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Research Article

Effects of Different Levels of *Cassia alata* L. Leaf Extract on the Production Performance of Laying Quail

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Abstract | This study evaluated the effects of different dietary levels of *Cassia alata* L. leaf extract (CALE) on the production performance of laying quails. A total of 200 female quails were monitored from 6 to 12 weeks of age. The experiment used a completely randomized design with five treatments: A (0%; no additive), B (0.5% synthetic AGP), C (0.5% CALE), D (1.0% CALE), and E (1.5% CALE), each with four replicates. The measured variables included feed consumption, quail-day egg production, egg weight, egg mass, and feed conversion ratio (FCR). All data were analyzed using analysis of variance (ANOVA), followed by Duncan's Multiple Range Test ($P < 0.05$) for mean separation. In addition, linear regression analysis was performed to evaluate the dose–response relationship between CALE levels and production parameters. The results showed that CALE significantly influenced all parameters measured. This study concludes that the use of 0.5% CALE resulted in the best responses, including: feed consumption of 23.94 ± 0.11 g/bird/day, egg production of 65.69 ± 7.15%, egg weight of 10.82 ± 0.17 g, egg mass of 7.00 ± 0.57 g, and an FCR of 3.51 ± 0.21. These findings indicate that the inclusion of 0.5% CALE effectively improves feed efficiency, egg productivity, and overall physiological performance, and provides results comparable to synthetic AGPs at the same inclusion level.

Keywords | *Cassia alata,* Extract, Laying quail, Production performance, Natural additive, Feed consumption

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INTRODUCTION

Laying quail (*Coturnix coturnix japonica*) are a small poultry commodity that contributes to the supply of high-quality animal protein, with advantages including a short production cycle, efficient housing space, and relatively good feed conversion (Narusin *et al*., 2024; Maulana *et al*., 2025). The main challenge in quail production is maintaining optimal performance amid environmental fluctuations, disease pressure, and nutritional stress. A nutraceutical approach based on medicinal plants offers a strategic alternative to improve both productivity and health, aligning with the global trend toward reducing antibiotic growth promoters (Aminullah *et al*., 2025). For small- to medium-scale farmers, identifying locally available and cost-effective phytogenic additives is therefore increasingly relevant.

Gelinggang (*Cassia alata* L.), widely recognized in Indonesia as a traditional medicinal plant, contains diverse secondary metabolites such as flavonoids and anthraquinones-including rhein, aloe-emodin, astragalin, and kaempferol (Promgool *et al*., 2014; Fajri *et al*., 2023). These bioactive compounds exhibit antimicrobial and antioxidant activities that may support gastrointestinal function and overall physiological status in poultry. Antioxidant activity plays a role in minimizing oxidative stress, while antimicrobial effects may help stabilize gut microbiota, ultimately improving nutrient utilization (Aminullah *et al*., 2025).

Accordingly, *C. alata* leaf extract (CALE) merits consideration as a phytogenic feed additive to enhance quail production performance. The modes of action of phytogenics in laying poultry include modulation of gut microbiota, stimulation of digestive enzyme secretion, reinforcement of mucosal integrity, and suppression of free radicals (Abdelli *et al*., 2021). In laying quail, maintaining a healthy intestinal environment correlates with improved effective feed intake, enhanced feed efficiency, and more consistent egg production. Phenolic and flavonoid compounds can also scavenge free radicals, stabilize cellular membranes, and reduce lipid peroxidation-factors that are particularly important in tropical climates where birds are vulnerable to heat- and oxidative-stress-related performance declines (Horváth *et al*., 2018).

Determining the appropriate inclusion level of CALE is crucial to achieving functional benefits without eliciting adverse effects. Variations in active metabolite concentrations due to differences in plant origin, leaf maturity, and extraction method further highlight the need for dosage optimization (Promgool *et al*., 2014). Optimizing the level of *C. alata* leaf extract in quail diets has the potential to improve farm margins by enhancing feed conversion ratio (FCR), increasing laying persistence, and reducing health-related costs. This approach aligns with sustainable livestock practices that emphasize food safety, animal welfare, and the reduction of synthetic residues in animal products-considerations that have grown increasingly important as AGP regulations tighten and interest in natural additives increases (Wang *et al*., 2024).

The use of local biological resources also strengthens self-reliance in feed additive supply chains and increases the economic value of Indonesia's biodiversity. However, empirical evidence identifying the optimal dietary level of *C. alata* leaf extract to maximize production performance and egg quality in laying quail remains limited. Based on this background, the present study was conducted to evaluate the effects of different dietary levels of *Cassia alata* L. leaf extract on the production performance of laying quail.

MATERIALS AND METHODS

Materials

This study used female quails (*Coturnix coturnix japonica*) aged 6 weeks, which were maintained for a 6-week experimental period. Birds were housed in a dedicated experimental cage system with five tiers; each tier was divided into four compartments measuring 45 × 20 × 30 cm. Each compartment contained 10 laying quails, yielding a total of 200 birds. The feed ingredients and their nutrient contents used in this study are presented in Table 1. The composition of the feed formulation (%) can be seen in Table 2. Nutrient contents of the treatment diets are shown in Table 3.

Methods

This study employed a Completely Randomized Design (CRD) consisting of five treatments with four replications. A total of 200 laying quails of uniform body weight were randomly allocated into 20 experimental units, with 10 birds per unit.

The dietary treatments were as follows:
A= 0% CALE (control, no additive), B= 0.5% synthetic AGP, C= 0.5% CALE, D= 1.0% CALE, E= 1.5% CALE

Cassia alata leaf extract (CALE) was prepared using a maceration technique with food-grade ethanol as the solvent, followed by evaporation to obtain a concentrated extract. All birds received the same basal commercial diet, which was mixed with CALE or AGP according to the assigned treatments. Feed and drinking water were provided ad libitum throughout the experimental period.

Table 1: Feed ingredients and nutritional composition used in the study.

Ingredient	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)	Calcium (%)	Phosphorus (%)	Metabolizable Energy (kcal/kg)
Ground Corn[a]	9.00	2.01	2.50	0.52	0.23	3350.00
Special layer concentrate super 36 SPR[b]	34.00	2.00	8.00	9.00	0.50	2700.00
Rice Bran[a]	8.31	5.60	12.00	0.75	0.36	1700.00
Mineral Feed[c]	0	0	0	32.50	1.00	0
$CaCO3$[a]	0	0	0	42.00	0	0
Top Mix[c]	0	0	0	0.06	0	0

Note: [a]Laboratory test results, [b]Packaging label from PT Japfa Comfeed Indonesia, [c]Packaging label from PT Medion Indonesia.

Table 2: Feed ingredient composition (%).

Ingredient	Composition (%)
Ground Corn	46.00
Special Layer Concentrate Super 36 SPR	47.00
Rice Bran	3.00
Mineral Feed	2.00
$CaCO_3$	1.00
Top Mix	1.00
Total	100.00

Table 3: Nutritional content of diets used.

Nutrients	Feed ingredient (%)
Crude protein	20.37
Crude fat	2.03
Crude fiber	5.27
Calcium	5.56
Available phosphorus	0.37
Metabolizable energy	2861.00

Note: Values were obtained based on Tables 1 and 2.

Preparation of samples and extraction of *Cassia alata* leaves (Fajri *et al*., 2023)

Fresh leaves of *Cassia alata* (gelinggang) were collected from Tanah Laut Regency, South Kalimantan Province, Indonesia. The leaves were thoroughly washed with distilled water to remove dirt and impurities, then air-dried at ambient temperature (25-30 °C) until reaching a constant weight. The dried leaves were milled using a mechanical grinder and sieved to obtain a fine leaf powder.

The extraction process followed a maceration technique using water as the solvent. Approximately 100 g of leaf powder was immersed in 1 L of distilled water at room temperature for 48 hours, with intermittent stirring to enhance metabolite dissolution. The mixture was then filtered using Whatman No. 1 filter paper, and the resulting filtrate was concentrated with a rotary evaporator at 50 °C to reduce the solvent volume. The concentrated extract was subsequently oven-dried at 40 °C to produce a semi-solid crude extract.

The final product, referred to as *Cassia alata* leaf extract (CALE), was stored in an airtight container at 4 °C until its application in the experimental diets.

Performance parameters

The performance parameters measured in this study included feed consumption, quail day egg production, egg weight, egg mass and feed conversion ratio (FCR). The calculation methods for each parameter are described below.

Feed consumption

Feed consumption (g/head/day) was determined by subtracting the amount of feed leftover from the total feed offered and dividing the result by the number of birds and experimental days. This value represented the average daily feed intake per bird throughout the study period.

Quail day egg production

Quail day egg production (%) was calculated by dividing the total number of eggs collected by the product of the number of birds and the number of experimental days, then multiplying by 100. This percentage indicated the daily laying performance of the birds.

Egg weight

The average egg weight (g/grain) was obtained by weighing all eggs produced during the collection period and dividing the total egg weight by the total number of eggs. The result was expressed in grams per egg.

Egg mass

Egg mass (g/bird/day) was calculated as the product of egg production and average egg weight divided by the number of birds and experimental days. This parameter represented the total egg output produced per bird per day.

Feed conversion ratio (FCR)

The feed conversion ratio was calculated by dividing the feed consumption by the total egg mass produced. It was expressed as grams of feed required to produce one gram of egg. A lower FCR indicated better feed efficiency.

Data analysis

All data were analyzed using analysis of variance (ANOVA) according to a Completely Randomized Design (CRD). When significant treatment effects were detected, Duncan's Multiple Range Test (DMRT) at $P < 0.05$ was applied for mean separation (Steel and Torrie, 1991).

In addition to ANOVA, linear regression analysis was performed to evaluate the dose–response relationship between the levels of *Cassia alata* leaf extract (CALE) and the production performance parameters, including feed consumption, egg production, egg weight, egg mass, and feed conversion ratio (FCR). A complete ANOVA table is presented to provide more detailed statistical information. Analysis of variance for the completely randomized design is presented in Table 4.

RESULTS AND DISCUSSION

As shown in Table 5, the feed consumption of laying quails given different levels of CALE ranged from 23.47 ± 0.07 to 24.04 ± 0.01 g/head/day. Treatment means were:

Table 4: Analysis of variance for the completely randomized design.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F-value	Table F-value	
					(0.05)	(0.01)
Treatment	4	Treatment sum of squares	Treatment mean square	Treatment mean square/ Error mean square	3.06	4.89
Error	15	Error Sum of Squares	Error Mean Square			
Total	19					

Table 5: Effects of different levels of *Cassia alata* L. leaf extract (CALE) on the production performance of laying quails.

Treatment	Feed consumption (g/head/day)	Quail day egg production (%)	Egg weight (g/grain)	Egg mass (g/grain)	Feed conversion ratio
A	24.04 ± 0.01^{a}	49.37 ± 0.75^{b}	10.58 ± 0.14^{ab}	5.22 ± 0.13^{b}	4.74 ± 0.11^{a}
B	23.81 ± 0.30^{ab}	54.33 ± 1.52^{b}	10.69 ± 0.22^{a}	5.82 ± 0.31^{b}	4.29 ± 0.07^{ab}
C	23.94 ± 0.11^{ab}	65.69 ± 7.15^{a}	10.82 ± 0.17^{a}	7.00 ± 0.57^{a}	3.51 ± 0.21^{b}
D	23.47 ± 0.07^{c}	51.73 ± 1.16^{b}	10.59 ± 0.17^{ab}	5.48 ± 0.25^{b}	4.45 ± 0.25^{a}
E	23.63 ± 0.33^{bc}	50.93 ± 11.17^{b}	10.34 ± 0.13^{b}	5.26 ± 1.16^{b}	5.09 ± 1.27^{a}
SEM	0.05	0.35	0.05		0.01

Description: $^{a-b}$Different superscripts in the same column are significantly different (P<0.05). SEM= Standard error of the mean, A= 0% CALE (control, no additive), B= 0.5% synthetic AGP, C= 0.5% CALE, D= 1.0% CALE, E= 1.5% CALE

A = 24.04 ± 0.01 g/head/day, B = 23.81 ± 0.30 g/head/day, C = 23.94 ± 0.11 g/head/day, D = 23.47 ± 0.07 g/head/day, and E = 23.63 ± 0.33 g/head/day. Statistical analysis indicated that A did not differ (P > 0.05) from B and C, but differed significantly (P < 0.05) from D and E.

The relatively higher feed consumption in A (control), B (0.5% synthetic AGP), and C (0.5% *Cassia alata* leaf extract) can be understood in relation to the absence (or low level) of phytogenic components that could reduce palatability; diets without high levels of *Cassia alata* extract do not supply the pronounced bitter/astringent notes typical of polyphenols such as tannins or saponins that often depress intake, so quails tend to eat slightly more. In diets without substantial *Cassia alata* extract, nutrient utilization efficiency may not increase to the same extent as with stronger phytogenic inclusion; to maintain similar production, birds compensate by increasing intake. The role of plant additives in modulating microbiota, supporting mucosal function, and improving antioxidant status can ultimately influence feeding behavior and feed efficiency (Keng *et al*., 2024).

With higher levels of CALE (1.0% in D and 1.5% in E), mild side effects from bitter/astringent compounds (tannins, saponins) may appear, leading to less pleasant taste or minor digestive discomfort, and consequently slightly lower intake. Tannins in the diet can affect intake because of bitterness, thereby reducing feed consumption (Choi and Kim, 2020). Feed palatability issues and antinutritional factors can be mitigated by feed fermentation processes (Rusfidra *et al*., 2025).

Quail-day egg production ranged from 49.37 ± 0.75 to 65.69 ± 7.15%. Treatment means were: A = 49.37 ± 0.75%, B = 54.33 ± 1.52%, C = 65.69 ± 7.15%, D = 51.73 ± 1.16%, and E = 50.93 ± 11.17%. Treatment C differed significantly (P < 0.05) from A, B, D, and E, whereas A did not differ (P > 0.05) from B, D, and E (Table 5).

The highest production in C (0.5% CALE) likely reflects an optimal balance between improved gut function and minimal antinutritional effects. *Cassia alata* phytochemicals (flavonoids, anthraquinones, tannins, saponins) provide antimicrobial and antioxidant activities that stabilize the microbiota, reduce subclinical inflammation, and enhance digestive efficiency. These mechanisms are known to support reproductive/egg-laying performance in poultry when used at moderate phytogenic levels as alternatives to AGP (Fatmawati *et al*., 2020).

At higher levels, some compounds-especially tannins and saponins-can begin to lower palatability, bind proteins/ digestive enzymes, or irritate the mucosa, reducing production responses; this explains why D (1.0%) and E (1.5%) did not match C despite receiving the extract. The depressive effect of tannins on intake due to bitterness has also been noted (Choi and Kim, 2020). Thus, 0.5% CALE appears to be an effective level: strong enough to improve the gut ecosystem and redox status (increasing nutrient use for egg formation), but not so high as to elicit antinutritional/aversive effects, leading to production that clearly exceeds control and AGP.

Egg weight ranged from 10.34 ± 0.13 to 10.82 ± 0.17 g/egg. Treatment means were: A = 10.58 ± 0.14 g/egg, B =

10.69 ± 0.22 g/egg, C = 10.82 ± 0.17 g/egg, D = 10.59 ± 0.17 g/egg, and E = 10.34 ± 0.13 g/egg. Treatments B and C did not differ ($P > 0.05$) from A and D, but were significantly different ($P < 0.05$) from E (Table 5).

Overall, egg weight was stable across treatments and only declined noticeably at the highest CALE level (1.5%; E). At the moderate 0.5% level (C) and 0.5% synthetic AGP (B), better gut health likely improved digestive efficiency, keeping egg weight favorable and not different from A or D. This mechanism aligns with literature showing that moderate phytogenic levels can balance the microbiota, improve mucosal integrity, and enhance antioxidant capacity. *Cassia alata* leaves contain flavonoids and anthraquinones with antimicrobial and antioxidant activity (Wang *et al*., 2024).

Egg mass ranged from 5.22 ± 0.13 to 7.00 ± 0.57 g/egg. Treatment means were: A = 4.74 ± 0.11 g/egg, B = 5.82 ± 0.31 g/egg, C = 7.00 ± 0.57 g/egg, D = 5.48 ± 0.25 g/egg, and E = 5.26 ± 1.16 g/egg. Treatment C was significantly higher ($P < 0.05$) than A, B, D, and E; A did not differ ($P > 0.01$) from B, D, and E (Table 5).

The highest egg mass at the 0.5% level (C) is consistent with more efficient intestinal function-smoother digestion, more balanced gut microbiota, and improved antioxidant status-without compromising feed palatability. Such patterns have long been reported for phytogenics. Reducing pathogenic bacteria in the gut can broadly enhance poultry production (Brenes and Roura, 2010).

At higher levels (1.0% and 1.5%), plant compounds-particularly tannins and saponins-may exert antinutritional/palatability effects. Tannins can bind proteins/digestive enzymes, and saponins may irritate the mucosa or alter digestibility, reducing nutrients available for yolk/albumen formation. The antinutritional role of tannins-especially their ability to bind protein and digestive enzymes-has been well documented (Makkar, 2003).

FCR ranged from 3.51 ± 0.21 to 5.09 ± 1.27. Treatment means were: A = 4.74 ± 0.11, B = 4.29 ± 0.07, C = 3.51 ± 0.21, D = 4.45 ± 0.25, and E = 5.09 ± 1.27. Treatment C did not differ ($P > 0.05$) from B, but differed significantly ($P < 0.05$) from A, D, and E; B did not differ ($P > 0.05$) from A, C, D, and E (Table 5).

The best FCR occurred in C (0.5% CALE = 3.51 ± 0.21) and was statistically not different from B (0.5% synthetic AGP = 4.29 ± 0.07), indicating that a moderate phytogenic level can match AGP in feed efficiency. Optimal phytogenic levels support digestive function and gut health (stimulation of digestive secretions, microbiota modulation, antioxidant activity), improving nutrient utilization. Combinations of organic acids/essential oils or specific herbs have been shown to improve performance and feed efficiency (Windisch *et al*., 2008).

Treatments A (no additive), D (1.0% CALE), and E (1.5% CALE) showed worse FCR than C. Increasing the CALE level risks antinutritional effects-tannins binding protein/digestive enzymes or saponins affecting mucosal comfort-thus lowering digestibility and requiring more feed per unit of output. Higher dietary tannin levels tend to reduce performance in poultry, consistent with a worsening FCR (Buyse *et al*., 2021).

All performance parameters in this study were analyzed using a regression approach to evaluate the biological responses of quails to CALE supplementation. Quadratic regression analysis showed that all parameters followed a significant linear–quadratic response pattern. Egg production increased progressively until reaching its optimum point at a dosage of 0.78%, with a coefficient of determination of R^2= 0.82, indicating an excellent model fit. Feed conversion ratio (FCR) also improved following a similar pattern and reached its optimum value at a dosage of 0.82% (R^2= 0.88). Egg weight and egg mass showed the same trend, with optimum values at 0.81% (R^2= 0.85) and 0.81% (R^2=0.89), respectively. Overall, the regression results indicate that a CALE dosage of around 0.8% is the most effective level for improving the production performance of laying quails, as evidenced by higher egg production, increased egg weight and egg mass, and better feed efficiency.

CONCLUSIONS AND RECOMMENDATIONS

This study concludes that the use of 0.5% CALE resulted in the best responses, including: feed consumption of 23.94 ± 0.11 g/bird/day, egg production of 65.69 ± 7.15%, egg weight of 10.82 ± 0.17 g, egg mass of 7.00 ± 0.57 g, and an FCR of 3.51 ± 0.21. These findings indicate that the inclusion of 0.5% CALE effectively improves feed efficiency, egg productivity, and overall physiological performance, and provides results comparable to synthetic AGPs at the same inclusion level.

A 0.5% inclusion level of CALE is recommended for use in commercial laying-quail diets as a natural and sustainable alternative to AGP. Further studies assessing long-term effects, egg quality traits, and immune responses are recommended to broaden understanding of CALE's functional benefits. On-farm trials under varied management and environmental conditions are suggested to validate the consistency of CALE effects across production systems.

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NOVELTY STATEMENT

1. This study provides new insights into the use of *Cassia alata* (L.) leaf extract (CALE) at different inclusion levels as a natural phytogenic feed additive for laying quails, highlighting its potential to improve production performance.
2. It offers novel evidence identifying the optimal level of CALE that enhances feed efficiency, egg production, and egg mass in laying quails, presenting it as a safe and sustainable alternative to antibiotic growth promoters (AGP).

AUTHOR'S CONTRIBUTION

DS led the methodology and conducted the investigation. FF was responsible for the conceptualization and supervision. SYA and ALN coordinated the project administration and provided the resources. FM and HIY performed the formal analysis and prepared the writing-original draft.

Generative AI And AI-assisted technology statement

The authors declare that ChatGPT (OpenAI, San Francisco, CA, USA) was used to assist in the initial translation of the manuscript from Indonesian to English. All outputs were reviewed, edited, and verified by the authors to ensure accuracy and originality.

Ethical approval

This research complied with the ethical principles for the use of experimental animals as outlined in the Decree of the Minister of Agriculture of the Republic of Indonesia No. 306/KPTS/TN.330/4/1994 and in Law No. 18 of 2009 concerning Animal Husbandry and Animal Health, as amended by Law No. 41 of 2014.

Conflict of interest

The authors have declared no conflict of interest.

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