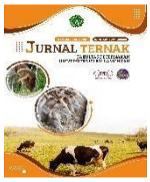
JURNAL TERNAK
Volume 15 (2) 2024 pp. 54-59
ISSN 2684-6799 (Online)
ISSN 2086-5201 (Print)
Available online
S4-Accredited – SK No. 85/M/KPT/2020
Journal Page is available at http://www.jurnalpeternakan.unisla.ac.id/index.php/ternak/index



Optimizing Laying Hen Productivity and Egg Quality through Combination of Inorganic and Organic Trace Minerals Supplementation

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ARTICLE INFO

Article history:
Received 18 November 2024
Revised 24 November 2024
Accepted 9 Desember 2024

Keywords:
Laying hen
inorganic trace mineral
organic trace mineral
egg quality

IEEE style in citing this article:
Baluh Medyabrata Atmaja, Rifqi Hidayatulloh, Muhammad Irvan Ali,Amelia Lulu Rosalin Hutabarat, Wenni Meika Lestari, Satri Yusasra Agasi, Hanna Dzawish Shihah, " Optimizing Laying Hen Productivity and Egg Quality through Combination of Inorganic and Organic Trace Minerals Supplementation," Animal Husbandry Journal: Scientific Journal of the Faculty of Animal Husbandry, Lamongan Islamic University, vol. 15, no. 2, pp. 54-59, 2024.

ABSTRACT

This research investigates the effects of combining inorganic trace minerals (ITMs) and organic trace minerals (OTMSs) on the performance and egg quality of laying hens. The study employed a completely randomized design (CRD), assigning 60 laying hens to three treatment groups, each consisting of 10 replications of two hens. The treatment groups were as follows: T0 = commercial feed (control), T1 = commercial feed + 500 grams/ton ITMSfeed, and T2 = commercial feed + 500 grams/ton ITMSfeed + 500 grams/ton OTMSS feed. The results revealed that the treatments did not significantly affect performance (P > 0.05). However, eggshell weight was significantly higher (P < 0.05) in the T1 and T2 groups compared to the T0 group. Eggshell thickness was significantly higher (P < 0.05) in the T2 group compared to the T0 and T1 groups. In conclusion, the addition of a combination of inorganic trace minerals (ITMs) and organic trace minerals (OTMs) to the feed can significantly improve eggshell weight and thickness but does not have a significant effect on the overall performance of laying hens.

1. Introduction

Microminerals play an important role in poultry nutrition to optimize production performance and egg quality in laying hens. The use of inorganic trace minerals (ITMs) in poultry feed is widespread, but their limited bioavailability and antagonistic interactions in the digestive tract can lead to poor

ISSN 2684-6799 (Online)
Baluh Medyabrata Atmaja, et. al./Jurnal Ternak 15 (2) 2024 pp. 54-59 ISSN 2086-5201 (Print)

absorption and higher excretion rates [1]. Additionally, organic trade minerals (OTMs) in chelated form can also be used as an alternative due to their better bioavailability. Research conducted by [2] and [3] explains that the addition of OTMs to poultry feed can increase eggshell thickness and reduce fecal mineral retention without negatively impacting layer hen productivity. Given the significant benefits of OTMs, comprehensive evaluations of the combination of ITMs and OTMs in poultry feed are still very limited. The use of ITMs has the disadvantage of low bioavailability and environmental impact due to higher excretion levels [1]. Combining ITMs and OTMs can provide a balanced approach to boost layer hen productivity and reduce environmental impact, thereby aligning with the objectives of sustainable poultry farming [4], [5].

Integrating ITMs and OTMs into poultry feed can show a promising solution, as both complement each other. [5] shows that OTMs in the form of chelates can improve growth performance and egg quality, while [6] also emphasizes chelation technology that can enhance the bioavailability of minerals. Additionally, OTMs can reduce the antagonistic effects commonly seen with ITMs, improve nutrient utilization, and reduce environmental impact [1]. Adding certain minerals, like selenium (Se) and zinc (Zn), to poultry feed in their natural forms can help them keep more of their tissues and be healthier [7, 8, 9]. Putting these minerals together with ITMs could be a game-changing idea. Numerous study results substantiate the advantages of OTMs, including studies by [10] and [3] that examine the impact of OTMs on the production performance of laying hens. Particularly for laying hens during the production period, the synergistic potential of combining OTMs and ITMs remains underexplored. Furthermore, studies [7], [11] underscore the significance of specific organic minerals like selenium (Se) and zinc (Zn). There is still limited research on how the combination of these minerals with ITMs can optimize performance and sustainability in poultry production.

This research aims to examine the influence of the combination of ITMs and OTMs on the quality ad performance egg of laying hens. This study's originality is its attempt to bridge the information gap about the synergistic benefits of combining ITMs and OTMs, emphasizing characteristics like feed conversion, egg production, and eggshell thickness. By evaluating performance and egg quality, this research can provide practical insights into poultry nutrition effectively and sustainably.

2. Method

Bird, Experimental Diet and Design

This research was conducted over 4 weeks at a commercial layer chicken farm in Tanggerang, West Java, Indonesia. A total of 60 laying hens (ISA Brown strain, 50 weeks old) of female gender were given commercial feed obtained from PT. Charoen Phokphan (Table 1). The laying hens were divided into three treatment groups: T0 (commercial feed), T1 (commercial feed + 500 grams/ton ITMs feed), and T2 (commercial feed + 500 grams/ton ITMs feed and 500 grams/ton OTMs feed). The added mineral premixes, ITMs and OTMs, had concentrations of Fe: 30 or 35 mg/kg, Zn: 20 or 40 mg/kg, Cu: 10 or 10 mg/kg, Mn: 20 or 40 mg/kg, and Se: 0.15 or 0.1 mg/kg, respectively. With three treatments and ten replications, this experiment was arranged using a completely randomized design. (RAL).

In the same cage, the experimental breed of chickens was kept in a three-dimensional, three-tier cage (each cage containing 2 laying hens and measuring 40 cm × 30 cm × 30 cm) with ad libitum feeding and drinking. Conventional standards from commercial layer chicken farms regulate lighting, temperature, and humidity.

Table 1. Nutrient content of commercial layer chicken feed

Nutrients	Contents According to the Label
Moisture	Max. 13.0 %
Crude Protein	17.5 - 18.5 %
Crude Fat	Min. 3.0 %
Crude Fiber	Max. 7.0 %
Ash	Max. 14.0 %
Calcium	3.25 - 4.25 %
Phosphorus	Min. 0.55 %
Aflatoxin	Max. 50 ppb

ISSN 2684-6799 (Online)
ISSN 2086-5201 (Print)

Data Collection

The calculation of feed consumption is based on the difference between the amount of feed provided and the amount remaining. Hen-day production (HDP), a key measure of laying hen productivity, is calculated by dividing the total number of eggs produced by the number of hens present during the same period. The calculation of egg mass is based on the HDP and egg weight. The weight of the eggs produced and the amount of feed consumed determine the feed conversion. Weigh the eggshell after separating it from the egg contents to determine its weight. Micrometer to measure the thickness of the eggshell, taking measurements at the blunt, middle, and pointed ends of the egg, and then calculate the average.

Statistical Analysis

The data is analyzed using SPSS version 25.0. The study uses a one-way ANOVA with a significance level of 5%. The Duncan's multiple range test is used to assess the variability across treatment groups.

3. Results and Discussion

Laying Hen Performance

The productivity of layer hens may enhance with the use of ITMs or a mix of ITMs and OTMs. However, the findings demonstrate that dietary supplementation with ITMs or a combination of ITMs and OTMs did not significantly affect ($P > 0.05$) average feed intake, egg mass, egg weight, egg production, or feed conversion ratio. (Tabel 2).

Table 2. Performance of laying hens aged 50-54 weeks

Parameters	Diets			SE	p-value
	T0	T1	T2		
Feed consumption (g/bird/day)	105.90	106.27	107.47	0.464	0.363
Egg mass (g/bird/day)	53.71	55.14	53.88	0.771	0.726
Egg weight (g/bird/day)	57.65	58.75	56.14	0.614	0.227
Hen day production (%)	93.10	93.80	96.00	1.044	0.513
Feed conversion	1.84	1.81	1.92	0.022	0.149

Note: T0: laying hen provided with basal diet, T1: diet supplemented with ITM; T2: diet supplemented with ITMs and OTMs; SE: standard error.

The results of this study are consistent with several previous studies where the addition of ITMs to the feed showed an inconsistent tendency toward the performance of laying hens. This is supported by [12], who reported that ITMs does not have a significant effect on egg production or feed consumption. Similarly, [13] states that the addition of ITMs to feed affects performance, but its efficiency is often lower compared to OTMs. Conversely, the addition of OTMs, as shown by [10] and [14], often demonstrates better bioavailability and improved production parameters, such as increased egg production and egg weight. The lack of synergy observed in the combination of ITMs and OTMs also contradicts the findings of [15], which reported an increase in absorption and feed conversion ratio when both types of minerals were used together. These differences may be due to the experimental design, the source of minerals, or the feed composition.

The fact that adding ITMs or ITMs + OTMs to layer chicken feed did not significantly improve performance parameters suggests that the use of these minerals in layer chicken feed under similar conditions needs to be reevaluated. Although the use of OTMs has shown better performance in studies [10] and [14], the cost of using OTMs is higher, thus requiring a balance between cost efficiency and bioavailability. This research also raises questions about the potential environmental impact of using ITMs due to higher excretion rates and lower retention, as indicated by the findings of [16]. So, this

https://doi.org/10.30736/jt.v15i2.247

study makes a lasting contribution to improving mineral supplementation plans. It also highlights the need for more research to look into specific ways to improve laying hen performance and economic yields.

Egg Quality

The findings, as presented in Table 3. reveal significant variations in eggshell quality parameters among the dietary treatments. Groups T1 and T2 demonstrated a significantly higher eggshell weight (P<0.05) compared to the control group (T0), with T2 showing the highest weight at 7.54 g/egg. Similarly, eggshell thickness was significantly greater in T2 compared to both T0 and T1 (P<0.05). Conversely, there were no significant differences observed in broken egg percentages and eggshell color across the three groups (P > 0.05). The results indicate that the inclusion of organic trace minerals (OTMs) in diets significantly enhanced eggshell weight and thickness without affecting other egg quality metrics.

Table 3. Egg quality of 50 – 54 week old layer chickens

Parameters	Diets			SE	p-value
	T0	T1	T2		
Eggshell Weight (g/egg)	5.63^{a}	6.88^{b}	7.54^{b}	0.373	0.032
Eggshell Thickness (mm)	0.49^{a}	0.53^{a}	0.73^{b}	0.048	0.012
Broken egg (%)	3.57	0.35	0.71	1.078	0.426
Eggshell Color	6.10	5.36	5.62	0.245	0.474

Note: ^{a,b} The mean marked by different superscript letters within the same row is significantly different (p<0.05); T0: laying hens provided with a basal diet, T1: diet supplemented with ITM; T2: diet supplemented with ITMs and OTMs; SE : standard error.

The research by [10], which found that laying hens fed with OTMs-supplemented feed showed better egg shell strength and thickness compared to those receiving ITMs, is consistent with the increase in egg shell weight and thickness in the T2 group. This increase is due to the higher bioavailability of organic minerals, which allows for more efficient calcium and mineral deposition in the eggshell matrix. Additionally, [14] reported that using OTMs can reduce mineral waste and increase mineral retention, thereby improving the performance of laying hens. The study [17], which emphasizes other factors such as genetic or environmental influences, explains that the absence of significant changes in egg production and shell color may be due to the minimal influence of trace minerals on these parameters.

This research emphasizes the importance of using organic minerals in poultry nutrition due to their higher bioavailability compared to ITMs. Essential minerals like zinc, manganese, and selenium efficiently combine into feed, significantly affecting eggshell thickness, as noted by [18], [19], and [20]. As reported by [21] and [19], the increase in eggshell weight and thickness does not always lead to an improvement in eggshell integrity, resulting in eggs breaking easily due to their fragility. Additionally, the lack of significant improvement in eggshell color and broken eggs indicates that OTMs supplementation more affects the interior quality of the egg than the exterior quality.

4. Conclusions

The addition of a blend of inorganic trace minerals (ITMs) and organic trace minerals (OTMs) in the diet may markedly enhance the weight and thickness of eggshells, however it does not substantially affect the performance of laying hens.

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