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Dietary effect of *Tamarindus indica* leaf meal on the growth performance, cell-mediated immunity, carcass yield, and economic traits in broiler chickens

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Abstract

The addition of synthetic antibiotics into broiler diets was banned in the European Union due to growing public health concerns. As a result, interest in the effects of different phytobiotic plants on animal health and production performance increases. The tamarind (*Tamarindus indica* Linn.) is a medicinal plant containing crude protein, fiber, vitamins, and amino acids. Thus, this study was conducted to investigate the potential of tamarind leaf meal (TLM) on the broiler chicken's growth performance, cell-mediated immunity, carcass yield, and economic traits. Seventy-five (75) broiler chicks, regardless of sex, were randomly distributed into five dietary treatments replicated three times with five birds per replication. The five dietary treatments were: T_1-commercial ration (control); T_2- homemade ration (HR) + 0% TLM; Treatment 3- HR + 1% TLM; T_4- HR + 3% TLM, and T_5- HR + 5% TLM. The collected data were subjected to one-way Analysis of Variance (ANOVA) in a Completely Randomized Design using the Statistical Package for Social Science (SPSS) version 17.0 software. A significant difference in the growth performance and cell-mediated immunity parameters was observed in bi-weekly final weight, bi-weekly body weight gain, bi-weekly voluntary feed intake, slaughter weight, dressed weight, and cell-mediated immunity, while the feed conversion ratio and dressing percentage showed no significant differences. Moreover, the overall result and the return above feed and chick cost indicated a promising prospect for broiler chickens. In conclusion, incorporating 3% tamarind leaf meal into broiler diets is feasible in broiler chicken production.

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Introduction

Broiler chicken (*Gallus gallus domesticus* L.) plays a significant economic role in most developing countries and is essential for the rapidly growing populations' food security. However, the gradual increment of the human population resulted in an increased demand for animal protein in developing countries (Lagua and Ampode, 2021). In order to meet the demand for poultry meat products, synthetic antibiotic growth promoters (AGPs) are usually added to animal feed to stimulate growth, minimize mortality by preventing infections, improved gut function, antimicrobial activity, and antioxidative actions (Windisch *et al.,* 2008). However, synthetic antibiotics had indirect adverse effects on human health because of residues in chicken meat and the increased resistance of certain microbes (Yang *et al.*, 2009; WHO, 2012). The resistant cells survive and grow in low levels of antibiotics, resulting in an antibiotic-resistant population in the final products. Further, antibiotics as growth promoters in animal feed have been banned in the European Union since January 2006 (Laing and Wongtangtintharn, 2013).

Alternative substances and strategies for promoting animal growth and disease prevention are being investigated, and phytobiotic feed additives have received increased attention as they have gained acceptance (Nanekarani *et al.*, 2012). Likewise, if birds are not fully supplied with medicines become vulnerable to disease and stress (Catolico and Ampode, 2019)**.** Therefore, it is a constant challenge for animal nutritionists and health experts to use various medicinal plants as antibiotic substitutes in broiler diets (Zhang *et al.*, 2009).

Furthermore, rising feed costs have made poultry production a losing proposition in many parts of the world. To overcome such a problem, farmers utilized local feed ingredients to reduce the high costs of feed and antibiotics. Due to the high cost of feeds and the scarcity of essential raw materials, poultry farmers are searching for systems that can identify feed ingredients with lower costs and high biological values that can supplement conventional energy and protein sources (Laing and Wongtangtintharn, 2013).

Tamarind (*Tamarindus indica* Linn.) is a medium-sized tree in the Caesalpinaceae family. It has been used as a medicinal plant for centuries, and its fruits are the most valuable part, which has been reported as curative in several pharmacopeias (Gumgumjee *et al.,* 2012). Tamarind leaves also contain crude protein, fat, fiber, and vitamins such as riboflavin, thiamine, ascorbic acid, niacin, and β-carotene (El-Siddig *et al.,* 2006). Furthermore, it has been reported that tamarind leaves extract improved the hematological response and blood chemistry of Yankasa rams (Garba and Abubalar, 2012). In the Philippines, limited research was conducted on the utilization of tamarind leaf meals in the poultry diet. Thus, this study was conducted to ascertain the potential of tamarind leaf meal graded levels on the growth performance, immune response, carcass yield, and economic traits in broiler chickens.

Methodology

Handling and procurement of broiler chickens

The investigation was carried out following Good Animal Husbandry Practices standards for the care and use of laboratory animals. Furthermore, chickens were handled humanely in accordance with ethical standards. The experiment used seventy-five (75) day-old broiler chicks of both sexes. These day-old broiler chicks were obtained from a reputable source and housed at the experimental poultry station of the College of Agriculture, Sultan Kudarat State University, Lutayan Campus.

Preparation of experimental cages

All facilities were cleansed and disinfected one week before the chicks' arrival to avoid the spread of infection. The brooder pen had a 1-meter width × 2-meter height built of galvanized iron sheets. This was cleaned and disinfected with a commercial disinfectant before the experimental birds were placed for brooding (Catolico and Ampode, 2019). After the brooding stage, the broiler chicks were transferred to grower cages with the required standard floor area requirement of 1 square foot per bird (Catolico and Ampode, 2019). The grower cages were made of local materials and built-in raised colony-style pens. The experimental cages were built with provisions for optimal ventilation and the avoidance of excessive cold temperatures.

Brooding and rearing management

The day-old chicks were placed in the brooding pen, and old newspapers were used as beddings or litter throughout the brooding phase and were frequently changed. The broiler chickens were provided with two 50 watts electric bulbs as a source of artificial heat until they could regulate their body temperature. Throughout the whole brooding time, the chicks were fed with commercial booster mash (14 days). After the brooding period, the chicks were transferred to the grower cages, and the recommended feeding program for broiler chickens was followed. Moreover, proper sanitation, cleanliness, and chicken dung removal were done regularly to get rid of flies and foul odor.

Feeding and water management

All experimental birds were fed *ad libitum* to ensure that they were fed continually. The broiler chickens were provided with experimental rations from the 15th to 28th days, given starter mash, and gradually shifted to grower mash from day 29th to day 42nd. The *ad libitum* feeding was done at 6:00 in the morning, 12:00 noon, and 3:00 pm. The given rations were weighed and recorded. Separate feed containers were provided for each treatment, and feed refuse was collected and weighed after a day. Also, clean and fresh drinking water was provided throughout the feeding experiment. All birds were treated equally as to other environmental requirements throughout the experimental period.

Health management

All procedures to secure the health status of the experimental birds are based on the methods of Ampode *et al.* (2020). A standard dose of electrolytes and multivitamins was administered via drinking water seven (7) days before the onset of the experiment. This was done to fortify the birds' immune systems against management-related stress. The experimental pens were disinfected with a standard commercial disinfectant solution seven (7) days before the experiment, allowing for a seven (7) day downtime period. Furthermore, cleanliness and sanitation were implemented throughout the experimental period. Proper biosecurity measures were observed, including setting up fences to avoid unauthorized persons or stray dogs which would disturb the experimental area.

Preparation of homemade ration

The homemade ration was prepared after purchasing all the feed ingredients. The tamarind leaves were collected from Barangay, Blingkong, Lutayan, Sultan Kudarat. These were dried, hammer milled using an attrition mill, and sieved through a 1 mm sieve before being added to the formulation. The tamarind leaf meal was analyzed for proximate analysis following the methods of AOAC (2016). The nutrient analysis was used to formulate the starter and finisher rations. The maximum amount of feedstuff included in the ration was considered following the Philippine Recommendations for Livestock Feed Formulation (Table 1, 2, and 3).

Experimental design and treatment

Seventy (75) day-old broiler chicks, regardless of sex, were used in the study. These birds were randomly distributed into five (5) dietary treatments, replicated three (3) times with five birds per replication, and arranged in a Completely Randomized Design (CRD). The experimental treatments were as follows:

T_1 – Commercial ration

T_2 - Homemade ration without tamarind leaf meal (Control)

T_3 - Homemade ration with 1% tamarind leaf meal

T_4 - Homemade ration with 3% tamarind leaf meal

T_5 - Homemade ration with 5% tamarind leaf meal

Slaughtering of birds

At the end of the investigation, broiler chickens were starved for 12 hours, and the final weight was recorded before slaughter. One bird per replicate of body weights close to each replicate's average body weight means was slaughtered (Haruna and Odunsi, 2018). The methods in slaughtering the experimental birds are based on the rules and regulations on humane handling in slaughtering animals for food (DA, 2008; Escobillo and Ampode, 2020).

Data gathered

The following experimental parameters were collected to assess the growth performance of broilers.

1. Final Body Weight (g) - refers to the weight of the birds at 42 days

2. Body Weight Gain (g) - measures the body weight gain of experimental birds and computed using this formula

BWG = Final weight – Initial weight

3. Average Daily Gain (g) - measures the daily gain in weight, and this was

computed using the formula:

$$ADG\ (g) = \frac{\text{Final weight (g) - initial weight (g)}}{\text{Number of feeding days}}$$

4. Voluntary Feed Intake (g) – measures the total weekly feed consumption of the birds and computed using this formula:

VFI (g) = Total Feed Given – Feed Refused

5. Feed Conversion Ratio

$$\text{Feed Conversion Ratio} = \frac{\text{Total Feed Intake (g)}}{\text{Total Weight Gain (g)}}$$

6. Dressing Percentage (%)

$$\text{Dressing percentage} = \frac{\text{Weight of dressed chicken (g)}}{\text{Fasted live weight of chicken (g)}} \times 100$$

7. Cell-mediated Immunity – The cell-mediated immunity will be determined according to the formula of Fu-Chang *et al.* (2004) and Haruna and Odunsi (2018) as follows:

$$\text{Spleen Index} = \frac{\text{Spleen Weight}}{\text{Body Weight}} \times 100$$

$$\text{Bursa Index} = \frac{\text{Bursa of Fabricius Weight}}{\text{Body Weight}} \times 100$$

8. Return Above Feed and Chick Cost = Gross Income – (feed cost + treatment cost of tamarind leaf meal + cost of day-old chick)

Statistical analysis

The data gathered were subjected to a One-Way Analysis of Variance (ANOVA), and treatment means were compared using Tukey's Honest Significant Difference (HSD) Test using Statistical Package of Social Science software of version 17.0. A $p<0.05$ was considered significant.

Results and discussion

Bi-weekly final weight

Feeding broilers with different levels of tamarind leaf meal showed no significant difference in broilers' weight at the 15-28 days feeding trial (Table 4). However, the inclusion of tamarind leaf meal showed a significant effect ($p<0.05$) on the final weight of broiler chickens at 29-42 days.

The results revealed that T_1 fed with commercial ration had the highest final weight with 1356.73 grams. Although there's a significant effect of feeding tamarind leaf meal, the data showed that T_1 is still comparable to T_2, T_3, and T_4, while T_5 got the lowest final weight. The present study's result contradicts the findings of Jamroz *et al.* (2009), who reported that animal diets containing a high amount of tannin have no significant effect on the broilers' final weight. The broiler chickens' slightly decreasing final weight might be due to the fiber and possible tannin content in the tamarind leaf meal. The excess tannin caused improper digestion of some minerals required for metabolism, eventually decreasing the growth rate (Alkasanand Al-Shukri, 2018).

Body weight gain

The study's result revealed no significant difference in body weight gain at days 15-28 of the feeding trial (Table 4). However, it was evident that a significant result was observed on 29-42 days where T_1 got the highest body weight gain and slightly decreased when birds fed with graded levels of Tamarind leaf meal.

Although significant results were observed on days 29-42, birds fed with commercial ration are comparable in T_4 and T_5, with 1% and 5% tamarind leaf meal inclusion in the diet.

Table 1. Composition and calculated analysis of experimental starter ration for broilers with graded levels of tamarind leaf meal.

Ingredients	TREATMENTS				
	1	2	3	4	5
Ground Yellow Corn	-	54.00	53.00	51.00	50.69
Rice Bran D1	-	8.00	8.00	8.00	8.00
Soybean, US	-	22.87	23.00	23.00	20.00
Fish meal, 60 %	-	6.00	6.00	6.00	7.36
Copra Meal	-	5.00	5.00	5.00	5.00
Tamarind Leaf Meal		0.00	1.00	3.00	5.00
Dicalcium phosphate	-	0.81	0.81	0.78	0.66
Limestones	-	0.77	0.77	0.77	0.77
Lysine HCL	-	0.10	0.20	0.20	0.10
D-L Methionine	-	0.20	0.20	0.20	0.20
L threonine	-	0.10	0.10	0.10	0.10
Vit. Premix	-	1.00	1.00	1.00	1.00
Salt	-	0.30	0.30	0.30	0.30
Vegetable Oil	-	0.85	0.62	0.65	0.82
TOTAL	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
Crude Protein	-	21.98	21.91	21.85	21.54
Crude Fiber	-	4.09	6.14	7.30	4.64
Moisture	-	12.62	12.63	12.41	11.91
Ash	-	6.58	5.92	8.76	8.25
Metabolizable Energy	-	2925.58	2894.48	2864.87	2912.58
Phosphorus	-	0.42	0.44	0.48	0.44
Calcium	-	0.85	1.03	1.4	0.87
Lysine	-	1.24	1.4	1.51	1.26
Methionine	-	0.59	0.6	0.63	0.6
Meth+Cyst	-	0.74	0.75	0.77	0.79
Threonine	-	0.91	0.96	1.05	0.92
Tryptophan	-	0.24	0.25	0.25	0.24

T_1: Commercial ration; T_2: HR + 0% TLM; T_3: HR + 1% TLM; T_4: HR + 3% TLM; T_5: HR + 5% TLM

[1]Vitamin Mineral Premix: Vitamin A 5,000,000 i.u. Vitamin D3 2,000,000 i.u. Vitamin E 2,000 i.u. Riboflavin 4,350 mg, Thiamine 1,800 mg, Pyridoxine 50 mg, Niacin 40,150 mg, Calcium Pantothenate 5,500 mg, Biotin 0.1 mg, Folic Acid 90 mg, Para Amino Acid Benzoic Acid 4,000 mg, Inositol 0.74 mg, Manganese Sulfate 98,000 mg, Ferrous Sulfate 40,000 mg, Potassium Iodine 1,500 mg, Cobalt Carbonate 800 mg, Copper Sulfate 3,000 mg, Zinc Oxide 40,000 mg, DL- Methionine 23,000 mg, L-Lysine 22,000 mg, Lecithin 20,000 mg, Cod Liver Oil 160,000 mg, Carrier q.s ad.

The present findings confirm the results of Saleh *et al.* (2012), who reported that birds supplemented with an aqueous solution of tamarind pulp significantly increased (p<0.05) the body weight gain of broiler chickens.

The cumulative body weight gain of broiler chickens from days 15-42 significantly decreased. The broiler chickens fed with graded levels of tamarind leaf meals had lower body weight than T_1 or birds fed with commercial ration. However, based on the statistical analysis, T_1 is still comparable to T_2 (0 % TLM), T_3 (1 % TLM), and T_4 (3 % TLM) in the diets. This could be due to the amount of crude fiber in the tamarind leaf meal, which causes improper

digestion of some minerals required for metabolism.

Bi-weekly voluntary feed intake

The bi-weekly voluntary feed intake of broiler chickens was significantly (p<0.05) affected when graded levels of tamarind leaf meal were incorporated into the diets (Table 4).

Table 2. Composition and calculated analysis of finisher ration for broilers with graded levels of tamarind leaf meal.

Ingredients	TREATMENTS				
	1	2	3	4	5
Ground Yellow Corn	-	55.50	55.50	55.50	54.00
Rice Bran D1	-	11.00	10.00	10.00	9.00
Soybean, US	-	20.00	20.00	18.00	18.00
Fish meal, 60 %	-	5.50	5.50	7.00	7.00
Copra Meal	-	4.00	4.00	3.00	3.00
Tamarind Leaf Meal		0.00	1.00	3.00	5.00
Dicalcium phosphate	-	0.81	0.81	0.81	0.81
Limestones	-	0.77	0.77	0.77	0.77
Lysine HCL	-	0.10	0.10	0.10	0.10
D-L Methionine	-	0.20	0.20	0.20	0.20
L threonine	-	0.10	0.10	0.10	0.10
Vit. Premix	-	0.87	0.87	0.87	0.87
Salt	-	0.30	0.30	0.30	0.30
Vegetable Oil	-	0.85	0.85	0.35	0.85
TOTAL	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
Crude Protein	-	19.31	19.94	19.11	19.78
Crude Fiber	-	3.53	4.60	12.38	9.24
Moisture	-	12.02	11.90	12.58	12.05
Ash	-	8.34	7.88	7.49	7.12
Metabolizable Energy	-	2944.83	2947.95	2936.29	2955.43
Phosphorus	-	0.41	0.41	0.45	0.45
Calcium	-	0.82	0.82	0.88	0.88
Lysine	-	1.16	1.15	1.18	1.19
Methionine	-	0.57	0.57	0.58	0.58
Meth+Cyst	-	0.71	0.71	0.74	0.76
Threonine	-	0.86	0.86	0.87	0.88
Tryptophan	-	0.23	0.23	0.23	0.23

T_1: Commercial ration; T_2: HR + 0% TLM; T_3: HR + 1% TLM; T_4: HR + 3% TLM; T_5: HR + 5% TLM

[1]Vitamin Mineral Premix: Vitamin A 5,000,000 i.u. Vitamin D3 2,000,000 i.u. Vitamin E 2,000 i.u. Riboflavin 4,350 mg, Thiamine 1,800 mg, Pyridoxine 50 mg, Niacin 40,150 mg, Calcium Pantothenate 5,500 mg, Biotin 0.1 mg, Folic Acid 90 mg, Para Amino Acid Benzoic Acid 4,000 mg, Inositol 074 mg, Manganese Sulfate 98,000 mg, Ferrous Sulfate 40,000 mg, Potassium Iodine 1,500 mg, Cobalt Carbonate 800 mg, Copper Sulfate 3,000 mg, Zinc Oxide 40,000 mg, DL- Methionine 23,000 mg, L-Lysine 22,000 mg, Lecithin 20,000 mg, Cod Liver Oil 160,000 mg, Carrier q.s ad.

The cumulative voluntary feed intake of birds from days 15-42 revealed that experimental birds fed with commercial ration had the highest feed intake with 2254.00 grams, but still comparable to T_2, T_4, and T_5 with 2042.60 grams, 2136.27 grams, 2121.80 grams, respectively. However, the lowest feed intake was observed in T_3 with 1977.27 grams. The results of the study are contrary to the findings of Aengwanich *et al.* (2009), who reported that feed intake of broiler chickens fed with tamarind leaf meal had no significant effect (p>0.05) on the feed intakes. However, their findings are contrary to Olumo (1995), who reported that broiler chickens' feed intake significantly increased when tamarind pulp extract was supplemented. The present study revealed that the inclusion of tamarind leaf meal resulted in slightly decreasing feed intakes. Although the feed intake of broiler chicken decreased, the final weight and body weight gain were not negatively affected as data revealed that birds fed with graded levels of tamarind leaf meal are statistically comparable to the birds fed with commercial ration.

Table 3. Proximate analysis of tamarind leaf meal.

NUTRIENT	OP (%)
Dry Matter	90.37
Moisture	9.63
Crude Protein	11.18
Crude Fiber	20.18
Ash	11.09

Analyzed following the methods described by the AOAC (2016).

This might be due to the insufficient adaptation with the supplied feed additives or the nutrients like amino acids and crude fiber present in tamarind leaf meals. Although crude fiber provides no nutrients or energy, it is a good source of dietary fiber. This fiber content may aid in maintaining beneficial effects on intestine and colon physiology (McPherson, 1982; and Hassan *et al.*, 2016), which aid improve digestion and metabolism activities, thus, meeting the nutrient requirements at lower intakes. On the other hand, the increase of feed intakes of broiler chickens supplemented with tamarind pulp extract may be due to the amount of sugar in tamarind pulp that might help meet the feed intake energy requirements.

Table 4. The effects of tamarind leaf meal on the growth performance of broiler chickens.

Parameters	Days		
	15-28	29-42	15-42
Bi-weekly final weight, grams			
T_1-Control	628.40	1356.73^a	1356.73^a
T_2-0% TLM	669.13	1301.80^{ab}	1301.80^{ab}
T_3-1% TLM	688.33	1304.80^{ab}	1304.80^{ab}
T_4-3% TLM	639.00	1320.20^{ab}	1320.20^{ab}
T_5-5%TLM	602.87	1289.93^b	1289.93^b
P value	0.085^{ns}	0.043*	0.043*
CV (%)	5.40	8.84	1.77
Bi-weekly body weight gain, grams			
T_1-Control	416.00	728.33^a	1144.33^a
T_2-0% TLM	458.40	632.67^b	1091.07^{ab}
T_3-1% TLM	476.33	616.47^b	1092.80^{ab}
T_4-3% TLM	424.73	628.20^{ab}	1105.93^{ab}
T_5-5%TLM	390.87	687.07^{ab}	1077.93^b
P value	0.087^{ns}	0.015*	0.032*
CV (%)	8.19	25.38	1.97
Average Daily Gain, grams			
T_1-Control	29.71	52.02^a	81.74^a
T_2-0% TLM	32.74	45.20^b	77.93^{ab}
T_3-1% TLM	34.02	44.03^b	78.06^{ab}
T_4-3% TLM	30.34	48.66^{ab}	79.00^{ab}
T_5-5%TLM	27.92	49.08^{ab}	77.00^b
P value	0.087^{ns}	0.015*	0.032*
CV (%)	8.19	25.38	1.97
Voluntary feed intake. grams			
T_1-Control	930.93^a	1323.07^a	2254.00^a
T_2-0% TLM	857.80^b	1184.80^{ab}	2042.60^{ab}
T_3-1% TLM	853.33^b	1097.20^b	1977.27^b
T_4-3% TLM	872.27^{ab}	1264.00^{ab}	2136.27^{ab}
T_5-5%TLM	870.93^{ab}	1250.87^{ab}	2121.80^{ab}
P value	0.027*	0.043*	0.011*
CV (%)	2.96	34.44	3.54
Feed Conversion Ratio			
T_1-Control	1.37	1.83	1.97
T_2-0% TLM	1.87	1.87	1.87
T_3-1% TLM	1.80	1.83	1.81
T_4-3% TLM	2.05	1.86	1.93
T_5-5%TLM	2.25	1.82	1.97
P value	0.066^{ns}	0.985^{ns}	0.070^{ns}
CV (%)	11.49	7.10	3.70

TLM = Tamarind leaf meal; CV = Coefficient of Variance;
* =significant at (p<0.05), means having a similar superscript is not significantly different using HSD test.
ns =not significant at (p>0.05).

Table 5. Mean slaughter weight, dressed weight, and dressing percentage (%) of broilers fed with graded levels of tamarind leaf meal.

Parameters	TREATMENT					Total	Mean	CV (%)	P value
	1	2	3	4	5				
Slaughter wt., g	1362.07^{a}	1241.8^{bc}	1211.47^{c}	1306.87^{ab}	1223.27^{c}	6345.48	1269.10	0.00	2.07**
Dressed wt., g	950.24^{a}	844.47^{ab}	839.91^{b}	913.59^{ab}	846.71^{ab}	4394.92	878.98	0.021	4.54*
Dressing %	69.74	68	69.33	69.92	69.25	346.24	69.25	0.927	1.44^{ns}

T_1: Commercial ration; T_2: HR + 0% TLM; T_3: HR + 1% TLM; T_4: HR + 3% TLM; T_5: HR + 5% TLM

ns =not significant at (p>0.05).

*=significant at (p<0.05), means having a similar superscript is not significantly different using the HSD test.

**=significant at (p<0.01), means having a similar superscript is not significantly different using the HSD test.

Bi-weekly feed conversion ratio

The feed conversion ratio of broiler chickens had no significant effect (p>0.05) when the Tamarind leaf meal was incorporated into the diet (Table 4). The feed conversion ratio measures the efficiency with which the bodies of livestock convert animal feed into the desired output, which means that the lower the value, the more efficient the birds are in converting feed to live weight (Dumaup and Ampode, 2020). The present study's revealed that from days 15-42, birds in T_3 fed with 1% tamarind leaf meal had the lowest feed conversion ratio with 1.81 kilograms, followed by T_2, T_4, T_1, and T_5 with 1.87, 1.93, 1.97 and 1.97 in kilograms. These findings are contrary to Sinde *et al.* (2015), who reported that supplementation of tamarind pulp's aqueous solution significantly improved the feed conversion ratio of broiler chickens. A significant result of the feed conversion ratio could be due to the probiotics or the live microorganisms present in the aqueous solution of tamarind pulp that might aid improved protein digestion.

Table 6. Mean of cell-mediated immunity of broilers fed with graded levels of tamarind leaf meal.

Parameters	TREATMENT					CV (%)	P value
	1	2	3	4	5		
Bursa weight, g	0.80^{a}	0.66^{abc}	0.62^{bc}	0.75^{ab}	0.54^{c}	9.37	0.005**
Bursa index (%)	0.06^{a}	0.06^{a}	0.05^{ab}	0.06^{a}	0.04^{b}	0.00	0.034*
Spleen weight, g	6.83^{a}	4.32^{b}	4.99^{b}	5.35^{ab}	3.69^{b}	12.71	0.001**
Spleen index (%)	0.50^{a}	0.35^{b}	0.41^{ab}	0.41^{ab}	0.30^{b}	14.04	0.008**

T_1: Commercial ration; T_2: HR + 0% TLM; T_3: HR + 1% TLM; T_4: HR + 3% TLM; T_5: HR + 5% TLM

*=significant at (p<0.05), means having a similar superscript is not significantly different using the HSD test.

**=significant at (p<0.01), means having a similar superscript is not significantly different using the HSD test.

Slaughter weight, dressed weight, and dressing percentage

The average slaughter weight, dressed weight, and dressing percentage of broiler chickens fed with graded levels of tamarind leaf meal are presented in Table 5. A significant effect (p<0.05) was observed in the slaughter weight. The T_1 got the highest weight with 1362.07 grams, followed by T_4, T_2, T_5 with 1306.87 grams, 1241.80 grams, 1223.27 grams, and the lowest was T_3 with 1211.47 grams. Likewise, T_1 got the highest dressed weight with 950.24 grams, followed by T_4, T_5, T_2 with 913.59 grams, 846.41 grams, 844.47 grams, and the lowest was T_3 with 839.91 grams.

The dressing percentage, or carcass yield as it is sometimes referred to, is the proportion of ending live weight yielded after animals have been eviscerated. In this study, the dressing percentage (%) of the broiler chicken fed with graded levels of tamarind leaf meal had no significant (p>0.05) difference from 15 to 42 days. In the dressing percentage (%), T_4 got the highest weight with 69.92 grams, followed by T_1, T_3, T_5 with 69.74 grams, 69.33 grams, 69.25 grams, and the lowest was observed in T_2 with 68.00 grams. The result of the present study confirms the findings of Saleh *et al.* (2012) and Chong *et al.* (2013), who reported no significant difference in dressing percentage of the broiler chicken fed with tamarind leaf powder.

Table 7. Return above feed and chick cost of broiler chickens fed with graded levels of tamarind leaf meal#.

PARTICULARS	TREATMENTS				
	1	2	3	4	5
Final live weight, kg	1356.73	1241.80	1211.47	1320.87	1223.27
Price/kg live weight (Php)	130.00	130.00	130.00	130.00	130.00
Gross return/head (Php)	176.37	161.43	157.49	171.71	159.03
Cost of DOC/head (Php)	30.00	30.00	30.00	30.00	30.00
Feed Consumption (kg/head)					
a. CBM (kg)	0.28	0.28	0.28	0.28	0.28
b. Starter (kg)	0.93	0.85	0.85	0.87	0.87
c. Finisher (kg)	1.32	1.18	1.10	1.20	1.25
Price/kg of Feed (kg)					
a. CBM (kg)	36.00	36.00	36.00	36.00	36.00
b. Starter (kg)	33.22	25.52	22.60	22.29	21.00
c. Finisher (kg)	36.00	24.00	24.84	24.51	24.56
Total Feed Cost (Php)					
a. CBM (kg)	10.08	10.08	10.08	10.08	10.08
b. Starter (kg)	30.89	21.69	19.21	19.39	18.27
c. Finisher (kg)	47.52	28.32	27.32	29.41	30.70
Total Cost (Php)	118.49	90.09	86.61	88.88	89.05
RAFCC*	57.88	71.34	70.88	82.83	69.98

T_1: Commercial ration; T_2: HR + 0% TLM; T_3: HR + 1% TLM; T_4: HR + 3% TLM; T_5: HR + 5% TLM

#All costs were shown in PhP (Philippine peso); 1 USD = 50.30 PhP

* RAFCC: Return above feed and chick cost.

Cell-mediated immunity

The spleen weight, bursa weight, bursa, and spleen indices showed significant differences ($p<0.05$) among treatment means (Table 6). In avian species, adaptive immunity encompasses both humoral and cell-mediated immune responses. The humoral or antibody-mediated immune responses effectively combat extracellular antigens. On the other hand, cell-mediated immunity is focused on eliminating intracellular antigens that have entered cells via the endocytic pathway or that have been created within the cell, such as viral proteins and proteins emerging from neoplastic cell transformation (Erf, 2004; Eladia and Ampode, 2021). In the present study, it is evident in the numerical values that birds in T_1 fed with commercial ration had higher spleen weight, bursa weight, bursa, and spleen indices. However, statistical analysis revealed that experimental birds fed with commercial ration are comparable to the birds fed with tamarind leaf meal levels. This implies that the bigger the immunity index, the stronger the broiler chickens' immune response (Fu Chang *et al.*, 2004; Latif *et al.*, 2014; Dumaup and Ampode, 2020). Thus, the result of the study emphasized that the inclusion of tamarind leaf meal in broiler diets could help boost the cell-mediated immunity of broiler chickens.

Return above feed and chick cost

The return above feed and chick cost (RAFCC) refers to the amount gained from the study's treatment (Table 7). It demonstrates whether the given treatment positively or negatively impacted profit gaining (Catolico and Ampode, 2019). Among the five dietary treatments, T_4 with 3% TLM had the highest return of Php 82.83, followed by T_2 with Php 71.34; T_3 with Php 70.88; T_5 with Php 69.98 and T_1 got the lowest return above feed and chick cost with Php 57.88.

Conclusion

The inclusion of tamarind leaf meal in broilers diet had a significant effect on the growth performance, cell-mediated immunity, and dressed weight. Moreover, incorporating 3% tamarind leaf meal in the diet of broiler chickens obtained higher profit. However, further study on tamarind leaf meal is recommended for a long duration of the research in other species of monogastric and ruminant animals, and a digestibility study is also recommended to assess the nutrient flow and retention directly from digestive sites.

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Author's contribution

Both authors contributed equally as co-first authors of this manuscript.

Conflict of interest

The authors declared no conflict of interest.

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