Research Article

Moringa (*Moringa oleifera* Lam.) Pod Meal: Nutrient Analysis and its Effect on the Growth Performance and Cell-Mediated Immunity of Broiler Chickens

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Abstract | The poultry industry recently utilized locally abundant plant sources that are phytobiotics and environmentally friendly to improve production performance and boost the fowl's immune system. However, plants may contain some anti-nutritive factors that might negatively affect the production performance. A total of sixty-day-old broiler chickens were used to investigate the potential of Moringa (*Moringa oleifera* Lam.) Pod Meal (MPM) on production performance and cell-mediated immunity. The broiler chickens were assigned in a Completely Randomized Design experimental set-up with four dietary treatments. Each treatment was replicated three times, with five birds in every replication and fed with MPM at 0 (T1), 5 (T2), 10 (T3), and 15% (T4) levels in 42 days feeding trial. Moringa pod meals' chemical composition contains 13.02% crude protein, 36.98% crude fiber, 5.94% ash, and 11.33% moisture. The results revealed no significant differences (p>0.05) in the final weight, body weight gain, average daily gain, and feed conversion ratio of broiler chickens. Numerically, the highest final weight and weight gains were observed in birds fed with MPM. Moreover, the voluntary feed intake was significantly (p<0.05) affected when MPM was incorporated into the diet. There were no significant differences (p>0.05) observed in the indicators of cell-mediated immunity (immune organ indices), but numerical values showed higher in broiler chickens fed with MPM than broilers without MPM in the diet. The highest return of investment was observed in T3 with PhP106.48, and T1 obtained the lowest income generated with Php101.49 per bird. In light of the findings, incorporating MPM in the diets seems potential to improve broiler chickens production and immune responses, however further studies using large population of birds should be warranted.

Keywords | Malunggay, Broiler chicken, Growth performance, Lymphoid organs, Immune response

Received | December 29, 2020; **Accepted** | January 19, 2021; **Published** | April 15, 2021
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Citation | Eladia RE, Ampode KMB (2021). Moringa (*Moringa oleifera* Lam.) Pod meal: nutrient analysis and its effect on the growth performance and cell-mediated immunity of broiler chickens. J. Anim. Health Prod. 9(2): 170-177.
DOI | http://dx.doi.org/10.17582/journal.jahp/2021/9.2.170.177
ISSN | 2308-2801

INTRODUCTION

Poultry production provides a base for the socio-economic advancement in most developing countries, which has led to increased demand for poultry products (Hussein & Jassim, 2019). In the Philippines, the chicken industry is considered one of the fastest-growing livestock sectors, with a total inventory of 186.33 million birds (PSA, 2020). The country's population and income growth are increasing along with the demand for chicken products. However, the broiler industry faces threats, and one of these is the increasing consumer concerns over food safety, product quality, animal welfare, and environmental issues associated with industrialized poultry production systems (Chang, 2007). To improve poultry production's economic status, various researchers developed preferences such as using natural or organic supplements instead of using synthetic or inorganic medicaments (Zeweil et al., 2006).

Synthetic growth enhancers or antibiotics have been utilized to prevent diseases and improve chicken production performance (Thomke & Elwinger, 1998). However, the utilization of antibiotics as growth promoters has some disadvantages; these include residual effects, drug toxicity, and bacteria resistance development (Ogbe & John, 2012; Alabi et al., 2017). Thus, antibiotics in poultry diets as a growth promoter have been banned in the European Union since 2006 (Teteh et al., 2013).

The poultry industry recently utilized locally abundant plant sources that are phytobiotics and environmentally friendly to boost the fowl's immune system without the additional cost of synthetic antibiotics (Mapatac, 2017). Herbs and herbal products are generally believed to be safer and less expensive. Moreover, herbs can improve metabolism, digestion and possess bacterial and immunostimulant activities (Ghazalah and Ali, 2008). Various medicinal plants have been incorporated into poultry diets to obtain a rapid body weight gain, better feed efficiency, and higher production. However, plants may contain some anti-nutritive factors that might negatively affect the production performance. Hence, any plant that can be used to improve productivity should be investigated to determine the limits of incorporation in animal feed. One of the locally abundant medicinal plants that could be utilized to improve growth and boost chickens immune response is the Moringa.

Moringa *(Moringa oleifera* Lam.*),* also known as malunggay is a medicinal herb in the genus Moringa (family Moringaceae) under the order Brassicales. It is considered a miracle tree because of its rich resource of various nutrients with high biological value (Mahfuz & Piao, 2019). Further, it is used as an immune enhancer, antioxidant, growth promoter, and hypo-cholesterol effect on chickens (Mahfuz and Piao, 2019). According to Lannaon (2007), Starbo broilers fed with Moringa leaf decoction significantly improved the chickens performance, such as final weight, feed consumption, and daily weight gain compared to the birds without Moringa supplementation. Moreover, Du et al. (2007) also reported that the higher levels of Moringa leaf meal in Arbor acres strain broiler chicken diets reduced the contents of uric acids, triglycerides, and albumin or globulin ratio in the serum. Likewise, Ahmad et al. (2017) also reported that supplementation of Moringa showed a positive impact on growth, immunity, and broiler chickens serum biochemistry. However, limited research was conducted on utilizing Moringa pod meal as feedstuff to broiler chickens. Thus, this study was conducted to determine the growth performance, economic viability, and cell-mediated immunity of broiler chickens fed with Moringa Pod Meal.

MATERIALS AND METHODS

Experimental birds, diets, and management

All procedures used in the study are in accordance with the Good Animal Husbandry practices guidelines in rearing poultry and livestock animals in the Philippines (PNS/BAFPS, 2008). Sixty (60) day-old broiler chicks were purchased from a reliable Agrivet supply in Koronadal City and housed at St. Alexius College Demonstration Farm, San Felipe, Tantangan, South Cotabato. During the brooding period, the artificial heat was provided using two incandescent 25-watts bulbs for fourteen (14) days to regulate their body temperature. The experimental birds are randomly distributed into four (4) treatments and replicated three (3) times, having five (5) birds in every replication and raised in a monitor type poultry house.

The poultry house is made of bamboo and plywood, and the broiler chickens were placed in a cage measuring one square foot per bird and fed *ad libitum,* and each pen was provided with a waterer and feeding trough. The day-old chicks were fed with commercial chick booster mash during the brooding period from 1-14 days old. The feeding trial started at 15 days old and lasted for 42 days, with two (2) feeding periods, the starter and the finisher phase. The experimental birds were given a starter ration from days 15 to 28 and gradually shifted to a finisher ration from 29 to 42 days. The formulated diets and the total amino acids' calculated analysis met or exceeded the nutrient requirements based on the Philippines Recommends for Livestock Feed Formulation PCAARRD, (2000). The experimental diet was incorporated with graded levels of Moringa Pod Meal at 0% (T1), 5% (T2), 10% (T3), and 15% (T4) of the diet (Table 1).

Collection and preparation of Moringa Pod Meal

Fresh and tender moringa pods were purchased at the public market and grocery store in Koronadal City. The Moringa pods were washed with tap water and sun-dried for two days to attain 12-15% moisture content (Ahmad et al., 2018; PCAARRD, 2000) and ground using an attrition mill. The Moringa pod meal was subjected to proximate analysis following the methods described in AOAC (2016). The result of the chemical anlysis were used in formulating the experimental rations.

Evaluation of the growth performance

Initial weight (g/bird) was taken on the 15th day-old chicks right after the brooding period. At the end of the study, the broiler chickens final weight was recorded using a sensitive digital weighing scale. The final weight of the birds was subtracted from its initial weight. The body weight gain (BWG) was measured every two (2) weeks to monitor its

Table 1: Composition and chemical analysis of the experimental diets

Ingredients (% as fed basis)	**Starter Diet** (15-28 days)				**Finisher Diet** (29-42 days)			
	T1 0%	T2 5%	T3 10%	T4 15%	T1 0%	T2 5%	T3 10%	T4 15%
Hammered Corn	58.00	54.00	51.70	45.00	61.72	58.51	54.81	52.32
Soybean Meal	26.00	25.54	24.31	28.00	23.26	22.49	23.13	21.70
Rice Bran D1	6.00	5.00	4.00	5.00	5.00	4.00	3.00	3.00
Fish Meal, 60%	4.00	4.00	4.00	1.00	4.00	4.00	4.00	4.50
Copra Meal	3.00	3.00	3.00	3.00	2.00	2.00	0.50	0.50
MPM[1]	0.00	5.00	10.00	15.00	0.00	5.00	10.00	15.00
Dicalcium Phosphate	0.73	0.40	0.50	0.20	1.50	1.50	1.00	0.05
Limestones	0.70	0.90	0.79	0.55	0.70	0.30	0.55	0.70
Lysine	0.12	0.08	0.05	0.05	0.05	0.10	0.05	0.02
D-L Methionine	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.05
L threonine	0.10	0.05	0.05	0.01	0.02	0.10	0.05	0.01
Tryptophan	0.05	0.08	0.05	0.10	0.10	0.10	0.09	0.10
Vitamin Premix[2]	0.50	0.50	0.50	0.50	0.50	0.50	0.60	0.50
Salt (NaCl)	0.25	0.50	0.50	0.54	0.40	0.60	1.42	1.35
Vegetable Oil	0.50	0.90	0.50	1.00	0.70	0.70	0.70	0.20
Total (kg)	100	100	100	100	100	100	100	100
Chemical Analysis (% DM)[3]								
Crude Protein	19.10	20.48	19.64	20.86	18.87	19.53	19.00	19.52
Crude Fiber	2.91	4.14	7.55	11.23	5.15	7.47	9.61	6.88
Moisture	10.26	10.84	11.23	11.75	13.28	11.91	12.46	12.22
Ash	9.32	6.02	5.49	6.75	5.40	4.69	5.08	5.57
Calculated Analysis								
ME (kcal/kg)	2969	2970	2968	2970	2988	2989	2989	2989
Phosphorus	0.41	0.56	0.83	0.98	0.49	0.75	0.91	1.00
Calcium	0.78	0.87	0.88	0.83	0.89	0.87	0.93	0.92
Lysine	1.35	1.35	1.4	1.57	1.26	1.28	1.36	1.45
Methionine	0.48	0.49	0.55	0.58	0.56	0.52	0.56	0.58
Meth+Cys	0.74	0.83	0.92	1.00	0.70	0.79	0.88	0.97
L-Threonine	0.91	0.99	1.08	1.21	0.95	0.99	1.07	1.16
Tryptophan	0.34	0.34	0.37	0.39	0.33	0.34	0.35	0.37

[1] Moringa Pod Meal

[2] Per 500 grams vitamin premix contains; Vitamin A (150,000 IU), Vitamin D3 (30,000 IU), Vitamin E (500 IU), Selenium (100mg), Potassium Iodide (100mg), Cobalt Sulfate (30mg), Manganese Sulfate (3,700mg), Ferrous Sulfate (1600mg), Copper Sulfate (1,500mg), Zinc Sulphate (220mg), Dicalcium Phosphate (97%), Carrier (q.s.ad)

[3] Analyzed following the methods described by the AOAC (2016) 20th edition (Escobillo and Ampode, 2020)

weight gain. The feed intake was determined by weighing the amount of feed given and subtracted to the feed refused every morning. The feed conversion ratio (FCR) was determined by calculating the total amount of feed consumed over the broilers final body weight gain.

Cell-mediated Immunity

The experimental birds were fasted for twelve (12) hours to free from any contamination and empty their gizzard after 42 days (Bortoluzzi et al., 2013). After fasting, birds are individually weighed, and birds nearest to the mean weight per replication were slaughtered to evaluate the immune response by weighing the lymphoid organs. A single slit was made below the earlobe to cut the jugular vein and allowing the blood to drain, and scalded in the water at a temperature of 60°C for easy removal of the feathers. After de-feathering, they were eviscerated and dressed. Following a true visual appraisal, the bursa and spleen were

Table 2: Proximate Analysis of Moringa Pod Meal (MPM)

NUTRIENT	MPM (%)
Crude Protein	13.02
Crude Fiber	36.98
Ash	5.94
Moisture	11.33

Analyzed following the methods described by the AOAC (2016) 20th edition (Escobillo and Ampode, 2020)

Table 3: Effect of MPM dietary treatments on broiler growth performance

Parameter (days)	Treatment					
	T1 0%	**T2 5%**	**T3 10%**	**T4 15%**	**CV[1]**	**P value**
Initial Weight (g)	378.93 ±5.22	378.80 ±3.12	382.47 ±11.76	382.27 ±14.59	2.589	0.942[ns]
Final Weight (g)						
15-28	1033.47± 26.99[ab]	980.53 ±8.01[b]	978.80 ±52.66[b]	1061.20 ±23.46[a]	3.165	0.033[*]
29-42	1520.07 ±28.70	1543.47 ±27.80	1569.07 ±48.63	1532.40 ±36.81	2.365	0.448[ns]
15-42	1520.07 ±28.70	1543.47 ±27.80	1569.07 ±48.63	1532.40 ±36.81	2.365	0.448[ns]
Body Weight Gain (g)						
15-28	654.53 ±23.61	601.73 ±10.68	596.33 ±62.36	678.93 ±21.20	5.592	0.055[ns]
29-42	493.27 ±34.21[ab]	589.60 ±80.09[a]	590.27 ±59.62[a]	444.53 ±36.71[b]	10.554	0.029[*]
15-42	1141.13 ±30.18	1164.67 ±26.94	1186.60 ±52.22	1150.13±23.35	3.018	0.456[ns]
Average Daily Gain (g)						
15-28	46.75 ±1.69	42.98 ±0.76	42.60 ±4.45	48.50 ±1.51	5.592	0.055[ns]
29-42	35.23 ±2.44[ab]	42.11 ±5.72[a]	42.16 ±4.26[a]	31.75 ±2.62[b]	10.554	0.029[*]
15-42	40.75 ±1.08	41.60 ±0.96	42.38 ±1.87	54.47 ±22.41	3.018	0.456[ns]
Feed Intake (g)						
15-28	871.60 ±3.74[a]	836.00 ±5.50[b]	823.13 ±15.52[b]	889.27 ±9.41[a]	1.130	0.000[**]
29-42	1048.60 ±16.38[b]	1024.93 ±3.01[b]	1155.00 ±2.31[a]	982.47 ±12.41[c]	0.993	0.000[**]
15-42	1920.20 ±12.64[b]	1860.93 ±6.59[c]	1978.13 ±17.01[a]	1871.73 ±3.95[c]	0.591	0.000[**]
FCR[2]						
15-28	1.33 ±0.54	1.39 ±0.16	1.39 ±0.13	1.31 ±0.03	5.216	0.476[ns]
29-42	2.13 ±0.17	1.76 ±0.26	1.97 ±0.19	2.22 ±0.16	9.772	0.090[ns]
15-42	1.68 ±0.04	1.60 ±0.04	1.67 ±0.07	1.63 ±0.03	2.719	0.185[ns]

[1]CV : Coefficient of Variance; [2]FCR: Feed Conversion Ratio; ns: not significant ($p>0.05$)

[a,b,c]Means ±SD with different superscripts in the same row differ significantly ($p<0.05$)

Table 4: Effects of Moringa pod meal on the Spleen weight, Bursa weight and their indices in broiler chickens

Lymphoid Organs	Treatments					
	T1 0%	**T2 5%**	**T3 10%**	**T4 15%**	**CV[1]**	**P Value**
Spleen weight	2.0± 0.00	3.0 ±0.00	3.0 ±1.00	2.33 ±0.58	22.37	0.160[ns]
Bursa weight	2.33 ±0. 58	2.67± 0.58	2.67 ± 0.58	2.33 ±1.15	30.54	0.900[ns]
Spleen index	0.13 ±0.002	0.19 ±0.035	0.19 ±0.058	0.15 ±0.034	18.94	0.141[ns]
Bursa index	0.13 ±0.002	0.19 ±0.004	0.19 ±0.58	0.15 ±0.34	27.95	0.926[ns]

[1]CV: Coefficient of Variance; ns: not significant ($p>0.05$)

immediately removed and individually weigh (g). The spleen and Bursa indices were calculated using the formula of Fu-Chang et al. (2004), Latif et al. (2014), Haruna and Odunsi (2018), and Dumaup and Ampode (2020), as shown below:

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

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

Cost and Return Analysis

The return above feed and chick cost was determined by subtracting the cost of chicks and feeds from bird sales at the end of the study.

Statistical Analysis

Data collected were subjected to one-way Analysis of Variance (ANOVA) in a Completely Randomized Design. The comparison of treatment means was analyzed using Tukey's Honest Significant Difference (HSD) Test in Statistical Package of Social Science computer software version 17.0. The differences were statistically assessed at P<0.05.

Table 5: Return above feed and chick cost of broiler chickens fed with graded levels of Moringa pod meal

Particulars	**Treatments**			
	T1 0%	**T2 5%**	**T3 10%**	**T4 15%**
Final live weight, kg	1520.07	1543.47	1569.07	1532.4
Price/kg live weight (Php)	130.00	130.00	130.00	130.00
Gross return/head (Php)	197.61	200.65	203.98	199.21
Cost of DOC/head (Php)	30.00	30.00	30.00	30.00
Feed Consumption (kg/head)				
a. CBM[1] (kg)	0.57	0.57	0.57	0.57
b. Starter ration (kg)	0.87	0.84	0.82	0.89
c. Finisher ration (kg)	1.05	1.02	1.16	0.98
Price/kg of Feed (kg)				
a. CBM[1] (kg)	33.50	33.50	33.50	33.50
b. Starter ration (kg)	24.22	25.28	24.23	22.52
c. Finisher ration (kg)	24.71	25.56	24.64	24.33
Total Feed Cost (Php)				
a. CBM[1] (kg)	19.10	19.10	19.10	19.10
b. Starter ration (kg)	21.11	21.13	19.94	20.03
c. Finisher ration (kg)	25.91	26.20	28.46	23.90
Total Cost (Php)	96.12	96.43	97.50	93.02
RAFCC[2] (PhP)	101.49	104.22	106.48	106.19
RAFCC[2] (USD)	2.11	2.17	2.22	2.21

[1]CBM: Chick Booster Mash; [2]RAFCC: Return Above Feed and Chick Cost; DOC: day old chick; kg: kilogram; PhP: Philippine Peso; USD: United States Dollar

RESULTS

Chemical Analysis of Moringa Pod Meal

The Moringa Pod Meal's chemical composition contains 13.02% crude protein, 36.98% crude fiber, 5.94% ash, and 11.33% moisture (Table 2).

Growth performance

Significant differences (p<0.05) were only evident in the final weight at 15-28 days, where T4 (15% MPM) was significantly higher than T1 (0% MPM). However, T1 (0% MPM) was substantially higher than T2 (5% MPM) and T3 (10% MPM). The body weight gain and average daily gain were significantly different (p<0.05) at days 29-42, where T3 (10% MPM) got the highest weight gains compared to T1 (0% MPM). The final cumulative weight, body weight gain, average daily gain, feed intake, and feed conversion ratio from days 15-42 were not significantly affected (p>0.05), as summarized in Table 3. The same trend was observed in body weight gain that birds in T3 (10% MPM) obtained higher body weight gain, followed by birds in T2 (5% MPM) and T4 (15% MPM). Moreover, on the average daily gain, the higher value was observed in T4 (15% MPM), followed by T3 (10% MPM) and T2 (5% MPM), and the lowest weight gain was observed in T1 (0% MPM). The feed intake of birds under different treatment groups differed significantly (p<0.05). The same trend was observed that broiler chickens fed with MPM showed higher values than the T1 (0% MPM). Numerically, the cumulative feed conversion ratio revealed that birds in T2 fed with 5% MPM showed better FCR than T1 (0% MPM).

Cell-Mediated Immunity

The spleen and bursa are the immune organs of interest here, and results revealed no significant (p>0.05) differences among treatment means (Table 4). However, numerical values revealed that birds fed with MPM have stronger immunity than T1 (0% MPM). The heaviest spleen weight was observed in birds fed with 5% and 10% MPM, and T1 (0% MPM) had the lowest spleen weight. Statistically, no significant differences were observed in the spleen weight, bursa weight, spleen, and bursa indices.

Return Above Feed and Chick Cost

As shown in Table 5, the T3 (10% MPM) obtained the highest final weight with 1569.07g/bird, followed by T2 (1543.47 g/bird) and T4 (1532.40 g/bird), while the control showed the lowest value of 1520.07g/bird. With the same amount of price per kilo (Php130/kg), T3 revealed a potential asset for the higher market with Php203.98 gross income per chicken compared to the control with Php197.62/chicken. With this result, T3 showed the highest return above feed and chick cost amounting to Php106.48/chicken compared to the T1 (0% MPM) with Php101.49/chicken.

DISCUSSION

Chemical Composition of Moringa Pod Meal

In the present study, the chemical analysis of Moringa Pod Meal in terms of crude protein and ash content is lower compared to the analysis of Ahmad et al. (2018), who reported that the MPM has 18.98% crude protein and 7.88 ash content, respectively. The current moisture analysis of the Moringa pod meal is 11.33% on a fed basis. It is recommended that moisture content in stored feedstuff is less than 12% (PCAARRD, 2000). The dry matter content of less than 85% normally results in the spoilage of feed ingredients due to mold growth, especially in tropical countries where year-round temperatures and relative humidity are relatively high (Hamito, 2010; Mutayoba et al., 2011). The Moringa pod meal's crude fiber content in the study was comparable to the findings obtained by Melesse et al. (2012) that Moringa green pods contained 37.5% and 35.9% when planted in mid and lower elevations at 1,700 meters and 1,100 meters above sea level. This value of fiber might help improve the gut health and immune function of farm animals (Jha et al., 2019). The variation of proximate chemical analysis could be due to the timing or stage of maturity of the feed ingredients, harvesting method, environmental conditions and weather, such as rain and humidity (Mutayoba et al., 2011), and soil fertility.

Growth Performance

As presented in Table 3, birds supplemented with MPM exhibited an increase in the final weight and body weight gain compared with broiler chickens without MPM supplementation. Within the feeding period, body weight gain increased in birds supplemented with 5% and 10% MPM. Numerically, the average daily gain increases as the levels of MPM supplementation increases. Moreover, feed intake was higher in birds supplemented with 10% MPM. In contrast, the feed consumption was comparable to other experimental groups, which ultimately improves the feed conversion ratio (FCR) in birds fed diet with Moringa pod meal.

The present findings are contrary to Nkukwana (2012), who reported a significant increase in weight when birds are supplemented with *Moringa oleifera* leaf meal than birds without *Moringa oleifera* in the diet. Moreover, Hassan et al. (2016) reported that the inclusion of 0.15 and 0.3% *Moringa oleifera* leaf meal significantly improved the growth performance of broiler chickens reared under heat stress conditions. Similarly, Helal et al. (2017) revealed that the rabbit's growth performance improved when diets are supplemented with a mixture of Moringa leaves and rosemary. On the other hand, the study's recent findings confirm with Gadzirayi et al. (2012) that supplementation of *Moringa oleifera* leaf meal did not significantly influence the final weights over the control group or birds without Moringa in the diet. The same findings was reported by Onunkwo and George (2015), that supplementation of *Moringa oleifera* in the diet had no significant influence on the average daily weight gain and body weight in broiler chickens.

Likewise, broiler chickens voluntary fed intake was significantly affected ($p<0.05$) when graded MPM levels were incorporated into the diet. The result is supported by Portugaliza & Fernandez (2012), who reported that supplementation of *Moringa oleifera* aqueous leaf extracts in drinking water significantly decreased the feed intake of broilers as the concentration increased. This could result from improved digestion and metabolism activities of *Moringa oleifera* (Alabi et al., 2017; Ghazalah & Ali, 2008), thus, meeting the nutrients requirements at lower feed intake.

The results of the FCR indicate that the birds fed with Moringa pod meal showed better results than the broilers without Moringa pod meal in the diet. It implies that Moringa pod meal can be used as a natural growth promoter with no adverse effect on broiler chickens production performance. This could be due to the presence of bioceutical agents, bacterial and immune-stimulant activities of the *Moringa oleifera* plant (Lannaon, 2007; Ghazalah & Ali, 2008).

Cell-mediated immunity

Adaptive immunity in avian species includes both humoral and cell-mediated immune responses. The humoral or antibody-mediated immune responses are effective against extracellular antigens. In contrast, the cell-mediated immunity responses are specialized in removing intracellular antigens, such as viral proteins and proteins resulting from neoplastic cell transformation, which have entered cells through the endocytic pathway or have been generated within the cell (Erf, 2004).

In the present study, the indicators of cell-mediated immunity i.e., bursa and spleen indices showed no significant differences among treatment means. Numerically, the same trend was observed that broiler chickens fed with Moringa pod meal showed higher spleen and bursa indices than birds without Moringa pod meal in the diet. It implies that the bigger the immunity index, the stronger the broiler chickens immune response (Fu Chang et al., 2004). The result of the study is supported by Yang et al. (2006) and Abd El-Hack et al. (2018), who reported that Moringa could improve nutrition and support immune functions of poultry and animal. The same author reported that responses of Moringa include reduced *Escherichia coli* and increased *Lactobacillus* counts in the intestine, demonstrating an enhanced immune response.

Return above Feed and Chick Cost

The total expenses were reduced when MPM was incorporated into the diets. Moringa pod meal can be considered a valuable raw material essential to the feed industry to formulate a balanced diet and lesser feed cost without adverse effect on broiler chickens production performance.

CONCLUSIONS

The body weight gain showed higher value for birds fed with MPM diets than for those fed diets without Moringa pod meal. Moreover, 10% MPM inclusion showed a sufficient amount for the higher final weight and other growth performance parameters such as weight gain, feed intake, and feed conversion ratio. There were no significant differences in the lymphoid organ indices, however numerically the lymphoid organs showed higher in broiler chickens fed with MPM than broilers without MPM in the diet. The return above fed and chick cost of broiler chickens fed with 10% MPM is more profitable than birds fed without MPM in the diet. However, a future digestibility study is recommended to assess the nutrient flow and retention directly from digestive sites.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interests.

ACKNOWLEDGMENT

The authors are grateful to Mr. Juster Escobillo for his valuable support throughout the conduct of the study. The authors also acknowledge Ms. Julie Mie Y. Belongan for facilitating the proximate analysis of feeds and chicken meat at the Office of the Regional Animal Feed Analysis Laboratory of the Department of Agriculture XII, Cotabato City.

AUTHORS CONTRIBUTION

The authors contributed equally to this manuscript.

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