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**Research article**

# Effect of dietary *Salvinia molesta* meal on performance and blood lipid profile of growing quail

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## Abstract

The study aimed to evaluate the effect of dietary *Salvinia molesta* meal on the performance and blood lipid profile of growing quail. A total of 240 day-old quails were reared for six weeks. The study used a completely randomized design with four treatments and five replicates. The treatments consisted of control rations without *Salvinia molesta* meal and fish oil, and rations with fish oil containing 2%, 4%, and 6% of *Salvinia molesta* meal. The results showed that the use of a 2% level of *Salvinia molesta* meal yielded better body weight gain compared to the 4% and 6 % of *Salvinia molesta* meal group. Dietary up to 6% *Salvinia molesta* meal decreased final body weight, feed intake, and increased blood cholesterol. Triglyceride, HDL, and LDL levels were not affected by treatments. So, the inclusion of 2% *Salvinia molesta* meal can be used in the ration of growing quail without negatively affecting feed intake, body weight gain, first laying egg, triglycerides, HDL, and LDL of blood. Inclusion of up to 6% decreases the performance of growing quail.

**Keywords**: Body weight, Blood, Cholesterol, Quail, *Salvinia molesta.*

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# INTRODUCTION

Laying quail is one of the prospective poultry to be raised economically since it has a faster production and requires a smaller yard. However, the efficiency of quail rearing is highly dependent on the cost of feed, which represents one of the largest components of the production cost. Therefore, exploration of local feed ingredient sources is necessary. One of them is *Salvinia molesta* which is an aquatic plant commonly found in ponds, and lakes or can also be cultivated (Leterme et al., 2009). As a floating plant, it has a rapid growth rate that can reduce the quality and availability of water in the pond. *Salvinia molesta* growth varies considerably in response to variations in water nutrient content, with the potential for rapid growth when nutrient levels of water are high (European and Mediterranean Plant Protection Organization, 2017).

*Salvinia molesta* meal contains some minerals, xanthophylls pigments, and β-carotene of 111.24 ppm (Anderson et al., 2011). Based on our study, *Salvinia molesta* meal contains 11.19% crude protein, 21.14% crude fiber, 1.43% calcium, and 4572 kcal/kg gross energy. Moreover, the dominant fatty acids in *Salvinia molesta* include palmitic acid (21.96%), oleic acid (6.99%), lauric acid (5.30%), linoleic acid (4.84%) and linolenic acid (0.75%) (Meliandasari et al., 2016). On the other hand, the limitation of using *Salvinia molesta* meal in addition to high crude fiber is also due to the presence of antinutrients, namely saponins of 0.85g /100g, tannins of 4.32g/100 g, cyanide of 20.94 g/100g and phytic acid of 0.15 g/100g (Paranamana et al., 2015).

*Salvinia molesta* meal can be applied as an alternative poultry feed ingredient. A previous study indicated that the inclusion of *Salvinia molesta* meal in the laying quail of up to 7.5% did not interfere with the protein efficiency ratio or nitrogen retention (Rahmawati et al., 2016). The use of up to 18% in the ration did not affect the physicochemical meat of 10-week-old native chickens (Mulasari et al., 2014). Dietary *Salvinia molesta* meal in broiler chickens up to 12% and 18% significantly increased blood cholesterol but decreased blood triglycerides, besides reducing body weight gain and increasing ration conversion (Meliandasari et al., 2014). *Salvinia molesta* meal supplementation of up to 6% in broiler rations did not affect body weight (Santoso et al., 2017). In local ducks, the use of 15% *Salvinia molesta* meal reduced the feed conversion ratio (Santoso and Setiadi, 2016). However, there are limited studies that report on the use of *Salvinia molesta* leaf meal in quail feed containing Lemuru fish oil. Therefore, this study aimed to evaluate the impact of the provision of *Salvinia molesta* meal in the ration of laying quail based on Lemuru fish oil on the blood lipid profile.

# MATERIALS AND METHODS

## Animal and Housing

All procedures in the study were approved by the Animal Ethics Board of IPB University. A total of 240-day-old *Coturnix-coturnix japonica* quail with an average body weight of 6.66 ± 0.19 g was used. Quails were randomly distributed into 4 treatments and 5 replicates in a completely randomized design. Quails were fed the treatments starting at the age of one day until 6 weeks in the colony cage in 1.2m x 1.3m x 0.80 m size. Cages were equipped with a 25-watt heat lamp, feeder, and drinker.

## Rearing Management

Sanitization of cages was carried out 2 weeks before the bird's arrival. A 25-watt light bulb was installed in each unit as a heater during the starter period, while during the grower phase, only one of the 8-watt LED lights was used as lighting in each unit. Starter ration was provided from one to 3 weeks old and grower ration was provided from 4 to 7 weeks old. Body weight weighing was performed on day-old quails and repeated every week. Vitamins were provided after quail weighing. Drinking water was provided *ad libitum* and feed was served twice a day at 7 am and evening at 5 pm. Temperature and humidity measurements were taken 3 times a day, in the morning, afternoon, and evening. ND La Sota vaccine was given at 5 days of age through oral drops to prevent Newcastle Disease, and ND G7B-AI vaccine was given at 27 days of age through intramuscular injection to prevent Newcastle Disease, Infectious Bronchitis, and Avian Influenza.

## Ration

The treatment ration consisted of starter ration (0-3 weeks) and grower ration (3-6 weeks). The starter ration was prepared with a protein content of 28%, and a metabolizable energy of 2900 kcal/kg, while the grower ration was prepared with crude protein of 17% and metabolic energy of 2900 kcal/kg (Leeson and Summers 2005). The treatment rations were in the form of mash containing 2%, 4%, and 6% of *Salvinia molesta* meal and Lemuru fish oil, while the control ration did not use *Salvinia molesta* meal and Lemuru fish oil. The composition and nutrient content of the starter and grower rations are shown in Table 1 and Table 2.

**Table 1** Composition and nutrient content (as fed) of starter ration (0-3 weeks)

| Ingredients | *Salvinia molesta* meal | | | |
|---|---|---|---|---|
| | 0% (control) | 2% | 4% | 6% |
| Yellow corn | 42.50 | 38.00 | 36.50 | 35.00 |
| Soybean meal | 25.00 | 24.50 | 24.00 | 23.50 |
| Coconut meal | 6.50 | 6.50 | 6.50 | 6.50 |
| Corn gluten meal | 15.00 | 15.00 | 15.00 | 15.00 |
| Fish meal | 8.00 | 8.00 | 8.00 | 8.00 |
| *Salvinia molesta* meal | 0 | 2.00 | 4.00 | 6.00 |
| Lemuru fish oil | 0 | 3.00 | 3.00 | 3.00 |
| CaCO3 | 1.50 | 1.50 | 1.50 | 1.50 |
| DCP | 1.00 | 1.00 | 1.00 | 1.00 |
| Premix* | 0.50 | 0.50 | 0.50 | 0.50 |
| Total | 100 | 100 | 100 | 100 |
| Cost (IDR/kg) | 8515.38 | 8529.38 | 8482.38 | 8435.38 |
| Nutrient content | | | | |
| Metabolizable energy (kcal /kg) | 2932.75 | 2994.15 | 2975.45 | 2956.75 |
| Crude protein (%) | 28.38 | 28.00 | 27.88 | 27.76 |
| Crude fat (%) | 2.67 | 5.53 | 5.50 | 5.47 |
| Crude fiber (%) | 3.39 | 3.69 | 4.06 | 4.43 |
| Lysine (%) | 1.49 | 1.47 | 1.46 | 1.44 |
| Methionine (%) | 0.67 | 0.67 | 0.67 | 0.67 |
| Calcium (%) | 1.39 | 1.42 | 1.45 | 1.47 |
| Available phosphorus (%) | 0.85 | 0.84 | 0.84 | 0.83 |

* premix content per 1 kg: Vitamin A, 2000000 IU; Vitamin D3, 400000 IU; Vitamin E, 600 mg; Vitamin B1, 200 mg; Vitamin B2, 1000 mg; Vitamin B12, 1000 mg; Vitamin K, 200 mg; Niacinamide, 1500 mg; Ca-d-penthotenate, 500 mg; Folic Acid, 100 mg; Choline Chloride, 20000 mg; Lysine, 15000 mg; Dl-Methionine, 20000 mg; Magnesium Sulfate, 6800 mg; Ferrous Sulfate, 5000 mg; Manganese Sulfate, 10000 mg; Cupri Sulfate, 100 mg; Zinc Sulfate, 2000 mg; Potassium Iodide, 20 mg; Antioxidant and Carrier qs ad, 1000 g

**Table 2** Composition and nutrient content (as fed) of grower ration (3-6 weeks)

| Ingredients | *Salvinia molesta* meal | | | |
|---|---|---|---|---|
| | 0% ( control) | 2% | 4% | 6% |
| Yellow corn | 53.00 | 50.00 | 50.00 | 50.00 |
| Rice bran | 13.00 | 12.00 | 11.00 | 10.00 |
| Soybean meal | 15.00 | 14.00 | 13.00 | 12.00 |
| Coconut meal | 6.45 | 6.45 | 6.45 | 6.45 |
| Corn gluten meal | 6.00 | 6.00 | 6.00 | 6.00 |
| Fish meal | 3.00 | 3.00 | 3.00 | 3.00 |
| *Salvinia molesta* meal | 0 | 2.00 | 4.00 | 6.00 |
| Lemuru fish oil | 0 | 3.00 | 3.00 | 3.00 |
| CaCO3 | 1.50 | 1.50 | 1.50 | 1.50 |
| DCP | 1.30 | 1.30 | 1.30 | 1.30 |
| Premix* | 0.50 | 0.50 | 0.50 | 0.50 |
| L-Lysine | 0.10 | 0.10 | 0.10 | 0.10 |
| DL-Methionine | 0.15 | 0.15 | 0.15 | 0.15 |
| Total | 100 | 100 | 100 | 100 |
| Cost (IDR/kg) | 7105.34 | 7134.34 | 7102.34 | 7070.34 |
| Nutrient content | | | | |
| Metabolizable energy (kcal/kg) | 2900.05 | 2971.85 | 2963.55 | 2955.25 |
| Crude protein (%) | 18.17 | 17.62 | 17.33 | 17.04 |
| Crude fat (%) | 2.91 | 5.80 | 5.81 | 5.83 |
| Crude fiber (%) | 4.37 | 4.59 | 4.88 | 5.17 |
| Lysine (%) | 0.97 | 0.94 | 0.91 | 0.88 |
| Methionine (%) | 0.55 | 0.54 | 0.55 | 0.55 |
| Calcium (%) | 1.11 | 1.14 | 1.16 | 1.19 |
| Available phosphorus (%) | 0.85 | 0.82 | 0.81 | 0.79 |

* premix content per 1 kg: Vitamin A, 2000000 IU; Vitamin D3, 400000 IU; Vitamin E, 600 mg; Vitamin B1, 200 mg; Vitamin B2, 1000 mg; Vitamin B12, 1000 mg; Vitamin K, 200 mg; Niacinamide, 1500 mg; Ca-d-penthotenate, 500 mg; Folic Acid, 100 mg; Choline Chloride, 20000 mg; Lysine, 15000 mg; Dl-Methionine, 20000 mg; Magnesium Sulfate, 6800 mg; Ferrous Sulfate, 5000 mg; Manganese Sulfate, 10000 mg; Cupri Sulfate, 100 mg; Zinc Sulfate, 2000 mg; Potassium Iodide, 20 mg; Antioxidant and Carrier qs ad, 1000 g

## Preparation of *Salvinia molesta* meal

Fresh *Salvinia molesta* plants were harvested from a cultivation pond and separated into leaves and roots. The leaves were cut into small pieces and sun-dried for 5 days. Subsequently, the leaves were dried in an oven at 60°C to minimize the degradation of bioactive compounds. The leaves were finely ground with a 1 mm screen and ready to be analyzed and mixed according to the treatment level in the quail feed. The nutrient content of *Salvinia molesta* meal is presented in Table 3.

**Table 3** Nutrient content of *Salvinia molesta* meal

| Nutrient | % |
|---|---|
| Dry matter | 87.04 |
| Crude protein | 11.19 |
| Crude fiber | 21.14 |
| Crude fat | 1.63 |
| Nitrogen free extract | 43.23 |
| Ash | 9.84 |
| Calcium | 1.43 |
| Phosphorus | 0.27 |
| Gross Energy (kcal/ kg) | 4572 |

## Performances Measurement

The initial body weight was weighed upon the arrival of the bird. The final weight was weighed at the end of the study (week 6th). Body weight gain was obtained from the difference between final body weight and initial body weight. The feed intake was obtained from the difference between feeding and remaining feed. The feed conversion ratio (FCR) was obtained by dividing feed intake by body weight gain. Control of the presence of eggs in each cage was carried out daily to obtain the age of the first egg laying.

## Blood collection

Blood sampling was performed on 39-day-old quails from 2 quails per replicate. Before the blood was taken, quails were fasted overnight with access to drinking water. Blood was taken with a syringe at the jugular vein as much as 1 mL and transferred into Ethylene Diamine Tetraacetic Acid (EDTA) anticoagulant tubes. Blood was centrifuged at 8000 rpm for 15 minutes. The plasma obtained was then put into Eppendorf tubes for further analysis. Lipid profile concentrations were measured using Atomic Absorption Spectrophotometry (Shimadzu AA-7000).

## Cholesterol Measurement

Blood cholesterol was measured based on the method described by Rodriguez et al. (2000). Sample tubes were filled with 10 µL of blood plasma and 1000 µL of cholesterol oxidase p-aminophenazone (CHOD-PAP) reagent kit (number 101592). Blank tubes were filled with 10 µL of distilled water and 1000 µL of reagent kit; standard tubes were filled with 10 µL of cholesterol standard solution and 1000 µL of reagent kit. The samples were homogenized with a vortex for 10 seconds. Then, it was incubated for 10 minutes. Then the absorbance value was read at a wavelength of 500 nm with a spectrophotometer. Blood cholesterol concentration was calculated by the formula:

Cholesterol level (mg/dL) = (Sample absorbance)/(Standard absorbance)× 200 mg/dL

## Triglyceride Measurement

Triglyceride was measured based on the method described by Rodriguez et al. (2000). The sample tube was filled with 10 µL of blood plasma and 1000 µL of reagent kit glycerol phosphate oxidase p-aminophenazone (GPO-PAP) (number 116392). Blank tubes were filled with 10 µL of distilled water and 1000 µL of reagent kit; standard tubes were filled with 10 µL of triglyceride standard solution and 1000 µL of reagent kit. The sample was homogenized with a vortex for 10 seconds. Then, it was incubated for 10 minutes. Then the absorbance value was read at a wavelength of 500 nm with a spectrophotometer. Triglyceride concentration was calculated by the formula:

Triglyceride levels (mg / dL) = (Sample absorbance)/ (Standard absorbance) × 200 mg / dL

## High-Density Lipoprotein (HDL) Measurement

HDL level was measured based on the method described by Gordon et al. (1977). The sample tube was filled with 200 µL of blood plasma and 500 µL of HDL cholesterol precipitant with kit number 108491. Then, it was vortexed for 10 seconds and then centrifuged for 5 minutes. 100µL of clear liquid was taken and 1000µL of cholesterol oxidase p-aminophenazone (CHOD-PAP) reagent kit ( number 101592) was added. The blank tube was filled with 100µL of distilled water and 1000 µL of reagent kit; the standard tube was filled with 100 µL of cholesterol standard solution and 1000 µL of reagent kit. After that, it was incubated for 5 minutes. Then the absorbance value was read at a wavelength of 500 nm with a spectrophotometer. Blood HDL levels were obtained by the formula:

HDL levels (mg / dL) = (Sample absorbance)/ (Standard absorbance) × 175 mg / dL

## Low-Density Lipoprotein (LDL) Measurement

Determination of LDL levels was carried out using the formula of Friedwald et al. (1972) with conditions including no chylomicrons, triglyceride concentration less than 400 mg dL-1, and dysbetalipoproteinemia (type 2 hyperlipoproteinemia).

LDL cholesterol (mg/dL) = total cholesterol - HDL cholesterol - (Triglycerides)/5

## Data Analysis

The data obtained were analyzed by analysis of variance (ANOVA) with the IBM SPSS Statistics 22. Then, Duncan's Multiple Range Test was performed to analyze the significance data at P<0.05.

# RESULTS

## Quail Performances

Dietary 4% and 6% *Salvinia molesta* significantly (P<0.01) decreased feed intake and body weight gain compared to the inclusion of 2% *Salvinia molesta* meal and the control treatment (Table 4). Diets containing 2% *Salvinia molesta* meal yielded the highest feed intake and body weight gain compared to the 4% and 6% groups. The provision of *Salvinia molesta* meal in quail rations for the growth period significantly (P < 0.01) decreased the final body weight but had no effect on the age at first egg laying.

**Table 4** Performance characteristics of 6 weeks of quail age

| *Salvinia molesta* meal (%) | Feed intake (g/bird) | Body weight gain (g/bird) | Feed conversion ratio |
|---|---|---|---|
| 0 | 458.22 ± 33.92$^{a}$ | 118.67 ± 6.77$^{a}$ | 3.87 ± 0.37 |
| 2 | 459.14 ± 13.86$^{a}$ | 122.57 ± 5.02$^{a}$ | 3.75 ± 0.10 |
| 4 | 423.52 ± 10.69$^{b}$ | 108.88 ± 4.54$^{b}$ | 3.90 ± 0.19 |
| 6 | 426.69 ± 9.78$^{b}$ | 108.26 ± 3.71$^{b}$ | 3.94 ± 0.10 |
| Mean | 441.89 ± 17.06 | 114.59 ± 5.01 | 3.86 ± 0.19 |

Different superscripts in the same column are significantly different at P <0.05

**Table 5** Mean final body weight and the first time of laying

| *Salvinia molesta* meal (%) | Final body weight (g/bird) | First laying (day) |
|---|---|---|
| 0 | 125.16 ± 6.70[a] | 48.4 ± 5.13 |
| 2 | 129.29 ± 4.86[a] | 49.4 ± 3.21 |
| 4 | 115.57 ± 4.44[b] | 51.6 ± 4.77 |
| 6 | 114.98 ± 3.85[b] | 52.8 ± 3.90 |
| Mean | 121.25 ± 4.96 | 50.55 ± 4.25 |

Different superscripts in the same column are significantly different at P <0.01

## Blood Lipid Profile

The inclusion of 4% and 6% *Salvinia molesta* meal in quail rations significantly (P<0.05) increased cholesterol levels and had no significant effect on triglyceride, LDL, and HDL levels (Table 6).

**Table 6** Blood lipid profile of 6 weeks of quail age

| Parameter | *Salvinia molesta* meal | | | |
|---|---|---|---|---|
| | 0% (control) | 2% | 4% | 6% |
| Cholesterol (mg/dl) | 158.29±20.10[a] | 155.42±18.50[a] | 199.75±40.64[ab] | 214.04±9.46[b] |
| Triglycerides (mg/dl) | 81.42±35.36 | 92.84±41.15 | 76.11±16.85 | 78.11±7.48 |
| HDL (mg/dl) | 55.99±13.89 | 41.30±14.9 | 60.35±17.02 | 70.88±10.23 |
| LDL (mg/dl) | 86.02±24.88 | 95.55±28.14 | 124.18±23.10 | 127.53±17.95 |

Different superscripts in the same row indicate significant differences (P<0.05); HDL= High-Density Lipoprotein; LDL= Low-Density Lipoprotein

# DISCUSSION

## Quail Performances

Diets containing 2% *Salvinia molesta* meal yielded the highest feed intake and body weight gain but higher levels decreased the performance of growing quail. The use of 2% *Salvinia molesta* meal in a diet containing fish oil showed similar performance to the control diet. It indicated that the level of crude fiber and anti-nutrients in *Salvinia molesta* meal could be tolerated by quails. On the other hand, feed intake, final body weight, and body weight gain decreased with the addition high level of *Salvinia molesta* meal may be caused by crude fiber and antinutrient content such as saponins and tannins. *Salvinia molesta* meal contains saponins of 0.85 g/100 g, tannins of 4.32 g/100 g, cyanide of 20.94 g/100 g, and phytic acid of 0.15 g/100 g (Paranamana et al., 2015). Saponins have a bitter taste that can reduce the palatability of the ration (Salim et al., 2023), consequently reducing feed intake and the availability and absorption of nutrients needed for growth and egg production. High *Salvinia molesta* meal in the ration (4% and 6%) may have increased tannin levels. It was in line with Gena et al. (2014) and Santoso et al. (2017), that broiler growth, final body weight, and feed efficiency decreased by using 12% *Salvinia molesta* meal due to tannin content and crude fiber. Tannins can inhibit digestive enzymes such as trypsin and amylase, which are essential for breaking down proteins and carbohydrates in the digestive system (Besharati et al., 2022). When these enzymes are inhibited, the digestion and absorption of nutrients from feed are impaired, leading to decreased nutrient availability for growth and egg production.

Meanwhile, the crude fiber content of the ration at 6% *Salvinia molesta* meal reached 4.43% in the starter ration and 5.71% in the grower ration (Table 1; Table 2). Another study by Leterene et al. (2009) reported that *Salvinia molesta* meal contained NDF of 518-629 g/g, ADF of 358-414 g/g, and lignin of 123-168 g/g. Crude fiber consists of cellulose, hemicellulose, and lignin, which are complex carbohydrates that cannot be digested by poultry due to the lack of appropriate enzymes. As a result, feed containing high levels of crude fiber can pass through the digestive system relatively undigested, reducing the overall digestibility of the feed. This means less nutrients are absorbed from the feed, leading to slower growth rates and poorer feed efficiency. In addition, feed with high crude fiber is bulky and fills the digestive tract which can limit the space available for nutritious feed (Mandey et al., 2017). As a result, quail consume less feed leading to reduced nutrient intake and slower growth rates.

In this study, the use of 2% *Salvinia molesta* meal was recommended to be used as a feed ingredient for growing quail, but the use of higher *Salvinia molesta* meal (4% and 6%) tended to reduce feed efficiency. However the feed conversion value in this study is still in accordance with reported by Rohman et al. 2018 with a feed conversion ratio of 3.48 to 3.58, and Aisyah et al. (2013) at 4.15 to 4.27 for the growth quail period.

The provision of 4 and 6% *Salvinia molesta* meal in the ration tended to delay the first egg laying of quail. Like many plants, *Salvinia molesta* may contain anti-nutrition compound that could interfere with the absorption of nutrients. For instance, tannin can bind to proteins that are resistant to enzymatic digestion. This binding can reduce the accessibility of proteins to digestive enzymes, leading to decreased protein digestibility. On the other hand, protein is needed in the formation of reproductive organs and hormones (Tang et al., 2023). Moreover, the delay in the first egg laying in our study may also be attributed to the crude fiber content in the diet provided to the quails. High crude fiber levels above 3% can reduce the digestibility of essential nutrients including energy and protein, which are essential for the growth and development of the reproductive tract, whereas a crude fiber level of 2-3% is recommended for grower birds as it increases gizzard size and feed efficiency (Ali et al., 2022).

## Blood Lipid Profile

In this study, triglyceride, LDL, and HDL levels did not differ between treatments. Meanwhile, blood cholesterol levels with the use of 6% *Salvinia molesta* meal yielded the highest cholesterol, also its level was higher than reported by Meliandasari et al. (2016) with cholesterol levels of 140.76 mg/dl in the inclusion of up to 18% *Salvinia molesta* meal in quail diet. Our results contradict the results of Santoso et al. (2017) who found that dietary *Salvinia molesta* meal of up to 6% decreased cholesterol levels compared to the control treatment. The low cholesterol in the control may be due to the absence of fat source from Lemuru fish oil. Fish oil, including Lemuru fish oil, is rich in calories due to its high-fat content. Diets high in fat contribute to increased energy intake and altered lipid metabolism. High-fat diets have been associated with increased cholesterol levels in poultry. Moreover, some dietary oils, particularly animal-based oils like fish oil, may contain cholesterol. While plant-based oils are cholesterol-free, animal-based oils may contain varying amounts of cholesterol. Dietary cholesterol can contribute to elevated blood cholesterol levels in poultry, particularly when consumed in high amounts (Izuddin et al., 2023). Also, Putri et al. (2022) stated that rations based on Lemuru fish oil and *Salvinia molesta* meal did not reduce blood and egg cholesterol but increased omega-3 levels in eggs. Indeed, Lemuru fish oil contains 22.44% omega 3, 11.22% EPA, and 10.53% DHA (Putri et al., 2022). Basically, as an effort to maintain homeostatic conditions, birds perform a cholesterol feedback regulation system when cholesterol intake is low, birds tend to increase endogenous cholesterol synthesis to normal cholesterol limits. This condition may not be able to reduce cholesterol levels to the extreme. Moreover, in our study increasing *Salvinia molesta* levels in the diet increased blood cholesterol levels probably attributed to its anti-nutrient content. Anti-nutrients such as tannins can bind to bile salts and form insoluble complexes in the digestive tract that are excreted out of the body (Naumann et al., 2020). Indeed, bile salts are the end product of cholesterol catabolism in the liver, and homeostasis of bile salts and cholesterol is important to maintain liver injury (Chiang, 2017). Therefore, as a response the liver compensates by synthesizing more bile salts from cholesterol, hence it may cause increased production and blood cholesterol.

The increasing use of *Salvinia molesta* meal from 0% (control) to 6% in containing fish oil showed a positive effect on blood HDL (High-Density Lipoprotein) levels from 55.99 mg/dl to 77.88 mg/dl. HDL is good cholesterol as it helps transport cholesterol from tissues and blood vessels back to the liver, where it is processed and excreted, whereas LDL transports cholesterol from the liver to the tissues (Yu et al., 2019). Adequate blood cholesterol levels are essential for reproductive health and egg formation in quails. It supports hormone production, yolk formation, cell membrane integrity, and energy storage, all of which are essential for reproductive initiation and healthy embryo development (Elkin et al., 1999; Chen et al., 2019).

The inclusion of 2% *Saelvinia molesta* produced lower cholesterol than the 6% *Saelvinia molesta* group. This may be due to the level of bioactive compounds in *Salvenia molesta* working effectively. Polyphenols can reduce serum cholesterol due to the excretion of cholesterol through excreta. Moreover, polyphenols increase the activity of hydroxyl-3-methyl-glutaryl-CoA as a cholesterol synthesis-limiting enzyme through the induction of cholesterol 7-alpha hydroxylase enzyme which is responsible for cholesterol homeostasis (Chen et al., 2012; Darmawan et al., 2022).

# CONCLUSIONS

2% *Salvinia molesta* meal can be applied in the ration of growing quail without negatively affecting body weight gain and feed intake. Inclusion of up to 6% decreases the performance of growing quail and increases blood cholesterol, but does not affect feed conversion, first laying time, triglycerides, HDL, and LDL of quail blood.

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# AUTHOR CONTRIBUTIONS

DMS: designed the study, analyzed data; wrote draft manuscript, and reviewed; Y and AR: collected data and analyzed data; WH: analyzed samples and wrote draft manuscript; AD: wrote draft manuscript, and analyzed data. All authors have approved the manuscript.

# CONFLICT OF INTEREST

The authors declare no conflict of interest

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