Biotech Studies 33(2), 98-105
http://doi.org/10.38042/10.38042/biotechstudies.1504007

BIOTECH STUDIES

RESEARCH PAPER

Effects of turmeric meal supplementations on performance, carcass traits, and meat antioxidant enzymes of broilers fed diets containing monosodium glutamate

Olumuyiwa Joseph Olarotimi

Department of Animal Science, Faculty of Agriculture, Adekunle Ajasin University, P.M.B. 001, Akungba-Akoko, Nigeria

How to cite:
Olarotimi, O. J. (2024). Effects of turmeric meal supplementations on performance, carcass traits, and meat antioxidant enzymes of broilers fed diets containing monosodium glutamate. *Biotech Studies*, *33*(2), 98-105. https://doi.org/10.38042/biotechstudies.1504007

Article History
Received 18 November 2023
Accepted 01 June 2024
First Online 24 June 2024

Corresponding Author
Tel.: +234 803 565 00 55
E-mail:
olumuyiwa.olarotimi@aaua.edu.ng

Keywords
Antioxidant enzymes
Broilers
Carcass traits
Intestinal microflora
Turmeric

Abstract

The use of monosodium glutamate (MSG) as a potential taste enhancer in poultry nutrition is discouraged due to its perceived adverse effects. Hence, this study evaluated the impacts of turmeric powder (TP) on performance and some meat qualities of chickens fed MSG. Three hundred broilers were divided into four diets: T_1 (control), T_2 (1.25 g MSG/kg), T_3 (1.25 g MSG/kg and 1.25 g TP/kg), and T_4 (1.25 g MSG/kg and 2.50 g TP/kg). Results indicated increased (*P<0.05*) feed intake with a decrease (*P<0.05*) in weight gain resulting in poor feed conversion ratio (*P<0.05*) in T_2. However, inclusions of TP positively enhanced (*P<0.05*) these parameters in T_3 and T_4. Carcass characteristics did not differ significantly (*P>0.05*) between T_1 and T_2 but were improved (*P<0.05*) in T_3 and T_4. Organ weights were higher (*P<0.05*) in T_2 but were restored (*P<0.05*) in T_3 and T_4. While meat CAT and GSH-Px decreased (*P<0.05*), and MDA and cholesterol increased (*P<0.05*) in T_2, significant reversal of these trends was observed in T_3 and T_4. Hence, the inclusion of MSG without TP led to compromised performance, carcass, organ weights, and meat antioxidant enzymes in T_2 while they were ameliorated in T_3 and T_4.

Introduction

Several factors influence the feed consumption of broiler chickens, consequently impacting nutrient intake levels, production efficiency, and the profitability of the enterprise. While various factors affect feed intake, farmers often overlook the role of feed palatability. The palatability of feed largely depends on the ingredients used, with unappealing smells and tastes leading to reduced intake and diminished returns on investment (Maroof et al., 2017). Moreover, non-conventional feedstuffs, although cheaper and easily accessible, are generally less preferred by chickens (Ababor et al., 2023).

Factors like spoilage due to the rancidity of fats and oils, sugar molding, and protein putrefaction, commonly found in long-term stored feed, can also adversely affect feed palatability. Deteriorating feed quality leads to the development of aversive flavors and odors for the birds (Windisch et al., 2008). To address these challenges and improve productivity, farmers may consider using feed additives like monosodium glutamate (MSG) to enhance feed palatability (Khalil & Khedr, 2016). MSG is renowned for intensifying the savory flavor of food, as natural glutamate does in various cuisines (Ikeda, 2002). Several studies have highlighted the positive impact of MSG on feed intake and animal performance. For instance, Osman & Mohammed (2021) observed a statistically significant increase in both feed consumption and body mass gain in broilers when subjected to 5 g/L concentration of MSG. Gbore et al. (2016) observed that MSG had favorable effects on feed intake, body weight gains, and feed conversion ratio in female rabbits. Similarly, Rezaei et al. (2022) found a significant increase in piglet weight growth when gilts were fed a diet containing 1.15% MSG.

Nevertheless, it has been hypothesised that the overconsumption of MSG in livestock diets may have detrimental impacts on the overall health and welfare of farm animals (Zanfirescu et al., 2019). According to Olarotimi (2020), it was suggested that the excessive incorporation of MSG at levels exceeding 0.5g/kg in the diet of broilers resulted in the development of oxidative stress and a decline in overall antioxidant capacity. The use of excessive amounts of MSG has been associated with alterations in antioxidant systems and renal indicators, as suggested by Paul et al. (2012). According to Sharma et al. (2013), there was a considerable increase in the serum electrolyte levels of rats that were administered high quantities of MSG, as compared to the control group. According to the findings of Olarotimi et al. (2020), it was observed that the inclusion of MSG at a concentration of 1.00 g/kg diet and higher resulted in a decrease in both daily sperm production and efficiency in cocks. Consequently, the researchers concluded that a high level of MSG in the diets of male chickens has the potential to considerably diminish their reproductive capabilities.

To counteract the potential negative effects of MSG, incorporating antioxidants as feed additives has emerged as a promising strategy. The use of organic antioxidants, particularly phyto-additives like turmeric (Curcuma longa), has gained significant research attention (Kermanshahi & Riasi, 2006; Olarotimi, 2018). Turmeric has been recognized for its various properties, including being an antimicrobial, anti-inflammatory, and antioxidant agent. It contains essential minerals and antioxidants, which contribute to its potential as a beneficial feed additive for broiler chickens (Adegoke et al., 2018; Youssef et al., 2014). Thus, the aim of this study was to evaluate the effects of incorporating turmeric meals in the diets of broiler chickens fed high dietary MSG, focusing on their performance and meat antioxidative enzymes.

Materials and Methods

Experimental materials, site, design, and animals

Turmeric powder was obtained by first sourcing fresh turmeric rhizomes from the local market, and they were thoroughly washed with clean water to remove any extraneous materials and then drained. Thereafter, the rhizomes were grated and air-dried under a shade for a week. After they were thoroughly dried, they were milled to produce turmeric powder (TP). The MSG used was procured from the nearest departmental store. The study was conducted at the Poultry Unit, Teaching and Research Farm of Adekunle Ajasin University, Akungba Akoko, Nigeria, after obtaining approval from the University's Research and Ethics Committee for the ethical use and care of animals. Ethics Reference No: AAUA/FA/ANS/014/2024. Three hundred (300) day-old, mixed sex Arbor-acre broiler chicks were purchased from a dependable hatchery. Their weights were captured and documented before they were randomly assigned to four treatment groups labeled as T1, T2, T3, and T4. These groups received diets containing different quantities of MSG and TP per kilogram of food: (0.00 g MSG and TP), (1.25 g MSG), (1.25 g MSG and 1.25 g TP), and (1.25 g MSG and 2.50 g TP) respectively. Each of the four treatment groups was replicated five times, with each replication consisting of 15 birds. Throughout the six-week experiment, the chicks were provided with starter and finisher diets (Table 1) and had unrestricted access to fresh water for the whole experimental weeks.

Table 1. Gross composition of the basal diet for the experimental birds

Ingredients(kg)	**Starter (1 to 3 weeks)**	**Finisher (4 to 6 weeks)**
Maize	47	57
Corn bran	10	10
Rice bran	5	5
Soybean meal	15	15
Groundnut cake	15	5
Fish meal	5	5
Bone meal	1.2	1.1
Limestone	0.8	1.1
Lysine	0.3	0.2
Methoinine	0.25	0.15
Salt	0.2	0.2
Vitamin-Mineral Premix	0.25	0.25
Total	**100**	**100**
Calculated Nutrients		
ME (Kcal/Kg)	2975.04	3054.24
Crude Protein (%)	23.01	19.31
Fat	5.34	5.16
Calcium (%)	1.1	1.15
Phosphorus (%)	0.49	0.46
Lysine (%)	1.35	1.12
Methionine (%)	0.62	0.49
Crude Fibre (%)	4.17	3.94

Experimental data collection

The body weight gain (BWG) and feed intake (FI) were documented on a weekly basis. The weekly feed conversion ratio (FCR) was estimated as follows:

FCR = FI/BWG

At the end of the feeding trial, 25 birds per treatment (5 birds per replicate) were selected randomly and humanely sacrificed. The weights of the eviscerated organs such as the lungs, gizzard, heart, kidneys, and liver were captured and recorded using a sensitive laboratory weighing balance. The dressing percentage as the percentage ratio of the live weight to that of the dressed weight of the birds determined. The intestinal microflora population was determined according to Engberg et al. (2004) and Tsiouris et al. (2020). Briefly, the intestinal contents were extracted into a sterile 15-mL container and subsequently homogenized in 9 mL of sterile PBS (Phosphate Buffered

Solution). Serial tenfold dilutions ranging from 10^3 to 10^7 were then prepared. Lactobacilli enumeration was conducted using De Man–Rogosa–Sharpe (MRS) agar, with plates incubated anaerobically at 37 °C for 48 h to calculate lactic acid bacteria counts. Total anaerobic bacteria were enumerated using Plate Count Agar (PCA) and anaerobic incubation at 37 °C for 48 h, with anaerobiosis achieved by placing the inoculated plates in a jar. The anaerobic environment was generated using Anaerocult® and confirmed using Anaerotest®. Lactose-negative bacteria were counted on MacConkey agar, with colonies appearing as red and colorless after aerobic incubation at 38°C for 24 h. Furthermore, breast meats were sampled after dressing and evisceration to determine the antioxidant enzymes of the meat. The meat catalase, glutathione peroxidase, and cholesterol activities were determined as described by Farman & Hadwan (2021) and reported by Olarotimi et al. (2022). Briefly, the samples were packaged aerobically in oxygen-permeable bags and stored in a freezer at -18°C for a duration of 20 days. Subsequently, the extent of lipid oxidation in the meat was assessed using the thiobarbituric acid (TBA) assay method. Catalase activity in the meat was determined by monitoring the reduction in absorbance at 240 nm, indicative of hydrogen peroxide (H_2O_2) consumption. Glutathione peroxidase activity was determined by spectrophotometric monitoring of $NADPH^+$ oxidation at a wavelength of 340 nm. The total cholesterol concentration of the meat was determined by colorimetric method and the values were read at the absorbance of 550 nm.

Statistical analysis

Data collected were subjected to One-Way Analysis of Variance (ANOVA) using SAS (2008, software version 9.2). Significant differences between the treatment means were compared using Tukey's Honestly Significant Difference (HSD) option of the same software at 5% level of significance.

Results and Discussion

Performance of broilers fed diets containing Monosodium Glutamate and turmeric powder

The outcomes from the evaluation of broilers that were provided with diets containing varying amounts of MSG and TP are shown in Table 2. Throughout the trial stages, notable decreases (*P<0.05*) were observed in the body weight gains (BWG) of the birds on T_2 compared to those on the control diet (T1). Conversely, the inclusion of 1.25 and 2.5 g TP/kg diet led to significant (*P<0.05*) improvements in the BWG during both experimental phases and overall, in contrast to the broilers on T_1 and T_2. Notably, the birds on a diet T_4 exhibited the most favorable BWG. Similarly, the starter, finisher, and overall total feed intake (TFI) among the birds fed with 1.25 g MSG/kg diet alone (T_2) were significantly (*P<0.05*) higher than the TFI recorded among the birds on the control diet. Conversely, the TFI observed among birds fed diets with varying amounts of TP were significantly (*P<0.05*) lower than those on T_2. Birds on diet T_4 demonstrated lower TFI compared to those on T_3, although the difference was not statistically significant (*P>0.05*). However, both diets T_3 and T_4 displayed significantly (*P<0.05*) higher TFI when compared to the control diet.

Regarding the feed conversion ratio (FCR), broilers on diet T_2 showed the least significant (*P<0.05*) values as against the FCR by birds on diets T_1, T_3 and T_4 respectively at the starter and finisher phases as well as the overall. The FCR values among the birds on diets T_3 and T_4 were statistically similar (*P>0.05*) to those of the control diet during both the starter and finisher phases of the experiment. However, the FCR recorded among the birds on diet T_3 during the overall phase was significantly higher (*P<0.05*) than the values obtained for the birds fed diet T_4 and the control diet.

Performance metrics, including BWG, TFI, and FCR, are commonly employed to assess the effectiveness and profitability of poultry farming. The noticeable increase in TFI among the birds fed MSG during all experimental

Table 2. Performance of broilers fed diets containing MSG and turmeric powder

Parameters	T_1	T_2	T_3	T_4	SEM	P-value
Starter Phase (1 to 21 days)						
Initial Body Weight (g/bird)	35.00	34.20	33.60	33.20	0.54	0.31
Body Weight Gain (g/bird)	650^b	619^c	668^a	673^a	38.7	0.02
Feed Intake (g/bird)	1510^c	1830^a	1620^b	1550^b	58.7	0.02
Feed Conversion Ratio	2.32^b	2.96^a	2.43^b	2.30^b	0.16	0.01
Finisher Phase (22 to 42 days)						
Body Weight Gain (g/bird)	1510^b	1480^c	1640^a	1670^a	111	0.03
Total Feed Intake (g/bird)	3220^c	3670^a	3580^b	3540^b	180	0.01
Feed Conversion Ratio	2.13^b	2.48^a	2.18^b	2.12^b	0.19	0.01
Overall (1 to 42 days)						
Body Weight Gain (g/bird)	2160^c	2099^d	2308^b	2343^a	106	0.01
Total Feed Intake (g/bird)	4730^d	5500^a	5200^b	5090^c	189	0.02
Feed Conversion Ratio	2.19^c	2.62^a	2.25^b	2.17^c	0.12	0.01

Values are means and SEM (Standard Error of Means). Means in a row without a common superscript letter differ significantly (*P*<0.05). Diets: T_1 (control), T_2 (1.25 g MSG/kg), T_3 (1.25 g MSG/kg and 1.25 g TP/kg), and T_4 (1.25 g MSG/kg and 2.50 g TP/kg).

stages suggested that the incorporation of MSG up to1.25 g/kg in broiler diets, as implemented in this study, is an effective nutritional tactic for enhancing the taste of poultry feed. This finding further corroborated earlier research, which consistently highlighted the positive effects of MSG on the FI and BWG of livestock (Gbore et al., 2016; Olarotimi & Adu, 2022; Osman & Mohammed, 2021; Zhelyazkov, 2018).

However, despite the increased TFI recorded in this study, the significant decrease observed in the BWG among the broilers on diet T_2 suggested that a high MSG inclusion in broiler diets might impede BWG. This is in line with the assertions of Kondoh & Toril (2008) that a high MSG inclusion rate in diets could induce stress, leading to heightened energy expenditure and subsequently reduced BWG in animals. Similarly, Yamazaki et al. (2011) observed diminished body weight in rats fed a high MSG diet, despite an increase in FI, attributing it to reduced growth and sex hormone activity or decreased fat content and deposition.

Furthermore, the inclusion of 1.25 and 2.50 g TP/kg diet proved to be effective in enhancing the BWG of broilers on diets T_3 and T_4, with a corresponding reduction in TFI compared to birds on diet T_2. Additionally, the FCR of birds on diets containing TP was better than those of birds fed a diet without TP. The positive impact of TP on broilers fed a high MSG inclusion could be attributed to its rich reservoir of bioactive compounds. Previous studies reported improved growth performance in broiler chickens fed a diet with 0.2 g/kg TP (Rajput et al., 2013). Kafi et al. (2017) also documented improved BWG, FI, and FCR in broilers supplemented with 0.75% turmeric. The results aligned with Durrani et al. (2006), who noted increased BWG and FCR with a significant reduction in FI in broilers fed 0.5% TP.

The significant enhancement in body weight observed throughout all experimental stages at the TP inclusion levels utilized in our study may be attributed to the antioxidant activity of turmeric, capable of stimulating protein synthesis by the animal's enzymatic system. The substantial reduction in FI among broilers fed MSG with TP, compared to those fed only MSG, concurred with Emadi & Kermanshahi (2007), who reported a significant reduction effect of turmeric on FI alongside corresponding BWG. Earlier reports also documented the best FCR among birds fed TP (Durrani et al., 2006, Raghdad & Al-Jaleel 2012), attributing this to the enhanced dietary efficiency among broilers fed TP at the levels used in this study.

Carcass traits, relative organ weights, and intestinal microflora of broilers fed MSG and TP

The data on carcass attributes, relative organ weights, and intestinal microflora of the birds fed MSG alongside varying amounts of TP are presented in Table 3. The results of the current study indicated no significant difference (*P>0.05*) in the final live weights (FLW), dressed weights (DW), and dressed percentages (DP) of the birds on both T_1 and T_2. Nevertheless, significant (*P<0.05*) increases were noted in FLW, DW, and DP among the birds on diets T_3 and T_4 compared to birds on both T_1 and T_2, with T_4 showing the most significant increase. The relative weights of the hearts, livers, bile, and lungs of the birds on T_2 were found to be notably (*P>0.05*) higher than those recorded among the control birds, as well as T_3 and T_4 when compared. The gizzard, proventriculus, and spleen as well as intestinal microflora of the birds across all treatments were not significantly affected (*P>0.05*).

The absence of significant differences recorded for FLW, DW, and DP among broilers fed diet T_2 indicated that the inclusion of MSG at 1.25 g/kg diet did not enhance the carcass characteristics of broiler chickens. Increased carcass breast meat quantity and decreased abdominal fat are among the critical factors used to assess the profitability of broiler production (Adetunji et al., 2019). However, the fortification of these MSG-treated diets with 1.25 and 2.5 g TP/kg diet demonstrated the potential of TP in enhancing the overall meat quality of broiler chickens, countering the limiting effects of MSG on carcass and meat quality. The significant increases observed in the FLW, DW, and DP was evidence of the positive effects of turmeric powder

Table 3. Carcass traits, relative organ weights and intestinal microflora of broilers fed MSG and turmeric powder

Parameters	T_1	T_2	T_3	T_4	SEM	P-value
Carcass Characteristics						
Final Live Weight (g/bird)	2195.00^b	2133.30^b	2341.60^a	2376.2^a	122	0.01
Dressed Weight (g/bird)	1950^c	1907^c	2150^b	2200^a	109	0.01
Dressed Percentage (%)	88.84^b	89.39^b	91.82^a	92.58^a	4.18	0.02
Relative Organ Weights						
Heart	2.39^b	3.93^a	2.51^b	2.22^b	0.18	0.01
Liver and Bile	11.30^b	17.00^a	11.90^b	11.10^b	0.71	0.01
Gizzard and Proventriculus	16.80	16.70	16.57	16.30	0.83	0.11
Lungs	4.16^{ab}	4.54^a	3.70^b	4.11^{ab}	0.20	0.01
Spleen	0.87	0.76	0.78	0.76	0.03	0.34
Intestinal Microflora						
Aerobic Bacteria	7.57	7.78	7.30	7.74	0.37	0.28
Lactobicillus	7.44	7.59	7.56	8.37	0.37	0.13
Lactose Negative	6.90	6.39	6.87	7.30	0.23	0.30

Values are means and SEM (Standard Error of Means). Means in a row without a common superscript letter differ significantly (*P*<0.05). Diets: T_1 (control), T_2 (1.25 g MSG/kg), T_3 (1.25 g MSG/kg and 1.25 g TP/kg), and T_4 (1.25 g MSG/kg and 2.50 g TP/kg).

on enhancing carcass traits. Our findings were in complete agreement with the findings of Raghdad & Al-Jaleel (2012), who reported a substantial increase in the dressing yield of chickens fed diets supplemented with turmeric.

The observed elevation in the relative organ weights of the heart, lungs, liver, and bile among the broilers fed a diet containing 1.25 g MSG/kg diet indicated the hypertrophic effects of high MSG inclusion in broiler diets on the vital organs of broiler chickens, which could potentially lead to serious health challenges for the animals. For instance, the hypertrophy of the heart signifies an increased thickness of the heart muscle, which typically predisposes affected animals to cardiovascular damage. El Malik & Sabahelkhier (2019) and Okon et al. (2013) previously reported a significant increase in the tissue weight of the heart in rats fed elevated levels of MSG. Additionally, the hepatotoxic effects of MSG have been previously emphasized (Dharita et al., 2023). The enlarged liver and bile weights observed among broilers fed a diet containing 1.25 g MSG/kg diet confirmed the hepatotoxic potential of MSG, particularly when administered at high levels and for an extended duration. Banerjee et al. (2021) explained that liver hypertrophy occurs due to the dilatation of the central hepatic vein with lysed erythrocytes and distorted hepatocytes, caused by impaired membrane permeability resulting from high MSG inclusion.

However, the ameliorative effects of TP at the two inclusion levels used in the present study were clearly evident. The antioxidant and anti-inflammatory properties of turmeric may have been responsible for the significant reduction in the weights of the lungs, heart, liver, and bile among broilers on diets T_3 and T_4, making them comparable to the values recorded for broilers on the control diet. The decreased lung, liver, and heart relative weights of birds fed TP indicated the nephroprotective, hepatoprotective, and anti-inflammatory properties of TP, demonstrating its restorative effects when used as dietary supplements in broilers fed diets containing MSG for improved palatability. MSG has been proven to generate reactive oxygen species (ROS), causing oxidative stress (Olarotmi, 2020, Olarotimi & Adu, 2022). Turmeric, on the other hand, is a known phyto-additive that contains natural antioxidants (Olarotimi, 2018). It is capable of scavenging the ROS generated by high MSG inclusion, thus safeguarding the vital organs of the body against oxidative stress. Since the dietary incorporation of phytogens in broiler diets has been reported to reduce cholesterol levels in meat and liver (Oloruntola et al., 2018), the reduced cholesterol concentration in the liver of the broilers on diets T_3 and T_4 in this study may explain the lower weights of the liver compared to the liver weights of birds on diet T_2. Consumers of meat from broilers fed TP would also benefit from its anti-cholesterolemic effects, resulting in the production of leaner meat and potentially protecting humans from the risks of hypercholesterolemia, atherosclerosis, and coronary heart diseases (Shen et al., 2019). The proper functioning of the gastrointestinal tract (GIT) and the composition of the gut microbial population are crucial for effective nutrient absorption, immune system development, and resilience against diseases in chickens. Changes in the composition of the GIT microbial community can negatively impact feed efficiency, productivity, and overall health outcomes for poultry (Shang et al., 2018). From this study, the gut integrity of the broilers was maintained, as the inclusions of MSG and TP did not individually or synergistically alter the intestinal microflora counts of the birds. The role of non-pathogenic intestinal bacteria in inhibiting pathogen proliferation, enhancing growth performance, and reducing morbidity and mortality in poultry cannot be overstated (Abd El-Hack et al., 2022).

Meat antioxidant status and cholesterol of broilers fed MSG and turmeric powder

Figures 1 to 4 depict the meat antioxidant enzymes and cholesterol levels of broilers fed diets with a high inclusion of MSG, both with and without the addition of turmeric powder. The current study revealed that the meat catalase (CAT) (Figure 1) and glutathione peroxidase (GSH-Px) (Figure 2) activities in the meat from broilers fed T_2 were significantly (*P<0.05*) reduced compared to the values recorded among the control birds for the same parameters. However, the inclusion of both 1.25 and 2.50 g TP/kg diet significantly (*P<0.05*) increased the antioxidant enzyme activities of the meat among broilers on diets T_3 and T_4, respectively, when compared with birds on T_2, with significantly higher values recorded among the broilers on diet T_4 for both parameters. Furthermore, the concentrations of meat malondialdehyde (MDA) (Figure 3), and cholesterol (Figure 4) were found to be significantly (*P<0.05*) higher among the broilers on diet T_2 compared to birds from other diets, respectively. Although the inclusion of 1.25 g TP/kg diet significantly reduced the values of these parameters among broilers on T_3, it still remained higher (*P<0.05*) than the values recorded among the birds on the control diet for the same parameters. Notably, doubling the inclusion of TP in diet T_4 significantly (*P<0.05*) further decreased the meat MDA and cholesterol concentrations to a level comparable (*P>0.05*) with the values recorded on the control diet.

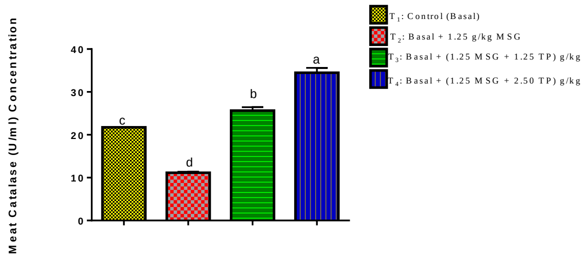

Figure 1. Meat catalase of broilers fed MSG and turmeric powder.

It is evident that the inclusion of MSG at 1.25 g/kg diet in broilers' diet compromised the oxidative stability of the meat as well as its cholesterol concentrations. The meat CAT and GSH-Px were noticeably depressed among the broilers fed diet T_2, while the MDA and meat cholesterol were significantly elevated. The primary function of antioxidative enzymes in meat is to preserve it against oxidative decomposition (Gbore et al., 2021). Cellular damage controlled by the absorption of superoxide and hydrogen peroxide occurs in meat whenever there is a reduction in the activities of antioxidative enzymes and an increase in MDA and meat cholesterol. This study suggests that the high inclusion of MSG promotes higher meat lipid peroxidation and cholesterol deposition due to the significantly higher meat MDA and cholesterol concentrations observed among broilers fed diet containing MSG. Adetunji et al. (2019) previously proposed that the inclusion of MSG up to 1.00 g/kg in broiler diets did not compromise meat quality parameters such MDA and antioxidative enzymes. The lipid peroxidation and antioxidant capacity of meat are typically indirectly linked (Gbore et al., 2021), highlighting the reason for an increase in lipid peroxidation of the breast meat in response to reduced antioxidative enzyme activities among the broilers fed MSG. Consequently, this implies a deterioration in meat quality among the birds fed MSG, posing significant health risks to humans as lipid peroxidation favors implies morbidity (Gbore et al., 2021).

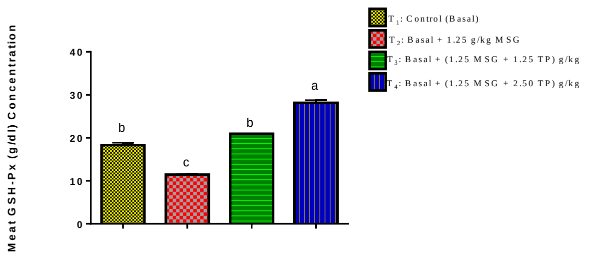

Figure 2. Meat glutathione peroxidase of broilers fed MSG and turmeric powder.

Noteworthy is the ameliorative role of the inclusion of TP at 1.25 and 2.5 g/kg diet in this study, clearly restoring the quality of the meat from the broilers, as observed among the birds fed diets T_3 and T_4, respectively. The restorative effect of TP observed on meat antioxidative enzymes of broilers fed diets T_3 and T_4 suggests that turmeric has a complementary effect on the concentrations of catalase and glutathione peroxidase, resulting in improved meat antioxidant status of the birds. From this study, it can be deduced that the ameliorative effects of turmeric are quantity-dependent, as better enhancement of the meat antioxidant enzymes was recorded among the broilers on diet T_4. The results also confirmed the cholesterolemic potentials of MSG as well as the anticholesterolemic effects of turmeric. The presence of curcumins in turmeric is responsible for its antioxidant activities and its capability to stimulate superoxide dismutase, catalase, and glutathione peroxidase activities, as well as its anticholesterolemic property (Olarotimi, 2018). Earlier studies have also reported the tendency of phytogens to mitigate meat lipid peroxidation (Gbore et al., 2021; Oloruntola et al., 2018). The apparent reduction in meat cholesterol concentration in response to an increasing level of TP further strengthens the anticholesterolemic effects of turmeric.

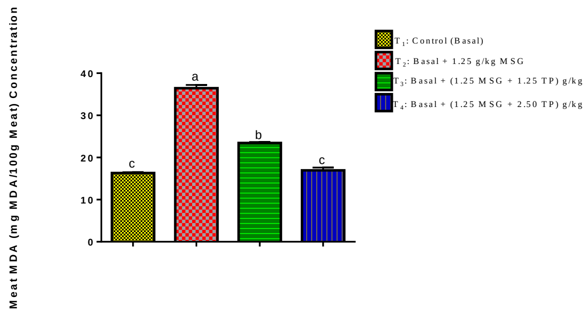

Figure 3. Meat malondialdehyde of broilers fed MSG and turmeric powder.

Overall, incorporating MSG at 1.25 g/kg diet in broilers' diets enhanced feed palatability, resulting in increased feed intake but without corresponding body weight gain and improvement in feed conversion ratio. There was no enhancement in the dressed weight and dressed weight percentage of the broilers. Furthermore, the inclusion of MSG appeared to potentially compromise the integrity of internal organs, including the heart, lungs, liver and bile. The study also indicated a significant reduction in meat catalase and glutathione peroxidase levels, accompanied by notable increases in lipid peroxidation and cholesterol. However, the incorporation of TP at 1.25 and 2.5 g/kg diet played a restorative role by enhancing the performance and carcass traits, along with the enhancement of the antioxidative enzymes of the meat.

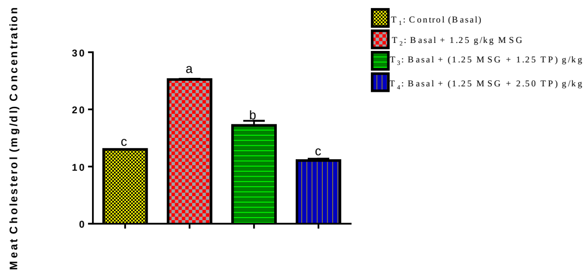

Figure 4. Meat cholesterol of broilers fed MSG and turmeric powder.

Conclusion

In conclusion, the findings of this study shed light on the effects of incorporating MSG and TP in broiler diets. While MSG at 1.25 g/kg diet enhanced feed palatability, it did not translate into improvements in body weight gain or feed conversion ratio. Moreover, it appeared to have adverse effects on the integrity of internal organs and meat quality parameters. Conversely, the inclusion of TP at 1.25 and 2.5 g/kg diet showed promising results, enhancing performance, carcass traits, and antioxidative enzymes in meat. Of particular note, diets containing 2.50 g/kg TP demonstrated the most favorable outcomes. Based on these findings, it is recommended to feed broilers with a diet containing 1.25 g/kg MSG alongside 2.50 g/kg TP inclusion to optimize broiler production.

Ethical Statement

The entire procedure complied with the guidelines for the Care and Use of Laboratory Animals, and the experimental protocol was approved by institution's Animal Research Ethics Committee. Ethics Reference No: AAUA/FA/ANS/4759/2023.

Acknowledgements

The author appreciates the management and individuals at the Teaching and Research Farm and Nutrition Laboratory of the University for assistance received during the field and bench work.

References

Ababor, S., Tamiru, M., Alkhtib, A., Wamatu, J., Kuyu, C. G., Teka, T. A., Terefe, L. A. & Burton, E. (2023). The use of biologically converted agricultural byproducts in chicken nutrition. *Sustainability*, *15(19),* 14562. https://doi.org/10.3390/su151914562

Abd El-Hack, M.E., El-Saadony, M.T., Salem, H.M., El-Tahan, A.M., Soliman, M.M., Youssef, G.B.A., Taha, A.E., Soliman, S.M., Ahmed, A.E., El-Kott, A.F., Al Syaad, K.M., & Swelum, A.A. (2022). Alternatives to antibiotics for organic poultry production: types, modes of action and impacts on bird's health and production. *Poultry science*, *101(4),* 101696. https://doi.org/10.1016/j.psj.2022.101696

Adegoke, A.V., Abimbola, M.A., Sanwo, K.A., Egbeyale, L.T., Abiona, J.A., Oso, A.O. & Iposu, S.O. (2018). Performance and blood biochemistry profile of broiler chickens fed dietary turmeric (*Curcuma longa*) powder and cayenne pepper (*Capsicum frutescens*) powders as antioxidants. *Veterinary and Animal Science*, *6*, 95–102. https://doi.org/10.1016/j.vas.2018.07.005

Adetunji, A.O., Olarotimi, O.J., Adu, O.A., Oladeji, I.S. & Onibi, G.E. (2019). Meat quality and consumer acceptability of broiler chickens fed different levels of monosodium glutamate (MSG). *Journal of Poultry Research, 16 (1),* 1-6. https://doi.org/10.34233/jpr.483081

Banerjee, A., Mukherjee, S. & Maji, B. K. (2021). Worldwide flavor enhancer monosodium glutamate combined with high lipid diet provokes metabolic alterations and systemic anomalies: An overview. *Toxicology reports*, *8*, 938–961. https://doi.org/10.1016/j.toxrep.2021.04.009

Dharita M.J., Varsha T.D., Shyamla R.K., Harshada B.P. & Pallavi M.M. (2023). Effect of monosodium glutamate on hepatotoxicity and nephrotoxicity: A mini review. *World Journal of Biology Pharmacy and Health Sciences, 15(1),* 152–159. https://doi.org/10.30574/wjbphs.2023.15.1.0318

El Malik, A. & Sabahelkhier, M.K. (2019). Changes in lipid pro-file and heart tissues of wistar rats induce by using monosodium glutamate as food additive. *International Journal of Biochemistry and Physiology, 4(1),* 141-147. https://doi.org/10.23880/ijbp-16000147

Emadi, M. & Kermanshahi, H. (2007). Effect of turmeric rhizome powder on the activity of some blood enzymes in broiler chickens. *International Journal of Poultry Science*, 6, 48-51. https://doi.org/10.3923/ijps.2007.48.51

Engberg, R.M., Hedemann, M.S., Steenfeldt, S. & Jensen, B.B. (2004). Influence of whole wheat and xylanase on broiler performance and microbial composition and activity in the digestive tract. *Poultry Science,. 83(6,* 925-38. https://10.1093/ps/83.6.925

Farman, A.A. & Hadwan, M.H. (2021). Simple kinetic method for assessing catalase activity in biological samples. *MethodsX*, *8*, 101434. https://doi.org/10.1016/j.mex.2021.101434

Gbore, F.A., Oloruntola, O.D., Adu, O.A., Olarotimi, O.J., Falowo, A.B. & Afolayan, E.O. (2021). Serum and meat antioxidative status of broiler chickens fed diets supplemented with garlic rhizome meal, moringa leaf meal and their composite. *Tropical Animal Health and Production, 53*, 26. https://doi.org/10.1007/s11250-020-02438-9

Gbore, F.A., Olumomi, O.R., Aworetan, I.M. & Gabriel-Ajobiewe, R.A.O. (2016). Oral administration of monosodium glutamate alters growth and blood parameters in female rabbits. *European Journal of Biological Research, 6 (3),* 218-225. https://doi.org/10.5281/zenodo.150297

Ikeda, K. (2002). New seasonings. *Chemical senses, 27(9),* 847-849. https://doi.org/10.1093/chemse/27.9.847

Kafi, A., Uddin, M.N., Uddin, M.J., Khan, M.M.H. & Haque, M.E. (2017). Effect of dietary supplementation of turmeric (*Curcuma longa*), ginger (*Zingiber officinale*) and their combination as feed additives on feed intake, growth performance and economics of broiler. *International Journal of Poultry Science, 16, 257-265.* https://doi.org/10.3923/ijps.2017.257.265

Kermanshahi, H. & Riasi, A. (2006). Effect of turmeric rhizome powder (Curcuma longa) and soluble NSP degrading enzyme on some blood parameters of laying hens. *International Journal of Poultry Science, 5,* 494–498. https://doi.org/10.3923/ijps.2006.494.498

Khalil, R.M. & Khedr, V. (2016). Curcumin protects against monosodium glutamate neurotoxicity and decreasing NMDA2B and mGluR5 expression in rat hippocampus. *Neurosignals, 24*, 81-87. https://doi.org/10.1159/000442614

Kondoh, T. & Torii, K. (2008). MSG intake suppresses weight gain, fat deposition, and plasma leptin in male Sprague-Dawley rats. *Physiology and Behaviour, 95,* 135-144. https://doi.org/10.1016/j.physbeh.2008.05.010

Maroof, K., Oka, T., Fujihara, M. & Bungo, T. (2017). Effect of supplemental japanese pepper seed on the palatability of feed in chicks. *The journal of poultry science*, *54(4),* 278–281. https://doi.org/10.2141/jpsa.0160150

Okon, A.K., Jacks, T.W., Amaza, D.S., Peters, T.M. & Otong, E.S. (2013). The effect of monosodium glutamate (MSG) on the gross weight of the heart of albino rats. *Scholar Journal of Applied Medical Sciences, 1(2),* 44-47.

Olarotimi, O.J. & Adu, O.A. (2022). Growth performance, blood indices and hormonal responses of broiler chickens fed monosodium glutamate. *Iranian Journal of Applied Animal Science, 12(2),* 341-352. https://dorl.net/dor/20.1001.1.2251628.2022.12.2.14.5

Olarotimi, O.J., Gbore, F.A., Adu, O.A., Oloruntola, O.D. & Falowo, A.B. (2022). Effects of ginger meal supplementation on performance and meat antioxidative enzymes of broilers fed monosodium glutamate. *Acta Fytotechnica et Zootechnica, 25(3),* 174–184. https://doi.org/10.15414/afz.2022.25.03.174-184

Olarotimi, O.J. (2018). Turmeric (*Curcuma Longa*): An underutilized phytogenic additive in poultry nutrition. *Turkish Journal of Agriculture - Food Science and Technology, 6 (1),* 102-106. https://doi.org/10.24925/turjaf.v6i1.102-106.1572

Olarotimi, O.J. (2020). Serum electrolyte balance and antioxidant status of broiler chickens fed diets containing varied levels of monosodium glutamate (MSG). Bulletin of the National Research Center, *44* (103). https://doi.org/10.1186/s42269-020-00360-6

Olarotimi, O.J., Adu, O.A., Olarotimi, A.O. (2020). High level dietary inclusion of monosodium glutamate lowers daily sperm production and efficiency in cocks. *European Journal of Biological Research, 10(3),* 240-250. https://doi.org/10.5281/zenodo.3969026

Oloruntola, O.D., Agbede, J.O., Ayodele, S.O. & Oloruntola, D.A. (2018). Neem, pawpaw, and bamboo leaf meal dietary supplementation in broiler chickens: Effect on performance and health status. *Journal of Food Biochemistry,* e12723. https://doi.org/10.1111/jfbc.12723

Osman, I. & Mohammed, A. (2021). Assessing the efficacy of monosodium glutamate as a growth enhancer in broiler chicken production. *Asia Pacific Journal of Sustainable Agriculture, Food and Energy*, *9(2),* 29-37. https://doi.org/10.36782/apjsafe.v9i2.104

Paul, M.V., Abhilash, M., Varghese, M.V., Alex, M. & Harikumaran, N.R. (2012). Protective effects of alpha-tocopherol against oxidative stress related to nephrotoxicity by monosodium glutamate in rats. *Toxicology Mechanisms and Methods, 22(8),* 625–630., https://doi.org/10.3109/15376516.2012.714008

Raghdad, A. & Al-Jaleel, A. (2012). Use of turmeric (*Curcuma longa*) on the performance and some physiological traits on the broiler diets. *The Iraqi Journal of Veterinary Medicine*, *36 (1),* 51-57. https://doi.org/10.30539/iraqijvm.v36i1.548

Rajput, N., Muhammad, N., Yan, R., Zhong, X. & Wang, T. (2013) Effect of dietary supplementation of curcumin on growth performance, intestinal morphology and nutrients utilization of broiler chicks. *Journal of Poultry Science*, 50: 44–52. https://doi.org/10.2141/jpsa.0120065

Rezaei, R., Gabriel, A. S. & Wu, G. (2022). Dietary supplementation with monosodium glutamate enhances milk production by lactating sows and the growth of suckling piglets. *Amino acids*, *54(7),* 1055–1068. https://doi.org/10.1007/s00726-022-03147-3

SAS (Statistical Analysis System Institute) (2008). SAS/ STAT User's Guide: version 9.2 for windows, SAS Institute Inc., SAS Campus Drive, Cary, NC, USA.

Shang, Y., Kumar, S., Oakley, B., & Kim, W.K. (2018). Chicken gut microbiota: importance and detection technology. *Frontier in Veterinary Science, 23(5),* 254. https://doi.org/10.3389/fvets.2018.00254

Sharma, A., Prasongwattana, V., Cha'on, U., Selmi, C., Hipkaeo, W., Boonnate, P., Pethlert, S., Titipungul, T., Intarawichian, P., Waraasawapati, S., Puapiroj, A., Sitprija, V., & Reungjui, S. (2013). Monosodium glutamate (MSG) consumption is associated with urolithiasis and urinary tract obstruction in rats. *PloS one*, *8*(9), e75546. https://doi.org/10.1371/journal.pone.0075546

Shen, M., Xie, Z., Jia, M., Li, A., Han, H., Wang, T. & Zhang, L. (2019). Effect of bamboo leaf extract on antioxidant status and cholesterol metabolism in broiler chickens. *Animal, 9,* 699-711. https://doi.org/10.3390/ani9090699

Tsiouris, V., Kontominas, M.G., Filioussis, G., Chalvatzi, S., Giannenas, I., Papadopoulos, G., Koutoulis, K., Fortomaris, P. & Georgopoulou, I. (2020). The effect of whey on performance, gut health and bone morphology parameters in broiler chicks. *Foods*, *9 (5),* 588. https://doi.org/10.3390/foods9050588

Windisch, W., Schedle, K., Plitzner, C. & Kroismayr, A. (2008). Use of phytogenic products as feed additives for swine and poultry. *Journal of Animal Science, 86,* 140-148. https://doi.org/10.2527/jas.2007-0459

Yamazaki, R.K., Brito, G.A. & Coelho, I. (2011). Low fish oil intake improves insulin sensitivity, lipid profile and muscle metabolism on insulin resistant MSG obese rats. *Lipids Health and Diseses, 10,* 66-72. https://doi.org/10.1186/1476-511X-10-66

Youssef, M.K.E., El-Newihi, A.M., Omar, S.M. & Ahmed, Z.S. (2014). Assessment of proximate chemical composition, nutritional status, fatty acid composition and antioxidants of curcumin (Zingiberaceae) and mustard seeds powders (Brassicaceae). *Food and Public Health, 4,* 286-292. https://doi.org/10.5923/j.fph.20140406.05

Zanfirescu, A., Ungurianu, A., Tsatsakis, A. M., Nițulescu, G. M., Kouretas, D., Veskoukis, A., Tsoukalas, D., Engin, A. B., Aschner, M. & Margină, D. (2019). A review of the alleged health hazards of monosodium glutamate. *Comprehensive reviews in food science and food safety*, *18(4),* 1111–1134. https://doi.org/10.1111/1541-4337.12448

Zhelyazkov, G. (2018). Effect of monosodium glutamate dietary supplementation on some productive traits of common carp (*Cyprinus carpio*) cultivated in net cages. *Agricultural Science and Technology, 10(3),* 204-207. https://doi.org/10.15547/ast.2018.03.039