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Research article

Physiological performance and productivity of quail layer period supplemented with coconut shell liquid smoke grade 3

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Abstract

Coconut shell liquid smoke (CSLS) contains flavonoids, tannins, and saponins. It has antioxidant characteristics that can help quail to overcome oxidative stress. This study aimed to analyze the effect of coconut shell liquid smoke grade 3 on the physiological performance and productivity of the quail layer period. The research method used a completely randomized design consisting of 5 treatment levels with 3 replications, namely P0 (control), P1 (0.25 mL/L CSLS), P2 (0.50 mL/L CSLS), P3 (0.75 mL/L CSLS) and P4 (1 mL/L CSLS). Variables measured included physiological performance (hematology, superoxide dismutase, malondialdehyde and heterophil/lymphocyte ratio), productivity (water intake, feed intake, egg production, egg mass, and feed conversion ratio), and physical egg quality (egg weight, thick egg white height and percentage of eggshell). The results showed that supplementing CSLS had no significant effect ($P > 0.05$) on productivity and physical egg quality. The optimum FCR value was obtained at P1 (3.35). Hematology and stress indicators in P1 revealed that quail supplemented with CSLS can lower oxidative stress. It was concluded that CSLS could reduce oxidative stress in the quail layer period. It was found that the optimum stress indicators and FCR were obtained at a dose of 0.25 mL/L CSLS (P1).

Keywords: Coconut shell liquid smoke, Physical egg quality, Physiological performance, Productivity, Quail.

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INTRODUCTION

Quail (*Coturnix coturnix japonica*) is an egg-producing animal. Quail farming has several advantages such as a very short production cycle, low capital requirements, and no need for large areas of land. However, quail, like other poultry, is susceptible to stress, particularly stress caused by high environmental temperatures (Batool et al., 2021).

Based on data from Statistics Indonesia (2022), the lowest environmental temperature in Indonesia was 20.3 °C, and the highest was 33.7 °C. This environmental temperature in Indonesia surpasses the comfort zone of poultry, particularly quail. Quail prefers temperatures between 18-21 ºC (Wasti et al., 2020). Furthermore, quail lack sweat glands and practically their entire body is covered in feathers, making it difficult for them to dissipate body heat into the environment. This condition produces oxidative stress in quail. According to Surai et al., (2019), oxidative stress is an imbalance between antioxidants and free radicals. Excessive free radical production results in reactive oxygen species (ROS). Through a sequence of lipid peroxidation events, ROS can cause cell damage, particularly to lipid membranes. This compromises immune function, as seen by decreased performance, higher heterophil/lymphocyte (H/L) ratio, and liver malondialdehyde (MDA), therefore antioxidants may be one option to minimize free radicals (Mahmoud et al., 2013; Surai et al., 2019). Based on the source, antioxidants are classified into two types, namely endogenous antioxidants and exogenous antioxidants (Kumar et al., 2021). Endogenous antioxidants are antioxidants that the body produces naturally, such as glutathione peroxidase, catalase, and superoxide dismutase (SOD). Exogenous antioxidants are those that come from food or other natural sources. A natural source that has the potential to act as an exogenous antioxidant is liquid smoke (Hatta et al., 2018).

Liquid smoke was generated by the condensation of water vapor produced during pyrolysis at high temperatures and classified into three grades (Keryanti et al., 2019). The extent of separation and purification phases, including filtration, distillation, redistillation, and purification utilizing absorbent zeolite or activated carbon, determines the difference between each liquid smoke grade (Keryanti et al., 2019). According to Kailaku et al. (2017), grade 1 liquid smoke is often used as a food preservative, grade 2 as an antioxidant and antibacterial agent, and grade 3 as a wood preservative, rubber processing, and odor removal agent. Liquid smoke is made from agricultural and plantation waste containing lignin, hemicellulose, and cellulose, such as rice husks, cocoa shells, wood, and coconut shells (Abdullah et al., 2017). Aside from that, coconut shell liquid smoke contains phenolic chemicals, flavonoids, tannins, saponins, and acids that have antibacterial and antioxidant effects (Pasaribu et al., 2021).

Several research on the effects of antioxidants on poultry has found that it has a beneficial impact. According to Ogbuagu and Ayo (2023), utilizing antioxidants produced from L-serine at a level of 200 mg/kg feed could boost broiler chicken production, meat, and bone quality. Pimson et al. (2018) found that using antioxidants derived from curcumin at a level of 10% in feed increased antioxidant activity, performance, and blood biochemistry in broiler chickens. Giving 2.5% liquid smoke from eucalyptus wood as antioxidants to broiler quail (*Colinus virgianus*) produced the highest results in body weight gain and feed conversion ratio (Diogenes et al., 2019). Grade 3 coconut shell liquid smoke administered by drinking water at a dose of 1 mL/L yields the optimum results for body weight gain, feed conversion ratio, and economic value in the quail grower period (Fadhila et al., 2023). Similar studies on the effects of antioxidants, particularly those derived from coconut shell liquid smoke on the physiological performance and productivity of quail (*Coturnix coturnix japonica*) during the layer period have never been conducted. Based on the above description, this study aims to analyze the physiological performance and productivity of quail (*Coturnix*

coturnix japonica) during the layer period supplemented with grade 3 coconut shell liquid smoke.

MATERIALS AND METHODS

Time and Location

This study was conducted from August to October 2023. Coconut shell liquid smoke was created at the Forest Products Technology Research and Development Center Laboratory. Qualitative and quantitative phytochemicals of coconut shell liquid smoke were conducted at The Laboratory of the Research Center for Spice and Medicinal Plants. Quail rearing was carried out at Arkan Quail Farm, Bogor Regency. Blood samples from quail were tested at the Research and Diagnostic Laboratory, RSHP SKHB IPB. SOD and MDA levels were measured at the Physiology Laboratory, SKHB IPB. The protocols employed in this study were approved by the SKHB IPB's Animal Ethics Commission (No. 112/KEH/SKE/IX/2023).

Experimental Design

This study used a completely randomized design with 5 doses of coconut shell liquid smoke through drinking water, namely P0 (0 mL/L), P1 (0.25 mL/L), P2 (0.50 mL/L), P3 (0.75 mL/L) and P4 (1 mL/L). The animals utilized were 150 female laying quail *(Coturnix coturnix japonica)* aged 7 to 11 weeks. Feed and drinking water were provided *ad libitum*. The feed used is the New Hope P100 commercial feed from PT. New Hope Indonesia, with nutritional composition shown in Table 1. The cage utilized is a 5-level colony cage with dimensions of 100 cm length x 75 cm width x 180 cm and is outfitted with feeders, a gallon of water, a lamp, and a thermometer. Each cage length is divided into two cage plots measuring 50 cm. Using Microsoft Excel 360, a total of ten quail were randomly put in each cage plot. At 11 weeks of age, following a 24-hour fast before slaughter, blood and liver samples (3 random birds of each treatment level) were collected from the quail to evaluate physiological status. Blood samples were collected from the brachial vein using a 1 cc syringe. Rotate it in a figure-eight pattern within an EDTA blood tube. The blood-filled EDTA tube is placed inside the cool box. Blood samples were examined at The Research and Diagnostic Laboratory, RSHP, IPB. Quails are slaughtered by cutting off the blood vessels (jugular vein and carotid artery), respiratory tract (trachea), and digestive tract (esophagus) in the neck so that the blood runs out completely. The head and feet are chopped, and the viscera are removed to acquire quail liver. Samples of quail liver were placed in a plastic ziplock bag and brought to the Physiology Laboratory, SKHB IPB. Quail liver samples were kept at -18 °C in the freezer.

Table 1 Nutrient content of New Hope P100 quail feed

Nutrient	Content (%)
Water	13.0
Protein	20.0
Fat	7.0
Crude fiber	7.0
Ash	14.0
Calcium	2.5-3.5
Total phosphorus	0.8-1.0
Lysine	0.9
Methionine	0.4
Methionine + cystine	0.6

Source: PT. New Hope Indonesia

Procedures

Preparation of Coconut Shell Liquid Smoke

The coconut shell used was 3 kg and had to be sturdy, rigid, and blackish. Coconut shells were obtained from Dramaga Market in Bogor Regency. The coconut shell is shattered to make it smaller and easier to place in the furnace. The pyrolysis method is used to produce coconut shell liquid smoke for 5 hours at a temperature of 400 °C (Mulyawanti et al., 2020). The end products are charcoal and gas. The gas product will be condensed into the liquid while passing through the condenser. This liquid is collected and left overnight in a distillation flask.

Phytochemical Analysis of Coconut Shell Liquid Smoke

Phytochemical analysis of coconut shell liquid smoke is qualitative and quantitative. The phytochemical composition observed was flavonoids, tannins, and saponins. The method of qualitative phytochemical analysis is referred to by Rao et al. (2016). Meanwhile, quantitative phytochemical analysis for flavonoid and tannin levels was performed using UV-Vis spectrophotometry (Formagio et al., 2014), while saponin levels were determined using a TLC Scanner (Aziz et al., 2019).

Quail Rearing

Quail rearing includes preparing the cage, observing the environmental temperature, supplying feed and drinking water, and collecting eggs. Cage preparation includes cleaning and sanitizing the cage installing treatment labels depending on randomization results in each cage plot fitted with a feeder, gallon of water, and lamp around the cage, and placing the quail. Cage preparation begins one week before the quail arrives. Temperatures are recorded every day in the morning (06.00-07.00 a.m.), afternoon (00.00-01.00 p.m.), and evening (04.00-05.00 p.m.). Feeding and drinking water (including coconut shell liquid smoke) are administered in the morning (06.00-07.00 a.m.), meanwhile, egg collection is carried out every afternoon (04.00-05.00 p.m.).

Physiological Performance

Physiological performance observations include hematology and stress indicators. Hematological analysis includes erythrocytes, hemoglobin, hematocrit, leukocytes, and leukocyte differentiation. Stress indicators include superoxide dismutase, malondialdehyde, and the heterophils/lymphocytes ratio.

A Neubauer hemocytometer was used to measure erythrocytes and leukocytes (Tang et al., 2015). The Mindray BC-2800 Vet Auto Hematology Analyzer machine was used to measure hemoglobin and hematocrit. The number of heterophils, lymphocytes, monocytes, eosinophils, and basophils is used to calculate leukocyte differentiation.

SOD testing refers to the method of Maskar et al. (2015). The liver was weighed to 0.5 g and then coarsely minced. The chopped organs were homogenized in 2.5 mL of phosphate buffer (PB) (pH 7). The homogenate was placed in a tube and centrifuged at 3000 rpm for 10 minutes at 4 °C. The supernatant was collected, and 0.8 mL of 96% chloroform ethanol was added in a 3:5 ratio. The solution was vortexed and centrifuged at 3000 rpm for 10 minutes at 4 °C. A total of 1 mL of supernatant was collected, and 2.8 mL of sodium carbonate buffer (pH 10.2) and 100 µL of epinephrine were added. At the first, second, third, and fourth minutes, absorbance was measured using a spectrophotometer with a wavelength of 480 nm. SOD levels are calculated using the following formula:

$$\%\ \text{Inhibition} = \frac{\text{Abs B - (Abs S4-1)}}{\text{Abs B}} \times 100\%$$

$$\text{SOD activity (U/mL)} = \frac{\%\ \text{Inhibition} \times 10}{50\%} \times 0{,}1$$

Where Abs B is the absorbance of the blank and Abs S4-1 is the absorbance of the 4th minute tested sample minus the 1st minute.

MDA levels were determined using the method of Ulhusna et al. (2019) with some modifications. Everything is done in the cold. The liver was weighed to 0.5 g and then coarsely minced. Chopped organs are homogenized in 5 mL of phosphate buffer saline (PBS) (pH 10,2). The homogenate was placed in a tube and centrifuged at 3500 rpm for 10 minutes at 4 °C. The supernatant was collected and placed in an Eppendorf tube. A total of 1 mL of supernatant was collected and placed in a test tube. Add 4 mL of 0.25 N HCl a combination of 15% trichloroacetic acid (TCA), 0.38% thiobarbituric acid (TBA), and 0.5% butylated hydroxytoluene (BHT). The reaction tube was heated in an oven at 80 °C for 1 hour. The tube was centrifuged at 3500 rpm for 10 minutes at 4 °C. A UV-Vis spectrophotometer was used to measure the supernatant at a wavelength of 532 nm. Tetramethoxypropane (TMP) with concentrations of 1, 5, 8, 13, 18 µ is used in the standard solution to produce a standard curve. MDA concentrations were estimated using linear regression of the TMP standard curve.

The H/L ratio is calculated using the findings of leukocyte differentiation analysis. This ratio represents the ratio of heterophils per lymphocyte.

Productivity and Physical Egg Quail

Observing quail productivity covers both performance and physical egg quality. The quail performance measured included feed intake (g/head/day), water intake (mL/head/day), egg production (%), egg mass (g/head/day), and feed conversion ratio. The physical egg quality was determined by measuring egg weight (g/egg), thick egg white height (mm), and eggshell percentage (%).

Data Analysis

The data was processed using the Microsoft Excel 360 application. The data were evaluated using one-way analysis of variance (ANOVA). If the treatment shows an actual effect, the Duncan test should be repeated. Meanwhile, hematology, stress indicators, and feed conversion ratio data were analyzed descriptively.

RESULTS

Environmental Temperature

According to observations, the temperature of the quail rearing environment was 23-26 °C in the morning, 27-39 °C in the afternoon, and 25-31 °C in the afternoon. The temperature in the environment is over the quail's comfort zone, resulting in oxidative stress. Exogenous antioxidants can be used to mitigate the harmful effects of oxidative stress (Kumar et al., 2021).

Phytochemical of Coconut Shell Liquid Smoke

The qualitative and quantitative phytochemical content of coconut shell liquid smoke included flavonoids, tannins, and saponins. Table 2 showed the results of these observations. Phytochemical analysis showed coconut shell liquid smoke contained flavonoid levels of 0.43%, tannin levels of 28.46%, and saponin levels of 1.48%.

Table 2 Phytochemical content of coconut shell liquid smoke

Phytochemical	Quantitative (%)
Flavonoid	0.43
Tannin	28.46
Saponin	1.48

Analysed in The Laboratory of the Research Center for Spice and Medicinal Plants, Bogor, Indonesia

Hematology

Hematological values recorded in quails included erythrocytes, hemoglobin, hematocrit, leukocytes, and leukocyte differentiation (heterophils, lymphocytes, monocytes, eosinophils, and basophils). Table 3 displayed the outcomes of these observations. The average erythrocytes ranged from 2.18-2.92 x 106/mm3; hemoglobin 13.20-16.47 g/dL; hematocrit 31.00-41.50 (%); leukocytes 24.70-27.24 x 103/mm3; heterophils 6.09-7.01 x 103/mm3; lymphocytes 15.60-16.46 x 103/mm3; monocytes 2.04-3.25 x 103/mm3; eosinophils 0.60-1.38 x 103/mm3; and basophils undetectable in quail hematology values.

Table 3 Hematological values of quail supplemented with coconut shell liquid smoke

Variables	P0	P1	P2	P3	P4
Erythrocytes (10^6/mm^3)	2.70±0.28	2.18±0.37	2.92±0.41	2.72±0.42	2.68±0.09
Hemoglobin (g/dL)	16.10±1.21	13.20±1.96	16.47±2.03	15.53±1.14	14.40±0.99
Hematocrit (%)	38.17±2.52	31.00±4.65	41.50±5.18	38.87±3.78	36.50±1.10
Leukocytes (10^3/mm^3)	27.24±1.00	24.7 ±2.78	26.93±1.20	26.73±0.88	26.71±0.25
Leukocyte differentiation (10^3/mm^3)					
Heterophils	7.01±0.93	6.09±1.50	6.82±0.96	6.61±0.68	6.24±0.55
Lymphocytes	15.60±1.04	16.03±2.01	16.14±2.44	16.46±0.21	16.21±0.72
Monocytes	3.25±0.95	2.04±0.42	2.49±0.63	2.59±0.40	3.01±0.98
Eosinophils	1.38±0.63	0.60±0.36	1.48±0.43	1.07±0.14	1.25±0.14
Basophils	N/D	N/D	N/D	N/D	N/D

Note: P0= drinking water without coconut shell liquid smoke (CSLS); P1= drinking water with CSLS 0.25 mL/L; P2= drinking water with CSLS 0.50 mL/L; P3= drinking water with CSLS 0.75 mL/L; P4= drinking water with CSLS 1 mL/L. N/D= non detected

Stress Indicators

Quail stress indicators are identified based on SOD, MDA levels and H/L ratio. The results of this test can be seen in Table 4. The results of the stress indicator observations showed that SOD levels in group P1 (149.43 unit/mL) were higher than in group P0 (103.43 unit/mL). MDA levels were lower in group P1 (0.01 nmol/mg) than in group P0 (0.06 nmol/mg). Group P1 and P4 (0.38%) obtained the lowest H/L ratio than in group P0 (0.45%).

Table 4 Stress indicator of quail supplemented with coconut shell liquid smoke

Variables	P0	P1	P2	P3	P4
SOD (unit/mL)	103.45±25.80	149.43±22.76	121.84±8.60	105.75±25.39	112.64±18.10
MDA (nmol/mg)	0.06±0.03	0.01±0.01	0.02±0.00	0.03±0.02	0.02±0.02
H/L (%)	0.45±0.06	0.38±0.08	0.43±0.09	0.40±0.05	0.38±0.02

Note: P0= drinking water without coconut shell liquid smoke (CSLS); P1= drinking water with CSLS 0.25 mL/L; P2= drinking water with CSLS 0.50 mL/L; P3= drinking water with CSLS 0.75 mL/L; P4= drinking water with CSLS 1 mL/L.

Quail Productivity

Quail performance observed included water intake, feed intake, egg production, egg mass, and feed conversion rate. The observation results are presented in Table 5. Statistically, the average water intake (58-66 mL/head/day), feed intake (23.15-23.29 g/head/day), egg production (57.44-62.11%), and egg mass (5.73-6.95 g/head/day) were not significantly different ($P > 0.05$). The lowest feed conversion ratio (FCR) value in this study was obtained in group P1, while the highest one was in group P0.

Table 5 Productivity of quail supplemented with coconut shell liquid smoke

Variables	P0	P1	P2	P3	P4
Water intake (mL/head/day)	66±4.21	63±2.25	66±5.12	58±2.26	64±8.03
Feed intake (g/head/day)	23.15±0.17	23.29±0.04	23.28±0.04	23.26±0.05	23.21±0.09
Egg production (%)	56.33±2.42	62.11±6.34	58.67±2.99	57.44±2.99	59.78±4.28
Egg mass (g/head/day)	5.73±0.83	6.95±1.76	6.64±0.77	6.03±0.40	6.38±1.42
Feed conversion ratio	4.04±0.60	3.35±0.77	3.51±0.44	3.86±0.26	3.64±0.74

Note: P0= drinking water without coconut shell liquid smoke (CSLS); P1= drinking water with CSLS 0.25 mL/L; P2= drinking water with CSLS 0.50 mL/L; P3= drinking water with CSLS 0.75 mL/L; P4= drinking water with CSLS 1 mL/L.

Physical Egg Quality

Physical egg quality observed were egg weight, thick egg white height, and eggshell percentage. These results can be seen in Table 6. The application of coconut shell liquid smoke had no significant influence ($P > 0.05$) on egg weight (10.12-11.24 g/egg), thick egg white height (4.89-5.22 mm), and eggshell percentage (11.88-11.93%).

Table 6 Physical egg quality of quail supplemented with coconut shell liquid smoke

Variables	P0	P1	P2	P3	P4
Egg weight (g/egg)	10.12 ± 1.06	1.,03 ± 1.61	11.24 ± 0.79	10.48 ± 0.22	10.59 ± 1.59
Thick egg white height (mm)	4.89 ± 0.13	4.99 ± 0.17	5.22 ± 0.03	4.91 ± 0.17	4.97 ± 0.11
Eggshell (%)	11.93 ± 0.04	11.88 ± 0.00	11.92 ± 0.04	11.89 ± 0.03	11.92 ± 0.01

Note: P0 = drinking water without coconut shell liquid smoke (CSLS); P1= drinking water with CSLS 0.25 mL/L; P2= drinking water with CSLS 0.50 mL/L; P3= drinking water with CSLS 0.75 mL/L; P4= drinking water with CSLS 1 mL/L.

DISCUSSION

Phytochemical of Coconut Shell Liquid Smoke

Flavonoids, tannins, and saponins are found in coconut shell liquid smoke. This is in line with the findings of Pasaribu et al. (2021). Flavonoids are secondary metabolites of polyphenols that have antioxidant characteristics because they contain 15 carbon atoms and a hydroxyl group (Banjarnahor and Artanti, 2018). Flavonoids, as antioxidants, can give hydrogen atoms and reduce the rate of autooxidation by converting free radicals to a stable state. Tannin is a polyphenolic molecule that functions as an antioxidant by establishing a benzene ring to a hydroxyl group (Tong et al., 2022). The mechanism of tannin as an antioxidant is to scavenge free radicals by donating electrons and hydrogen atoms. Saponins are glycoside molecules with hydroxyl groups and two forms of aglycones, namely steroids and triterpenoids, which give them antioxidant and antibacterial characteristics (Sun et al., 2014). Saponin functions as an antioxidant, increasing antioxidant enzymatic activities of catalase, glutathione content, and SOD. Saponin works as an antibacterial agent by inhibiting the growth of microorganisms and damaging bacterial cell walls (Zaynab et al., 2021). Based on the activity of flavonoids, tannins, and saponins in coconut shell liquid smoke is expected to counteract oxidative stress and boost body resistance.

Hematology

The erythrocyte and hematocrit levels observed in this study were below the normal range for quail, according to Mahmoud et al. (2013) (3.04-3.60 x 10^6/mm^3 and 45.20-48.90%) and Ayoola et al. (2015) (3,24-4,56 x 10^6/mm^3 and 43.32-51,68. Erythrocytes work by transferring oxygen from the lungs to all body cells and hematocrit is the percentage of erythrocyte volume in 100 mL of blood. Low erythrocyte concentration and hematocrit levels are produced by quail suffering oxidative stress, which tends to increase drinking water intake compared to feed intake, causing blood volume to increase and nutritional adequacy in erythrocyte production to decrease. Hemoglobin levels in this study were normal for quail, ranging from 12.01-17.23 g/dL (Mahmoud et al., 2013; Ayoola et al., 2015). This demonstrates that the oxygen content in the quail's bodily tissue is adequate. Leukocytes are blood components that contribute to the body's immune system. Lymphocytes, monocytes, heterophils, eosinophils, and basophils are all components of leukocyte differentiation. The leukocyte average in this study was higher than in previous studies by Mahmoud et al. (2013) 17.20-22.91 x 10^3/mm^3 and Ayoola et al. (2015) 17,58-21,62 x 10^3/mm^3. This study's increased leukocyte count was triggered by oxidative stress, which harmed bodily cells and boosted the immune system. However, supplementing coconut shell liquid smoke at a dose of 0.25 mL/L of drinking water (P1) was able to lower leukocyte concentrations and bring them closer to normal. On the other hand, eosinophil and lymphocyte numbers tend to be in the normal range (1.01-1.86 x 10^3/mm^3 and 8.05-16.89 x 10^3/mm^3) according to Mahmoud et al. (2013), but above the Ayoola et al. (2015) (0.00-0.11 x 10^3/mm^3 and 11.02-14.55 x 10^3/mm^3). This variation is due to Mahmoud et al. (2013) applying temperatures that are like this research (22-40 °C) whereas Ayoola et al. (2015) utilized 22 °C. As reported by Mahmoud et al. (2013), the drop in lymphocytes and eosinophils corresponded to a decrease in ambient temperature. Heterophil and monocyte values are above normal (4.50-5.93 x 10^3/mm^3 and 0.41-0.90 x 10^3/mm^3) (Mahmoud et al., 2013), however, according to Ayoola et al. (2015), the heterophil values are still within the normal range (5.59-8.04 x 103/mm3). However, the discrepancy in the outcomes of this study compared to other studies is due to oxidative stress in quail, which causes damaged cells in the body to be seen as foreign objects. According to Swaggerty et al. (2020), heterophils and monocytes collaborate to combat foreign objects in the body. There were no basophil values found in this research. Nevertheless, this does not mean that basophil cells do not exist; rather, their size is quite small and is typically identified in a count of 1,000 leukocyte cells (Abdul-Majeed and Abdul-Rahman, 2021).

Stress Indicators

SOD is an intracellular enzyme that catalyzes the dismutation reaction and converts superoxide anions (O_2^-) into oxygen molecules (O_2) and hydrogen peroxide molecules (H_2O_2) (Truong and King, 2023). The findings of liver SOD observations showed that supplementing coconut shell liquid smoke at a dose of 0.25 mL/L could increase capable of liver SOD. The low liver SOD in P2, P3 and P4 were due to the TAR content (total aerosol residue) in CSLS grade 3 which can hemolyze blood cells in the liver and cause damage to the blood cells. According to Jain et al. (2021) TAR is toxic and carcinogenic, it can damage liver cells by accumulating toxic compounds in the liver. MDA is the product of lipid peroxidation, which is utilized as a biological biomarker to assess the degree of oxidative stress (Jumadin et al., 2022). MDA levels decreased after supplementing coconut shell liquid smoke, particularly at P1. The high SOD value at P1 also stimulates a decrease in lipid peroxidation, resulting in low MDA levels. Conversely, the high MDA values in P2, P3, and P4 were caused by the TAR content in CSLS, which may result in liver cell necrosis by binding proteins and unsaturated lipids to cell membranes, leading to lipid peroxidation and cell damage (Jain et al., 2021).

The H/L ratio represents the ratio of heterophils per lymphocyte, which is used to assess stress in quail (Nazar et al., 2018). According to the observations, P1 and P4 had the lowest H/L ratio. A low H/L ratio implies a low level of stress in quail (Nazar et al., 2018). This reveals that the flavonoid, tannin, and saponin content of coconut shell liquid smoke can support the immune system and keep quail healthy.

Quail Productivity

The addition of coconut shell liquid smoke did not influence water intake and feed intake ($P > 0.05$). This is due to age, rearing environment temperature, and uniform feed metabolic energy content. Fadhila et al. (2023) said water intake is controlled by quail age, environmental temperature, and metabolic energy in feed. According to observations, the average water intake ranged from 58-66 mL/head/day, or the equivalent of 2.45-2.86 times the average feed intake. This showed that quail were exposed to extreme environmental temperatures, and they consume a lot of water. According to Orakpoghenor et al. (2021) poultry water intake varies from 1.6 to 2.0 times feed intake at normal temperatures, but poultry exposed to high environmental temperatures can consume more than 2.0 times feed intake. The level application of coconut shell liquid smoke did not affect egg production and egg mass ($P > 0.05$). This is controlled by the temperature of the rearing environment as well as the uniform mineral content of the feed. According to Ashour et al. (2020), nutritional content and mineral mass influence egg mass. Quail fed with coconut shell liquid smoke at a level of 0.25 mL/L in drinking water (P1) achieved the optimum average feed conversion ratio value (3.35). Low feed conversion indicates that the quail is particularly efficient in absorbing nutrients into products (Abbas et al., 2015). Furthermore, coconut shell liquid smoke contains saponin as an antibiotic that can destroy pathogenic bacteria in the intestinal villi, allowing for efficient nutrient absorption (Zaynab et al., 2015). However, increased feed conversion ratio at P2, P3, and P4 was caused by the tannin content in coconut shell liquid smoke which can bind protein and inhibit feed absorption (Paengkoum et al., 2021). Of all the variables studied, FCR is the primary measure of quail production (Yi et al., 2018).

Physical Egg Quality

The total weight of an egg is the sum of its components, which include albumin, egg yolk, and eggshell. The results showed that the coconut shell liquid smoke treatment had no significant effect on egg weight ($P > 0.05$). This is due to the uniform protein content of the feed. According to Ratriyanto et al. (2017), the protein content of feed affects the synthesis of albumin and egg yolk proteins, which are the two most important components in determining egg weight.

The supplementing coconut shell liquid smoke did not influence thick egg white height ($P > 0.05$). This is due to the protein composition of the feed and the uniformity of the environmental temperature. According to Hanafy and Attia (2018), the protein level of the feed increases the height of the thick egg whites generated, the thicker the egg whites, the greater the protein content of the egg whites.

In this research, the eggshell percentage was not significant ($P > 0.05$). This is due to the mineral content of the feed consumed, as well as the quail's uniform age. According to Nepomuceno et al. (2014), eggshells are regulated by age, nutritional management, health conditions and genetics.

CONCLUSIONS

It was concluded that coconut shell liquid smoke (CSLS) could reduce oxidative stress in the quail layer period. It was found that the optimum stress indicators and FCR were obtained at a dose of 0.25 mL/L CSLS (P1).

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AUTHOR CONTRIBUTIONS

We indicate the specific contributions of each author with initials, i.e.
Conception and design of the study: NU and RMF
Acquisition of data: RMF
Analysis and/or interpretation of data: NU and RMF
Drafting the manuscript: RMF and HM
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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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