Carcass characteristics and meat quality of quail given drinking water enriched with a coconut shell liquid smoke grade 1

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Abstract. The research aims to study the effect of the coconut shell liquid smoke (CSLS) in drinking water with different doses on carcass characteristics, physical quality and meat nutritional quality of quail. The research method used a completely randomized design with five treatment groups T0 (control), T1 (0.25mL/L), T2 (0.5ml/L), T3 (0.75ml/L) and T4 (1ml/L). Two Hundred female quails were randomly divided into four replications with ten quails/replication. CSLS is given to quails starting at 5 weeks of age, and at the age of 13 weeks, forty quails were slaughtered (two per replication), after which, the carcasses were weighed and divided into commercial part. Physical quality testing and proximate analysis of meat were carried out on breast meat. The results showed that CSLS at T4 significantly ($P<0.05$) increased slaughter weight by 204.5±6.13 and carcass weight by 125.7±3.81. Physical meat quality parameters were not significantly affected ($P>0.05$). In contrast, chemical meat quality was influenced, with differences observed in moisture, ash, and fat content, while protein remained unchanged. In conclusion, grade 1 coconut shell liquid smoke has the potential to be used as a natural additive to improve the carcass quality of female quail.

1 Introduction

It is imperative to acknowledge the significance of quail in addressing the global demand for animal protein. The primary purpose of quail husbandry is to produce eggs; however, when the females reach a point of diminishing returns in terms of egg production, their meat can serve as an alternative source of protein, in addition to those from chickens, ducks, turkeys, and pigeons. According to the Ministry of Agriculture of the Republic of Indonesia, the quail population exhibited a 71.43% increase from 2022 to 2023. This figure indicates a growing public interest in quails.

A multitude of factors inherent to the agricultural industry, including management practices, nutritional regimens, environmental influences, and disease prevalence, have the potential to induce stress in poultry populations. It has been determined that stress in poultry is a substantial factor influencing poultry production. This is evidenced by the findings that stress accelerates the respiratory rate and increases body heat. According to data from the Central Statistics Agency, the average environmental temperature in Indonesia in 2023 was 27.2°C, with a minimum of 19.9°C and a maximum of 35.7°C. The optimal temperature range for quail production is 18-26°C [1]. These conditions result in elevated levels of stress experienced by quails due to their inability to effectively dissipate excess heat from their bodies. Consequently, this results in the generation of free radicals within their organisms. The presence of free radicals has been demonstrated to induce oxidative stress in quails. [2] Oxidative stress, a byproduct of heat stress, can be mitigated by the administration of antioxidants, which function as a defense system against free radicals. Liquid smoke, a natural ingredient, has demonstrated antioxidant properties [3]. Liquid smoke is isolated by the pyrolysis process of wood components such as cellulose, hemicellulose, and lignin [4]. Liquid smoke from coconut shells contains a variety of organic compounds, including phenols, triterpenoid flavonoids, saponins, and acids, which possess antimicrobial and antioxidant properties [5].

The utilization of coconut shell liquid smoke has been demonstrated to enhance performance in poultry species such as broiler chickens and quails [6,7]. However, research on the use of coconut shell liquid smoke, especially grade 1, and its effect on the carcass quality of female quails has not been widely conducted. Therefore, this study is important to determine carcass production and the effect of physical and chemical quality of quail meat given coconut shell liquid smoke through drinking water.

2 Materials and methods

2.1 Material

A total of 200 female laying quails (*Coturnix coturnix japonica*) aged 5 to 13 weeks were randomly allocated into five treatment groups: The experimental design comprised five distinct treatment levels (T0 [control], T1 [0.25 mL/L], T2 [0.5 ml/L], T3 [0.75 ml/L], and T4 [1 ml/L]), with four replicates allocated for each treatment. Each replicate consisted of ten quails. The development of coconut shell liquid smoke was undertaken at the Forest Products Technology Research and Development Centre Laboratory. A phytochemical analysis of the liquid smoke was conducted at the Laboratory of the Standard Testing of Spice, Medicinal and Aromatic Plant Instruments in Bogor, Indonesia. The feed utilized was a commercial product known as P100 crumble feed, manufactured by PT New Hope. This feed was formulated to contain 20% protein, 7% fat, and 7% crude fiber. The quails were housed in a 5-tier cage with dimensions of 100 centimeters in length, 60 centimeters in width, and 180 centimeters in height. The quails were raised at the Arkan Quail Farm in Bogor, West Java. The physical quality testing of the meat was conducted at the Department of Animal Science and Technology's laboratory at IPB University. The chemical quality testing of the meat was conducted at the Biotech Centre, IPB University.

2.2 Research procedure

Liquid smoke is derived from the process of preparing dry, clean coconut shells, which are then fragmented into small pieces. These are subsequently placed in a pyrolysis reactor and

heated at 300°C for 5 hours to produce grade 3 liquid smoke [8]. The tar is subsequently collected and distilled to produce grade 2 liquid smoke. This is then filtered with commercial activated charcoal to obtain grade 1 liquid smoke [9]. The presence of flavonoids, tannins, saponins, and phenols in the liquid smoke was determined as per standard phytochemical screening procedures described by [10].

The feeding and watering of the subjects is conducted in the morning, commencing at 07:00. The feeding method involves the administration of coconut shell liquid smoke. Temperature recordings are obtained at four distinct time points: 7:00 a.m., 12:00 p.m., 5:00 p.m., and 10:00 p.m. A total of 40 quails (2 quails per repetition) were selected for observation to ascertain carcass characteristics and meat quality. Prior to slaughter, a 12-hour fast was observed, followed by weighing and slaughtering of the quails. The carcasses were weighed and subsequently divided into various anatomical regions, including the breast, thigh, drumstick, wing, back, head, and neck.

Subsequently, a set of 40 samples of quail breast meat was subjected to physical and chemical testing. The meat was then chilled at 4°C for 24 hours prior to undergoing a physical quality assessment, which encompassed the measurement of pH, water holding capacity, and cooking loss. The proximate composition of quail meat as a chemical quality test was determined according to the following reference [11]. Water and ash content were measured using the gravimetric method, protein was tested using the Kjeldahl method, and lipid content was determined by the Soxhlet method.

2.3 Statistical analysis

The carcass, physical quality, and chemical composition of quail meat were analyzed using one-way analysis of variance (ANOVA) with the General Linear Model (GLM). In the event of substantial disparities, the analysis was pursued with Tukey's test. The analysis was conducted using Minitab 20 statistical software.

3 Results and discussion

3.1 Environmental temperature

It is imperative to meticulously monitor the environmental temperature of the quail enclosure, as it exerts a substantial influence on the quail's productivity and overall health. As illustrated in Table 1, the ambient temperature of the environment during the study, from morning to night, exceeded the quails' comfort zone. During daylight hours, elevated ambient temperatures can result in elevated levels of heat stress experienced by quails. [12] Heat stress is one of the environmental factors that causes significant economic losses in the poultry industry. The effects of this stress include oxidative stress, reduced feed efficiency, reduced body weight, reduced egg production, and reduced egg and meat quality.

Table 1. Environmental temperature during the rearing of quails aged 5-13 weeks.

Observation	Temperature (°C)
07:00	26.4-28.3
12:00	35.6-37.7
17:00	32.9-35.2
22:00	25.1-26.5

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3.2 Phytochemical of coconut shell liquid smoke

Coconut shell liquid smoke has been found to contain a variety of bioactive compounds. As illustrated in Table 2, the results of qualitative tests on coconut shell liquid smoke containing phenolic compounds, flavonoids, tannins, and saponins are presented.

Table 2. Phytochemical analysis of coconut shell liquid smoke.

Fitokimia	Content
Tanin	+
Flavonoid	+
Saponin	+
Fenol	+

3.3 Carcass characteristics

Carcass characteristics represent pivotal parameters in the evaluation of poultry production quality. The carcass is the part of the chicken that has been separated from the blood, feathers, internal organs, legs, neck, and head. The carcass characteristics that are taken into consideration include slaughter weight, carcass weight, and percentage, as well as breast, thigh, wing, drumstick, and back weight. As illustrated in Table 3, the female quails in the T4 group exhibited the highest slaughter weight, a result that reached statistical significance ($P < 0.05$). The T4 treatment demonstrated the most favorable outcomes in terms of carcass weight and percentage. The findings suggest that the administration of grade 1 liquid smoke not only stimulates body weight growth but also increases the proportion of meat produced.

The outcomes concerning carcass components, specifically the weights of the breast, thigh, drumstick, wing, and back of 13-week-old female quails, did not exhibit any disparities among the treatments. The breast is the part of the carcass that has a higher weight compared to other parts. The breast constitutes the most substantial muscle storage site in poultry, including quails, thus rendering it the most preferred and economically valuable part [13].

Table 3. Carcass characteristics of quail female 13 weeks old.

Carcass traits	Treatment				
	T0	T1	T2	T3	T4
Slaughter weight (g)	184.5±6.87 ^{b}	185.5±6.08 ^{b}	177.5±2.96 ^{b}	192.1±8.52 ^{a} ^{b}	204.5±6.13 ^{a}
Carcass weight (g)	101.7±3.22 ^{b}	104.1±5.3 ^{b}	100.2±1.85 ^{b}	116.8±7.63 ^{a}	125.7±3.81 ^{a}
Carcass percentage (%)	55.2±2.17 ^{b}	55.2±1.34 ^{b}	56.5±1.79 ^{ab}	60.8±3.13 ^{a}	61.5±0.12 ^{a}
Breast (g)	38.4±2.38	39.5±2.73	38.9±1.74	42.1±1.69	42.9±4.82
Thigh (g)	13.1±0.16	12.4±1.15	12.2±1.04	12.7±1.22	12.9±1.95
Legs(g)	10.1±0.51	9.6±0.76	9.4±0.75	9.9±0.39	10.1±1.08
Wing (g)	7.5±0.75	7.8±0.61	7.3±1.0	7.6±0.38	7.2±0.3
Back (g)	20.3±0.78	20.7±2.03	18.7±1.23	20.9±2.85	19.4±2.51

T0=control/without coconut shell liquid smoke (CSLS); T1= 0.25ml CSLS/L drinking water; T2= 0.5ml CSLS/L drinking water; T3= 0.75ml CSLS/L drinking water; P4 = 1ml CSLS/L drinking water. Superscripts^{a,b} in the same row indicates a significant difference ($P< 0.05$).

3.4 Physical quality meat

Physical meat quality assessment is a pivotal indicator that consumers consider when evaluating meat quality, as it impacts processing efficiency, consumer preference, and economic factors. The physical quality of meat is a critical factor in evaluating its freshness, tenderness, juiciness, and shelf life. The findings presented in Table 4 indicate that the incorporation of coconut shell liquid smoke in quail drinking water at various concentrations did not exert an influence on the physical quality of quail meat. This finding suggests that the administration of coconut shell liquid smoke to quails did not result in any alterations to the physical quality of the meat. The pH value ranged from 5.60 to 5.73. This pH value is within the normal range for quails, which is 5.94 [14]. The cooking loss and water holding capacity exhibited comparable trends across the various treatments, attributable to the pH of the meat remaining within the standard range.

Table 4. Physical quality meat of quail female 13 weeks old.

Variables	Treatment				
	T0	**T1**	**T2**	**T3**	**T4**
pH	5.66±0.06	5.69±0.12	5.73±0.10	5.65±0.01	5.60±0.07
Cooking loss (%)	43.38±2.62	40.95±1.90	42.62±1.80	44.65±3.10	44.30±2.45
Water holding capacity (%)	27.61±1.11	28.23±1.47	27.61±0.57	28.12±1.07	28.23±1.47

T0=control/without coconut shell liquid smoke (CSLS); T1= 0.25ml CSLS/L drinking water; T2= 0.5ml CSLS/L drinking water; T3= 0.75ml CSLS/L drinking water; P4 = 1ml CSLS/L drinking water.

3.5 Chemical quality meat

The effect of the liquid smoke treatment derived from coconut shells on the chemical quality parameters of quail meat is illustrated in Table 5. The analysis revealed that the moisture content, ash content, and fat content exhibited significantly different outcomes ($P<0.05$).

Table 5. Chemical quality meat of quail female 13 weeks old.

Variables	Treatment				
	T0	**T1**	**T2**	**T3**	**T4**
Moisture (%)	63.73 ± 1.63^{bc}	65.89 ± 2.40^{ab}	60.91 ± 2.74^{cd}	68.91 ± 1.80^{a}	58.75 ± 1.79^{d}
Ash (%)	0.91 ± 0.02^{c}	1.34 ± 0.04^{a}	0.83 ± 0.02^{c}	0.89 ± 0.01^{c}	1.06 ± 0.08^{b}
Protein (%)	27.48 ± 0.66^{a}	26.96 ± 1.57^{a}	26.05 ± 0.45^{ab}	24.54 ± 0.79^{b}	27.47 ± 0.90^{a}
Fat (%)	4.68 ± 0.12^{c}	6.51 ± 0.35^{b}	4.29 ± 0.12^{c}	7.41 ± 0.11^{a}	7.37 ± 0.29^{a}

T0=control/without coconut shell liquid smoke (CSLS); T1= 0.25ml CSLS/L drinking water; T2= 0.5ml CSLS/L drinking water; T3= 0.75ml CSLS/L drinking water; P4 = 1ml CSLS/L drinking water. Superscripts $^{a, b, c, d}$ in the same row indicates a significant difference ($P < 0.05$).

The lowest moisture content was found in T4. This finding suggests that quail meat in T4 exhibits a prolonged shelf life compared to meat in other treatments. As indicated by the second equation, an elevated moisture content in meat can render it vulnerable to microbial proliferation if not managed with the requisite degree of care. The highest concentrations of fat were observed in the T3 and T4 samples of quail meat. This increase in fat content is

likely related to the role of phenolic compounds in liquid smoke, which can affect lipid metabolism and oxidative stability. Phenols present in liquid smoke have been observed to engage with free radicals, thereby enhancing lipid stability within biological tissues. Protein levels exhibited no statistically significant variation (P>0.05), with a range of 26.05% to 27.48%. This finding indicates that the incorporation of coconut shell liquid smoke does not alter the primary protein composition of muscle tissue.

4 Conclusion

The administration of 1 milliliter of liquid smoke derived from grade 1 coconut shells per liter of drinking water has been demonstrated to result in a significant increase in the slaughter weight and carcass weight of 13-week-old female quails. The administration of coconut shell liquid smoke has been demonstrated to exert an influence on the chemical quality of water and fat content, while maintaining constant protein content, without compromising the physical quality of the meat. The utilization of grade 1 coconut shell liquid smoke as a natural additive has the potential to enhance the quality of the carcasses of female quails.

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