmeric

Figure 1 shows the antioxidant activity of black pepper and turmeric extracts, which was determined using the DPPH free radical scavenging assay. The activities were compared against ascorbic acid, a standard antioxidant used as a positive control. The results indicate that the free radical scavenging activity for both spices is dose-dependent, with inhibition percentages increasing as the concentration of the extract rises from 0.2 to 1.0 mg/mL. Ascorbic acid consistently demonstrated the highest antioxidant capacity across all concentrations. Both turmeric and black pepper exhibited substantial antioxidant properties, with turmeric showing a slightly higher scavenging activity (72.15 %) than black pepper (69.03 %) at the maximum tested concentration of 1.0 mg/mL.

Table 3: Phytochemical composition of black pepper and turmeric

Phytochemical	Black Pepper	Turmeric
Oxalate (%)	28.60	8.85
Saponins (%)	0.45	0.80
Alkaloids (%)	23.28	25.43
Flavonoids (%)	4.40	16.80
Tannins (mg/100g)	11.40	30.05
Cyanide (mg/100g)	2.00	2.06
Phytate (mg/100g)	162.25	116.76
Total Phenol (%)	1.15	25.30

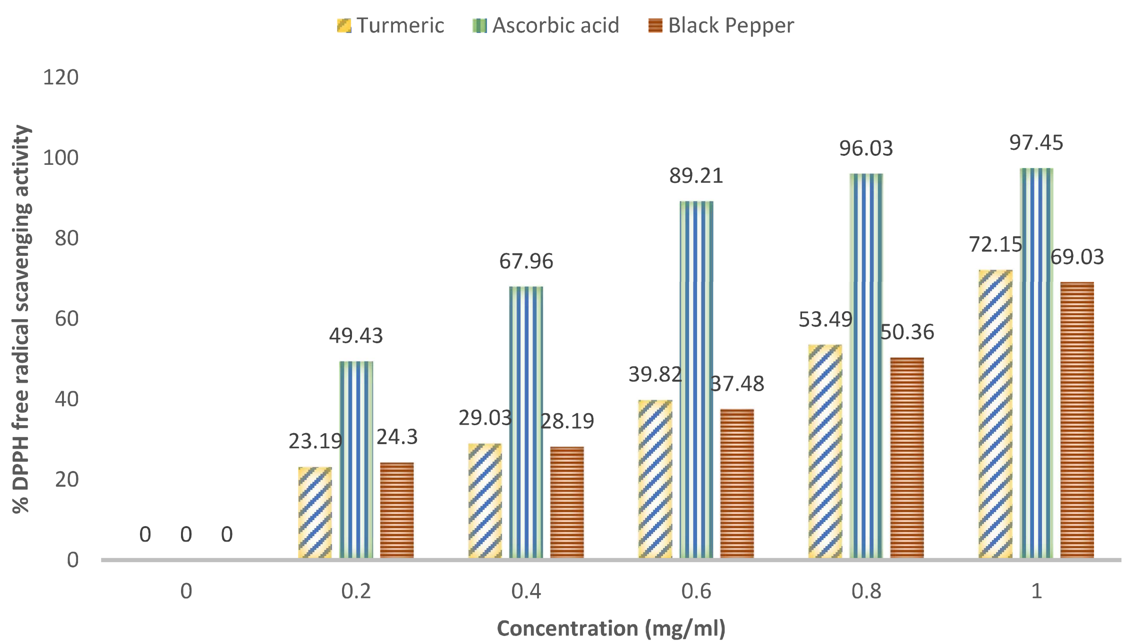

Figure 1: Free radical scavenging activity of turmeric and black pepper

Growth performance of broiler chickens administered varying mixtures of turmeric and black pepper as phytogenic feed additives

The results in Table 4 show the effect of different dietary mixtures of turmeric and black pepper on the growth performance. The results showed a significant effect ($p \leq 0.05$) on total feed intake. In contrast, other growth performance parameters such as weight gain, final body weight and feed conversion ratio were not significantly affected. (p>0.05) Specifically, including the photobiotic led to decreased feed intake, with the control group consuming significantly more feed than those in Treatment 4 (T4). The reduction in feed intake observed in the treatment groups may be linked to the feed's palatability. The pungent and distinct flavours of turmeric and black pepper might have made the feed less palatable to the chickens than the control diet, resulting in lower consumption. This effect appeared to be dose-dependent, as the groups with higher spice concentrations tended to have lower intake values.

Despite the lower feed intake in the treatment groups, there was no significant effect (p>0.05) on body weight gain or feed conversion ratio. The feed conversion ratio was numerically the best (lowest) in the T3 group (1.79), suggesting a potential improvement in nutrient utilisation. This indicates that while the birds ate less, they could more efficiently convert the feed to body mass. This enhanced efficiency could be attributed to the spices' bioactive compounds: curcumin in turmeric and piperine in black pepper. These bioactive compounds possess antioxidant properties and can improve gut health, enhancing nutrient absorption and feed efficiency even when feed intake is reduced (Ashayerizadeh *et al*., 2023). Supplementation with turmeric and black pepper improved gut morphology and nutrient utilisation in Japanese quails, leading to better feed conversion despite no increase in feed intake (Ashayerizadeh *et al.*, 2023). Akbarian *et al*. (2012) reported no significant effect of turmeric and black pepper on feed intake or growth performance. This contrasts with the current study's finding on feed intake but aligns with results obtained for other growth parameters. Differences in spice inclusion levels, ratios, or basal diet composition may explain this discrepancy.

Table 4: Growth performance of broiler chickens fed diets containing varying mixtures of turmeric and black pepper as phytogenic feed additives

		Treatments					
Parameters	T1	T2	T3	T4	SEM	P-Value	Sig.
IBW (g)	40.66	40.70	40.61	40.66	0.22	0.61	NS
FBW (g)	1618.80	1571.20	1673.40	1512.00	78.98	0.92	NS
TFI (g)	3124.20[a]	2967.10[ab]	2861.70[ab]	2787.00[b]	51.73	0.05	*
BWG (g)	1578.14	1530.50	1632.79	1471.34	78.98	0.92	NS
FCR	2.05	2.01	1.79	2.04	0.95	0.78	NS

ab = signifies the means on a row that is significantly (p≤0.05) different from each other, TFI= Total feed intake BWG= Body weight gain, FCR= Feed conversion ratio, T1= (Treatment 1; control without the (phytobiotic) black pepper and turmeric), T2= Treatment 2; diet containing 0.075 % black pepper plus 0.225 % turmeric), T3= (Treatment 3; diet containing a combination of 0.15 % black pepper and 0.15 % turmeric), T4= diet containing a combination of 0.075 % black pepper and 0.225 % turmeric), SEM= Standard error of mean, P-Value = Probability value, Sig = Significance, * = Significant, NS = Not significant.

Apparent nutrient digestibility of broiler chickens fed diets containing varying mixtures of turmeric and black pepper as phytogenic feed additives.

The results in Table 5 show the effect of varying mixtures of turmeric and black pepper on the apparent nutrient digestibility of broiler chickens. The results showed that the dietary treatments significantly ($p \leq 0.05$) affected the evident nutrient digestibility. The administration of varying mixtures of turmeric and black pepper in broiler diets has significantly improved nutrient digestibility, with a balanced combination of 0.150% turmeric and 0.150 % black pepper (T3) yielding the best results. This synergistic effect is primarily attributed to the bioactive compounds curcumin in turmeric and piperine in black pepper. Piperine enhances the bioavailability of curcumin and stimulates digestive enzymes, which improve nutrient absorption efficiency in the gastrointestinal tract. The variation in nutrient digestibility of broiler chickens fed diets containing mixtures of turmeric and black pepper could be attributed to antioxidant properties found in both curcumin and piperine, which reduce stress in the gastrointestinal tract of broiler chickens, which leads to proper utilization of nutrients, digestive enzyme stimulation and the presence of the active compound. The differences could also be attributed to the inclusion and combination potency level.

The result obtained from this research agreed with the findings of Sugiharto *et al.* (2020), who reported that the combination of turmeric and black pepper in broiler feed directly affected the nutrient digestibility of broiler chickens. Similarly, Herrero-Encinas *et al.* (2023) researched spice extracts on growth performance and nutrient digestibility, including black pepper. Their findings demonstrated that supplementation with spice extract had a significant ($p \leq 0.05$) effect on nutrient digestibility across treatment groups.

Table 5: Nutrient digestibility of broiler chickens fed diets containing varying mixtures of turmeric and black pepper as phytogenic feed additives

	Treatments					
Parameters (%)	T1	T2	T3	T4	SEM	P-Value
Dry matter	69.04^{b}	68.63^{b}	77.23^{a}	67.28^{b}	1.53	0.05
Crude protein	72.06^{b}	75.39^{b}	87.17^{a}	76.03^{b}	1.72	0.00
Crude fibre	65.98^{b}	61.64^{b}	75.49^{a}	67.57^{ab}	1.80	0.03
Ether extract	65.27	64.77	67.96	62.99	1.21	0.59
Ash	67.02^{ab}	63.24^{b}	73.30^{a}	61.52^{b}	1.68	0.04
Nitrogen Free Extract	65.75^{b}	61.99^{b}	74.55^{a}	61.92^{b}	1.76	0.02

ab = signifies the means on a row are significantly ($p \leq 0.05$) different from each other, T1= (Treatment 1; control without black pepper and turmeric), T2= Treatment 2; diet containing 0.075 % black pepper plus 0.225 % turmeric), T3= (Treatment 3; diet containing a combination of 0.15 % black pepper and 0.15 % turmeric), T4= diet containing a combination of 0.075 % black pepper and 0.225 % turmeric), SEM= Standard error of mean, P-Value = Probability value

Effect of diets containing varying mixtures of black pepper and turmeric as phytogenic feed additives on carcass characteristics and internal organ weights of broiler chickens

The results in Table 6 show the effect of dietary combinations of black pepper and turmeric on the carcass characteristics (slaughter weight, dressed weight, and primal cuts) and internal organ weights of broiler chickens. The result showed that the dietary treatments did not significantly affect most parameters ($p>0.05$). The only parameter significantly affected ($p\leq0.05$) was the wings. The range of values obtained for slaughter weight (1461.67–1617.67 g) and dressed weight (1404.00–1552.00 g). The weights of internal organs expressed as a percentage of live weight were not significantly different ($p>0.05$) across all treatment groups. This suggests that including varying mixtures of turmeric and black pepper did not induce any toxic effects or place undue metabolic stress on the birds. For instance, a non-significant change in liver weight often indicates that the organ functions normally without inflammation or hypertrophy.

Several studies have reported that phytogenic additives such as turmeric and black pepper do not consistently alter carcass yield parameters like slaughter weight, dressed weight, and primal cuts in broilers. For instance, Attia *et al*. (2017) found that turmeric supplementation up to 1% did not significantly affect the carcass yield or significant cut percentages in broiler chickens. However, it improved meat quality and antioxidant status. Similarly, Jamroz *et al.* (2005) reported that black pepper inclusion did not significantly change carcass weight or dressing percentage but improved feed efficiency and gut health. Abdel-Wareth *et al*. (2019) also observed no significant changes in liver and heart weights in broilers fed diets supplemented with turmeric powder, suggesting no metabolic stress or toxicity.

on the meat quality of broiler chickens

The meat quality of broiler chickens fed diets containing varying combinations of turmeric and black pepper is presented in Table 7. The effects of adding different mixtures of turmeric and black pepper on the meat quality of broiler chickens showed varying trends across treatments. Cooking yield was significantly reduced ($p\leq0.05$) in T4, which had the highest level of turmeric (0.225 %) and the lowest level of black pepper (0.075 %). This suggests that the high inclusion of turmeric may have affected moisture retention during cooking. Conversely, T3, a balanced combination of turmeric and black pepper (0.15 % each), yielded the highest cooking yield, indicating a possible synergistic effect in enhancing meat moisture retention. Cooking loss followed an inverse pattern to cooking yield, with T4 recording the highest loss and T3 the lowest. This confirms the relationship between cooking yield and loss, as lower water retention during cooking often results in higher losses. The higher cooking loss in T4 could be attributed to the increased turmeric level, which might have affected muscle protein binding capacity. Water holding capacity (WHC) was also significantly higher ($p\leq0.05$) in T1 and T3, while the lowest values were observed in T2 and T4. These results align with the cooking yield values, suggesting that better WHC contributes to improved cooking yield. The enhanced WHC in T3 could be due to the balanced antioxidant properties of turmeric and black pepper, which may have stabilised muscle proteins and prevented excessive water loss. There were no significant differences in pH values among the treatments, indicating that dietary inclusion of turmeric and black pepper did not alter the postmortem glycolysis or acidification of the muscle. The relationship between cooking yield and cooking loss is well documented, where higher cooking loss corresponds to lower cooking yield due to reduced water retention. Higher turmeric levels may minimise muscle protein binding capacity, increasing cooking loss, whereas Treatment 3 improved water-holding capacity and cooking yield, likely due to their combined antioxidant effects (Samuel *et al*., 2024; Kyakma *et al*., 2022). No significant changes in meat pH values were observed with turmeric and black pepper supplementation, indicating that these dietary additives do not alter postmortem glycolysis or muscle acidification, consistent with other broiler meat quality studies (Sugiharto *et al*. 2020).

Table 6: Carcass characteristics and internal organ weights of broiler chickens fed diets containing varying mixtures of black pepper and turmericas phytogenic feed additives

Parameters (g)	T1	T2	T3	T4	SEM	P-value	Sig
Slaughter weight	1461.67	1559.33	1617.67	1613.33	59.07	0.31	NS
Dressed weight	1404.00	1507.67	1552.00	1550.00	57.56	0.29	NS
Primal cut expressed as a (percentage of dressed weight)							
Thigh	16.45	16.54	15.73	18.95	0.70	0.43	NS
Back	20.08	20.98	18.66	22.57	0.76	0.36	NS
Breast	27.01	26.40	26.63	24.90	0.74	0.81	NS
Drumsticks	18.23	18.63	16.34	19.49	0.57	0.26	NS
Wings	15.13^{b}	14.96^{b}	18.39^{ab}	20.43^{a}	0.84	0.02	*
Internal organ weight expressed as a percentage of live weight							
Liver	1.65	1.62	1.58	1.53	0.04	0.79	NS
Intestine	2.39	2.60	2.10	2.10	0.15	0.62	NS
Gizzard	2.09	1.86	1.72	1.85	0.06	0.22	NS
Spleen	0.07	0.08	0.06	0.09	0.01	0.74	NS
Heart	0.57	0.45	0.48	0.45	0.02	0.18	NS
Lungs	0.70	0.60	0.49	0.54	0.03	0.72	NS
Proventriculus	0.45	0.45	0.48	0.53	0.02	0.50	NS

^{ab} = means across treatment group were significantly ($p \leq 0.05$) different; T1= Control without black pepper and turmeric; T2= combination of 0.225% black pepper plus 0.075% turmeric; T3= combination of 0.15% black pepper plus 0.15% turmeric; T4= combination of 0.075% black pepper plus 0.225% turmeric; SEM = Standard error of mean; P-value = Probability value; Sig = Significance; * = Significant; NS = Not significant.

Dietary effect of varying mixtures of turmeric and black pepper as phytogenic feed additives

Effect of diets containing varying mixturesofturmeric and black pepper as phytogenic feed additives on the sensory evaluation of broiler chicken meat

The results in Table 8 show the effect of diets containing varying combinations of turmeric and black pepper on broiler chicken's sensory evaluation (meat colour, juiciness, appearance, flavour, aroma, tenderness, and overall acceptability). The sensory assessment for taste and tenderness of the meat samples was significantly (p≤0.05) affected across the treatments. However, other parameters, including meat colour, juiciness, appearance, aroma, and overall acceptability, were not significantly (p>0.05) affected by the dietary inclusion of turmeric and black pepper. It was observed that the treatment with the highest level of turmeric (0.225 %) and the lowest level of black pepper (0.075 %), T4, resulted in the highest scores for flavour and tenderness.

The significant improvement in meat flavour (p≤0.05) observed in the group receiving 0.225 % turmeric and 0.075 % black pepper (T4) is likely due to the deposition of aromatic compounds from these spices into the meat matrix. Curcumin is a bioactive compound in turmeric characterised by a unique aromatic profile, whereas black pepper contains piperine, which has been shown to enhance the bioavailability of curcumin (Shoba *et al*., 1998). The observed synergistic interaction between these compounds may account for the increased flavour scores in the T4 group, suggesting a dose-dependent modulation of the flavour profile by consumers. This finding aligns with studies showing that dietary inclusion of turmeric and black pepper can enrich meat flavour by transferring volatile and non-volatile aromatic compounds (Srinivasan, 2014). Similarly, tenderness was significantly enhanced (p≤0.05) in the T4 group. The improvement in meat texture may be attributed to the antioxidant properties of curcumin, which protects muscle fibres from oxidative damage, thereby preserving meat integrity (Srinivasan, 2018).

Table 7: Effect of diets containing varying mixtures of turmeric and black pepper as phytogenic feed additives on the meat quality of broiler chickens

			TREATMENTS				
Parameters	**T1**	**T2**	**T3**	**T4**	**SEM**	**P-value**	**Sig.**
CY (%)	61.39^{a}	59.55^{a}	61.58^{a}	55.77^{b}	0.82	0.009	*
CL (%)	38.33^{b}	40.30^{b}	38.00^{b}	44.16^{a}	0.85	0.008	*
WHC (%)	26.84^{a}	20.85^{b}	26.88^{a}	22.35^{b}	0.88	0.002	*
pH	6.38	6.09	6.35	6.10	0.80	0.467	NS

^{ab} = means across treatment group were significantly (p≤0.05) different; CL= Cooking loss, WHC= Water Holding Capacity; CY=Cooking yield T1= Control without black pepper and turmeric; T2= combination of 0.225% black pepper plus 0.075% turmeric; T3= combination of 0.15% black pepper plus 0.15% turmeric; T4= combination of 0.075% black pepper plus 0.225% turmeric; SEM = Standard error of mean; P-value = Probability value; Sig = Significance; * = Significant; NS = Not significant.

Table 8: Effect of diets containing varying mixturesofturmeric and black pepper as phytogenic feed additives on the sensory evaluation of broiler chicken meat

	Treatments						
Parameters	T1	T2	T3	T4	SEM	P-value	Sig
Colour	6.62	6.25	6.32	6.67	0.11	0.52	NS
Juiciness	6.98	6.55	6.82	7.16	0.10	0.20	NS
Appearance	7.13	6.75	6.75	7.16	0.09	0.31	NS
Flavour	7.21^{ab}	6.65^{b}	7.04^{ab}	7.44^{a}	0.11	0.05	*
Aroma	7.10	6.94	6.93	7.30	0.10	0.63	NS
Tenderness	7.24^{b}	7.40^{ab}	7.07^{b}	7.78^{a}	0.10	0.04	*
Overall acceptability	7.53	7.49	7.28	7.62	0.73	0.44	NS

^{ab} = means across treatments on a row are significantly different (p≤0.05), T1= Control without black pepper and turmeric; T2= combination of 0.225% black pepper plus 0.075% turmeric; T3= combination of 0.15% black pepper plus 0.15% turmeric; T4= combination of 0.075% black pepper plus 0.225% turmeric; SEM = Standard error of mean; P-value = Probability value; Sig = Significance; * = Significant; NS = Not significant.

CONCLUSION AND RECOMMENDATION

The findings of this study indicate that dietary treatments had a significant (p ≤ 0.05) effect on feed intake but did not markedly influence other growth performance parameters. Apparent nutrient digestibility varied significantly (p ≤ 0.05) among treatments, except for ether extract, which remained unaffected. The dietary interventions did not alter most carcass characteristics and internal organ weights. However, meat quality parameters were significantly (p ≤ 0.05) impacted, except for meat pH, which showed no notable differences. Only meat flavour and tenderness exhibited significant (p ≤ 0.05) variations among organoleptic attributes, while others remained consistent across treatments.

Treatment 3 (0.150 % black pepper plus 0.150 % turmeric) demonstrated the most promising results, enhancing apparent nutrient digestibility and select meat quality traits. Based on these findings, it is recommended that broiler diets incorporate this blend to optimise overall performance and meat quality. Further research could explore long-term effects and economic viability under commercial production conditions.

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