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Research Article

Effect of Different Levels of Beetroot Powder (*Beta vulgaris* L.) in the Diet on the Productive Performance of Older Laying Hens

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Abstract | This experiment was carried out to investigate the impact of supplementing different dietary levels of beetroot (*Beta vulgaris* L.) powder on the productive performance of laying hens during the late production phase (51–70 weeks of age). A total of five dietary treatments were employed, including a control group (without supplementation) and four experimental groups that received increasing levels of beetroot powder. Productive traits measured included hen-day egg production (HD%), average egg weight, cumulative egg number, egg mass, and feed conversion ratio (FCR). The results indicated that dietary beetroot powder significantly ($p \leq 0.05$) enhanced egg production, particularly during the later laying periods. Hens fed 2% beetroot powder (T5) recorded the highest HD% (95.36%) compared with the control (92.60%). Similarly, average egg weight was significantly improved ($p \leq 0.05$) in hens receiving 1–2% beetroot powder. The cumulative egg number and egg mass also increased significantly ($p \leq 0.05$) in the third and fifth treatments, respectively. No significant differences ($p > 0.05$) were observed in FCR among treatments, suggesting that beetroot supplementation did not adversely affect feed efficiency. The improvement in laying rate and egg mass at higher inclusion levels of beetroot powder can be attributed to its rich content of natural pigments (betalains), antioxidants, and bioactive compounds, which enhance gut health, nutrient digestibility, and metabolic activity. In conclusion, the inclusion of beetroot (*Beta vulgaris* L.) powder up to 2% in layer diets improved egg production rate and egg mass without negative effects on feed utilization. Beetroot powder may serve as an effective natural feed additive to support high productivity and maintain performance in aging laying hens.

Keywords | Beetroot powder, Beta vulgaris L., Laying hens, Egg production, Egg mass, Antioxidant additive

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INTRODUCTION

The global poultry industry plays a vital role in providing affordable, high-quality animal protein to meet the growing demand for human nutrition. Among poultry species, laying hens are of particular economic importance, as egg production contributes substantially to global food security. However, a progressive decline in productive efficiency is commonly observed as hens advance in age, typically after 50 weeks of production (Birhanu *et al.*, 2023). This decline is associated with physiological and metabolic changes, including reduced intestinal absorptive capacity, impaired enzymatic activity, hormonal fluctuations, and increased oxidative stress in tissues (Saibaba *et al.*, 2021). Consequently, egg production, egg weight, and feed conversion efficiency deteriorate during the late laying phase, leading to higher production costs and shorter productive lifespans.

Modern poultry nutrition research has therefore focused on identifying natural, cost-effective feed additives that can mitigate these age-related declines. The use of plant-derived bioactive compounds has emerged as a sustainable alternative to synthetic growth promoters (Dhalimy and Ali, 2022; Lee *et al*., 2025; Al-Sharifi and Ali, 2025). Such compounds exhibit antioxidant, antimicrobial, and immunomodulatory properties that can enhance intestinal morphology, improve nutrient digestibility, and stabilize the gut microbiota, all of which are essential for maintaining high performance in aging layers (Johnson, 2024). Among these promising plant-based additives, red beetroot (*Beta vulgaris* L.) has recently gained scientific attention due to its rich composition of betalains, phenolic acids, flavonoids, nitrates, vitamins, and essential minerals (Kopřiva *et al*., 2014; de Souza *et al*., 2019; Prasetyo *et al*., 2024). Betalains, the main pigments in beetroot, act as powerful antioxidants and free radical scavengers, protecting intestinal epithelial cells and metabolic organs from oxidative damage (Sokolova *et al*., 2024). Moreover, dietary beetroot supplementation has been shown to enhance hepatic and intestinal antioxidant enzyme activities, including catalase, superoxide dismutase, and glutathione peroxidase, thereby improving nutrient assimilation and overall metabolic efficiency (Chen *et al*., 2021; Jiang *et al*., 2024; Thiruvengadam *et al*., 2024).

Several experimental studies have explored the inclusion of beetroot powder and its by-products in poultry diets. Şengül (2021) reported a significant increase in egg production and egg weight in quails supplemented with 1–1.5% beetroot powder, while Prasetyo *et al*. (2024) observed improved laying performance and egg mass in hens fed 1% beetroot pulp and peel powder. Similarly, Sarmiento-Garcia *et al*. (2023) demonstrated that moderate beetroot supplementation improved feed efficiency without adverse effects on egg quality. In broilers, beetroot extract or juice has been shown to enhance growth performance and antioxidant capacity, reducing oxidative stress and improving feed utilization efficiency (Selim *et al*., 2013; Vasiljeva *et al*., 2018; Grace *et al*., 2020). Additionally, Betalain, an important component of beetroot, has been shown to significantly increase specific and non-specific immunity in animal models (Gulave *et al*., 2025). Despite these encouraging findings, there remains limited scientific evidence regarding the effect of dietary beetroot supplementation on the productive performance of aging laying hens, particularly beyond 50 weeks of age. The decline in nutrient absorption efficiency and increased oxidative damage during this stage necessitate nutritional interventions that can sustain production and improve metabolic resilience. Beetroot, as a natural antioxidant and metabolic enhancer, may offer a dual benefit: protecting cells from oxidative stress and improving digestive function through enhanced enzyme activity and gut integrity. Therefore, Beetroot powder is a natural, eco-friendly additive that supports productivity and physiological performance in older hens.

Therefore, this study was designed to evaluate the effect of different dietary inclusion levels of beetroot (*Beta vulgaris* L.) powder (0, 0.5, 1.0, 1.5, and 2.0%) on the productive performance of laying hens aged 51–70 weeks, focusing on parameters such as hen-day egg production (HD%), egg weight, cumulative egg number, egg mass, and feed conversion ratio (FCR).

MATERIALS AND METHODS

This study was conducted in a private commercial layer farm located in Al-Mameera area, Hillah City, Babylon Governorate, under the supervision of the College of Agriculture, Al-Qasim Green University, Department of Animal Production, for a period of five months (20 weeks) from December 14, 2024, to May 2, 2025, in addition to a two-week adaptation period (December 1–13, 2024) prior to the start of the experiment. All experimental procedures were carried out in line with animal ethical standards.

A total of 140 Lohmann Brown-Classic laying hens, aged 50 weeks, producing brown-shelled eggs, were used in this experiment. Birds were randomly distributed into five dietary treatments (T1–T5) with four replicates per treatment and seven hens per replicate, according to a completely randomized design (CRD).

Experimental treatments

T1: Control diet (without beetroot powder).
T2: Basal diet + 5 g beetroot powder/kg feed (0.5%).
T3: Basal diet + 10 g beetroot powder/kg feed (1.0%).
T4: Basal diet + 15 g beetroot powder/kg feed (1.5%).
T5: Basal diet + 20 g beetroot powder/kg feed (2.0%).

Diet composition

All diets were formulated to be iso-caloric and iso-nitrogenous, following the recommendations of the National Research Council (NRC, 1994) for laying hens. The composition of the basal diet is presented in Table 1.

Beetroot powder preparation and chemical analysis

Fresh red beetroot roots (*Beta vulgaris* L.) were washed, sliced, shade-dried, and ground to a fine powder its particle size typically ranges between (150-425 microns). The chemical composition of beetroot powder was determined at the Animal Wealth Laboratory, Ministry of Agriculture – Quality Control Division, Baghdad, using the procedures outlined in AOAC (2019), as shown in Table 2.

Table 1: Feed ingredients and nutrient composition (% dry matter).

Feed ingredient	**%**
Yellow corn	55.0
Wheat bran	5.5
Soybean meal (46% CP)	24.0
Protein premix 2.5%	2.5
Vegetable oil	1.3
Limestone	10.85
Dicalcium phosphate (21% P)	0.5
DL-Methionine	0.1
L-Lysine	0.05
Salt	0.1
Mycotoxin binder	0.1
Total	100
Calculated nutrient composition	
Metabolizable energy (kcal/kg feed)	2723
Crude protein (%)	16.00
Calcium (%)	3.95
Available phosphorus (%)	0.37

The calculated chemical composition of the basal diet, derived from the formulated feed ingredients, was metabolizable energy 2723 kcal/kg, crude protein 16%, calcium 3.95%, and available phosphorus 0.37%. The protein premix (ProVimi, Netherlands) contained per kg: 5.9% crude protein and 3600 kcal ME. It also included 6.4% Ca, 5.7% P, and 6.5% Na. Additionally, it had 4000 mg Fe, 2800 mg Zn, and 600 mg Cu. Other components were 8.35 mg Co, 60 mg I, and 10 mg Se. The premix provided 5.9% methionine, 1.5% lysine, and 1200 mg niacin. It also contained 400,000 IU vitamin A, 140,000 IU vitamin D_3, and 2000 mg vitamin E. Furthermore, it had 100 mg vitamin K, 90 mg vitamin B_1, 160 mg vitamin B_2, 200 mg vitamin B_6, and 1000 µg vitamin B_{12}.

Experimental management and data collection

All hens were housed under similar environmental and sanitary conditions. The room temperature was between 18-22 °C and the humidity was 55-60%. The lighting program consisted of 16 hours of light and 8 hours of darkness per day, with feed and water provided ad libitum. Data were collected weekly for hen-day egg production (HD%), egg weight (g), cumulative egg number (eggs/hen/28 days), egg mass (g/hen/day), and feed conversion ratio (g feed/g egg). At the end of the fifth production period, two eggs per replicate were collected and stored under refrigeration (4 °C) and room temperature for 0 and 15 days, to assess egg stability under different storage conditions.

Table 2: Chemical composition of beetroot powder.

Component	**%**
Crude fiber	11.8
Crude protein	10.5
Ash	8.5
Moisture	5.37
Ether extract	0.2
Metabolizable energy (kcal/kg)	2232

Statistical analysis

Data were analyzed using one-way ANOVA under the completely randomized design (CRD). Differences among means were evaluated using Duncan's multiple range test (Duncan, 1955) at a significance level of $p \le 0.05$. Statistical analysis was conducted using SAS (2012).

RESULTS AND DISCUSSION

Hen-day egg production (HD%)

Table 3 shows the effect of different dietary levels of beetroot (*Beta vulgaris* L.) powder on hen-day egg production (HD%) during the period from 51 to 70 weeks of age (mean ± SE). During the first period (51–54 weeks), treatments T4 and T5 showed a significant ($p \le 0.05$) improvement compared with the control (T1) and T3, while T2 did not differ significantly. In the second period (55–58 weeks), T5 achieved the highest production (94.52%). No significant differences were found during the third period (59–62 weeks). In the fourth and fifth periods (63–70 weeks), T3 and T5 were significantly ($p \le 0.05$) superior to the other treatments, while T1 was higher than T2 and T4. Overall, T5 recorded the highest mean (95.36%), significantly higher than most treatments except T3.

Table 3: Effect of different levels of beetroot (*Beta vulgaris* L.) powder on hen-day egg production (HD%) of laying hens (mean ± SE).

Treatments	**51–54 wk**	**55–58 wk**	**59–62 wk**	**63–66 wk**	**67–70 wk**	**Overall mean**
T1 – 0.0% beetroot	88.90 ± 0.31^{B}	91.07 ± 1.34^{B}	95.15 ± 3.32	94.13 ± 0.34^{B}	93.75 ± 0.22^{B}	92.60 ± 0.54^{B}
T2 – 0.5% beetroot	91.58 ± 0.80^{AB}	92.09 ± 1.04^{B}	91.33 ± 3.27	93.24 ± 1.09^{C}	91.20 ± 0.79^{C}	91.89 ± 0.90^{B}
T3 – 1.0% beetroot	88.39 ± 0.70^{B}	92.86 ± 0.47^{B}	95.66 ± 1.75	96.05 ± 0.27^{A}	95.41 ± 0.72^{A}	93.67 ± 0.20^{AB}
T4 – 1.5% beetroot	93.75 ± 1.17^{A}	90.69 ± 0.21^{B}	92.98 ± 1.81	92.47 ± 0.23^{C}	91.71 ± 0.29^{C}	92.32 ± 0.98^{B}
T5 – 2.0% beetroot	94.01 ± 0.27^{A}	94.52 ± 0.49^{A}	95.66 ± 0.74	96.81 ± 0.40^{A}	95.79 ± 0.99^{A}	95.36 ± 0.87^{A}
Significance	*	*	N.S	*	*	*

Different superscript letters within the same column indicate significant differences ($p \le 0.05$). * = Significant; N.S = Not significant.

Table 4: Effect of beetroot powder supplementation on cumulative egg number (eggs/hen/28 days) (mean ± SE).

Treatments	51–54 wk	55–58 wk	59–62 wk	63–66 wk	67–70 wk	Total (140 days)
T1-0.0% beetroot	24.89 ± 0.35	25.50 ± 0.47	26.64 ± 0.45	26.36 ± 0.41	26.25 ± 0.45	129.64 ± 1.55 ^{B}
T2 – 0.5% beetroot	25.64 ± 0.25	25.79 ± 0.43	25.57 ± 0.46	26.11 ± 0.44	25.54 ± 0.52	128.64 ± 1.06 ^{B}
T3 – 1.0% beetroot	24.75 ± 0.24	26.00 ± 0.13	26.79 ± 0.23	26.89 ± 0.18	26.71 ± 0.24	131.14 ± 1.69 ^{A}
T4 – 1.5% beetroot	26.25 ± 0.30	25.39 ± 0.31	26.04 ± 0.26	25.89 ± 0.29	25.68 ± 0.32	129.25 ± 1.77 ^{B}
T5 – 2.0% beetroot	26.32 ± 0.17	26.46 ± 0.24	26.79 ± 0.10	27.11 ± 0.19	26.82 ± 0.14	133.50 ± 1.22 ^{A}
Significance	N.S	N.S	N.S	N.S	N.S	*

Different superscript letters within the same column denote significant differences (p≤0.05). * = Significant; N.S = Not significant.

Table 5: Effect of beetroot powder supplementation on egg weight (g) of laying hens (mean ± SE)

Treatments	51–54 wk	55–58 wk	59–62 wk	63–66 wk	67–70 wk	Overall mean
T1-0.0% beetroot	56.34 ± 1.48 ^{B}	57.15 ± 2.80	59.25 ± 1.03 ^{B}	59.65 ± 1.35 ^{B}	59.57 ± 1.73	58.39 ± 0.79 ^{B}
T2 – 0.5% beetroot	57.89 ± 1.25 ^{AB}	57.77 ± 2.03	58.56 ± 0.58 ^{B}	61.03 ± 0.62 ^{AB}	60.39 ± 1.90	59.13 ± 0.49 ^{B}
T3 – 1.0% beetroot	57.78 ± 1.16 ^{AB}	60.26 ± 0.57	62.45 ± 0.82 ^{A}	63.17 ± 0.52 ^{A}	62.75 ± 0.86	61.28 ± 0.45 ^{A}
T4 – 1.5% beetroot	60.55 ± 1.63 ^{A}	58.23 ± 2.33	61.10 ± 0.64 ^{AB}	60.99 ± 1.00 ^{AB}	60.40 ± 2.07	60.26 ± 0.73 ^{A}
T5 – 2.0% beetroot	60.31 ± 0.54 ^{AB}	60.54 ± 1.16	62.24 ± 1.13 ^{A}	62.86 ± 1.03 ^{A}	62.13 ± 0.68	61.62 ± 0.39 ^{A}
Significance	*	N.S	*	*	N.S	*

Values with different letters in the same column differ significantly (p≤0.05). * = Significant; N.S = Not significant.

Table 6: Effect of beetroot powder supplementation on egg mass (g/hen/day) (mean ± SE).

Treatments	51–54 wk	55–58 wk	59–62 wk	63–66 wk	67–70 wk	Overall mean
T1-0.0% beetroot	50.19 ± 0.55 ^{B}	52.32 ± 0.38 ^{B}	56.57 ± 0.72 ^{B}	56.38 ± 0.44 ^{B}	56.01 ± 1.41 ^{B}	54.20 ± 0.34 ^{B}
T2 – 0.5% beetroot	53.08 ± 1.18 ^{AB}	53.37 ± 0.54 ^{B}	53.63 ± 0.32 ^{C}	57.04 ± 1.34 ^{B}	55.29 ± 0.52 ^{B}	54.46 ± 1.06 ^{B}
T3 – 1.0% beetroot	51.12 ± 0.94 ^{B}	55.95 ± 0.47 ^{AB}	59.78 ± 0.86 ^{A}	60.69 ± 0.28 ^{A}	59.92 ± 0.86 ^{A}	57.42 ± 0.42 ^{A}
T4 – 1.5% beetroot	56.86 ± 0.74 ^{A}	52.95 ± 0.30 ^{B}	56.90 ± 0.60 ^{B}	56.53 ± 1.25 ^{B}	55.51 ± 0.12 ^{B}	55.73 ± 0.78 ^{B}
T5 – 2.0% beetroot	56.70 ± 0.92 ^{A}	57.25 ± 0.78 ^{A}	59.54 ± 0.20 ^{A}	60.89 ± 0.79 ^{A}	59.51 ± 0.37 ^{A}	58.75 ± 0.36 ^{A}
Significance	*	*	*	*	*	*

Note: Different superscript letters within a column indicate significant differences (p≤0.05). * = Significant.

Table 7: Effect of beetroot powder supplementation on feed conversion ratio (g feed/g egg) (mean ± SE).

Treatments	51–54 wk	55–58 wk	59–62 wk	63–66 wk	67–70 wk	Overall mean
T1-0.0% beetroot	2.37 ± 0.13	2.31 ± 0.21	2.12 ± 0.16	2.13 ± 0.17	2.13 ± 0.14	2.20 ± 0.13
T2 – 0.5% beetroot	2.23 ± 0.09	2.24 ± 0.15	2.23 ± 0.14	2.09 ± 0.12	2.17 ± 0.16	2.19 ± 0.12
T3 – 1.0% beetroot	2.32 ± 0.09	2.11 ± 0.02	1.98 ± 0.06	1.95 ± 0.04	1.98 ± 0.07	2.06 ± 0.04
T4 – 1.5% beetroot	2.09 ± 0.10	2.26 ± 0.15	2.09 ± 0.09	2.11 ± 0.12	2.15 ± 0.13	2.13 ± 0.10
T5 – 2.0% beetroot	2.08 ± 0.03	2.07 ± 0.07	1.98 ± 0.04	1.94 ± 0.06	1.98 ± 0.02	2.01 ± 0.01
Significance	N.S	N.S	N.S	N.S	N.S	N.S

N.S = Not significant (p>0.05).

Cumulative egg number (eggs/hen/28 days)

Table 4 presents the effect of beetroot powder on the cumulative egg number per hen. No significant differences were observed among treatments within each production period (51–70 weeks). However, in the overall mean, T3 and T5 were significantly (p≤0.05) superior to T1, T2, and T4.

Egg weight (g)

Table 5 demonstrates that beetroot powder supplementation significantly improved egg weight, particularly in T4 during the first period (p≤0.05). No significant differences appeared in the second period, but T3 and T5 exhibited higher weights in later periods. Overall, T3, T4, and T5 recorded significantly heavier eggs than the control and T2 (p < 0.05).

Egg mass (g/hen/day)

Table 6 indicates that T4 and T5 were significantly (p≤0.05) superior to the control during the first period, while T5 achieved the highest mean value (57.25 g) during the second period. In later periods, T3 and T5 consistently outperformed other treatments, with T5 showing the highest overall egg mass (58.75 g).

Feed conversion ratio (g feed/g egg)

Table 7 shows no significant differences among treatments in feed conversion ratio (FCR) across all periods and in the overall mean.

DISCUSSION

The results of the present study demonstrated that dietary inclusion of beetroot (*Beta vulgaris* L.) powder had a positive influence on the productive performance of Lohmann Brown-Classic laying hens during the late laying period (51–70 weeks of age). Supplementation levels of 1.0–2.0% beetroot powder significantly improved hen-day egg production (HD%), cumulative egg number, egg weight, and egg mass, without negatively affecting feed conversion ratio (FCR).

The improvement in egg production traits observed in this study may be attributed to the diverse bioactive constituents of beetroot, including betalains, betaine, polyphenols, and natural nitrates, which are known to enhance blood circulation, nutrient absorption, and antioxidant defense mechanisms. These compounds promote nitric oxide synthesis, leading to improved oxygen delivery to reproductive organs and stimulation of ovarian activity, thereby increasing laying performance (Bastos and Schliemann, 2022; Bashir *et al*., 2024). Moreover, the antioxidant properties of betalains reduce oxidative stress and lipid peroxidation in ovarian and hepatic tissues, maintaining better follicular development and yolk precursor synthesis (Abd El-Hack *et al*., 2023; Razzak *et al*., 2024).

The significant improvement in hen-day egg production (HD%) and cumulative egg number in hens fed 1.0–2.0% beetroot powder reflects enhanced metabolic efficiency and laying persistency. This is attributed to the optimal absorption of feed in the intestines thanks to the addition of red beetroot powder, which acts as an antibacterial and antioxidant. The efficient absorption of nutrients in the digestive tract, resulting from the presence of these antibacterial agents, positively impacts egg production. (de Oliveira *et al*., 2021; Amelia *et al*., 2024). The positive influence of beetroot on laying persistency is consistent with Şengül (2021) and Prasetyo *et al*. (2024), who reported similar patterns in laying hens, which antioxidant function, thereby sustaining production in aging hens.

Likewise, the improvement in egg weight with beetroot inclusion, particularly at 1.0–2.0%, could be due to dietary nitrates in beetroot also promote blood flow to the oviduct and increase the deposition of yolk and albumen components, resulting in heavier eggs (Sentkowska and Pyrzyńska, 2023; Bogdanova *et al*., 2024). Additionally, beetroot's natural betaine acts as a methyl donor in the synthesis of methionine and choline, both of which are vital for yolk formation and lipoprotein transport (Singh *et al*., 2022). These findings are consistent with the observations of Tuță *et al*. (2023), who reported that the inclusion of natural antioxidants enhanced yolk lipid deposition and egg quality parameters.

The significant rise in egg mass in beetroot-supplemented groups further supports the hypothesis that both improved laying rate and egg weight contributed to a higher total output per hen per day. The antioxidant action of beetroot helps preserve reproductive tissue integrity, Flavonoids are among the biologically active components due to their excellent antioxidant potential, acting as functionally active, protective, and supportive compounds for the liver's optimal metabolic activity, promoting better digestion and nutrient utilization (Liga *et al*., 2023; Stoica *et al*., 2025). These effects correspond with findings from Suresh *et al*. (2023), who demonstrated that herbal additives enhanced egg mass by improving hepatic lipid metabolism and yolk precursor secretion.

Interestingly, despite improvements in all production parameters, feed conversion ratio (FCR) remained statistically unchanged, suggesting that beetroot improved physiological and metabolic efficiency rather than increasing feed intake. This indicates that hens converted nutrients more efficiently into egg mass under the influence of beetroot bioactives. Similar results were reported by Rossi *et al*. (2015) who observed stable FCR values in hens supplemented with natural pigment-rich phytogenic additives. Moreover, Abd El-Ghany and Babazadeh (2022) suggested that dietary nitrates and betaine help regulate energy metabolism and maintain nutrient balance, findings that align with the present results.

Through its antioxidant, circulatory, and metabolic modulation effects, without adversely impacting feed utilization. This suggests that beetroot powder can serve as a safe, eco-friendly, and functional natural additive that enhances laying persistency, egg size, and mass, particularly in hens during the late phase of production.

Overall, the results of this study clearly demonstrate that including beetroot powder at 20g/kg in the diet of laying hens enhances reproductive performance and productive efficiency

CONCLUSIONS AND RECOMMENDATIONS

Supplementing layer diets with 1.0–2.0% red beetroot powder during the late laying phase (51–70 weeks) significantly ($p \leq 0.05$) increases egg production rate, egg weight, and egg mass, without harming feed conversion efficiency. These benefits result from beetroot's bioactive compounds and antioxidants, which improve nutrient utilization and metabolic activity. Include 1–2% beetroot powder in layer diets to maintain productivity at older ages. Further research should assess its effects on egg quality and antioxidant status.

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NOVELTY STATEMENT

This study is among the first to test graded levels (0–2%) of red beetroot (*Beta vulgaris* L.) powder in Lohmann Brown-Classic laying hens, aged 51–70 weeks, under field conditions in Iraq. Including 1–2% beetroot powder significantly boosts egg production and egg mass without changing feed efficiency.

AUTHOR'S CONTRIBUTION

Zaid Abbas Ali Al-Amri conducted the experimental work, collected and analyzed the data, and drafted.the manuscript.

Emad Abdulgabbar Ali supervised the experiment, provided guidance in methodology and statistical analysis, and critically reviewed the manuscript.

Huda Qasim Al-Himdany designed the research concept, provided overall scientific supervision, revised and finalized the manuscript, and served as the corresponding author. All authors approved the final manuscript.

Generative AI or AI-assisted technology statement

No generative AI or AI technology was used.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Abd El-Ghany WA, Babazadeh D (2022). Betaine: A potential nutritional metabolite in the poultry industry. Animals, 12(19): 2624. https://doi.org/10.3390/ani12192624

Abd El-Hack ME, Salem HM, Khafaga AF, Soliman SM, El-Saadony MT (2023). Impacts of polyphenols on laying hens' productivity and egg quality: A review. J. Anim. Physiol. Anim. Nutr., 107(3): 928-947. https://doi.org/10.1111/jpn.13758

Al-Sharifi BM, Ali EA (2025). Effect of adding different levels of curcumin powder to the diet on some reproductive, fertility and hatchability performance of broiler breeders. J. Anim. Health Prod., 13(2): 243-250. https://doi.org/10.17582/journal.jahp/2025/13.2.243.250

Amelia RT, Ardyanto TD, Sari Y (2024). Investigation of antioxidant activity from beetroot juice (*Beta vulgaris* L) as a healthy drink for the prevention of non-communicable disease. AcTion: Aceh Nutr. J., 9(1): 82-90. https://doi.org/10.30867/action.v9i1.1444

AOAC (2019). Official Methods of Analysis of AOAC International, 21st Edition. AOAC International, Washington DC, USA.

Bashir R, Tabassum S, Adnan A, Rashid A, Adnan A (2024). Bioactive profile, pharmacological attributes and potential application of Beta vulgaris. J. Food Meas. Charact., 18(5): 3732-3743. https://doi.org/10.1007/s11694-024-02445-6

Bastos EL, Schliemann W (2022). Betalains as antioxidants. In: Plant antioxidants and health (pp. 51-93). Cham: Springer In. Publ., https://doi.org/10.1007/978-3-030-78160-6_9

Birhanu MY, Osei-Amponsah R, Yeboah Obese F, Dessie T (2023). Smallholder poultry production in the context of increasing global food prices: roles in poverty reduction and food security. Anim. Front., 13(1): 17-25. https://doi.org/10.1093/af/vfac069

Bogdanova NL, Gumanova NG, Kiselev AR, Drapkina OM (2024). Pharmacokinetic study and phytochemical analysis of beetroot powder as an initial stage of the development of an NO-boosting formulation as a food supplement with cardioprotective properties and potential donor of nitric oxide. Russ. Open Med. J., 13(4): 410. https://doi.org/10.15275/rusomj.2024.0410

Chen L, Zhu Y, Hu Z, Wu S, Jin C (2021). Beetroot as a functional food with huge health benefits: Antioxidant, antitumor, physical function, and chronic metabolomics activity. Food sci. Nutr., 9(11): 6406-6420. https://doi.org/10.1002/fsn3.2577

de Oliveira SPA, do Nascimento HMA, Sampaio KB, de Souza EL (2021). A review on bioactive compounds of beet (*Beta vulgaris* L. subsp. vulgaris) with special emphasis on their beneficial effects on gut microbiota and gastrointestinal health. Crit. Rev. Food Sci. Nutr., 61(12): 2022-2033. https://doi.org/10.1080/10408398.2020.1768510

de Souza LAZ, Lima HJDA, Martins RA, Assunção ASA, Junior DAN, Silva WF, da Silva FG (2019). Egg yolk colour and retinol concentration of eggs from laying hens fed diets containing carrot and beetroot meal. Czech J. Anim. Sci., 64(6): 252–259. https://doi.org/10.17221/54/2019-CJAS

Dhalimy SSAMA, Ali EA (2022). Effect of adding different levels of aqueous extract of lemongrass leaves on the hormonal, physiological, and immune traits for rooster of breeder broiler (ROSS 308). Int. J. Aqua Sci., 13: 353-61.

Duncan DB (1955). Multiple range and multiple F-tests. Biometrics, 11(1): 1–5. https://doi.org/10.2307/3001478

Grace TO, Olajide A, Dupe OM, Boluwatife T, Akinyemi MO (2020). Effect of beetroot juice (*Beta vulgaris*) on growth performance, blood profile and carcass characteristics of broiler chicken. Int. J. Poul. Sci., 19(7): 303-308. https://doi.org/10.3923/ijps.2020.303.308

Gulave S, Gilbile M, Palshikar G (2025). Herbal immune boosting formulations for better health. J. Med. Plants Stud., 13(2): 255-259. https://doi.org/10.22271/plants.2025.v13.i2c.1829

Jiang Y, Sun X, Ma L, Li F, Ma J, Li C (2024). The health benefits of red beetroot and its potential use in poultry industry using probiotic fermentation. Pak. J. Agric. Sci., 61(3): 750–758.

Johnson A (2024). The influence of feed additives on laying hen health, welfare, and egg quality. Poult. Sci. Rev., 30(2): 114–127.

Kopřiva V, Suchý P, Straková E, Žďárský M, Dvořák P (2014). Colour and viscosity of egg yolk after addition of beetroot to feed for laying hens. Acta Vet. Brno, 83(1): 39-44. https://doi.org/10.2754/avb201483010039

Lee J, Park H, Heo JM (2025). Dietary additives to extend laying persistency in aged hens. Korean J. Poult. Sci., 52(2): 85-103. https://doi.org/10.5536/KJPS.2025.52.2.85

Liga S, Paul C, Péter F (2023). Flavonoids: Overview of biosynthesis, biological activity, and current extraction techniques. Plants, 12(14): 2732. https://doi.org/10.3390/plants12142732

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

Prasetyo AK, Sudjarwo E, Hamiyanti AA (2024). Effect of the addition red beetroot powder (*Beta vulgaris* L. *Var. Rubra* L) as a feed additive in feed on production performance, egg yolk cholesterol and blood profile of laying hens. Int. J. Curr. Sci. Res. Rev., 7: 5517-5529.

Razzak MA, Sharif MK, Naz T, Rauf MA, Shahid F, Shahzad R, Inam A (2024). Evaluating the bioactive compounds of beetroot and their pharmacological activities in promoting health. Eur. J. Health Sci., 10(1): 13-30. https://doi.org/10.47672/ejhs.1802

Rossi P, Nunes JK, Rutz F, Anciuti MA, Moraes PVD, Takahashi SE, Dorneles JM (2015). Effect of sweet green pepper on yolk color and performance of laying hens. J. Appl. Poult. Res., 24(1): 10-14. https://doi.org/10.3382/japr/pfu003

Saibaba G, Ruzal M, Shinder D, Yosefi S, Druyan S, Arazi H, Friedman-Einat M (2021). Time-restricted feeding in commercial layer chickens improves egg quality in old age and points to lack of adipostat activity in chickens. Front. Physiol., 12: 651738. https://doi.org/10.3389/fphys.2021.651738

Sarmiento-García A, Olgun O, Kilinç G, Sevim B Gökmen SA (2023). Reuse of vegetable wastes in animal feed: the influence of red beet powder supplementation on performance, egg quality, and antioxidant capacity of layer quails. Trop. Anim. Health Prod., *55*(3): 153. https://doi.org/10.1007/s11250-023-03556-w

Selim NA, Youssef SF, Abdel-Salam AF, Nada SA (2013). Evaluation of some natural antioxidant sources in broiler diets: 1-effect on growth, physiological, microbiological and immunological performance of broiler chicks. Int. J. Poult. Sci., 12(10): 561-571. https://doi.org/10.3923/ijps.2013.561.571

Şengül AY (2021). Effect of supplementation of red beetroot powder in quail diets. Indian J. Anim. Sci., 91: 58-62. https://doi.org/10.56093/ijans.v91i1.113276

Sentkowska A, Pyrzyńska K (2023). Old-fashioned, but still a superfood red beets as a rich source of bioactive compounds. Appl. Sci., 13(13): 7445. https://doi.org/10.3390/app13137445

Singh SV, Deshpande AD, Somagond YM (2022). Betaine: A potent feed additive for amelioration of adverse effect of heat stress in livestock and poultry. Indian J. Anim. Sci., 92(3): 277-282. https://doi.org/10.56093/ijans.v92i3.122253

Sokolova DV, Shvachko NA, Mikhailova AS, Popov VS, Solovyeva AE, Khlestkina EK (2024). Characterization of betalain content and antioxidant activity variation dynamics in table beets (*Beta vulgaris* L.) with differently colored roots. Agron., 14(5): 999. https://doi.org/10.3390/agronomy14050999

Statistical Analysis System (SAS) (2012). User's guide. Statistical. Version 9.1th ed. SAS Inst. Inc., Cary, N.C. USA.

Stoica F, Râpeanu G, Rațu RN, Stănciuc N, Croitoru C, Țopa D, Jităreanu G (2025). Red beetroot and its by-products: A comprehensive review of phytochemicals, extraction methods, health benefits, and applications. Agriculture, 15(3): 270. https://doi.org/10.3390/agriculture15030270

Suresh S, D'Souza P, Marimuthu S (2023). Evaluation of phytogenic feed additive on egg production, egg quality and feed intake in layer chicken. EJ-Vet. Med., 3(1): 12-16. https://doi.org/10.24018/ejvetmed.2023.3.1.58

Thiruvengadam M, Chung IM, Samynathan R, Chandar SH, Venkidasamy B, Sarkar T, Simal-Gandara J (2024). A comprehensive review of beetroot (*Beta vulgaris* L.) bioactive components in the food and pharmaceutical industries. Crit. Rev. Food Sci. Nutr., 64(3): 708-739. https://doi.org/10.1080/10408398.2022.2108367

Tuță F, Dumitru M, Panaite TD, Hăbeanu M, Bunduc V (2023). Potential implications of natural antioxidants from plant to improve nutritional quality, oxidative stability and lipid degradation of egg yolk: A review. Arch. Zootech., 26(1): 28-55. https://doi.org/10.2478/azibna-2023-0003

Vasiljeva S, Smirnova G, Basova N, Babarykin D (2018). Cadmium-induced oxidative damage and protective action of fractioned red beet (*Beta vulgaris*) root juice in chickens. Proc. Latv. Acad. Sci., 72(6): 482–489.