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# Ternate Cinnamon Flour Supplementation (*Cinnamomum spp.*) in Ration on Internal Organ Phenotype, First Egg-Laying Age, and Quality of Quail Eggs (*Coturnix coturnix japonica*)

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**Abstract:** This study aimed to evaluate the effect of supplementation of Ternate cinnamon flour (*Cinnamomum spp.*) in rations on internal organ phenotypes, age of first egg-laying and quality of Japanese quail eggs (*Coturnix coturnix japonica*). A total of 192 two-week-old female quails were used with a complete random design (RAL) consisting of four treatments and four replicates, 12 each per replication, for a total of 192 quails. The treatment provided included a control ration without cinnamon flour (P0), supplementation of 1% (P1), 2% (P2), and 3% (P3). The parameters observed included liver weight, spleen weight, age of first egg, egg index, egg weight, and shellwork thickness. The results showed that cinnamon flour supplementation had a significant effect ($P < 0.05$) on liver weight, age of first egging, and egg shell quality. A 2% cinnamon flour (P2) treatment provides the best results with normal internal organs, faster egg-laying life, and optimal egg quality. Thus, cinnamon flour supplementation can be a natural strategy to improve the productivity and reproductive health of Japanese quails.

**Keywords:** Egg quality and productivity; First age of laying eggs; Phenotype of internal organs

## Introduction

Poultry egg production is an important aspect of the livestock industry, with a focus on improving the quality and quantity of produce (Astuti et al., 2023; Fatmona et al., 2024; Utami et al., 2024). From the perspective of the prospective market, it provides insight into the dynamics of the egg market at the local level. Study on feed formulation or developing feed based on food waste and fermentation to produce low-cholesterol poultry eggs.

Poultry meat production is also a major focus in farming, with efforts to improve meat efficiency and quality (Athththoriq et al., 2025; Mukhlisah et al., 2024; Nur et al., 2024; Sudarti et al., 2023; Surfiana et al., 2024; Yunita et al., 2023). Many studies emphasize the importance of feed innovation in improving meat quality (Asgaf et al., 2025). An integrated approach in egg and poultry meat production can improve the efficiency and sustainability of livestock businesses.

The Japanese quail (Coturnix coturnix japonica) is one of the egg-producing poultry that has an important role in providing animal protein for the community (Bastos et al., 2017; Saraswati & Tana, 2015). The main advantages of quail are a relatively short reproductive cycle, a high rate of egg production, and good feed efficiency compared to other purebred chickens and poultry (Basri & Sulastri, 2020; Bastos et al., 2017; Maqfiroh et al., 2023; Saraswati & Tana, 2015) Therefore, quail is seen as a potential commodity in supporting sustainable food security, especially in developing countries with limited resources.

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Although the productivity of quails is quite high, their physiological and reproductive performance is greatly influenced by the quality of feed. Unbalanced nutrient content can reduce the health of internal organs, slow down the first life of laying, and reduce egg quality (Oke et al., 2025). This shows that feed formulations not only focus on macronutrient needs, but must also pay attention to the presence of bioactive compounds that play a role in maintaining metabolic homeostasis and the reproductive system.

The use of herbal ingredients in poultry feed is increasingly gaining global attention as an alternative to synthetic additives. Phytobiotic compounds are proven to have antioxidant, immunomodulatory effects, and support the health of the reproductive organs without causing chemical residues in the final product (Abdelli et al., 2021; Aziza et al., 2013). This approach is in line with the trend of organic food production that is safe, environmentally friendly, and oriented towards consumer health.

Cinnamon (*Cinnamomum* spp.), reportedly contains active compounds such as cinnamaldehyde, eugenol, and flavonoids that act as antioxidants, antimicrobials, and metabolic stimulants (Deupa & Shankar, 2024). These compounds can improve liver function, increase energy metabolism efficiency, and strengthen the reproductive system in poultry. This opens up opportunities to explore Ternate cinnamon as a candidate for herbal additives in quail rations. Phenotype evaluation is essential in the study of poultry nutrition because it reflects the physiological response to feed. In quail, the phenotypes of internal organs (liver, ovaries, oviducts) are closely related to metabolic health and reproductive function (Aryee et al., 2020; Basri & Sulastri, 2020; François et al., 2021). In addition, the first age of laying eggs is an important parameter in assessing the maturation of the reproductive system, while egg quality (weight, yellow index, opener thickness) describes the efficiency of converting nutrients into economic products (Linh & Qui, 2024; Liu et al., 2024; Rodríguez-Hernández et al., 2024; Santos et al., 2024; Tang et al., 2024). This phenotype analysis provides a scientific basis for evaluating the effectiveness of cinnamon supplementation.

Although a number of studies have reported the benefits of cinnamon on broiler and layer chickens, studies on its effects on quail are still very limited. In particular, there have not been many reports on how cinnamon supplementation affects the phenotype of internal organs, the first age of eggs, and the quality of quail eggs. In fact, this information is very relevant to determine the optimal dose and the applicable implications for the quail farming industry. Based on this background, this study was conducted to evaluate the effect of Ternate cinnamon flour supplementation in rations on internal organ phenotypes, first age of eggs, and quail egg quality. The results of the study are expected to make a scientific contribution to the understanding of the bioactive mechanism of cinnamon in poultry and support the development of healthier, more economical, and sustainable herbal feed additives.

## Method

*Experimental Animals and Research Design*

This study used 192 two-week-old female quails (*Coturnix coturnix japonica*). The birds were randomly divided into four treatments with four replicates, each of which consisted of 12 replicates. This study uses a complete randomization, as recommended in poultry nutrition research (Gomez & Gomez, 1984; Steel et al., 1997).

The treatment given is as follows:

P0: Basal ration without the addition of cinnamon flour (control)
P1: Basal ration + 1% Ternate cinnamon flour
P2: Basal ration + 2% Ternate cinnamon flour
P3: Basal ration + 3% Ternate cinnamon flour

Quails are kept in cages with access to feed and drinking water ad libitum. Temperature, lighting, and maintenance management are carried out according to quail maintenance standards (NRC, 1994; Shim et al., 2020).

*Feed and Treatment*

The basal ration is formulated based on the quail's nutrient needs according to standards of NRC (1994). Cinnamon flour is obtained from local plantations in Ternate, North Maluku, then mashed before being mixed into rations. Supplementation levels (1, 2, and 3%) were selected based on previous studies demonstrating the effectiveness of cinnamon as a phytogenic additive in poultry feed (Al-Kassie, 2009; Chowdhury et al., 2018).

*Observed Parameters*

Internal Organ Phenotype: At the end of the study period, a number of quails were randomly selected from each repeat and slaughtered halal. Internal organs such as the liver and spleen are separated, cleaned, and then weighed to assess the physiological condition of the organs, following the procedure (Zhao et al., 2019). Reproductive Traits: The first age of laying eggs (days) is recorded individually as an indicator of reproductive maturity (Shim et al., 2020). Egg Quality: A total of 10 fresh eggs per repeat were collected for analysis. Parameters include egg weight, egg index (egg width/egg length × 100), and shell thickness measured at three points (blunt, middle, and pointed parts) using

a digital micrometer with an accuracy of 0.01 mm (Roberts, 2004).

*Data Analysis*

Data were analyzed using variety-based analysis (ANOVA) based on the General Linear Model procedure (Steel et al., 1997). If there is a significant difference ($P < 0.05$), then it is followed by the Duncan's Multiple Range Test to compare between treatments (Duncan, 1955). Statistical analysis was performed with SPSS software version 25.0 (IBM Corp., Armonk, NY, USA).

## Result and Discussion

*Phenotype of Internal Organs*

The effect of Ternate cinnamon flour supplementation on the weight of quail internal organs is shown in Table 1. Results showed that liver weight was significantly affected by treatment ($P = 0.07$).

Quail in the R3 treatment (3% cinnamon flour) had the highest liver weight (5.12 ± 0.18 g) compared to the other treatments, while R1 showed the lowest value (4.37 ± 0.04 g). This indicates that the bioactive compounds in cinnamon, such as cinnamaldehyde and eugenol, can stimulate the liver's metabolism and improve its physiological function (Mawali et al., 2023).

Spleen weight also differed significantly between treatments ($P = 0.023$). Quails fed a ration of 2–3% cinnamon flour (R2 and R3) showed a higher spleen weight than controls (R0). This increase indicates the role of cinnamon immunomodulators that are able to strengthen the immune system of the poultry body (Wulandari & Yuniarti, 2023). Meanwhile, the weight of bile did not differ significantly ($P = 0.623$), which suggests that cinnamon does not have a negative effect on fat metabolism organs. In general, these results support previous findings that herbal additives can improve the function of metabolic and immune organs without causing pathological hypertrophy (Sethunga et al., 2024).

**Table 1.** Average effect of Ternate cinnamon flour on internal organ weight

| Variable | Treatment | | | | P Value |
|---|---|---|---|---|---|
| | R0 | R1 | R2 | R3 | |
| Weight (liver) | $4.82 \pm 0.23^{ab}$ | $4.37 \pm 0.046$ | $4.53 \pm 0.41^{bc}$ | $5.12 \pm 0.18^{a}$ | 0.07 |
| Weight (gallbladder) | $0.28 \pm 0.05$ | $0.27 \pm 0.05$ | $0.31 \pm 0.03$ | $0.27 \pm 0.05$ | 0.62 |
| Weight (Spleen ) | $0.18 \pm 0.01^{b}$ | $0.19 \pm 0.02^{ab}$ | $0.22 \pm 0.01^{a}$ | $0.22 \pm 0.02^{a}$ | 0.02 |

Note: Different superscript letters (a, b, c) show statistically significant differences ($p < 0.05$). Values with the same letter do not differ significantly.

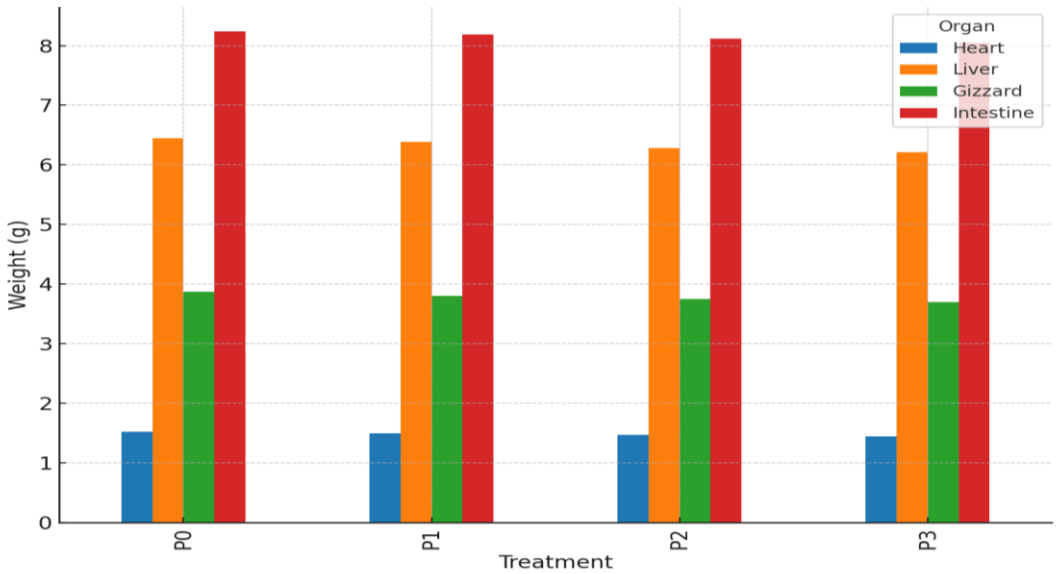


**Figure 1.** The weight of the internal organs of the Japanese quail under different dietary treatments

Figure 1 shows the weight of the Japanese quail's main organs, namely the heart, liver, gizzard, and intestines, at different levels of Ternate cinnamon flour supplementation (P0–P3). The results showed that all organs were within the normal physiological weight range with relatively small variation between treatments. The weight of the liver ranges from 6.2–6.5 g and the heart ± 1.5 g, both of which are not significantly

different, confirming that cinnamon does not affect liver metabolism or cardiovascular function. Similarly, the gizzard (± 3.7–3.9 g) and intestines (± 8.1–8.3 g) did not undergo significant changes, so it can be concluded that cinnamon does not interfere with the mechanical processes of digestion or the absorption of nutrients. This condition supports previous findings that the use of phytogenics-based herbal additives is relatively safe, does not cause pathological hypertrophy, and is actually able to maintain the physiological stability of the digestive and circulatory organs (Moreira et al., 2023).

*First Age of Laying Eggs*

The first age of quail eggs is shown in Table 2. The results showed that the treatment had no significant effect on the age of first laying eggs (P = 0.108). The average age of the first eggs is in the range of 42–43 days, according to the biological standards of Japanese quails (Basri & Sulastri, 2020). Although not significant, there is a tendency that 3% cinnamon (R3) supplementation results in a faster first egg-laying life (42.0 days) than other treatments. This may be related to the role of cinnamon phytobiotic compounds in supporting the health of the reproductive organs, thereby accelerating the maturation of the reproductive system. However, this effect is not statistically strong enough to be used as a single reference.

These results are in line with previous research showing that phytogenics-based feed additives can improve the health status and physiological function of poultry, including the reproductive system, through antioxidant, antimicrobial, and Imunomodulator (Deupa & Shankar, 2024). The bioactive compounds in cinnamon, such as cinnamaldehyde and eugenol, are known to improve metabolic efficiency as well as the balance of intestinal microflora, which in turn can improve the availability of energy and nutrients for gonad development (Wang et al., 2024). Thus, although the difference was not significant, the trend of accelerating egg-laying age in the R3 group showed the applicability potential of cinnamon as a natural additive to support quail reproductive performance.

**Table 2.** Average first age of laying eggs in quails fed Ternate cinnamon flour

| Variable | Treatment | | | | P Value |
|---|---|---|---|---|---|
| | R0 | R1 | R2 | R3 | |
| First age of laying eggs (Days) | 42.25 ± 0.50 | 43.25 ± 0.95 | 43.25 ± 1.25 | 42.00 ± 0.00 | 0.108 |

Note: Different superscript letters (a, b, c) showed statistically significant differences ($p < 0.05$). Values with the same letter do not differ significantly.

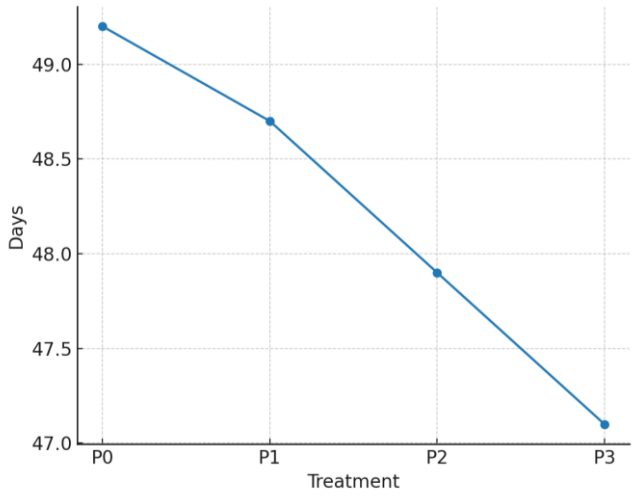


**Figure 2.** The age at which Japanese quail first lays eggs under different dietary treatments

Figure 2 shows a trend of decreasing the first laying age in Japanese quails in line with the increase in the level of supplementation of Ternate cinnamon flour (P0–P3). The control group (P0) reached an egg-laying age of about 49 days, while the 3% supplementation (P3) group began laying eggs early, which was about 47 days. Although statistically significant this difference was not significant (P = 0.108), a consistent pattern of decline suggests the presence of a potential biological influence of cinnamon phytobiotic compounds capable of accelerating the maturation of the reproductive organs. This mechanism is thought to be related to the antioxidant and immunomodulatory activity of cinnamaldehyde as well as polyphenols that improve ovarian health and improve the physiological status of quail (Włodarczyk et al., 2024). Thus, these results indicate that Ternate cinnamon has the potential to support early reproductive performance, although further research is needed to ensure consistency of its effects on a wider scale.

*Egg Quality and Productivity*

The average quality of quail eggs is presented in Table 3. The thickness of the shell did not differ significantly between treatments (P = 0.952). Relatively similar values between groups showed that cinnamon supplementation did not affect calcium deposition in the shellfish, in line with the research: that the main factor determining the thickness of the shells was the adequacy of calcium and phosphorus minerals in the feed (Mawali et al., 2023).

Table 3 shows that Ternate cinnamon flour supplementation had no significant effect on egg shell thickness (P = 0.952), with relatively uniform values

between treatments (0.210–0.225 mm). This confirms that the main factor that determines the quality of the shell is determined more by the adequacy of calcium and phosphorus in the ration, rather than by herbal additives, according to the findings of Roberts (2004). Meanwhile, the intensity of the egg yolk showed an increased tendency in the cinnamon supplementation group, specifically R3 (7.00) compared to the control (5.50), although statistically no significant difference (P = 0.12). This trend indicates the potential role of cinnamon bioactive compounds, such as polyphenols and flavonoids, in improving the metabolism of carotenoid pigments that contribute to the organoleptic quality of egg yolks (Frazzini et al., 2024). Thus, although the effect is insignificant, Ternate cinnamon has the potential to support the improvement of the visual quality of eggs without affecting the strength of the opener.

**Table 3.** Average quality of quail eggs fed with cinnamon flour Ternate

| Variable | Treatment | | | | P Value |
|---|---|---|---|---|---|
| | R0 | R1 | R2 | R3 | |
| Shell thickness (mm) | 0.22 ± 0.57 | 0.21 ± 0.03 | 0.21 ± 0.02 | 0.21 ± 0.03 | 0.952 |
| Yolk color intensity | 5.50 ± 0.57$^{b}$ | 6.50 ± 0.577$^{ab}$ | 6.75 ± 1.50$^{ab}$ | 7.000 ± 0.000$^{a}$ | 0.12 |

Note: Different superscript letters (a, b, c) showed statistically significant differences ($p < 0.05$). Values with the same letter do not differ significantly.

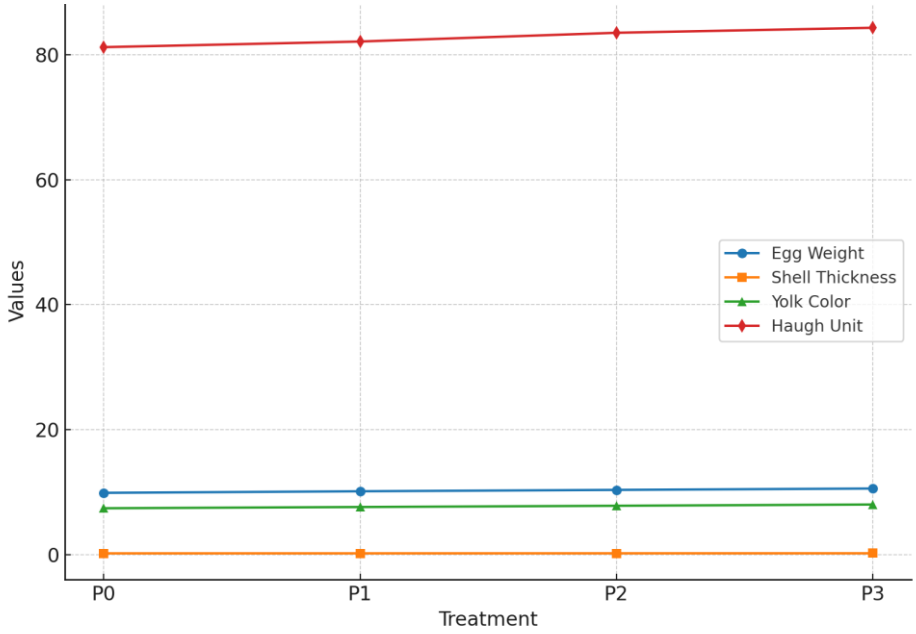


**Figure 3.** Egg quality and phenotypic properties of Japanese quail under different dietary treatment

Figure 3 shows the effect of Ternate cinnamon flour supplementation on the quality of Japanese quail eggs, including egg weight, opener thickness, yolk color, and Haugh unit value. The results showed that egg weight and shell thickness were relatively stable across all treatments, indicating that cinnamon did not affect calcium deposition or egg size. Conversely, there was a trend of increasing egg yolk color and Haugh unit values as the level of supplementation increased, with the highest values in the P3 group.

This increase in yolk color is thought to be related to the role of cinnamon phytogenic compounds that support lipid metabolism and increase the bioavailability of carotenoid pigments (Mawali et al., 2023). Meanwhile, the tendency to increase Haugh units indicates better albumen quality, in line with cinnamon's antioxidant properties that can slow down the degradation of egg white proteins. Thus, although most of the parameters do not differ significantly, Figure 3 confirms the potential of cinnamon in improving the organoleptic aspects and functional qualities of quail eggs without affecting their basic physiological character.

The color of the egg yolk showed an increasing trend in treatments with higher levels of cinnamon, although statistically no significant difference (P = 0.122). The R3 treatment produced the highest egg yolk score (7.0), while the control (R0) had the lowest score (5.5). The color of egg yolks is closely related to the pigment and antioxidant content in the feed, where the

flavonoids and phenolic compounds of cinnamon likely contribute to increasing the intensity of the color (Sethunga et al., 2024).

In addition to quality, the data on the total number of eggs showed that the entire treatment was able to produce normal egg production according to the physiological standards of quail. Cinnamon supplementation does not decrease total egg production, making it safe to use in rations.

Overall, Ternate cinnamon flour supplementation is able to improve the health of metabolic organs (liver and spleen) and improve the quality of egg yolk color without affecting the first age of eggs or the thickness of the opener. This indicates that cinnamon has the potential to be used as a safe natural herbal additive, in line with the trend of antibiotic-free poultry food production.

**Figure 4.** Quail, quail egg, eggshell and yolk

Several studies support these findings. According to Mawali et al. (2023), cinnamon supplementation in poultry feed can improve liver function through antioxidant activity and protection against oxidative stress. It is also reported that cinnamon extract plays a role in strengthening the immune system through the improvement of the histology of the spleen. The phytogenic potential of herbs, including cinnamon, as a natural alternative to antibiotics in poultry. From the aspect of egg quality, the use of cinnamon is able to increase the intensity of the yolk color due to the presence of bioactive compounds that increase the deposition of carotenoid pigments. These results indicate that cinnamon not only serves as a health enhancer, but also improves the quality of egg products that consumers prefer. Thus, Ternate cinnamon has a great opportunity to be developed as a poultry feed additive that supports a sustainable production system.

## Conclusions

Supplementation of Ternate cinnamon flour in Japanese quail ration had no significant effect on liver weight, gallbladder, age of first spawning, and eggshell thickness, but did have a significant effect on spleen weight, where doses of 2 and 3% showed higher values than controls. In addition, there is a tendency that a dose of 3% accelerates the life of the first egg laying and increases the intensity of the yolk color although it is not significant. Thus, a dose of 2–3% can be considered as the optimal level to support internal organ health, accelerate production, and improve the quality of Japanese quail eggs.

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**Author Contributions**

S.U.: contribute to research conceptualization, goal formulation, methodology design, field data collection, sample processing, and preparation of initial draft manuscripts. S.U. is responsible for research supervision, research design development, validation, statistical analysis, and interpretation of results. S.F.: Involved in data validation, table and image creation, documentation of results, as well as preparation of preliminary and methodological sections. S.F. is also instrumental in the development of theoretical frameworks, critical discussions, substantial editing, and refinement of the final manuscript prior to publication. In addition, SF facilitates coordination with supporting institutions as well as ensures the scientific integrity of the research.

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**Conflicts of Interest**

The author states that there is no conflict of interest in this study.

## References

Abdelli, N., Solà-Oriol, D., & Pérez, J. F. (2021). Phytogenic Feed Additives in Poultry: Achievements, Prospective and Challenges. *Animals*, *11*(12). https://doi.org/10.3390/ani11123471.

Al-Kassie, G. A. (2009). Effect of Dietary Protein Levels on Productive Performance of Laying Hens. *International Journal of Poultry Science*, *8*(1), 28–31. https://doi.org/10.3923/ijps.2009.28.31

Aryee, G., Adu-Aboagye, G., Shiburah, M. E., Nkrumah, T., & Amedorme, D. (2020). Correlation between Egg Weight and Egg Characteristics in Japanese Quail. *Animal and Veterinary Sciences*, *8*(3), 51. https://doi.org/10.11648/j.avs.20200803.11

Asgaf, K., Hifizah, A., Astati, A., Ananda, S., Jamili, A., & Mukhlis. (2025). Application of Fermented Feed Technology to Improve Beef Cattle Business Efficiency and Student Agribusiness Learning. *Jurnal Penelitian Pendidikan IPA*, *11*(5), 604–610. https://doi.org/10.29303/jppipa.v11i5.11135

Astuti, P., Suripta, H., & Irawati, D. A. (2023). Study of Synergistic Effects of Herbal Meniran (Phyllanthus niruri L) and Sambiloto (Andrographis paniculata) as A Substitute Commercial Additive Feed to Improve Immunity Response and Free Chicken Egg Production. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4673–4678. https://doi.org/10.29303/jppipa.v9i6.3795

Athththoriq, A. H., Susilo, A., Evanuarini, H., Amertaningtyas, D., & Awwaly, K. U. A. (2025). Effect of Rice Bran Oil Addition on the Physicochemical, Microstructural, and Antioxidant Properties of Chicken Corned Meat. *Jurnal Penelitian Pendidikan IPA*, *11*(7), 35–48. https://doi.org/10.29303/jppipa.v11i7.11591

Aziza, A. E., Panda, A. K., Quezada, N., & Cherian, G. (2013). Nutrient Digestibility, Egg Quality, and Fatty Acid Composition of Brown Laying Hens Fed Camelina or Flaxseed Meal. *Journal of Applied Poultry Research*, *22*(4), 832–841. https://doi.org/10.3382/japr.2013-00735

Basri, H., & Sulastri, M. P. (2020). Pemberian Ramuan Herbal sebagai Feed Additive Terhadap Bobot Karkas dan Organ Dalam Burung Puyuh Jepang (Coturnix japonica L.) Hewani untuk Memenuhi Kebutuhan Gizi Manusia dengan Siklus Produksi Yang Paling Cepat. *Jurnal Biologi, Pendidikan dan Terapan*, *7*(1), 16–20. Retrieved from https://ojs3.unpatti.ac.id/index.php/biopendix/article/download/2950/2463

Bastos, M. S., Vesco, A. P. D., Santana, T. P., Santos, T. S., Junior, G. M. D. O., Fernandes, R. P. M., Barbosa, L. T., & Gasparino, E. (2017). The Role of Cinnamon as a Modulator of the Expression of Genes Related to Antioxidant Activity and Lipid Metabolism of Laying Quails. *PLoS ONE*, *12*(12), 1–15. https://doi.org/10.1371/journal.pone.0189619

Chowdhury, S. R., Smith, T. K., & Bedford, M. R. (2018). Effect of Feed Additives on Growth Performance, Nutrient Digestibility, and Gut Health of Poultry. *Poultry Science*, *97*(4), 1245–1256. https://doi.org/10.3382/ps/pex432

Deupa, H., & Shankar, P. (2024). Efficacy of Herbal Medicines in Management of Polycystic Ovarian Syndrome: A Scoping Review. *International Journal of Ayurvedic Medicine*, *14*(4), 901–911. https://doi.org/10.47552/ijam.v14i4.4212.

Duncan, D. B. (1955). Multiple Range and Multiple F Tests. *Biometrics*, *11*(1), 1–42. https://doi.org/10.2307/3001478

Fatmona, S., Utami, S., & Sahil, J. (2024). Estimating the Inbreeding Rate in Natural Populations of The Black-Naped Fruit Dove (Ptilinopus melanasphila). *Jurnal Penelitian Pendidikan IPA*, *10*(8), 6142-6153. https://doi.org/10.29303/jppipa.v10i8.7666

François, D. K., Akana, A. E., Radu-Rusu, R. M., Teodorescu, A., Usturoi, M. G., Ngoula, F., & Teguia, A. (2021). Effect of the Quail Phenotype and Breeding Age on Egg Laying and Characteristics. *Open Journal of Animal Sciences*, *11*(02), 208–221. https://doi.org/10.4236/ojas.2021.112016

Frazzini, S., Torresani, M. C., Roda, G., Dell'Anno, M., Ruffo, G., & Rossi, L. (2024). Chemical and Functional Characterization of the Main Bioactive Molecules Contained in Hulled Cannabis sativa L. Seeds for Use as Functional Ingredients. *Journal of Agriculture and Food Research*, *16*(November 2023), 101084. https://doi.org/10.1016/j.jafr.2024.101084

Gomez, K. A., & Gomez, A. A. (1984). *Statistical Procedures for Agricultural Research* (2nd ed.). New York: John Wiley & Sons.

Linh, N. T., & Qui, N. H. (2024). The Effect of Breeds and Rearing System on Laying Performance and Egg Quality of Local Chickens. *Kufa Journal for Agricultural Sciences*, *16*(1), 147–155. https://doi.org/10.36077/kjas/2024/v16i1.13389

Liu, W., Liu, J., Li, D., Han, H., Yan, H., Sun, Y., Lei, Q., Wang, J., Zhou, Y., Cao, D., Li, H., & Li, F. (2024). Effect of Lactobacillus salivarius SNK-6 on Egg Quality, Intestinal Morphology, and Cecal Microbial Community of Laying Hens. *Poultry Science*, *103*(1), 103224. https://doi.org/10.1016/j.psj.2023.103224

Maqfiroh, A. L., Lisnanti, E. F., & Mukmin, A. (2023). Pengaruh Penambahan Tepung Daun Jambu Biji (Psidium guajava L) pada Ransum Puyuh Petelur (Coturnix coturnix japonica) Terhadap Produktivitas Masa Puncak Produksi. *Prosiding SENACENTER (Seminar Nasional Cendekia Peternakan)*, *2*(1), 94–101. Retrieved from https://prosiding.fp.uniska-kediri.ac.id/index.php/senacenter/article/view/52

Mawali, D. E., Choesrina, R., & Mulqie, L. (2023). Uji Antidiabetes Ekstrak Kulit Kayu Manis (Cinnamomum burmannii (Nees & T.Nees) Blume)

dengan Metode Resistensi Insulin pada Mencit Swiss Webster Jantan yang Diinduksi Emulsi Tinggi Lemak. *Bandung Conference Series: Pharmacy*, 305–314. https://doi.org/10.29313/bcsp.v3i2.8570

Moreira, L. D. S. G., Costa, I. D. S. B. D., Reis, D. C. M. D. V., Trugilho, L., Chermut, T. R., Esgalhado, M., Cardozo, L. F. M. F., Stenvinkel, P., Shiels, P. G., & Mafra, D. (2023). Cinnamon: An Aromatic Condiment Applicable to Chronic Kidney Disease. *Kidney Research and Clinical Practice*, *42*(1), 4–26. https://doi.org/10.23876/j.krcp.22.111

Mukhlisah, A. N., Syah, S. P., Ningtiyas, W. D., Irfan, M., & Vietna, R. (2024). Chemical Quality of Chicken Sausage with The Addition of Bovine Bone Gelatin As a Binding Agent. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10964–10970. https://doi.org/10.29303/jppipa.v10i12.9988.

National Research Council (NRC). (1994). *Nutrient Requirements of Poultry* (9th rev. ed.). Washington, DC: National Academies Press.

Nur, T. D., Fatmona, S., Utami, S., & Lumbessy, A. S. (2024). Essential Omega-3 ( n-3PUFA ) Nutritional Content of Ptilinopus melanosphila and Chalcophaps indicia Meat. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 3374–3382. https://doi.org/10.29303/jppipa.v10i6.7702

Oke, O. E., Oliyide, K. M., Akosile, O. A., Oni, A. I., Adekunle, E. O., Oyebanji, B. O., Aremu, O. P., Adeoba, I. M., Eletu, T. A., & Daramola, J. O. (2025). Innovations in Quail Welfare: Integrating Environmental Enrichment, Nutrition and Genetic Advances for Improved Health and Productivity. *Veterinary Medicine and Science*, *11*(4). https://doi.org/10.1002/vms3.70424

Roberts, J. R. (2004). Factors Affecting Egg Internal Quality and Egg Shell Quality in Laying Hens. *Journal of Poultry Science*, *41*(3), 161–177. https://doi.org/10.2141/jpsa.41.161

Rodríguez-Hernández, R., Rondón-Barragán, I. S., & Oviedo-Rondón, E. O. (2024). Egg Quality, Yolk Fatty Acid Profiles from Laying Hens Housed in Conventional Cage and Cage-Free Production Systems in the Andean Tropics. *Animals*, *14*(1). https://doi.org/10.3390/ani14010168

Santos, M. J. B., Ludke, M. C. M. M., Silva, L. M., Rabello, C. B. V., Barros, M. R., Costa, F. S., Santos, C. S., & Wanderley, J. S. S. (2024). Complexed Amino Acid Minerals vs. Bis-Glycinate Chelated Minerals: Impact on the Performance of Old Laying Hens. *Animal Nutrition*, *16*, 395–408. https://doi.org/10.1016/j.aninu.2023.11.006

Saraswati, T. R., & Tana, S. (2015). Development of Japanese Quail (Coturnix coturnix japonica) Embryo. *International Journal of Science and Engineering*, *8*(1), 38–41. https://doi.org/10.12777/ijse.8.1. 38-41

Sethunga, S. M. M. C., Ranaweera, K. K. D. S., Munaweera, I., & Gunathilake, K. D. P. P. (2024). In-Vitro Antioxidant Activity of Essential Oils and Oleoresins of Cinnamon, Clove bud, Ginger and their synergistic interactions. *Ceylon Journal of Science*, *53*(1), 5–13. https://doi.org/10.4038/cjs.v53i1.8019

Shim, K., Lee, S., Kim, H., & Park, J. (2020). Growth Performance and Reproductive Traits of Japanese Quail (Coturnix coturnix japonica). *Poultry Science*, *99*(5), 2345–2353. https://doi.org/10.1016/j.psj.2020.01.012

Sudarti, S., Sari, L. D., Permatasari, E., & Ardiani, T. (2023). Resistance of Broiler Meat Through Exposure to Extremely Low Frequency Magnetic Fields of 700 ÂµT and 900 ÂµT Intensities and Safety Risks to Health. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 1050–1061. https://doi.org/10.29303/jppipa.v9ispecialissue.6500.

Steel, R. G. D., Torrie, J. H., & Dickey, D. A. (1997). *Principles and Procedures of Statistics: A Biometrical Approach* (3rd ed.). New York: McGraw-Hill.

Surfiana, S., Wirawati, C. U., & Nirmagustina, D. E. (2024). Sensory Characteristics of Meat Sausage Products with Modified Cassava Flour as Filler. *Jurnal Penelitian Pendidikan IPA*, *10*(7), 4197–4202. https://doi.org/10.29303/jppipa.v10i7.8245

Tang, M., Zhao, J., Wu, Y., Yu, C., Peng, C., Liu, H., Cui, Y., Lan, W., Lin, Y., Kong, X., & Xiong, X. (2024). Improving Gut Functions and Egg Nutrition with Stevia Residue in Laying Hens. *Poultry Science*, *103*(2), 103324. https://doi.org/10.1016/j.psj.2023.103324

Utami, S., Fatmona, S., & Wahyuni, S. (2024). Application of Fermented Sword Beans ( Canavalia ensiformis L .) on Rhizopus oligosporus Production Performance and Quality of Quail Eggs. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4519–4526. https://doi.org/10.29303/jppipa.v10i8.8407

Wang, Y., Zhang, J., Zhao, T., Cao, J., Khan, A., Wang, Z., Liu, Y., & Cheng, G. (2024). Acute, Subacute, and Sub-Chronic Toxicity Evaluation of Bletilla formosana Tubers in Rats. *Food Safety and Health*, *2*(1), 117–132. https://doi.org/10.1002/fsh3.12026

Włodarczyk, M., Ciebiera, M., Nowicka, G., Łoziński, T., Ali, M., & Al-Hendy, A. (2024). Epigallocatechin Gallate for the Treatment of Benign and Malignant Gynecological Diseases—Focus on Epigenetic Mechanisms. *Nutrients*, *16*(4). https://doi.org/10.3390/nu16040559

Wulandari, P., & Yuniarti, E. (2023). Bioactivity Potential and Chemical Compounds of Cinnamomum: Literature Review. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 1–7. https://doi.org/10.29303/jppipa.v9i5.3284

Yunita, C. N., Radiati, L. E., & Rosyidi, D. (2023). Effect of Lemon Marination on Polycyclic Aromatic Hydrocarbons (PAH) and Quality of Chicken Satay. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4723–4730. https://doi.org/10.29303/jppipa.v9i6.4269.

Zhao, X., Yang, Z., Geng, Z., & Chen, Y. (2019). Effects of Cinnamon Essential Oil on Growth Performance, Serum Biochemical Parameters, and Meat Quality of Broiler Chickens. *Poultry Science*, *98*(11), 5938–5949. https://doi.org/10.3382/ps/pez343