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Physiological and Productivity Performances of Japanese Quails Supplemented with Cassava Leaf Paste

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ABSTRACT

This study aimed to evaluate and analyze the physiological performances of quails raised under this temperature range and then given cassava leaf paste to reduce the heat stress effects. The variables measured were blood chemical, stress indicators, body resistance, productivity, and quality of quail eggs. This experiment used 160 quails in a completely randomized design with 4 doses of cassava leaf paste as treatments with 4 replications, namely P0 (0 mg/g), P1 (5.29 mg/g), P2 (10.58 mg/g), and P3 (15.87 mg/g). The administration of cassava leaf paste for 30 days was carried out through 100 mL of drinking water for each dose. The results showed that administering various doses of cassava leaf paste to quails increased blood glucose and lower blood cholesterol concentrations. Administration of cassava leaf pastes in P3 treatment increased the oxygen saturation value of quail by 6.14% compared to the control treatment. Malondialdehyde (MDA) serum concentration as an indicator of oxidative stress significantly increased at a higher dose (P3) of cassava leaf paste administration. Meanwhile, the superoxide dismutase (SOD) serum concentration remains the same. Administration of cassava leaf pastes in P3 treatment decreased liver MDA by 66.66%, and P2 treatment increased liver SOD by 3.85% compared to the control treatment. The clearance test showed the presence of cassava leaf paste increased by 1.2% the death of Salmonella pullorum bacteria. The provision of cassava leaf paste can increase egg productivity and quality. The total cholesterol of egg yolks of quails receiving cassava leaf paste was lower than the control. In conclusion, applying cassava leaf paste can support the physiological performance such as blood chemistry (glucose levels, cholesterol, and oxygen saturation), stress indicators (serum and liver MDA and SOD concentrations), body resistance (total leukocyte count and the death rate of Salmonella pullorum bacteria), of quails, thereby increasing the productivity and quality of quail eggs.

Keywords: cassava leaf paste; eggs quality; physiological performance; productivity; quail

INTRODUCTION

Quail is a type of poultry that is well developed in Indonesia. Quails have many advantages, such as being easy to adapt to various maintenance conditions, not requiring a large cage space, being easy to manage, and not requiring high production costs. Quails also have a fast growth cycle, require less feed, and are very productive. On the other hand, quail has a weakness, which is prone to stress (Batool *et al.,* 2021). This stress can mainly be caused by hot environmental conditions and unpredictable weather (Al-Sagan *et al.,* 2020).

Supari *et al.* (2021) show that the environmental temperature in Indonesia ranges from 25-31 °C. The thermoneutral zone of poultry, including quail, is 18-21 °C (Wasti *et al.,* 2020). The high environmental temperature that exceeds the comfort zone range triggers physiological changes, including oxidative stress (Wasti *et al.,* 2020). Orhan *et al.* (2020) stated that the compound that can describe the indication of oxidative stress is malondialdehyde (MDA).

Heat stress can be overcome by providing antioxidants. Zhang *et al.* (2017) stated that vegetables are sources of antioxidants. One of these vegetables is cassava leaves (Laya & Koubala, 2020). Fresh cassava leaves contain chlorophyll 18.14 ppm but have high levels of cyanide acid, around 183 ppm (Morgan & Choct, 2016). Cyanide is a toxic compound (Alqahtani *et al.,* 2020). Using cassava leaf products as a paste is an alternative to overcome the cyanide acid content (Jumadin *et al.,* 2017).

Based on the proximate analysis results, the dry matter of cassava leaf paste contains 3.75% ash, 44.54% crude protein, 1.87% crude fiber, 2.09% fat, and 8.31%

carbohydrates. With high protein content and low crude fiber, cassava leaf paste has the potential to be used as a supplement for quail or poultry in general. In addition, cassava leaf paste contains 20.00% β-carotene, 0.26% chlorophyll, and 2.36% antioxidants. Cassava leaf paste also contains 6.30% flavonoids, 5.08% tannins, 3.52% saponins, 4.38% sitosterol, and 6.68% stigmasterol, as well as macro and micro minerals (Jumadin *et al.,* 2022). The proximate content of cassava leaf paste is expected to support the physiological performance and productivity of quail.

The contents of substances in this cassava leaf paste have properties and benefits in improving physiological performance. Jumadin *et al.* (2017) stated that administration of cassava leaf pastes increased feed digestibility and body weight. Administration of cassava leaf paste also increased the number of erythrocytes, haemoglobin, and hematocrit in quails exposed to heat stress (Jumadin *et al.,* 2018). The contents of bioactive substances in cassava leaf paste are expected to be able to overcome oxidative stress in Japanese quails. Research on the administration of cassava leaf paste and its impact on physiological performance, body resistance, productivity, and egg quality has not been found. The novelty of this research is that cassava leaf paste improves physiological performance, body resistance, and quail productivity; the effective dose of cassava leaf pastes on physiological aspects, productivity, and egg quality; and cassava leaf paste produces low cholesterol quail eggs. Therefore, this study was conducted to assess and evaluate the application of cassava leaf paste in supporting physiological performance (blood chemistry and stress indicators), body resistance, productivity, and egg quality in quails reared under natural conditions in tropical areas such as in Indonesia.

MATERIALS AND METHODS

Time and Locations

This research was carried out in several places, namely in the Jaja Quail Animal Cage, the Pilot Plant Seafast Center Laboratory of LPPM IPB, the Laboratory of the Center for Veterinary Research (BB Litvet) Bogor, the Bacteriology Laboratory of the FKH IPB, the Physiology Laboratory of the FKH IPB and the Laboratory of the Agro Industry Center of the Ministry of Industry. The research was carried out from December 2020 to December 2021. The procedures used in this study were under the rules of the Animal Ethics Commission of FKH IPB (No. 007/KEH/SKE/V/2021).

Preparation of Cassava Leaf Paste (*Manihot esculenta* Crantz)

Fresh cassava leaves were obtained from Ranca Bungur Village, Ranca Bungur District, Bogor Regency. The cassava leaves used were whole and undamaged leaves. The leaf part was the sixth leaf from the shoot. The leaves were washed with clean water and then dried at room temperature. Then the dried leaves were cut into small pieces to facilitate the process of crushing with a blender and extracted. A total of ± 50 grams of cassava leaf pieces were crushed in a blender using 125 mL of 70% ethanol for 3 minutes, intermittently every 1 minute. The solution of cassava leaves in ethanol was then filtered by a fine cloth, then the filtrate obtained was filtered again with a Buchner funnel using filter paper. The residue was washed with 75 mL 70% ethanol, and then filtered with a Buechner funnel. The filtrate was taken as a cassava leaf extract. Furthermore, the extract of the cassava leaves was evaporated for one hour at a temperature of 70 °C, resulting in a cassava leaf paste. The calculation of cassava leaf paste in this study was a dose conversion of quail with a body weight of 168 g given 5.29 mg/head/day (Jumadin *et al.,* 2017). Doses 2 and 3 were multiples of dose 1.

Cassava leaf paste contains nutritional compositions such as 18.54% water, 3.75% ash, 44.54% crude protein, 1.87% crude fiber, 2.09% fat, 8.31% carbohydrate, 20% β-carotene, 0.26% chlorophyll and 2.36% antioxidant. Cassava leaf paste also contains phytochemicals such as 6.3% flavonoids, 3.52% saponins, 5.08% tannins, 4.38% sitosterol, and 6.68% stigmasterol. In addition, cassava leaf paste contains macro minerals such as 3840 ppm P and 220 ppm Ca, as well as microminerals (230.16 ppm Fe, 21.36 ppm Cu, 175.96 ppm Mn, and 361.72 ppm Zn). Cassava leaf paste also contains 1.01 ppm of cyanide acid (Jumadin *et al*., 2022).

Preparation and Maintenance of Experimental Animals

Experimental animals used were female quails of layer period (aged 42 days) with as many as 160 tails. The cage used was a 4-storey colony cage with 16 plots, measuring 100 cm long x 30 cm wide x 20 cm high. Each plot was filled with 10 birds and their placement was done randomly. Each plot was equipped with excreta storage, lighting, feed and drinking containers. All cage plots were placed in open cages. The open cage was equipped with a digital thermostat.

Experimental Design

The study used a completely randomized design. The treatment was giving cassava leaf paste to quail, consisting of 4 levels/dose of cassava leaf paste, namely P0 (0 mg/g), P1 (5.29 mg/g), P2 (10.58 mg/g), and P3 (15.87 mg/g). The experiment was repeated 4 times, and each replication consisted of 10 quails. The administration of cassava leaf paste to quail was conducted through drinking water. The cassava leaf paste was given at 6 a.m., and all quail were fed for 1 hour. At the time of feeding, all drinking water was taken, so the quail were thirsty. After that, drinking water mixed with cassava leaf paste was given at each dose of 5.29, 10.58, and 15.87 mg/g. After the drinking water mixed with cassava leaf paste was used up, the drinking proceeds with ordinary drinking water.

Research Procedure

A total of 160 quails from the age of 42 days were fed commercial feed. Drinking water containing cassava leaf paste and commercial feed were provided *ad libitum*. Temperatures were recorded every morning, afternoon, evening, and night at 06.00 a.m., 12.00 p.m., 06.00 p.m, and 12.00 a.m. The provision of cassava leaf paste was carried out through drinking water in 100 mL at each treatment level. The composition of ration and nutritional content of the quail commercial feed is showed in Table 1.

The study was conducted by rearing quails for 30 days. Quail blood sampling and oxygen saturation measurements were carried out at the end of the study period (age 72 days). Observations of egg production performance and quality were carried out from the first day to the end of the study.

Three millilitres (3 mL) of blood samples were taken from the jugular vein using a syringe. The blood sample was put into a vacuum tube with the anticoagulant ethylene diamine tetra acetic acid tri-potassium (EDTA K3) and rotated in a figure-eight motion. The vacuum tube containing the blood was put into the cooling box. The blood was allowed to stand for 10 minutes. Then the blood samples were centrifuged at a speed of 3000 rpm for 5 minutes. The serum located at the top was separated to measure serum malondialdehyde and superoxide dismutase concentrations (Tugiyanti *et al.*, 2019).

Tests for malondialdehyde (MDA) and superoxide dismutase (SOD) levels in the serum were carried out at the end of the study before the quail was cut. At the same time, in the liver, the concentrations of MDA and SOD were measured after the quail was cut and dissected. Each treatment in each replication was represented by a quail for its liver to be harvested. The liver was stored in a plastic bag in the freezer.

Research Variables

Blood chemistry observations were detected through blood glucose, blood cholesterol, and oxygen saturation. Determination of quail blood glucose concentration was measured by the GOD-PAP method.

Table 1. Composition of ration and nutritional content of the quail commercial feed

Composition		Content
Metabolizable energy (kcal/kg)		
Water (%)	Max	12
Crude protein (%)		20-22
Fat (%)	Max	7
Crude fiber (%)	Max	7
Ash (%)	Max	14
Calcium (%)		3.2-4
Phosphor (%)		0.6-1.0
Lysine (%)	Min	0.9
Methionine (%)	Min	0.4
Methionine + cysteine (%)	Min	0.6

Determination of blood cholesterol concentration was carried out using the NESCO Multi-Check tool. Oxygen saturation was measured using a Yongker Handheld YK-820 pulse oximeter.

Stress indicators were measured by measuring serum and liver MDA and SOD concentrations. The procedure for testing serum and quail liver MDA levels was based on Dosoky *et al.* (2021). The procedure for testing serum and quail liver MDA levels consists of three stages: preparation of standard solutions, sample preparation, and measurement of MDA levels. The procedure for testing quail serum and liver SOD levels was based on Reda *et al.* (2020). The procedure for testing serum and quail liver SOD levels consists of three stages: preparation of standard solutions, sample preparation, and measurement of SOD activity.

Quail body resistance was observed by measuring total leukocytes and the clearance test. Determination of total leukocytes was carried out using the Neubauer method. A clearance test was performed using the method of Chen *et al.* (2020) by challenging the bacterium *Salmonella pullorum* at a lethal dose (10^8 cfu/mL). The clearance test steps include blood sample collection, *Salmonella pullorum* bacterial culture, and calculation of the clearance test.

Observation of quail egg productivity and quality included calculation of feed consumption, egg production, egg weight, feed conversion, Haugh Unit value, and total cholesterol in egg yolk. Feed consumption was calculated based on the difference between the feed given and the remaining feed. Egg production was calculated by dividing the number of eggs by the number of quails multiplied by 100%. Egg weight was obtained from the average data for weighing eggs per day (g/grain). Feed conversion was calculated from the ratio of the amount of feed consumed and the weight of the eggs produced. The Haugh unit (HU) value was calculated using the formula: HU= 100 log (white egg height – 1.7 x egg weight$^{0.37}$+ 7.57) (Fathi *et al.*, 2020). The total cholesterol content of egg yolks was analyzed using the Liebermann Burchard color reaction method (Herve *et al.*, 2019).

Data Analysis

Data on blood chemistry, stress indicators, body resistance, egg yolk cholesterol, and feed conversion were analyzed descriptively. Data about quail egg productivity (except feed conversion) were analyzed for analyses of variance. If there were significant differences, it was further tested using Duncan's multiple range test (Abuoghaba *et al.*, 2021).

RESULTS

Blood Chemistry

Observations of blood chemistry in this study included glucose, cholesterol, and oxygen saturation levels. The results of these observations are presented in Table 2. Administration of cassava leaf pastes in P2 treatment increased blood glucose concentrations by 76.68%

compared to the control treatment. The cholesterol concentration of quails receiving cassava leaf paste in P2 treatment was decreased by 8.81% compared to the control treatment. Administration of cassava leaf pastes in P3 treatment increased the oxygen saturation value of quail by 6.14% compared to the control treatment.

Stress Indicators

Oxidative stress occurs due to an imbalance between free radicals and antioxidants in the body's cells. Free radicals can increase lipid peroxidation, which breaks down into malondialdehyde (MDA) in the blood. The high levels of free radicals in the body can be indicated by the low activity of antioxidant enzymes (SOD) and high levels of MDA in the serum. The two stress indicators are presented in Table 3. The increased serum MDA levels promote SOD synthesis as well. Therefore, the administration of cassava leaf pastes also increased serum SOD compared to the control treatment. Administration of cassava leaf pastes in P3 treatment decreased liver MDA by 66.66%, and P2 treatment increased liver SOD by 3.85% compared to the control treatment.

Body Resistance

The body's resistance in this study included total leukocyte count and the death rate of *Salmonella pullorum* bacteria. The results of these observations are presented in Table 4. The total number of leukocytes at various doses of cassava leaf paste was still in the normal range. The ability to kill *Salmonella pullorum* bacteria by in vitro challenge test (by the clearance method) on quail blood treated with cassava leaf pastes (P1, P2, and P3) increased by 1.2% compared to P0.

Egg Productivity and Quality

The results of productivity and quality of quail eggs observations are presented in Table 5. Statistically, the average feed consumption (27.51-27.96 g/head/day) and the average egg weight (9.74-10.71 g/egg) of quails during the study were not significantly different ($p>0.05$). The application of cassava leaf paste had a significant effect ($p<0.05$) on the percentage of quail egg production during the study. Experimental quails in Groups P2 and P3 significantly ($p<0.05$) produced higher percentages of egg production than P0 and P1.

DISCUSSION

Blood Chemistry

Administration of cassava leaf paste increases blood glucose concentrations. The increase in blood glucose concentrations was caused by differences in the contents of flavonoids, saponins, and tannins in cassava leaf paste. Tugiyanti *et al.* (2019) stated that flavonoids, saponins, and tannins could increase the acidic conditions in the pancreas and duodenum, thereby increasing the amylase enzyme activity in breaking down

Table 2. Blood chemistry (glucose levels, cholesterol, and oxygen saturation) in quails given cassava leaf paste for 30 days

Variables	Treatments			
	P0	P1	P2	P3
Glucose (mg/dL)	99.33±1.24	145.33±1.06	175.5±1.29	118.50±1.22
Cholesterol (mg/dL)	17.35±0.35	16.07±0.89	15.82±0.51	16.35±0.64
Oxygen saturation (%)	89.50±0.57	90.75±2.21	91.25±1.50	95.00±0.81

Note: P0= cassava leaf pastes at a dose of 0 mg/g; P1= cassava leaf pastes at a dose of 5.29 mg/g; P2= cassava leaf pastes at a dose of 10.58 mg/g; P3= cassava leaf pastes at a dose of 15.87 mg/g.

Table 3. Stress indicators in quails given cassava leaf paste for 30 days

Variables	Treatments			
	P0	P1	P2	P3
Serum MDA(nmol/mL)	0.30±0.08	0.33±0.03	0.67±0.08	0.72±0.05
Serum SOD (unit/mL)	7.79±0.72	15.83±0.55	17.03±0.38	21.98±0.63
Liver MDA (nmol/mL)	0.03±0.03	0.02±0.01	0.02±0.01	0.01±0.00
Liver SOD (unit/mL)	59.94±7.95	61.93±3.93	62.25±2.04	57.99±5.50

Note: P0= cassava leaf pastes at a dose of 0 mg/g; P1= cassava leaf pastes at a dose of 5.29 mg/g; P2= cassava leaf pastes at a dose of 10.58 mg/g; P3= cassava leaf pastes at a dose of 15.87 mg/g.

Table 4. Body resistance of quails given cassava leaf paste for 30 days

Variables	Treatments			
	P0	P1	P2	P3
Leukocytes (10^3/mm^3)	3.00±0.55	2.50±0.50	3.50±0.21	4.00±0.67
Death rate of *Salmonella pullorum* (%)	98.80±0.75	99.98±0.00	99.99±0.00	99.99±0.00

Note: P0= cassava leaf pastes at a dose of 0 mg/g; P1= cassava leaf pastes at a dose of 5.29 mg/g; P2= cassava leaf pastes at a dose of 10.58 mg/g; P3= cassava leaf pastes at a dose of 15.87 mg/g.

Table 5. Productivity and quality of eggs in quails given cassava leaf paste for 30 days

Variables	Treatments			
	P0	P1	P2	P3
Feed consumption (g/head/day)	27.79±1.82	27.86±1.74	27.96±1.66	27.51±1.83
Egg production (%)	89.75±1.52[b]	89.49±1.85[b]	96.25±1.39[a]	90.58±2.28[a]
Egg weight (g/egg)	9.74±0,86	9.76±1.22	10.71±0.57	10.10±1.05
Feed conversion	2.85±0.21	2.85±0.18	2.61±0.05	2.72±0.18
Haugh units	90.80±0.79	91.60±0.88	92.95±0.73	90.11±0.99
Total yolk cholesterol (mg/g)	15.21±2.64	9.50±1.41	9.83±1.78	8.78±0.60

Note: Means in the same row with different superscripts differ significantly ($p<0.05$). P0= cassava leaf pastes at a dose of 0 mg/g; P1= cassava leaf pastes at a dose of 5.29 mg/g; P2= cassava leaf pastes at a dose of 10.58 mg/g; P3= cassava leaf pastes at a dose of 15.87 mg/g.

carbohydrates into glucose. The increased blood glucose concentrations are used for life activities and energy sources. This increase in blood glucose concentration is still in the normal range. Blood glucose concentrations in quails are 135.00-383.40 mg/dL (Scholtz *et al.,* 2009). Blood glucose in quails administered cassava leaf pastes at a dose of 15.87 mg/g (P3) decreased due to the accumulation of higher fiber content, and this fiber can lower blood glucose (Arif *et al.,* 2018). The crude fiber content of more than 6% in quails feed can lower blood glucose (Kamel *et al.,* 2019; Tugiyanti *et al.,* 2019).

Blood cholesterol levels of quails receiving cassava leaf paste decreased compared to the control treatment. The decrease in blood cholesterol levels was caused by the increase in the contents of fiber, flavonoids, and tannins in each dose of cassava leaf paste. Tugiyanti *et al.* (2019) stated that fiber could bind bile acids which are needed in fat absorption, so that fat absorption is inhibited and increases fat excretion, including cholesterol, through the feces. This condition encourages the liver to produce bile acids by utilizing cholesterol in the blood to decrease cholesterol in the blood (Hua *et al.,* 2017). Alagawany *et al.* (2021) stated that flavonoids and tannins could reduce blood cholesterol by reducing the activity of 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase, which functions as an enzyme in the process of cholesterol synthesis in the liver.

The administration of cassava leaf paste increased the oxygen saturation value of quail. The higher the dose of cassava leaf paste in this study resulted in a higher oxygen saturation value. The increase in oxygen saturation was due to the presence of chlorophyll in the cassava leaf paste. Chauhan (2014) stated that chlorophyll could carry oxygen into the body cells because its structure resembles hemoglobin. This structural similarity causes chlorophyll to be readily accepted naturally in the body tissues. By consuming chlorophyll, the amount of oxygen increases, so the body's energy supply is optimal.

Stress Indicators

Cells routinely produce free radicals and reactive oxygen species (ROS), which are part of the metabolic process. When the production of free radicals exceeds the antioxidant cellular defence, oxidative stress can occur. Malondialdehyde (MDA) is an end product of lipid peroxidation, which usually reflects the degree of oxidative stress (Wardiny *et al.,* 2020). Serum malondialdehyde (MDA) is a metabolite from lipid peroxidation by free radicals originating from various organs, including the liver, which is transported to the blood. Naturally, various antioxidants, both enzymatic and non-enzymatic, function as defences for cell organelles from the effects of damage due to the free radical reactions (Gonzalez-Rivas *et al.,* 2020). Enzymatic antioxidants, also known as preventative antioxidants, consist of superoxide dismutase (SOD), catalase, and glutathione peroxidase. Serum SOD is synthesized in the liver, kidneys, adrenal glands, heart, lungs, and pancreatic tissue (Surai *et al.,* 2019).

The increased serum MDA concentrations in quails given cassava leaf paste were due to fiber in the cassava leaf paste. According to Arif *et al.* (2021), fiber is resistant to hydrolysis but is easily fermented into short-chain fatty acids by microbes in the large intestine. The increased serum MDA concentrations promote SOD synthesis as well. Therefore, the addition of cassava leaf pastes also increased serum SOD concentration.

MDA concentrations in the liver are much lower than serum MDA concentrations because one of the functions of the liver is to detoxify toxic materials. In carrying out its detoxification function, the liver requires SOD as well as SOD which is synthesized by the other organs; therefore, SOD concentrations in the liver were found to be very high.

Administration of cassava leaf pastes decreased liver MDA and increased liver SOD concentration due to the presence of flavonoids. This effect follows the opinion of Van De Wier *et al.* (2017), who state that flavonoids have the ability as antioxidants because they are able to make free radicals more stable and less reactive and protect or increase endogenous antioxidants, including SOD.

Body Resistance

The total number of leukocytes at various doses of cassava leaf paste was still in the normal range. This normal range is in accordance with the opinion of Arshad *et al.* (2021), stating that the number of leukocytes in quail was 0.29-4.83 $10^3/mm^3$. This means that all the experimental quails are in good health conditions.

The ability to kill *Salmonella pullorum* bacteria by in vitro challenge test (by the clearance method) on quail blood administered with cassava leaf pastes (P1, P2, and

P3) increased compared to P0. This increase is caused by the contents of flavonoids, saponins, and tannins in cassava leaf paste having anti-bacterial activities. Khatimah *et al*. (2021) also presented similar results, which stated that administration of kasumba turate flower juice containing flavonoids, saponins, and tannins significantly increased quail body resistance to *S. pullorum* bacterial infection.

Egg Productivity and Quality

The best feed conversion value of 2.61 was achieved in quails treated with cassava leaf paste at a dose of 10.58 mg/g in drinking water (P2). The provision of cassava leaf paste containing flavonoids, tannins, and saponins can improve physiological performance and body resistance, both to heat stress and bacterial infections, causing quail to be healthier and more efficient in utilizing their feeds. Tugiyanti *et al.* (2019) stated that the flavonoid content of 5.41%, tannins of 5.54%, and saponins of 7.59% from avocado seed flour improved the performance of quail.

Observation of egg quality was done physically by measuring the Haugh Unit value and chemically by analyzing egg yolk cholesterol concentrations. The Haugh Unit (HU) values of quail eggs at P0 to P3 ranged from 90.11 to 92.95 and were not statistically significantly different. Eggs with this range of HU value, based on USDA (2020) are of very good quality, namely AA.

The application of cassava leaf pastes in drinking water during the production period of quail reduced the cholesterol content of the egg yolks produced. Quail with P3 treatment (the highest dose of cassava leaf paste) produced eggs containing the lowest cholesterol (8.78 mg/g). This decrease in cholesterol concentration is due to the high intake of crude fiber from drinking water with the treatment of the highest dose of cassava leaf paste (15.87 mg/g). Egg cholesterol concentrations produced by quails with P3 treatment decreased by 42.27% compared to egg yolk cholesterol concentrations in control quails without administration of cassava leaf paste. This result is a very useful finding because consumers have avoided quail eggs because their cholesterol contents are very high compared to chicken eggs. According to Herve *et al.* (2019) and Omri *et al.* (2019), the cholesterol content of chicken egg yolk is 17.01 mg/g, while the total cholesterol in quail egg yolk is 35.18 mg/g. With these findings, administration of cassava leaf paste to quails at a dose of 15.87 mg/g (P3) has the potential to produce low-cholesterol functional food.

CONCLUSION

Cassava leaf paste improves the physiological performance and performance of quail, such as blood chemistry, stress indicators, body resistance, productivity, and egg quality in quail. The cassava leaf paste at a dose of 10.58 mg/g resulted in the best feed conversion value (2.61). The cassava leaf paste at a dose of 15.87 mg/g produced eggs with the lowest yolk cholesterol (8.78 mg/g).

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organizations related to the material discussed in the manuscript.

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