Effects of Dietary Date Palm Pollen Powder and Vitamin E-Selenium Supplementation on Productive Performance of Laying Hens

Hawkar N. Saber[1]*, Mohammed A. Mohammed[2], and Sameerah H. Amen[3]

[1+2+3] Department of Animal Production, College of Agriculture, University of Kirkuk, Kirkuk, Iraq.

*Corresponding author. Email: akam24041@uokirkuk.edu.iq

Abstract

This study investigated the productive performance of laying hens fed diets supplemented with date palm pollen powder, either alone or in combination with vitamin E-selenium. A total of 120 White Lohmann hens, 40 weeks of age, were divided into six treatments (n = 20) in a completely randomized design, with five replicates of four hens each. The experimental schedule included a two-week adaptation period followed by five two-week production periods. The dietary treatments were as follows: a control diet; a control diet supplemented with 250 mg/kg vitamin E-selenium; 1 g/kg date palm pollen powder; 2 g/kg date palm pollen powder; 1 g/kg date palm pollen powder plus 250 mg/kg vitamin E-selenium; and 2 g/kg date palm pollen powder plus 250 mg/kg vitamin E-selenium.

Dietary supplementation significantly affected egg production percentage and egg mass during most experimental periods. The best overall response was observed in the sixth treatment, which included 2 g/kg date palm pollen powder plus 250 mg/kg vitamin E-selenium. This treatment maintained the highest egg production levels and improved egg mass as the hens advanced in age. Egg weight and feed conversion ratio were not significantly affected. The positive response observed in hens receiving this combination may be attributed to the complementary effects of the bioactive components of date palm pollen and the antioxidant roles of vitamin E and selenium. These components may help reduce oxidative stress, protect ovarian and reproductive tissues, and support reproductive efficiency, thereby improving egg production and overall productive performance.

The results suggest that dietary inclusion of 2 g/kg date palm pollen powder plus 250 mg/kg vitamin E-selenium may be a useful nutritional strategy for improving egg production percentage and egg mass in laying hens without significantly

ISSN 2072-3857

altering egg weight or feed conversion ratio. Further studies are recommended to evaluate the effects of this dietary combination on egg quality, reproductive physiology, oxidative stress indicators, and economic efficiency.

Keywords: Date palm pollen; Vitamin E; Selenium; Laying hens; Egg production; Egg mass; Antioxidants; Reproductive performance.

Introduction

Laying hens play a crucial role in global poultry production because eggs are a readily available and highly valued source of animal protein for human nutrition. The Food and Agriculture Organization (FAO) states that poultry products constitute a major source of animal protein worldwide, and eggs contain highly digestible protein of high biological value, along with many essential vitamins and minerals [5].

Oxidative stress is one of the most important challenges in modern poultry production, especially in high-yielding laying hens [20]. Wang et al. [20] reported that oxidative stress impairs ovarian function and egg-laying rate, as well as the production of reproductive endocrine hormones such as estradiol, follicle-stimulating hormone, and luteinizing hormone. Therefore, oxidative damage may hinder follicular development, ovulation, and the reproductive and productive performance of laying hens.

Date palm pollen is a natural substance that contains biologically active compounds, including phenolic and flavonoid compounds, which are highly valued for their antioxidant properties. [4] reported that date palm pollen extracts contain significant levels of total phenolic and flavonoid compounds and exhibit antioxidant and antimicrobial properties, indicating their potential use as natural antioxidants.

Date palm pollen has been shown to improve productive and reproductive performance in laying hens. [14] showed that dietary supplementation with date palm pollen improved egg weight, egg production, ovarian follicle development, hematological traits, and the levels of luteinizing hormone and follicle-stimulating hormone. A similar study reported that the addition of date palm pollen to laying-hen diets improved some egg traits and overall ovarian function [3].

In poultry nutrition, vitamin E is an important lipid-soluble antioxidant that protects cell membranes against lipid peroxidation and contributes to the overall antioxidant defense system. [19] reported that vitamin E is one of the most important lipid-soluble antioxidants in poultry and has a central role in the antioxidant defense network. Dietary antioxidants, such as vitamin E and selenium, may also modify antioxidant defense capacity. Under stress conditions, vitamin E may improve the productive response of laying hens. [2] observed that supplementation with vitamin E, either alone or in combination with other fat-soluble vitamins, improved some productive, egg-quality, hematological, and serum biochemical parameters in laying hens reared during summer. [1] also reported beneficial effects of vitamin A and selenium on productive performance, egg quality, and some blood parameters during the hot season.

The combination of date palm pollen and vitamin E-selenium may provide complementary antioxidant protection. Date palm pollen supplies natural polyphenols, flavonoids, amino acids, and minerals, whereas vitamin E helps protect biological membranes from oxidative damage. Based on previous findings [4,14,19], this combination may support ovarian activity, improve reproductive hormone balance, reduce oxidative stress, and enhance productive performance in laying hens.

Although date palm pollen, vitamin E, and selenium have been studied previously in poultry nutrition, the present study is novel because it examines the combined use of 2 g/kg date palm pollen powder and 250 mg/kg vitamin E-selenium in relatively older laying hens. The study was designed to determine whether this combination helps maintain productive traits, particularly egg production percentage and egg mass.

Thus, this study does not present these compounds as new feed additives. Instead, it investigates their combined use at specific dietary inclusion levels and during a defined production stage, which represents a distinct feature in relation to previous studies.

The objective of the present study was to assess the effects of dietary supplementation with date palm pollen powder, either alone or in combination with vitamin E-selenium, on productive traits of laying hens, including egg production percentage, egg weight, egg mass, and feed conversion ratio.

Materials and Methods

The experiment was conducted at the Poultry Farm of the Department of Animal Production, College of Agriculture, University of Kirkuk, beginning on 18

ISSN 2072-3857

September 2025. The experimental schedule included a 2-week preliminary adaptation period followed by five production periods, each lasting 2 weeks. During the adaptation period, the birds were allowed to adjust to the experimental diets and the housing environment.

A total of 120 White Lohmann hens, 40 weeks of age, were used in the experiment. The birds were weighed individually and then randomly assigned to six dietary treatments according to a completely randomized design (CRD). Each treatment included five replicates, with four hens per replicate.

The experiment consisted of one control group and five supplemented groups. The control group was fed the basal diet without supplementation. The second group was fed the basal diet supplemented with 250 mg/kg vitamin E-selenium. The third group was fed the basal diet supplemented with 1 g/kg date palm pollen powder. The fourth group was fed the basal diet supplemented with 2 g/kg date palm pollen powder. The fifth group was fed the basal diet supplemented with 1 g/kg date palm pollen powder plus 250 mg/kg vitamin E-selenium. The sixth group was fed the basal diet supplemented with 2 g/kg date palm pollen powder plus 250 mg/kg vitamin E-selenium.

The hens were housed in battery cages measuring 48 cm x 40 cm x 45 cm. The housing system consisted of four tiers, and one manually removable feeder was provided for each tier. Feed was offered manually. Water was supplied through nipple drinkers connected to a 2000 L tank. The hens were housed under a temperature range of 18-22 °C, with a 16 h light:8 h dark photoperiod, and appropriate ventilation standards were maintained. Feed was provided at 115 g/hen/day in two meals, the first at 07:00 and the second at 16:00.

The basal diet was formulated to meet the nutrient requirements of laying hens according to NRC (1994) recommendations. The basal diet contained ground wheat and corn, soybean meal, barley, vegetable oil, limestone, dicalcium phosphate, methionine, lysine, a mineral-vitamin premix, salt, choline chloride, and Limex. Date palm pollen powder was obtained from a herbal market in Kirkuk. The supplements were added to the basal diet at the specified inclusion levels and mixed gradually until a uniform distribution was achieved.

Five productive performance traits were evaluated across five 14-day test periods. Eggs were collected daily at 13:00. Hen-day egg production percentage was calculated using the following formula:

Hen-day egg production (%) = (number of eggs produced / number of live hens) x 100

Egg weight was recorded every two weeks, and egg mass was calculated as egg production percentage multiplied by average egg weight and divided by 100. Feed conversion ratio (FCR) was calculated as the ratio of feed intake to egg mass produced.

At the end of the experiment, final body weight was measured using a precise electronic weighing scale and compared with initial body weight. Data were analyzed using the SPSS statistical package. The experiment was analyzed as a completely randomized design (CRD), and Duncan’s multiple range test (Duncan, 1955) was used to compare treatment means at the 5% probability level. The following mathematical model was used:

$$Y_{ij} = \mu + T_i + e_{ij}$$

where Y_{ij} = observation of the trait under treatment i; μ = overall population mean; T_i = effect of treatment i (i = 1, 2, 3, 4, 5, 6); and e_{ij} = random error.

ISSN 2072-3857

Results and Discussion

Productive Traits

It is important to note that the present study evaluated selected productive traits only and did not directly measure oxidative stress or antioxidant status. Therefore, all discussion related to antioxidant mechanisms should be interpreted as a biologically plausible explanation based on previous studies rather than as a direct conclusion from the present experiment.

1. Egg Production Percentage

Table 1 presents the effects of dietary supplementation with date palm pollen powder, with or without vitamin E-selenium, on egg production percentage across different age intervals from 43-45 to 51-53 weeks. The data were analyzed at a significance level of $p <= 0.05$. During the 43-45 and 49-51 week periods, the third treatment performed better than the other treatments. However, the sixth treatment performed better during most periods, particularly at 45-47, 47-49, and 51-53 weeks. This indicates that supplementation with 2 g/kg date palm pollen powder plus 250 mg/kg vitamin E-selenium helped the birds maintain a better productive level as they advanced in age.

The increase in egg production percentage in the sixth treatment may be attributed to the combined nutritional and physiological roles of date palm pollen powder and vitamin E-selenium. Date palm pollen contains several bioactive and nutritive components, such as phenolic compounds, flavonoids, amino acids, and minerals, which may support metabolic activity and reproductive processes. Vitamin E and selenium contribute to the maintenance of cellular structural integrity and normal physiological functions in birds. Therefore, the improved productive response in T6 may reflect a multifactorial effect of these constituents on reproductive function rather than a single direct effect.

The contribution of date palm pollen to reproductive activity may also be related to its ability to support the reproductive axis and the secretion of hormones such as follicle-stimulating hormone (FSH) and luteinizing hormone (LH), which are important for follicular maturation and ovulation. This explanation is consistent with Saleh et al. [14], who reported that date palm pollen supplementation improved egg production, ovarian follicle development, and reproductive hormone levels. It is also consistent with Salhi et al. [15], who described the bioactive constituents of date palm pollen. In addition, vitamin E and selenium may help preserve the functional status of reproductive tissues and the liver, both of which are essential for the synthesis and transport of yolk precursors, including vitellogenin and very-low-density lipoprotein (VLDL), and for the process of oogenesis. This may help explain the findings of [6], [12], [13], and [16], who reported improvements in reproductive performance with the use of date palm pollen or selenium. However, because the present study did not measure oxidative stress markers or antioxidant enzyme activity, the antioxidant-related explanation should be considered a possible interpretation based on the available literature rather than a direct conclusion from this study.

ISSN 2072-3857

Table 1. Effect of different levels of date palm pollen powder, alone or combined with vitamin E-selenium, on hen-day egg production (%)

Treatment	43–45 weeks	45–47 weeks	47–49 weeks	49–51 weeks	51–53 weeks
1	86.79 ± 1.75ab	87.50 ± 4.62b	87.50 ± 3.14ab	88.93 ± 2.73b	85.71 ± 1.26b
2	84.64 ± 2.37b	87.50 ± 0.98b	87.14 ± 1.64b	91.07 ± 1.49b	87.86 ± 0.87b
3	89.29 ± 1.59a	81.07 ± 1.92b	85.71 ± 1.26b	91.07 ± 2.04a	88.57 ± 0.91b
4	82.14 ± 2.04b	85.00 ± 1.45b	87.86 ± 2.42ab	88.21 ± 0.71b	88.57 ± 1.84b
5	85.71 ± 0.98b	88.93 ± 1.04b	87.50 ± 1.79ab	90.00 ± 1.45b	88.57 ± 0.44b
6	86.07 ± 1.04ab	88.93 ± 2.22a	89.64 ± 1.73a	89.64 ± 1.18b	90.36 ± 1.66a
Significance	*	*	*	*	*

Means bearing different superscript letters within the same column differ significantly at $p \leq 0.05$. T1: control basal diet without supplementation; T2: basal diet + 250 mg/kg vitamin E-selenium; T3: basal diet + 1 g/kg date palm pollen powder; T4: basal diet + 2 g/kg date palm pollen powder; T5: basal diet + 1 g/kg date palm pollen powder + 250 mg/kg vitamin E-selenium; T6: basal diet + 2 g/kg date palm pollen powder + 250 mg/kg vitamin E-selenium.

2. Egg Weight

As shown in Table 2, average egg weight did not differ significantly among treatments across the studied age periods at $p <= 0.05$, as the means within each age period were denoted by the same letter. Therefore, dietary addition of date palm pollen powder at 1 or 2 g/kg, with or without vitamin E-selenium, did not produce a significant effect on egg weight.

Egg weight is mainly influenced by genetics, flock age, and the balance of dietary energy, protein, and amino acids. Methionine and linoleic acid are particularly important. When the basal diet is nutritionally adequate, antioxidant supplementation may support health and reproductive efficiency, but it may not necessarily alter egg weight. The findings of. [8] and [10] are in agreement with the present results. However, the findings

ISSN 2072-3857

of [14], who reported an improvement in egg weight following date palm pollen supplementation, differ from the present results. This difference may be due to differences in supplementation level, bird age, strain, study duration, or the nutritional adequacy of the basal diet.

Table 2. Effect of different levels of date palm pollen powder, alone or combined with vitamin E-selenium, on average egg weight (g)

Treatment	43–45 weeks	45–47 weeks	47–49 weeks	49–51 weeks	51–53 weeks
1	64.44 ± 2.18a	65.26 ± 2.18a	64.26 ± 1.06a	66.42 ± 2.08a	60.40 ± 1.38a
2	62.06 ± 1.07a	61.82 ± 0.93a	61.38 ± 0.66a	59.02 ± 2.43a	66.12 ± 0.71a
3	58.92 ± 3.11a	61.06 ± 1.69a	63.38 ± 0.75a	62.48 ± 3.38a	62.24 ± 2.83a
4	59.06 ± 1.50a	62.84 ± 1.90a	64.10 ± 1.15a	63.50 ± 1.36a	63.88 ± 0.58a
5	59.58 ± 1.38a	61.44 ± 0.39a	63.08 ± 0.79a	66.56 ± 2.25a	62.94 ± 1.66a
6	62.66 ± 0.90a	65.14 ± 2.77a	62.80 ± 2.48a	61.82 ± 1.93a	65.48 ± 2.76a
Significance	NS	NS	NS	NS	NS

NS: not significant. Means bearing the same superscript letter within the same column do not differ significantly at $p \leq 0.05$. Treatment descriptions are as indicated under Table 1.

3. Egg Mass (g/hen/day)

The effects of date palm pollen powder, with or without vitamin E-selenium, on egg mass during five age intervals from 43-45 to 51-53 weeks are shown in Table 3. Comparisons were conducted at $p <= 0.05$. Significant differences among treatments were observed in most age intervals, whereas no significant differences were observed during 49-51 weeks.

In the first age interval (43-45 weeks), the highest egg mass was recorded in T6 (52.90 g), followed by T5 (52.84 g), T1, and T3. Treatments T1, T3, T5, and T6 were significantly superior to T4, which recorded the lowest value (49.80 g), whereas T2 did not differ significantly from the other treatments. In the second age interval (45-47 weeks), T1, T2, T5, and T6 were significantly superior to T3 and T4. The highest egg mass was

ISSN 2072-3857

recorded in T5 (55.45 g), followed by T6 (55.06 g), indicating that the combination of date palm pollen and vitamin E-selenium was more effective than date palm pollen alone, as shown by T3 and T4.

In the third period (47-49 weeks), T6 and T4 outperformed T5 and T3. However, T6 and T4 did not differ significantly from T1 and T2. In the fourth period (49-51 weeks), no significant differences were observed among treatments, indicating that dietary supplementation did not produce a significant change in egg mass at this stage. In the fifth period (51-53 weeks), T4, T5, and T6 significantly outperformed T1, which recorded the lowest average (53.45 g). No significant differences were observed compared with T2 and T3.

The advantage of T6 in egg mass was not attributable to an increase in egg weight because egg weight did not differ significantly among treatments. Instead, the advantage of T6 was mainly associated with the higher and more sustained egg production percentage observed in this treatment. Because egg mass is a function of both egg weight and egg production percentage, egg mass can increase through an improvement in laying rate even when egg weight remains unchanged.

The advantage of T6 may be explained by the combined effects of date palm pollen and vitamin E-selenium on the nutrition and physiology of laying hens. Date palm pollen can be considered a source of bioactive and nutritive compounds that may positively affect reproductive and metabolic functions. It may also help maintain normal tissue function and support productive performance as hens age. This explanation is consistent with [16], [14], and [13], who reported improvements in egg production and egg mass following date palm pollen supplementation. The findings of [17,18] and [9] also support the role of vitamin E and selenium in productive and reproductive performance. However, because oxidative stress and antioxidant status were not measured in the present study, antioxidant mechanisms remain a likely explanation but cannot be confirmed from these results.

ISSN 2072-3857

Table 3. Effect of different levels of date palm pollen powder, alone or combined with vitamin E-selenium, on egg mass (g/hen/day)

Treatment	43–45 weeks	45–47 weeks	47–49 weeks	49–51 weeks	51–53 weeks
1	52.58 ± 1.21a	54.59 ± 3.29a	55.61 ± 1.45ab	56.53 ± 1.94a	53.45 ± 1.03b
2	51.53 ± 1.26ab	54.71 ± 0.73a	55.39 ± 1.11ab	58.10 ± 1.11a	54.91 ± 0.74ab
3	52.42 ± 0.76a	48.61 ± 1.34b	54.21 ± 1.53b	58.63 ± 1.48a	54.79 ± 1.45ab
4	49.80 ± 1.46b	52.99 ± 1.30b	56.98 ± 2.26a	56.57 ± 0.53a	55.32 ± 1.42a
5	52.84 ± 1.00a	55.45 ± 0.78a	54.35 ± 1.10b	57.91 ± 0.95a	55.35 ± 0.89a
6	52.90 ± 1.56a	55.06 ± 1.68a	56.07 ± 1.00a	57.64 ± 0.99a	56.85 ± 1.03a
Significance	*	*	*	NS	*

NS: not significant. Means bearing different superscript letters within the same column differ significantly at $p \leq 0.05$. Treatment descriptions are as indicated under Table 1.

4. Feed Conversion Ratio

The results in Table 4 show that there were no significant differences among treatments in feed conversion ratio during any of the studied age periods. All treatments had the same superscript letter within each period, indicating that date palm pollen powder, whether used alone or in combination with vitamin E-selenium, did not significantly affect feed conversion efficiency at p <= 0.05.

The absence of significant differences may be explained by the fact that feed conversion ratio is a composite trait that depends on both feed intake and egg mass produced. Although egg production and egg mass improved in some treatments, the similarity in feed intake among treatments and the stability of egg weight may have made the improvement insufficient to produce a significant difference in feed conversion ratio. This result partially differs from the findings of [14] and [13], who reported improvements in feed conversion

ISSN 2072-3857

ratio following date palm pollen supplementation, [9], who reported effects of some selenium sources on improving feed conversion efficiency. In contrast, [10], who found no clear effect of vitamin E and selenium on feed intake or feed conversion ratio. These differences may be attributed to bird type, productive age, selenium source, supplementation level, experimental duration, environmental conditions, and flock health status.

Table 4. Effect of different levels of date palm pollen powder, alone or combined with vitamin E-selenium, on feed conversion ratio (g feed/g egg)

Treatment	43–45 weeks	45–47 weeks	47–49 weeks	49–51 weeks	51–53 weeks
1	2.192 ± 0.051a	2.139 ± 0.134a	2.074 ± 0.056a	2.044 ± 0.071a	2.155 ± 0.043a
2	2.237 ± 0.056a	2.104 ± 0.029a	2.079 ± 0.041a	1.982 ± 0.040a	2.096 ± 0.028a
3	2.196 ± 0.033a	2.373 ± 0.068a	2.128 ± 0.057a	1.967 ± 0.050a	2.105 ± 0.056a
4	2.317 ± 0.069a	2.175 ± 0.052a	2.031 ± 0.078a	2.033 ± 0.019a	2.084 ± 0.054a
5	2.180 ± 0.042a	2.076 ± 0.029a	2.119 ± 0.044a	1.988 ± 0.033a	2.080 ± 0.033a
6	2.182 ± 0.068a	2.096 ± 0.063a	2.054 ± 0.037a	1.998 ± 0.034a	2.026 ± 0.038a
Significance	NS	NS	NS	NS	NS

NS: not significant. Means bearing the same superscript letter within the same column do not differ significantly at $p \leq 0.05$. Treatment descriptions are as indicated under Table 1.

Conclusions and Recommendations

The addition of 2 g/kg date palm pollen powder and 250 mg/kg vitamin E-selenium to the diet of laying hens resulted in a higher percent of hens laying and greater egg mass in the later stages of laying, whereas egg weight and feed conversion ratio were not significantly affected.

It is suggested to use 2 g/kg date palm pollen powder with 250 mg/kg vitamin E-selenium in the diets of laying hens to increase both the amount of eggs produced and the total egg mass. There is a need for more research of this supplementation on

ISSN 2072-3857

the status of antioxidants, laying hormones, egg quality, the activity of the ovary, and the overall profitability of this supplementation in the diets of laying hens.

References

[1] M. E. Abd El-Hack, K. Mahrose, A. A. Askar, M. Alagawany, M. Arif, M. Saeed, F. Abbasi, R. N. Soomro, F. A. Siyal, and M. T. Chaudhry, "Single and combined impacts of vitamin A and selenium in diet on productive performance, egg quality, and some blood parameters of laying hens during hot season," Biological Trace Element Research, vol. 177, no. 1, pp. 169–179, 2017.

[2] M. E. Abd El-Hack, M. Alagawany, V. Laudadio, R. Demauro, and V. Tufarelli, "Productive performance, egg quality, hematological parameters and serum chemistry of laying hens fed diets supplemented with certain fat-soluble vitamins individually or combined during summer season," Animal Nutrition, vol. 5, no. 1, pp. 49–55, 2019.

[3] S. H. Arheem, "The effect of using different levels of aqueous date palm pollen suspension on ovarian function and some egg traits in laying hens," Al-Furat Journal of Agricultural Sciences, vol. 6, no. 1, pp. 98–103, 2014.

[4] A. Daoud, D. Malika, S. Bakari, N. Hfaiedh, K. Mnafgui, A. Kadri, and N. Gharsallah, "Assessment of polyphenol composition, antioxidant and antimicrobial properties of various extracts of date palm pollen from two Tunisian cultivars," Arabian Journal of Chemistry, vol. 12, no. 8, pp. 3075–3086, 2019.

[5] Food and Agriculture Organization of the United Nations (FAO), Poultry in Human Nutrition. Rome, Italy: FAO, 2023.

[6] Z. Fu, T. Zhong, X. Wan, L. Xu, H. Yang, H. Han, and Z. Wang, "Effects of dietary vitamin E supplementation on reproductive performance, egg characteristics, antioxidant capacity, and immune status in breeding geese during the late laying period," Antioxidants, vol. 11, no. 10, Art. no. 2070, 2022.

[7] LOHMANN Breeders GmbH, LOHMANN LSL-LITE Layers: Management Guide—Cage Housing. Cuxhaven, Germany: LOHMANN Breeders GmbH, 2021.

[8] M. Mohiti-Asli, F. Shariatmadari, H. Lotfollahian, and M. T. Mazuji, "The influence of dietary vitamin E and selenium on egg production

ISSN 2072-3857

parameters, serum and yolk cholesterol and antibody response of laying hens exposed to high environmental temperature," Archiv für Geflügelkunde, vol. 74, no. 1, pp. 43–50, 2010.

[9] A. I. Muhammad, D. A. Mohamed, L. T. Chwen, H. Akit, and A. A. Samsudin, "Effect of selenium sources on laying performance, egg quality characteristics, intestinal morphology, microbial population and digesta volatile fatty acids in laying hens," Animals, vol. 11, no. 6, Art. no. 1681, 2021.

[10] Z. Nemati, H. Ahmadian, M. Besharati, S. Lesson, K. Alirezalu, R. Domínguez, and J. M. Lorenzo, "Assessment of dietary selenium and vitamin E on laying performance and quality parameters of fresh and stored eggs in Japanese quails," Foods, vol. 9, no. 9, Art. no. 1324, 2020.

[11] K. Qin, X. Cong, H. Wang, M. Yan, X. Xu, M. Liu, F. Song, D. Wang, X. Xu, J. Zhao, S. Cheng, Y. Liu, and H. Zhu, "Effects of supplementing selenium-enriched Cardamine violifolia to laying hens on egg quality and yolk antioxidant capacity during storage at 4 °C and 25 °C," Foods, vol. 13, no. 5, Art. no. 802, 2024.

[12] S. Qin, J. Zhu, S. Qin, X. Hu, J. Li, D. Tang, and Z. Shi, "Selenium yeast improves egg production performance by increasing antioxidant capacity, reproductive hormone levels and yolk precursor synthesis in late peak laying hens," Poultry Science, vol. 105, no. 2, Art. no. 106222, 2026.

[13] A. M. Refaie, M. H. Abd El-Maged, H. H. A. Abd El-Halim, H. R. H. Alghonimy, and S. A. M. Shaban, "Performance, physiological parameters and egg quality traits of laying hens as affected by dietary supplementation of date palm pollen," Journal of Animal Health and Production, vol. 10, no. 1, pp. 21–28, 2022.

[14] M. Saleh, D. Kokoszyński, M. A.-A. Mousa, and A. A.-K. Abuoghaba, "Effect of date palm pollen supplementation on the egg production, ovarian follicles development, hematological variables and hormonal profile of laying hens," Animals, vol. 11, no. 1, Art. no. 69, 2021.

[15] S. Salhi, M. Chentouf, H. Harrak, A. Rahim, C. Çakir, D. Çam, M. Öztürk, N. Hamidallah, J.-F. Cabaraux, and B. El Amiri, "Assessment of physicochemical parameters, bioactive compounds, biological activities, and nutritional value of the most two commercialized pollen types of date palm (Phoenix dactylifera L.) in Morocco," Food Science and Technology

International, vol. 30, no. 8, pp. 788–798, 2024.

[16] A. Q. Shanoon, M. S. Jassim, A. H. Mohamed, M. S. Latef, and A. M. A. Al-Raheem, “The effect of using different levels from date palm pollen in diet on productive performance and some eggs quality measurements for layer hens Lohman,” Animal and Veterinary Sciences, vol. 3, no. 6-1, pp. 1–4, 2015.

[17] P. F. Surai, Natural Antioxidants in Avian Nutrition and Reproduction. Nottingham, UK: Nottingham University Press, 2002.

[18] P. F. Surai, Natural Antioxidants in Avian Nutrition and Reproduction (Reprint). Nottingham, UK: Nottingham University Press, 2003.

[19] P. F. Surai, “Nutritional modulation of the antioxidant capacities in poultry: The case of vitamin E,” Poultry Science, vol. 98, no. 9, pp. 4030–4041, 2019.

[20] J. Wang, R. Jia, P. Celi, X. Ding, S. Bai, Q. Zeng, X. Mao, S. Xu, and K. Zhang, “The effect of oxidative stress on the chicken ovary: Involvement of microbiota and melatonin interventions,” Antioxidants, vol. 10, no. 9, Art. no. 1422, 2021.

ISSN 2072-3857