

Effect of chicken eggshell nanocalcium oxide supplement on quail eggshell quality (*Coturnix coturnix japonica*)

Inas Zhafira^{1*}, Mohammad Anam Al-Arif², Sri Pantja Madyawati³, Budi Prasetyo⁴, Agus Hadi Prayitno⁴, Yong Tao⁵, Merry Muspita Dyah Utami⁴, and Hadi Poernomo⁴

¹Master's Program in Reproductive Biology, Faculty of Veterinary Medicine, Universitas Airlangga, Campus C Universitas Airlangga, Mulyorejo Street, Surabaya 60115 Indonesia

²Department of Animal Husbandry, Faculty of Veterinary Medicine, Universitas Airlangga, Campus C Universitas Airlangga, Mulyorejo Street, Surabaya 60115 Indonesia

³Department of Veterinary Reproduction, Faculty of Veterinary Medicine, Universitas Airlangga, Campus C Universitas Airlangga, Mulyorejo Street, Surabaya 60115 Indonesia

⁴Poultry Business Management Study Program, Department of Animal Husbandry, Politeknik Negeri Jember, Mastrip Street PO Box 164, Jember 68101 Indonesia

⁵Department of Animal Science and Technology, Jiangsu Agri-animal Husbandry Vocational College, 8 East Phoenix Road (Fenghuang East Road), Hailing District, Taizhou City, Jiangsu Province, P.R. China 225300

*Corresponding author: inaszhafira2108@gmail.com

ARTICLE INFO

Received:

30 October 2025

Accepted:

16 October 2026

Published:

22 October 2026

Keywords:

Eggshell

Egg physical quality

Nanocalcium oxide

Poultry feed

Quail

ABSTRACT

This study aims to evaluate the effectiveness of nanocalcium oxide derived from layer chicken eggshells as a feed supplement in improving the physical quality of quail eggshells (*Coturnix coturnix japonica*). A major issue in quail egg production is the thin eggshell, which can reduce durability and overall egg quality. This study employed a completely randomized design (CRD) with four treatments: a control group (T0) without nanocalcium oxide supplementation and three experimental groups with increasing doses of nanocalcium oxide (T1: 0.5 g/kg feed, T2: 1 g/kg feed, and T3: 1.5 g/kg feed). The observed parameters included egg weight, eggshell weight, and eggshell thickness. The results showed that the addition of nanocalcium oxide to the feed did not significantly affect quail egg weight or eggshell weight. However, there was a significant difference in eggshell thickness, with the T3 treatment (1.5 g/kg feed) leading to a greater increase in thickness compared to the other treatments. These findings indicate that nanocalcium oxide from layer chicken eggshells has the potential to enhance the physical quality of quail eggshells, particularly by increasing their thickness, which plays a crucial role in improving resistance to physical damage.

INTRODUCTION

Data from the Directorate General of Livestock and Animal Health (Direktorat Jenderal Peternakan dan Kesehatan Hewan, 2023), shows that the total preliminary figure for quail egg in Indonesia in 2023 experienced a decline of 9.29%. However, the demand for quail eggs is very high is about 35% increasing even, which cannot be met by the farmers as of now (Wheindrata, 2024). This is partly due

to the weakness of quail eggs, which are easily physically damaged, causing the farmers to experience losses and reduce interest in quail farming (Rahmasari et al., 2021). This physical damage is influenced by external quality factors, namely the thinness of the quail egg shells, which is still a constraint (Tistiana et al., 2023). This greatly affects the economic sector, especially in terms of sales, namely eggs with thin shells are easily damaged or cracked, decreasing the selling value (Sun et al., 2019).



This work is licensed under a Creative Commons Attribution ShareAlike 4.0 International License.
Copyright © 2026 Jurnal Ilmu Peternakan Terapan

Improving the quality of quail egg shells can be done by using additional calcium from laying hen eggshells (Prayitno et al., 2020). The largest content of laying hen eggshells is calcium carbonate (CaCO_3), which is quite good compared to calcium from limestone and corals (Ori, 2011). The eggshells of the laying hen are composed of calcium carbonate (CaCO_3), which is as much as 85-95% Gangadoo et al. (2016), which can play an important role in forming bones and eggshells.

Calcium particle size affects calcium bioavailability if the size is small. Nanotechnology can be used to increase the effectiveness of calcium related to particle size from 1-100 nm. Dijkslag et al. (2023) reported that particle size plays a significant role in increasing mineral digestibility. Similarly, Peebles et al. (2021) demonstrated that supplementation of calcium in nanoparticle from in laying hen diets enhanced eggshell thickness. Hence, calcium particles in macro form can be converted into nanocalcium to improve intestinal absorption, thereby enhancing the effectiveness and efficiency to feed additives or supplements (Prayitno et al., 2016).

Nanocalcium oxide can be made using physical methods from eggshell powder heated at 1.000 °C. Then proceed with a top-down approach with a high-energy ball mill process to produce nano products in the form of calcium oxide (Prayitno et al., 2020). In a study conducted by Gangadoo et al. (2016) calcium carbonate, which was transformed into calcium oxide, can be used as a source of calcium that has high, superior, and effective catalytic activity. Prayitno et al. (2020) stated that nanominerals, one of which is nanocalcium, have the potential to be developed to increase the productivity and product quality of livestock. Based on the above description, this study aims to determine the effectiveness of laying hen eggshell's nanocalcium oxide on the physical quality of quail egg shells as an effort to improve eggshell quality and increase economic benefits.

Research by Abo El-Maaty et al. (2021) found that adding nanocalcium to laying hen feed T1: 0.5 g/kg feed, T2: 1 g/kg feed, and T3: 1.5 g/kg feed is increased egg weight, shell percentage, and shell thickness. Furthermore, nanocalcium supplementation also increased serum calcium

(Ca) and organic phosphorus (P) levels, positively impacting eggshell development, including the development of the palisade and mammillary layers.

MATERIALS AND METHODS

This experimental research is using a Completely randomized design (CRD). This study used a total of 48 seven-week-old Japanese quails (*Coturnix coturnix japonica*) with ranging from 160 to 180 g, which were randomized into four treatments with six replications, each replication consisting of two quails. The quails were given four treatments with the addition of laying hen eggshell nanocalcium oxide using commercial feed with doses of T0: 0 g (control), T1: 0.5 g/kg, T2: 1 g/kg, and T3: 1.5 g/kg for 4 weeks of the treatment phase. Feed adaptation was conducted over 3 weeks using a commercial feed replacement method. This involved staged mixing ratios of 50%, 70%, and 100% commercial feed with supplementary feed enriched with nanocalcium. Feeding is done twice a day with the amount of feed adjusted to daily feed requirements, this is done in the morning and evening.

This research was conducted in several places, namely the process of making the nanocalcium of the eggshell at the Faculty of Science and Technology, Airlangga University. The process of making calcium oxide, maintenance, sample treatment, and parameter collection was carried out at the Jember State Polytechnic.

The materials used in this study were laying hen eggshells' nanocalcium oxide (*Gallus gallus domesticus*). In addition, this study used commercial feed PP-3 from PT. Panca Patriot Prima. The equipment used in this study includes: battery wire cages with 2 levels, colony cages, furnaces, high-energy ball milling, blender, mortar, 200 mesh of filter paper, egg racks, gloves, masks, quail feeders and drinkers, ovens, digital scales, calipers, writing tools, boxes, 40% formalin, KMNO_4 , and cleaning tools for the cages.

The egg weight data was collected daily during the maintenance period and measured using digital scales in grams. Eggshell weight

was weighed after the shell was dried by air-drying at room temperature for 12 hours. After the drying process, measurements were carried out using digital scales with an accuracy of 0.01 (g). Eggshell thickness data were collected using calipers in millimeters (mm).

The data obtained in this study were analyzed statistically using Analysis of variance (ANOVA). If there were significant differences, Duncan's multiple range test was performed. Data analysis was carried out using SPSS 27 for Windows (Meena, et al., 2022).

RESULTS AND DISCUSSION

Based on the data analysis using ANOVA, the addition of laying hen eggshell's nanocalcium oxide did not significantly affect quail egg weight gain in the treatment group. This is indicated by a $P > 0.05$ score. These results are consistent with studies on the data calculations and analysis of egg weight, the results of the measurement of quail egg weights for 21 days from the 7th to the 9th week, with the mean and standard deviation of quail egg weights for each treatment listed in Table 1.

Table 1. Mean and standard deviation of quail egg weights (*Coturnix coturnix japonica*) with added laying hen eggshell's nanocalcium oxide at various doses (g)

Group	Egg weight
	(mean $\pm$ standard deviation)
T0	9.854 $\pm$ 0.472
T1	9.879 $\pm$ 0.544
T2	10.037 $\pm$ 0.502
T3	9.926 $\pm$ 0.363

Note: The mean result of the egg weight shows no significant differences ($P > 0.05$). T0 = control; T1 = commercial feed + laying hen eggshell nanocalcium oxide 0.5%; T2 = commercial feed + laying hen eggshell nanocalcium oxide 1%; T3 = commercial feed + laying hen eggshell nanocalcium oxide 1.5%

The replacement of laying hen eggshell powder with laying hen eggshell nanocalcium oxide at levels of 0.126-2.015% in laying hen feed, which also did not have a significant effect on egg weight in laying hens (Gangadoo et al., 2016). This may also be the reason for the insignificant differences in the provision of laying hen eggshell's nanocalcium oxide with doses of 0.5 g, 1 g, and 1.5 g in the ration on quail egg weight gain.

Furthermore, when looking at the effect of calcium particle size differences, which were much larger in a study conducted by Gangadoo et al. (2016), the addition of laying egg hen eggshell powder at levels of 0-4% also did not significantly affect quail egg weight gain. This may happen because the protein content and metabolizable energy among treatments were relatively the same, so there was no significant effect on egg weight when formulating rations with the same energy content.

The Weight of the Eggshell

Based on the data calculations and analysis of eggshell weight, the results of the

measurement of quail eggshell weights for 21 days from the 7th to the 9th week in Table 2.

Average quail eggshell weight across the four treatments with six replications during the study, namely T0 0.719; T1 0.746; T2 0.735; T3 0.760, ranging between 0.719 and 0.760. Feed with the addition of laying hen eggshell's nanocalcium oxide at 0.5% (T1), at 1% (T2), and at 1.5% (T3) did not result in a significant difference ($P > 0.05$) in the average quail eggshell weight produced compare to that produced without the addition of laying hen eggshell's nanocalcium oxide.

This finding in line with the research conducted where the addition of nanocalcium oxide at doses of 0.1-2 % and various doses in laying hen's rations also did not produce a significant difference in the weight of the eggshell. The addition of nanocalcium oxide can change the microstructure of the eggshell. This occurs because nanoparticles can alter the surface area of a substance without significantly increasing its weight (Abo El-Maaty et al., 2021). Dijkslag et al. (2023) reported that eggshell thickness is not always proportional with its weight, as its microscopic structure can change.

Table 2. Mean and standard deviation of quail eggshell weights (*Coturnix coturnix japonica*) with added laying hen eggshell's nanocalcium oxide at various doses (g)

Group	The weight of the eggshells (mean $\pm$ standard deviation)
T0	0.719 $\pm$ 0.018
T1	0.746 $\pm$ 0.029
T2	0.735 $\pm$ 0.059
T3	0.760 $\pm$ 0.030

Note: The mean results of the eggshell weight show no significant differences ($P>0.05$). T0 = control; T1 = commercial feed + laying hen eggshell nanocalcium oxide 0.5%; T2 = commercial feed + laying hen eggshell nanocalcium oxide 1%; T3 = commercial feed + laying hen eggshell nanocalcium oxide 1.5%

Nanocalcium can form more efficient calcium carbonate crystals, so the eggshell thickness increases even though the weight remains almost the same. In other words, the void spaces within the eggshell decrease, yet there is no significant increase in weight. However, in this study, the quail eggshell weight remained in the upper mean range, between 0.719 and 0.760.

The Thickness of the Eggshell

Based on the calculations and data analysis of the increase in eggshell thickness the results of measuring the quail eggshell's thickness for 21 days from the 7th to the 9th week, with the mean and standard deviation of quail eggshell weights for each treatment listed in Table 3.

The addition of laying hen eggshell nanocalcium oxide resulted in the mean quail eggshell thickness score across the four treatments with six replications during the study, T0 0.196; T1 0.206; T2 0.206; T3 0.217, ranging from 0.196 and 0.217. Then, the statistical analysis, showed that the provision of commercial feed without the addition of laying

hen eggshell nanocalcium oxide (T0) produced the thinnest eggshell thickness compared to treatments T1, T2, and T3. The addition of laying hen eggshell nanocalcium oxide at 0.5% (T1) and 1% (T2) did not show a significant difference, while the addition at 1.5% (T3) exhibit a significant difference ($P<0.05$) in the mean quail eggshell thickness compared to treatments T0, T1, and T2.

The highest mean value, 0.217, was observed in treatment T3, where laying hen eggshell's nanocalcium oxide was administered at a dose of 1.5 g/kg of feed. This finding is in line with the research conducted by Abo El-Maaty et al. (2021), which reported that the addition of nanocalcium at a dose of 1.5 g resulted in significantly different outcome, or a thicker eggshell compared to the other treatments. In addition, the quail's eggshell thickness that added the laying hen powder in their rations also showed a significant difference in the 6% and 8% treatments (Prayitno et al., 2016). The thicker the eggshell, the higher the calcium content, and that calcium is derived from feed that contains calcium minerals.

Table 3. Mean and standard deviation of quail eggshell thickness (*Coturnix coturnix japonica*) with added laying hen eggshell's nanocalcium oxide at various doses (mm)

Group	The thickness of the eggshell (mean $\pm$ standard deviation)
T0	0.196 ^a $\pm$ 0.004
T1	0.206 ^b $\pm$ 0.005
T2	0.206 ^b $\pm$ 0.011
T3	0.217 ^c $\pm$ 0.011

Note: The mean results of the eggshell weight show a significant difference ($P<0.05$). (T0 = control; T1 = commercial feed + laying hen eggshell nanocalcium oxide 0.5%; T2 = commercial feed + laying hen eggshell nanocalcium oxide 1%; T3 = commercial feed + laying hen eggshell nanocalcium oxide 1.5%; a = Significantly different from T1, T2, and T3; b = Not significantly different from T2, but significantly different from T0 and T3; c = Significantly different from T0, T1, and T2)

The use of laying hen eggshell's nanocalcium oxide in this study can be evaluated based on its effectiveness through particle sizes ranging from 104 to 926 nm in the egg formation process in quails. Calcium plays an important role in the eggshell's formation in the uterus. The process of eggshell calcification begins before the egg enters the uterus. A cluster of calcium is observed on the outer shell membrane before the egg leaves the isthmus. This is the beginning of the calcium accumulation process in the uterus. In the eggshell formation process, calcium carbonate must be formed from calcium ions that originate from the blood supply. Carbonate ions are derived from the blood and the shell gland (Suprijatna et al., 2005). In this regard, effective calcium absorption is essential to ensure that the calcium ion content in the blood is sufficient for the formation of calcium carbonate during eggshell formation. An increase in calcium level can improve the eggshell's composition and enhance the thickness of quail eggshells, which is one of the parameters of egg physical quality. The addition of laying hen eggshell's nanocalcium oxide to quail feed is effective in meeting quail nutritional requirements, reducing environmental waste and forming a thick and strong eggshell layer.

CONCLUSION

The addition of laying hen eggshell's nanocalcium oxide to the feed does not increase both egg and eggshell weight. However, it can increase the thickness of quail eggshell, with the greatest improvement being observed at a dose of 1.5 g.

ACKNOWLEDGMENTS

The authors express their gratitude to the Division of Animal Husbandry, Division of Division of Veterinary Reproduction, Faculty of Veterinary Medicine, Universitas Airlangga, for providing the laboratory facilities, technical support, and nanoparticle diagnostic equipment required for this study.

REFERENCES

Abo El-Maaty, H. A., EL-Khateeb, A. Y., Al-

Khalaifah, H., El-Sayed, E. S. A., Hamed, S., El-Said, E. A., Mahrose, K. M., Metwally, K., & Mansour, A. M. (2021). Effects of ecofriendly synthesized calcium nanoparticles with biocompatible sargassum latifolium algae extract supplementation on egg quality and scanning electron microscopy images of the eggshell of aged laying hens. *Poultry Science*, 100(2), 675–684. <https://doi.org/10.1016/j.psj.2020.10.043>

Dijkslag, M. A., Kwakkel, R. P., Martin-Chaves, E., Alfonso-Carrillo, C., & Navarro-Villa, A. (2023). Long-term effects of dietary calcium and phosphorus level, and feed form during rearing on egg production, eggshell quality, and bone traits in brown laying hens from 30 to 89 wk of age. *Poultry Science*, 102(5), 1–14. <https://doi.org/10.1016/j.psj.2023.102618>

Direktorat Jenderal Peternakan dan Kesehatan Hewan. (2023). Statistik dan Kesehatan Hewan 2023. Jakarta: Direktorat Jenderal Peternakan dan Kesehatan Hewan Kementerian Pertanian RI.

Gangadool, S., Stanley, D., Hughes, R. J., Moore, R. J., & Chapman, J. (2016). Nanoparticles in feed: Progress and prospects in poultry research. *Trends in Food Science and Technology*, 58, 115–126. <https://doi.org/10.1016/j.tifs.2016.10.013>

Ori, A. M. K. (2011). Review of the factors that influence egg fertility and hatchability in poultry. *International Journal of Poultry Science*, 10(6), 483–492. <https://doi.org/10.3923/ijps.2011.483.492>

Peebles, E. D., Oliveira, T. F. B., Kim, E. J., Olojede, O. C., Elliott, K. E. C., Lindsey, L. L., & Gerard, P. D. (2021). Research Note: Effects of the in ovo injection of organic zinc, manganese, and copper and posthatch holding time before placement on broiler body temperature during grow out. *Poultry Science*, 100(2), 755–759. <https://doi.org/10.1016/j.psj.2020.10.048>

Prayitno, A. H., Suryanto, E., & R. (2016). The effect of eggshell lactic calcium nanoparticle fortification on chemical and physical properties of chicken meatballs. *Buletin Peternakan*, 40(1), 39–46. <https://doi.org/10.21059/buletinpeternak.v40i1.9821>

- Prayitno, A. H., Prasetyo, B., & Sutirtoadi, A. (2020). Synthesis and characteristics of nano calcium oxide from duck eggshells by precipitation method. *IOP Conference Series: Earth and Environmental Science*, 411(1), 012033. <https://doi.org/10.1088/1755-1315/411/1/012033>
- Rahmasari, R., Hertamawati, R. T., & Cahyono, D. W. (2021). Kualitas telur puyuh yang beredar di pasar tradisional di Kecamatan Kaliwates Kabupaten Jember. *Jurnal Ilmiah Inovasi*, 21(1), 33–37. <https://doi.org/10.25047/jii.v21i1.2632>
- Sun, C., Liu, J., Yang, N., & Xu, G. (2019). Egg quality and egg albumen property of domestic chicken, duck, goose, Turkey, quail, and pigeon. *Poultry Science*, 98(10), 4516–4521. <https://doi.org/10.3382/ps/pez259>
- Suprijatna, E., Umiyati, A., & Ruhyat, K. (2005). (2005). Ilmu Dasar Ternak Unggas. Jakarta: Penebar Swadaya.
- Tistiana, H., Fitriana, F., & Utami, L. P. (2023). Pengaruh penambahan Spirulina platensis terhadap penampilan produksi dan kualitas telur puyuh. *TERNAK TROPIKA Journal of Tropical Animal Production*, 24(1), 20–28. <https://doi.org/10.21776/jtapro.2023.024.01.4>
- Wheindrata, H. (2024). Paduan Lengkap Beternak Burung Puyuh Petelur. Yogyakarta: Lily Publisher.