The effect of lemuru fish oil and *Moringa* leaf flour in feed on the internal organs, immune organs, and digestive organs of broiler chicken

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Abstract. The study aimed to evaluate the effects of adding Lemuru fish oil and *Moringa* leaf flour to the diet on the internal organs of broiler chickens. Two hundred broiler chickens were reared from day-old chicks until 35 days old. The treatments applied were T0= diet containing 2% palm oil without Moringa leaf flour; T1= diet containing 2% Lemuru fish oil without Moringa leafflour; T2= diet containing 2% Lemuru fish oil + 1% Moringa leaf flour; T3= diet containing 2% Lemuru fish oil + 2% Moringa leaf flour; and T4= diet containing 2% Lemuru fish oil + 3% Moringa leaf flour. Data were analyzed using one-way analysis of variance (ANOVA), and if significant differences were observed, a further test was conducted using Tukey's test. The results showed that the treatments did not affect (P>0.05) the percentages of internal organ and immune organ weights in broiler. The addition of Lemuru fish oil and Moringa leaf flour to the diet affected the percentages of ileum and cecum weights in broiler. This study concluded that adding Lemuru fish oil and Moringa leaf flour to broiler feed does not negatively affect internal organs and is beneficial for the digestive organs of broiler chickens.

1 Introduction

Broilers are a type of poultry known for their high productivity. Broilers can serve as a source of animal protein, as they contain 22.66% protein [1]. The high productivity of broiler chickens is supported by healthy and optimally functioning organs. Weak immune organs and a disrupted digestive tract can impair growth and increase the risk of disease in broiler chickens [2]. The intestine, an important organ for nutrient absorption and digestion, is directly exposed to external factors and is particularly susceptible to oxidative damage from dietary and environmental sources [3]. Lemuru fish oil and Moringa leaf flour as local feed ingredients can support the health of the internal organs of broiler chickens.

Lemuru fish oil can stimulate the production of anti-inflammatory factors, control intestinal inflammation, and promote intestinal health, thereby protecting the intestinal mucosal barrier under adverse conditions, which is crucial for maintaining optimal growth

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performance. Long-chain n-3 PUFAs derived from lemuru fish oil can modulate the immune status of monogastric species [4].

Moringa oleifera is a source of antioxidants due to the presence of several antioxidant compounds, such as phenolics, carotenoids, ascorbic acid, and flavonoids [5]. Recent studies have shown that antioxidants can increase animal growth performance. This increase is associated with a decrease in feed oxidation, increasein antioxidant capacity of the intestine and liver, and improved intestinal health [3]. Previous studies have only demonstrated the individual effects of lemuru fish oil and Moringa leaf flour. However, the combination of lemuru fish oil and Moringa leaf flour may provide complementary effects. Antioxidants from Moringa leaf flour can protect the long-chain n-3 PUFAs in lemuru fish oil from oxidation, allowing them to function optimally. In turn, lemuru fish oil may enhance the efficacy of bioactive compounds in Moringa leaf flour by improving the absorption of lipophilic antioxidants, such as carotenoids, from *Moringa*. This study aimed to evaluate the effects of adding lemuru fish oil and Moringa leaf flour to the feed on the internal organs of broiler chickens.

2 Materials and methods

2.1 Materials

Two hundred day-old chicks (DOC) of broiler chickens were used in this study. The diets were formulated according to the nutrient requirements of Cobb broilers. The experimental diets consisted of various feed ingredients, including yellow corn, rice bran, fish meal, soybean meal, meat and bone meal, crude palm oil, lemuru fish oil, Moringa leaf flour, dicalcium phosphate (DCP), calcium carbonate ($CaCO_3$), sodium chloride (NaCl), premix, L-lysine, DL-methionine, and tryptophan.

2.2 Cage and rearing method

The cages used in this study were open-house litter cages divided into 20 compartments (1 m × 1 m). The cages and maintenance equipment were sanitized and sterilized before use. Each cage was equipped with feeders and nipple drinkers. The cage floor was covered with approximately 5 cm of rice husk litter. Litter replacement was performed weekly to prevent excessive ammonia accumulation and minimize stress in broiler chickens. The cages were randomly labeled according to treatment and replicate number.

Feed and drinking water were provided ad libitum. Feed manufacturing was carried out at PT Jendela Fauna Indonesia, Bandung, West Java, Indonesia. The broiler chickens were reared for 35 days, and samples were collected at the end of the rearing period (day 35). Internal, immune, and digestive organs were evaluated by weighing them and measuring their lengths. The results of these measurements were expressed as a percentage of slaughter weight by dividing the organ weight or length by the slaughter weight and multiplying by 100%.

2.3 Experimental design

This study used a completely randomized design (CRD) with five treatments and four replications.
T0: diet containing 2% crude palm oil without Moringa leaf flour
T1: diet containing 2% lemuru fish oil without Moringa leaf flour
T2: diet containing 2% lemuru fish oil + 1% Moringa leaf flour
T3: diet containing 2% lemuru fish oil + 2% Moringa leaf flour
T4: diet containing 2% lemuru fish oil + 3% Moringa leaf flour

2.4 Data analysis

The data were analyzed using one-way analysis of variance (ANOVA) at a significance level of $P<0.05$. If significant differences were found, further analysis was conducted using Tukey's test in SPSS (version 24).

3 Result and discussion

3.1 Internal organs of broiler chicken

Table 1 shows the weights of the internal organs of broiler chickens during the study period (1–35 days).

Table 1. Weights of the internal organs of 35-day-old broiler chickens

Variables	T0	T1	T2	T3	T4
Liver (%)	2.10±0.21	2.42±0.27	2.10±0.13	2.24±0.10	2.11±0.13
Heart (%)	0.54±0.06	0.52±0.04	0.49±0.03	0.50±0.02	0.48±0.04
Kidney (%)	0.15±0.03	0.38±0.20	0.16±0.02	0.18±0.03	0.15±0.02
Ventriculus (%)	1.44±0.13	1.48±0.22	1.43±0.28	1.52±0.18	1.33±0.09
Proventriculus (%)	0.42±0.08	0.40±0.10	0.43±0.10	0.57±0.05	0.40±0.04
Bile (%)	0.09±0.05	0.08±0.02	0.09±0.01	0.08±0.04	0.08±0.05
Pancreas (%)	0.25±0.05	0.27±0.05	0.21±0.06	0.24±0.03	0.25±0.01

T0: diet containing 2% crude palm oil without *Moringa* leaf flour; T1: diet containing 2% lemuru fish oil without *Moringa* leaf flour; T2: diet containing 2% lemuru fish oil + 1% *Moringa* leaf flour; T3: diet containing 2% lemuru fish oil + 2% *Moringa* leaf flour; T4: diet containing 2% lemuru fish oil + 3% *Moringa* leaf flour.

The use of lemuru fish oil and Moringa leaf flour in broiler chicken diet showed no significant differences in the percentage of internal organ weights of 35-day-old broiler chickens among treatments. This is evidenced by the average percentages of internal organ weights remaining within the normal range. The normal liver weight of broiler chickens is approximately 31–51 g, or 1.70%–2.63% of live weight [6]. Another study reported that the normal liver weight ranges from 0.40%–1.40% of live weigh [7]. The normal kidney weight of broiler chickens ranges from 0.21%–0.28% [8]. The normal weight of the ventriculus is approximately 1.3%–2.3%, while the proventriculus ranges from 0.40%–0.59% [9]. The normal weight of the bile is around 0.11%–0.12%, and the pancreas ranges from 0.14%–0.35% [8].

This indicates that the use of lemuru fish oil and Moringa leaf flour in the diet does not negatively affect the internal organs of broiler chickens. Diets containing Moringa leaf flour did not directly influence organ development or weight in broiler chickens [10]. Internal organ weight is influenced by body size, genetics, and nutrient composition [11].

3.2 Immune organs of broiler chicken

Table 2 shows the weights of the immune organs of broiler chickens during the study period (1–35 days). The use of lemuru fish oil and Moringa leaf meal in broiler chicken feed showed no significant differences in the percentages of immune organ weights of 35-day-old broiler chickens among treatments. This indicates that diets containing lemuru fish oil and Moringa leaf flour do not negatively affect the immune organs of broiler chickens. Moringa leaves are a good source of vitamins (β-carotene, riboflavin, α-tocopherol, and ascorbic acid) that impact the immune and antioxidant systems [12]. The normal weights of immune organs in broiler chickens are approximately 0.11%–0.15% for the spleen, 0.18%–0.25% for the bursa of Fabricius, and 0.18%–0.25% for the thymus [13]. The weight of immune organs in broiler chickens is highly influenced by the lymphocyte content within these organs [14].

Table 2. Weights of the immune organs of 35-day-old broiler chickens

Variables	T0	T1	T2	T3	T4
Spleen (%)	0.17±0.04	0.23±0.13	0.13±0.03	0.19±0.03	0.14±0.07
Bursa Fabricius (%)	0.09±0.03	0.08±0.01	0.08±0.04	0.08±0.03	0.08±0.02
Thymus (%)	0.21±0.11	0.15±0.03	0.15±0.04	0.25±0.07	0.15±0.07

T0: diet containing 2% crude palm oil without *Moringa* leaf flour; T1: diet containing 2% lemuru fish oil without *Moringa* leaf flour; T2: diet containing 2% lemuru fish oil + 1% *Moringa* leaf flour; T3: diet containing 2% lemuru fish oil + 2% *Moringa* leaf flour; T4: diet containing 2% lemuru fish oil + 3% *Moringa* leaf flour.

3.3 Digestive organs of the broiler chicken

Table 3 shows the weights and relative lengths of the digestive organs of broiler chickens during the study period (1–35 days). The use of lemuru fish oil and Moringa leaf flour in broiler chicken feed affected the percentages of ileum and cecum weights of broiler chickens in the study ($P < 0.05$). However, it did not affect the relative length of the digestive tract broiler chickens in this study. The increases in body weight and improvements in feed conversion were accompanied by a decrease in cecal weight. This finding is consistent with Kim *et al*. [15], who stated that when a reduction in cecal weight is accompanied by an increase in body weight and improved feed conversion, it indicates that nutrients are being utilized in the anterior part of the digestive tract; therefore, the cecum does not need to increase its fermentative capacity.

Table 3. Weights and relative lengths of the digestive organs of 35-day-old broiler chickens

Variables	T0	T1	T2	T3	T4
Weight (%)					
Duodenum	0.53±0.06	0.58±0.06	0.51±0.10	0.53±0.05	0.54±0.02
Jejunum	1.06±0.16	1.06±0.11	0.99±0.09	1.12±0.09	1.09±0.09
Ileum	0.94±0.15^{ab}	0.83±0.06^{ab}	0.84±0.10^{ab}	0.77±0.05^{b}	1.03±0.14^{a}
Cecum	0.36±0,05^{a}	0.24±0.08^{ab}	0.21±0.06^{ab}	0.16±0.03^{b}	0.19±0.04^{ab}
Colon	0.11±0.03	0.09±0.02	0.11±0.01	0.10±0.01	0.09±0.01
Relative length (%)					
Duodenum	1.74±0.06	1.74±0.31	0.76±0.08	1.89±0.16	1.70±0.05
Jejunum	4.19±0.42	3.99±0.35	4.22±0.48	4.41±0.30	4.03±0.22
Ileum	4.59±0.39	4.33±0.28	4.62±0.29	4.75±0.34	4.57±0.38
Cecum	2.04±0.33	0.37±0.61	1.24±0.39	1.09±0.10	1.02±0.08
Colon	0.55±0.20	0.52±0.03	0.51±0.05	0.49±0.05	0.42±0.03

Different superscripts within the same row indicate significant differences. T0: diet containing 2% crude palm oil without *Moringa* leaf flour; T1: diet containing 2% lemuru fish oil without *Moringa* leaf flour; T2: diet containing 2% lemuru fish oil + 1% *Moringa* leaf flour; T3: diet containing 2% lemuru fish oil + 2% *Moringa* leaf flour; T4: diet containing 2%lemuru fish oil + 3% *Moringa* leaf flour.

4 Conclusion

This study concluded that the adding of lemuru fish oil and Moringa leaf flour in broiler feed had no negative effects on the internal and immune organs and was beneficial for the digestive organs of broiler chickens.

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