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Visceral Characteristics of Broiler Chickens (*Gallus gallus domesticus*) Supplemented with Turmeric Rhizome Powder (*Curcuma longa*)

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Abstract Curcumin is an active ingredient in turmeric known to serve as an antioxidant, anti-mutagen, and anti-carcinogen. A hundred broiler chickens were subjected to a feeding experiment subdivided into five treatments (0, 2.5, 5.0, 7.5, and 10 grams of turmeric rhizome powder per kilogram of basal diet) at four replications in a randomized complete block design and brooded at 15 days and 30 days under the feed trial to determine the effect of turmeric rhizome powder (TRP) on the visceral organs of broiler chickens. TRP increased the small intestinal length as well as the weight of the Fabricius bursa and liver ($p < 0.05$). TRP significantly reduced abdominal fat and small intestinal weight ($p < 0.05$). TRP administration did not alter the weight of the pancreas, heart, spleen, and gallbladder ($p > 0.05$). It is suggested that increased intestinal length improve water and nutrient absorption, whereas increased weight in the liver and bursa of Fabricius indicates an improved immune system in broiler chickens. More research into the serum glutamic pyruvic transaminase parameter in the blood to check the health state of the liver, as well as a confirmatory investigation on the influence of TRP on the heart's properties, is recommended.

Keywords Abdominal Fat, Broiler Chicken, Bursa of Fabricius, Curcumin, Gall Bladder, Heart Weight, Intestinal Length, Liver Weight, Spleen Weight, Turmeric

1. Introduction

Poultry meat is the second most extensively consumed meat in the world after pigs. With the growing population, the global need for meat is increasing, yet people are increasingly relying on poultry products for their dietary needs due to health risks linked with the intake of red meat. To address this rapidly expanding demand, breeders are generating fast-growing chickens through breeding initiatives. However, the quality of poultry products needs to fulfill customer expectations, which often drives farmers to employ antibiotics or growth promoters. The consumption of poultry meat is further encouraged due to the lack of cultural or religious limitations. Furthermore, patients with metabolic disorders such as hypertension, arthritis, and diabetes may prefer chicken meat over red meat as it contains less fat. However, investigations have indicated that the fast-growing breeds of chicken have increased fat content, particularly if they are grown indoors and for commercial purposes [1]. The breast meat of the slow-growing chickens contained more protein and α-tocopherol than the fast-growing chickens and half the amount of fat [2]. The current commercial chickens have significant fat deposition in the belly area [3]. The top quintile of fat had a significantly higher incidence of hypertension, impaired fasting glucose, and abdominal obesity, while the risk of these health issues was also significantly associated with higher levels of fat intake [4].

With the use of proper feeding management, chicken breeders may still be able to produce chicken with enhanced carcass yield and reduced belly fat content. The biological characteristics of turmeric powder make it a possible alternative to antibiotics for poultry nutrition. Research has indicated that when added to chicken feed, turmeric powder has had a good influence on the growth performance, reduced oxidative stress, and boosted the gut health of poultry [5,6]. Additionally, the transfer of curcumin, the active element in turmeric, from the chicken's diet to its flesh could also potentially provide health benefits to humans consuming such meat, such as anti-inflammatory and antioxidant effects [7]. Consequently, the inclusion of turmeric powder in the chicken diet can improve the efficiency, health, and quality of the meat produced [8] and give important insights into its possible influence on human health. The current study aims to examine the effects of increasing doses of turmeric powder on the visceral features of broiler chickens, specifically on their abdominal fat, liver, pancreas, heart, small intestine, bursa of Fabricius, gall bladder, and spleen. The present research was intended at examining the impact of escalating dosages of turmeric powder on the visceral features of broiler chickens. Specifically, this study attempts to establish the Visceral features in terms of abdominal fat, liver, pancreas, heart, small intestine, bursa of Fabricius, gall bladder, and spleen.

2. Materials and Method

2.1. Facilities and Other Equipment

The study used the following materials and equipment: rearing pens and brooding cages; weighing scales; electric bulbs (micro and macro); feeding troughs; plastic waterers; laminated sacks; newspaper beddings; oven driers; oven trays; net bags; plastic nets; syringes; pales; blood and serum analyzers; and mechanical/manual grinders.

2.2. Experimental Housing and Cages

The chicken house was created and designed particularly for research to meet the dimensions and orientation of the cages. The floor size of the house was 29 feet x 29 feet with 22 pieces of 12-foot-long galvanized roofing sheets. Its construction was made up of more than 95 percent bamboo material. It has a slatted floor with a height of 1 meter from the ground. There were four major pens created within the poultry house, each measuring 12.5 feet in length x 2 feet in width and 2 feet in height for every pen. Each primary pen refers to the blocking of the study based on the gradient of sunlight and was subdivided into the number of treatments of the study. Each main pen was subdivided into 5 cages, each having a floor area measurement of 2.5 feet × 2.5 feet. A total of 20 cages were created with 5 birds in each cage so that the total number of experimental birds was 100. There were 35 female and 65 male broiler chickens used in this study. The gender of the chickens was used as a covariate in statistical analysis.

2.3. Experimental Design and Layout

The layout of the experimental pen reflects the layout and design of the housing experiment. There were four major pens, each having five cages for each pen. Each main pen served as a block while each cage represented the treatment. The main pen was oriented perpendicular to the east-west direction such that blocking was dependent on the direction of the sunlight within the chicken house. The treatments were arranged in a randomized complete block design.

2.4. Turmeric Rhizome Powder (TWP)

The pure turmeric rhizome powder was purchased in Iligan City, Philippines. It has a relatively light yellow-brown with a very fine texture. The Regional Standards and Testing Laboratories, Department of Science and Technology X (DOST X), Philippines, examined the powdered turmeric rhizome powder. The Kjeldahl method was employed to determine crude protein content. A known weight of the sample was digested with concentrated sulfuric acid and a catalyst. The resulting ammonia was then distilled and collected in an acid solution. Nitrogen content was determined by titration or calorimetry. The protein content in a sample was calculated from the nitrogen content using a conversion factor that was based on the assumption that proteins contain 16% nitrogen by weight. Therefore, the nitrogen content obtained from the Kjeldahl method was multiplied by a conversion factor of 6.25 (which is 100 divided by 16) to calculate the protein content in the sample. The method was based on the Official method 976.05, OMA AOAC 18th Ed.

The Soxhlet extraction method was used to extract crude fat from the samples. A known weight of the sample was extracted with a solvent such as ether or hexane. The extract was evaporated, and the remaining fat was weighed to determine the crude fat content. The method used for chemical analysis was based on Official method 920.39, OMA, AOAC 18th Ed.

The Weende method was utilized to determine the crude fiber content of the sample. Initially, a known weight of the sample was subjected to boiling with dilute sulfuric acid to remove the protein content, followed by boiling with dilute sodium hydroxide to eliminate carbohydrates. The remaining material was weighed, and the crude fiber content was then calculated. For this calculation, the remaining material obtained after boiling the sample with dilute sulfuric acid and dilute sodium hydroxide was considered as the fiber fraction. The percent crude fiber content was calculated by dividing the weight of residue after digestion by the weight of the sample, multiplied by

100. Here, the weight of residue after digestion referred to the weight of the remaining material obtained after boiling the sample with dilute sulfuric acid and dilute sodium hydroxide. The weight of the sample referred to the original weight of the sample that was taken for analysis. The method used for chemical analysis was based on Official method 962.09, OMA, AOAC 18th Ed.

The ash content was determined by burning the samples in a muffle furnace at high temperatures to remove all organic matter. A known weight of the sample was taken and placed in a previously weighed crucible. The crucible containing the sample was then placed in a muffle furnace set at a temperature of 500C for 4-6 hours, to burn off all organic matter. The remaining residue was allowed to cool to room temperature in a desiccator and weighed. The weight of the residue was recorded as the inorganic or mineral content of the sample. The method used for chemical analysis was based on Official method 942.05, OMA, AOAC 18th Ed. The ash percent content was calculated by dividing the weight of residue after burning with the weight of the sample multiplied by 100.

The dry matter content was determined by drying the samples in an oven at a constant temperature until a constant weight was obtained. The weight of the dry matter was then divided by the weight of the original sample to determine the dry matter content. The method used for chemical analysis was based on Official method 925.23, OMA, AOAC 18th Ed.

The nitrogen-free extract was calculated by subtracting the sum of crude protein, crude fat, crude fiber, and ash from the total weight of the sample. This represented the carbohydrate content of the sample. The result of the proximate analysis of turmeric rhizome powder is presented in table 1.

Table 1. Proximate analysis of turmeric rhizome

Parameters	Results, %
Crude Protein	9.34
Crude Fat	2.46
Crude Fiber	3.87
Ash	6.60
Dry matter	85.00
Nitrogen Free Extract	62.73

Source: Result of proximate laboratory analysis from DOST-X, Philippines.

Table 2. Proximate analysis of commercial feeds used in the study.

Rearing (days)	CP (%)	CFb (%)	CF (%)	A (%)	DM (%)	NFE (%)
1-30	21.5	5.0	3.0	10.0	88.0	48.50
31-45	19.5	6.0	3.0	10.0	88.0	49.90

CP=Crude Protein, CF=Crude Fiber, CFb=Crude Fiber, CF=Crude Fat, A=Ash, DM=Dry Matter, and NFE=Nitrogen Free Extracts.

Source: Labels from the bags of commercial Feeds.

2.5. Visceral Organ Measurement

At 30 days of experimental feeding, four birds per treatment were randomly taken from the cage and slain for visceral organ characterization. To attain a uniform number of sub-samples per treatment, the researcher opted to sample only 4 birds per cage as there was a cage with one bird mortality before the end of the study. The abdominal fat was the fat that surrounded the gizzard and was positioned between the intestines and the abdominal muscles. The layer of fat expanded over the ischium and surrounded the bursa of Fabricius and the cloaca, where it was associated with the abdominal muscles in the area of the bursa of Fabricius and the cloaca [9]. The weight and length of the intestine were collected from the base of the gizzard up to the caecal junction immediately before the large intestine. The heart, gall bladder, spleen, bursa of Fabricius, and liver were removed delicately for individual measurement.

2.6. Statistical Analysis

The data were subjected to analysis of covariance procedure appropriate for a completely randomized design using the General Linear Model procedure of SAS University Edition. The live weight was considered a covariate, and the sex of the broiler was treated as a regular categorical factor included in the statistical model for visceral characteristics. The statistical analysis includes ANOVA. As a level of significance is taken, 0.05, that is, the value of the test statistics is considered as significant of $p < 0.05$.

3. Results and Discussion

3.1. Abdominal Fat

As shown in the abdominal fat column in Table 3, turmeric supplementation from the range of 5 to 10 grams per kilogram of basal diet significantly reduced the abdominal fats of birds compared to the control group ($p < 0.05$). The study of Hosseini-Vashan et al [9] found that supplementation of turmeric powder at 0.4 to 0.8 percent has significantly reduced the belly fat of birds in 28 days and 42 days fat sampling periods. The study in China has significantly indicated that supplementation of 100 to 300 mg/kg of feeds reduced the abdominal fat ratio ($p < 0.05$), compared to that of the control group [10]. The addition of 0.25, 0.5, and 0.75 percent of TRP has significantly reduced the abdominal fats of broiler chickens slaughtered at 49 days old [11]. The mechanism of fat reduction by ingesting turmeric powder is attributed to its effect on the inhibition of reactive oxygen species of enzymes such as lipoxygenases, which control the cell in the adipogenesis

process [12]. The lipoxygenase pathway is a key player in adipose tissue inflammation in animal models of obesity. Lipoxygenase isoforms have a unique pattern of translation in subcutaneous and omental (visceral) fatty tissue in humans and are predominantly produced by non-adipose cells [13]. This reduction in abdominal obesity can be attributed to the action of curcumin on adipocyte death or glucose removed from the blood [10,14]. The mechanism mentioned above explained the significant decrease in abdominal fats due to turmeric supplementation in broilers' diets.

3.2. Liver Weight

The liver weight column in Table 3 varies significantly with levels of TRP supplementation in a basal diet of broiler chickens ($p<0.05$). All turmeric groups have greater and heavier livers compared to the control group. The study of Mondal et al. [15] reported that turmeric powder supplementation at 0.5, 1.0, and 1.5 % to basal feeds of broiler chicken slightly increased the liver weight, however, the difference compared to control groups differs insignificantly. Turmeric supplementation at a rate of 0.25, 0.5, and 1.0 percent on basal feeds at 35 days feeding period did not vary when compared to the control group [16] [6]. However, some studies reported that turmeric significantly reduces the liver weight of broiler chickens supplemented with turmeric powder. Xie, et al. [17] reported that the liver weight significantly reduced in the 1,000 and 2,000 mg/kg curcumin groups compared to the control group ($p < 0.05$). However, the study of Yarru, et al. [18] indicated that the supplementation of *Curcuma longa* powder to aflatoxin-treated feeds ameliorated the negative effects of aflatoxin on broiler chicken and improved liver weights. Turmeric, with its active ingredient curcumin, has been demonstrated to protect the liver against several toxicants including carbon tetrachloride, aflatoxin B, and cyclophosphamide in mice, rats, and ducks. The curcuminoids showed a protective effect against aflatoxin B1 [19]. The inconsistencies about the effect of turmeric on liver weight may be attributed to some possible factors. For instance, in statistical analysis, some variables not within the control of researchers have to be noted diligently and be included as variables in the statistical analysis.

3.3. Small Intestine

The length and weight of the small intestine were significantly affected by TRP supplementation ($p(<0.05)$. The length of the small intestine significantly increases when 5 -10 grams of TRP was supplemented to a kilogram of basal diet compared to broilers fed with 0 and 2.5 grams of TRP in their diet. However, the weight of the small intestine significantly decreased with increasing supplementation of TRP in the broiler's diet. It is interesting to note that while the length of the small intestine increased with increasing TRP levels, the weight of the same intestine decreased. The advantage of having a longer small intestine is the efficiency of fluids and nutrient absorption and the breakdown of feed ingested by the animals. It increases the surface area for absorption because of the presence of villi and microvilli in the intestinal wall. This could be one of the reasons for the favorable growth of broiler chickens at an early age apart from being proven as growth promoters. The study of Kumar et al. [20] found that curcumin decreases the resting tone of the gut, and this may be the explanation for the greater length of the gut in albino mice. This may partially explain the historic usage of curcumin as an antispasmodic medication.

Table 3. The visceral characteristics of broiler chickens supplemented with levels of turmeric rhizome powder in commercial basal feed diets at 30 days feeding period.

Treatment, gTRP/kg feeds	Abdominal Fat (g)	Liver (g)	Pancreas (g)	Heart (g)	Small Intestine (g)	Small Intestine (cm)	Bursal weight (g)	Spleen Weight (g)	Gall bladder (g)
0	22.00^{ab}	22.23^{b}	4.61	28.16	79.98^{a}	153.95^{bc}	2.46^{c}	3.57	3.76
2.5	24.25^{a}	53.51^{a}	4.20	16.66	76.00^{a}	211.24^{b}	5.36^{a}	3.75	3.72
5	8.50^{c}	50.91^{a}	4.52	14.19	66.02^{b}	186.12^{c}	6.91^{b}	2.86	3.69
7.5	12.50^{bc}	58.03^{a}	3.63	11.12	52.58^{b}	183.90^{ac}	8.04^{b}	2.91	3.84
10	5.25^{c}	83.40^{a}	3.54	10.27	30.53^{b}	283.98^{a}	11.95^{ab}	3.17	3.76
Pr>F	0.001	0.05	0.41	0.15	0.02	0.04	0.03	0.11	0.90

$p>0.05$ has no significant differences between treatment means by F-test ANOVA

3.4. Bursa of Fabricius

The weight of the bursa of Fabricius of broiler chickens significantly increased with increasing rates of turmeric rhizome powder supplementation in the basal diet compared to the control group ($p < 0.05$). The bursa of Fabricius offers the conditions for young B-cells to develop toward fully functioning antibody-producing B-lymphocyte [21]. Naderi et al. [22] demonstrated that the mass of the Fabricius bursa either in the turmeric or cinnamon-supplemented groups was numerically bigger than that of the control and avilamycin-supplemented groups.

3.5. Heart, Pancreas, Gall Bladder, and Spleen Weight

The weights of the pancreas, gall bladder, heart, and spleen of broiler chickens were not significantly influenced by TRP supplementation in the basal diets ($p > 0.05$, Table 3). The study of Mondal et al. [15] reported that supplementation of turmeric powder at 0.5 to 1.5 percent did not significantly influence the heart weight of broiler chickens. Hussein et al. [23] reported that turmeric powder did not significantly influence the relative pancreas weight of broiler chickens when supplemented with 0.25 to 0.25 percent. Qasem et al. [24] reported that turmeric powder supplemented with the diet of broiler chickens at a rate of 10-20 grams per kilogram of basal feed did not significantly affects the relative weight of the pancreas. In this study, TRP did not significantly influence the weight of the gall bladder, however, the study on humans by Rasyid et al. [25] reported that turmeric induces contraction of the gall bladder.

4. Conclusion

In conclusion, supplementing the diet of broiler chickens with turmeric rhizome powder (TRP) exhibited a favorable effect on the small intestine, Fabricius bursa, and liver, as well as lower abdominal fat and small intestine weight. This implies that TRP can boost water and nutrient absorption, as well as the immune system, in broiler chickens. The recommended dosage of 5 grams of TRP per kilogram of feed for broiler chickens is suggested in this study and may produce positive health benefits. Further study should be undertaken to identify the long-term effects and ideal dose of TRP for poultry production.

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Conflicts of Interest

The author declares that there are no conflicts of interest.

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