Journal homepage
www.ajas.uoanbar.edu.iq
Anbar Journal of Agricultural Sciences
(University of Anbar – College of Agriculture)

THE IMPACT OF ADDING RAPHANUS SATIVUS SEEDS TO THE DIET OF BROILER BREEDERS ON EGG PRODUCTION AND QUALITY, HATCHABILITY, AND PHYSIOLOGICAL TRAITS

S. M. Abdulateef [1]* Z. J. M. Saed [1] Th. T. Mohammed [1]
A. B. Mohammed [2]

[1] Department of Animal Production, College of Agriculture, University of Anbar, Iraq.
[2] Department of Animal Production, College of Agriculture, Tikrit University, Iraq.

***Correspondence to:** Assist. Prof. Dr. Salwan M. Abdulateef, Department of Animal Production, College of Agriculture, University of Anbar, Iraq.
Email: ag.salwan.mahmood@uoanbar.edu.iq

Article info

Received: 2022-05-28
Accepted: 2024-09-25
Published: 2024-12-31

DOI-Crossref:
10.32649/ajas.2024.185833

Cite as:
Abdulateef, S. M., Saed, Z. J. M., Mohammed, Th. T., and Mohammed, A. B. (2024). The impact of adding *Raphanus Sativus* seeds to the diet of broiler breeders on egg production and quality, hatchability, and physiological traits. Anbar Journal of Agricultural Sciences, 22(2): 1594-1609.

Abstract

Enhancing the productivity and welfare of broiler breeders is a major challenge in poultry, as fertility, egg quality, and hatchability are mainly determined by nutrition and physiological conditions. The aim of this study was to determine the effect of adding radish (*Raphanus sativus*) seeds and vitamin E to the diets of broiler breeders (Ross 308) on their physiological and other vital traits. A total of 200 chickens including 20 roosters were used in five treatments comprising T1 (control), T2 (vitamin E 300 mg/kg), T3 (radish seeds 4 g/kg), T4 (radish seeds 6 g/kg), and T5 (radish seeds 8 g/kg). The T4 treatment was more effective than the cellular therapies producing better egg weight and hatchability. The data showed lowered cholesterol and LDL levels and higher HDL levels along with improved liver enzymes (ALT and AST) highlighting the functioning of tissues and organs and the overall health of the chickens. This reduction in oxidative stress, maintenance of hormonal balance, and improved nutrient absorption was due to the antioxidants in the radish seeds and vitamin E. Such additives improve eggshell quality and hatching and embryonic development in poultry which makes them a safe and eco-friendly alternative for

improving poultry performance and wellbeing. This study contributes towards sustainable agriculture practices in providing natural solutions for better consumer safety and food security by increasing production efficiency, improving food product quality, and reducing adverse environmental effects.

Keywords: Radish seeds, Vitamin E, Oxidative stress, Hormonal balance, Shell quality, Broiler breeders.

تأثير إضافة بذور الفجل (Raphanus sativus) إلى علائق أمهات فروج اللحم على انتاج البيض وجودته، ونسب الفقس، والصفات الفسيولوجية

سلوان محمود عبداللطيف [1]* زيد جميل محمد سعيد [1] ظافر ثابت محمد [1]

أركان برع محمد [2]

[1] قسم الإنتاج الحيواني، كلية الزراعة، جامعة الأنبار، العراق.

[2] قسم الإنتاج الحيواني، كلية الزراعة، جامعة تكريت، العراق.

***المراسلة الى:** الأستاذ المساعد الدكتور سلوان محمود عبد اللطيف، قسم الإنتاج الحيواني، كلية الزراعة، جامعة الأنبار، العراق.

البريد الالكتروني: ag.salwan.mahmood@uoanbar.edu.iq

الخلاصة

يعد تحسين إنتاجية وصحة أمهات دجاج اللحم تحدياً مهماً في صناعة الدواجن اذ تؤثر جودة التغذية والحالة الفسلجية بشكل كبير على خصوبة الدجاج وجودة البيض ونسب الفقس. تهدف هذه الدراسة الى تقييم تأثير إضافة بذور الفجل (*Raphanus sativus*) وفيتامين E الى علائق أمهات فروج اللحم Ross 308 على الصفات الإنتاجية والفسيولوجية، شملت التجربة 200 دجاجة (بما في ذلك 20 ديك) موزعة على خمس معاملات: T1 (السيطرة)، T2 (300 ملغ/كغ فيتامين E)، T3 (4 غ/كغ بذور الفجل)، T4 (6 غ/كغ بذور الفجل)، T5 (8 غ/كغ بذور الفجل). أظهرت النتائج تحسناً ملحوظاً في انتاج البيض ووزنه ونسب الفقس أذ تفوقت المعاملة T4 على جميع معاملات التجربة، كما بينت النتائج انخفاض مستويات الكوليسترول وLDL وزيادة في مستويات HDL بالإضافة الى تحسين إنزيمات الكبد (ALT وAST) مما يشير الى تحسن وظائف وصحة الدجاج بشكل عام. يعزى هذا التحسن الى مضادات الاكسدة الموجودة في بذور الفجل وفيتامين E التي تقلل الاجهاد التأكسدي وتنظم التوازن الهرموني وتحسن امتصاص العناصر الغذائية مثل الكالسيوم والزنك مما يعزز جودة القشرة الداخلية للبيض وتدعم التطور الجنيني للأجنة. تسلط هذه الدراسة الضوء على إمكانيات الإضافات الطبيعية كبديل مستدام وامن في تحسين انتاجية وصحة الدواجن. ويمكن ان تساهم هذه الدراسة في

دعم الاستراتيجيات الزراعية المستدامة عبر تعزيز كفاءة الإنتاج وتحسين جودة المنتجات الغذائية والحد من الاثار السلبية على البيئة مع تقديم حلول طبيعية تعزز الامن الغذائي وسلامة المستهلك.

كلمات مفتاحية: بذور الفجل، فيتامين E، الإجهاد التأكسدي، التوازن الهرموني، جودة القشرة، أمهات دجاج اللحم.

Introduction

The poultry industry is among the largest agricultural sectors in developing countries contributing substantially to meeting the demand for nutritional animal protein and enhancing food security. Despite its remarkable growth and development many issues still directly impact its production efficiency. The most concerning of these is low fertility which adversely affects production efficiency and directly influences egg quality as well as embryos which influences hatchability (31). Fertility development and better hatchability is directly associated with proper dating of broiler breeders. However, improving the physiological and productive performance of broiler breeders still requires natural alternatives that can be included in the feed (3) to enhance egg quality and hatchability (30). Radish seeds have proven to be effective in enhancing fertilization and hatchability due to their rich physiologically active compounds such as glucosinolates, flavonoids, and antioxidants (35).

As shown in (5) the health benefits of radish seeds, with regard to birds include the potential to improve the quality of eggs by strengthening their shells for promoting embryo survival and hatchability (19). Radish seeds have many health benefits, including boosting immunity, lowering oxidative stress, and balancing hormones. In addition, they are known to improve blood and biochemistry indicators such as hemoglobin levels, immunity, and liver and kidney enzymes, which promote overall health improvement in birds (23). The seeds contain ascorbic, folic, and other organic acids, in addition to a variety of essential amino acids which encourage the secretion of digestive nerve juices in the stomach and intestines. This improves digestion and creates an acidic environment that helps the proper breakdown of food, which in turn helps the body to digest proteins, fats, and sugars (19).

High in dietary fiber, radish seeds play an important role in improving bowel movements and facilitating digestion, as they absorb water and gel in the intestine, thereby softening the waste and facilitating the excretion process (13). They also help in managing blood sugar by the gradual absorption of carbohydrates, preventing fluctuations in glucose levels, which is essential in replenishing the energy of the birds (9). Glucosinolates and sulfates, effective substances derived from radish seeds, can potentially boost regulating hormones in the body that affect stress and reproductive hormones. The seeds reduce corticosterone levels (6) by reducing oxidative stress and improving the body's response to stress. Interestingly, radish seeds can also influence reproductive hormones such as progesterone and estrogen, promoting ovulation and enhancing poultry fertility. In combination, these actions mediate radish seeds that enhance egg quality and reproductive productivity, positively affecting hatchability (33).

Vitamin E and antioxidants from radish seeds reduce oxidative stress which helps the hens' reproductive systems and improves the egg quality (8). This aids broiler breeders in enhancing egg quality, fertility, and hatchability (33). Additionally, the combination of radish seeds and vitamin E can improve the productive and reproductive performance of chickens because of the synergistic effect of antioxidants. This contributes to improving fertility and hatchability rates as well as the physical attributes of the shell and egg content (9). The development of sustainable natural solutions in the poultry industry is important for improving product safety and reducing the use of industrial chemical additives that could harm the environment and public health (12). Radish seeds have natural advantages that increase production and quality in an eco-friendly way.

Despite the increasing interest in the use of natural additives in poultry nutrition, studies on the effect of radish seeds on fertility and hatchability in broiler breeders are still limited. Therefore, this study aimed to fill the gap by evaluating the addition of radish seeds to the diet of broiler breeders and its effect on their fertility, hatchability, egg quality, health and physiological indicators, and their productive performance.

Materials and Methods

This study was conducted over 84 days of three 28-day periods. It involved adding radish seeds and vitamin E separately to the diets of broiler breeders to examine their effect on the productive and reproductive performances and some blood traits of the birds. The experiment involved 200 chickens including 20 roosters of broiler breeders (ROSS 308) aged 52 weeks and above. The flock was weighed for homogeneity, and randomly distributed into five treatments of four replicates each containing 10 chickens and one rooster. They were fed a diet containing all the required nutrients as recommended by the producing company for this hybrid (Table 1). The treatments were: T1 - basic diet (control); T2 – adding 300 mg of vitamin E for 1 kg feed; T3 – adding 4 g radish seeds for 1 kg feed; T4 – adding 6 g radish seeds for 1 kg feed, and T5 - adding 8 g radish seeds for 1 kg feed.

Table 1: Composition of the experimental diets.

Ingredients	**%**	**Nutrient Composition (Calculated)	
Maize	**52.00**	Ingredients	**%**
Wheat	**14.00**	ME Kcal/kg	**2870**
Soybean meal 44 %	**18.00**	Crude protein %	**16.12**
Meat meal (40%) *	**5.00**	Of. Lysine 55 %	**0.86**
Vegetable oil	**2.65**	DL-methionine %	**0.376**
Calcium	**1.44**	Cys %	**0.265**
Lime stone	**6.82**	With +Cys %	**0.641**
NaCl	**0.09**	Calcium %	**3.376**
Total	**100**	Av. phosphorus %	**0.475**

*Protein concentrate for poultry feed Breedcom-5 special produced by the Dutch company WAFI. Representative energy: kilocal = 2100; crude protein 40%; crude fat 5%; crude fiber 2%; calcium 8%; phosphorus 2%; lysine 3.75%; methionine 2.85%; methionine + cysteine 3.20%; sodium 2.20%.
**According to the values of the chemical composition of the feed materials included in the composition of the diet, according to what was stated in (NRC, 1994).

The birds were housed in a 3x2 m pen which held 10 chickens and 1 rooster. The roosters were selected based on consistency of strength, homogeneity, and weight to

ensure their suitability for insemination. The chickens were raised in a closed hall equipped with a desert cooling system pad and air vacuum system. Longitudinal feeds (1.5 m) were used and the water was equipped with hanging automatic manholes. Sawdust was used to cover the floor at a thickness of about 5 cm and gently stirred occasionally during the experiment period. A nest box containing six 40×30 cm openings was also placed (28). The daily feeding system and feed quantity was based on the production guide of the company.

Measurement of production traits and egg production: The eggs were collected daily at 9.00 am and 1:00 pm throughout the study period, and production (hen-day-production) was calculated based on the number of chickens in each treatment. The production stage was divided into 3 periods of 52-55, 56-59, and 60-63 weeks each.

Average egg weight: The resulting eggs were weighed (collectively) two days a week (Monday and Tuesday) except for those not suitable for hatching. A special sensitive balance providing the nearest two decimal places per gram was used and the weights recorded for each repeater separately. Average egg weights were then calculated for each treatment (25).

Hatchability was calculated when the broiler breeders were aged 55, 59, and 63 weeks. All eggs produced were incubated within a week for each replicate. After hatching, the number of chicks, their average weights and the number of unfertilized eggs were recorded. Unhatched eggs were examined to determine the percentage of embryo deaths at the first, second and third weeks of incubation. The hatchability percentage was determined according to (25).

Blood samples were collected from two chickens of each repeater and randomly from the experimental coefficients of six chickens per treatment at ages 54, 58 and 62 weeks. The blood was collected from the jugular vein at a rate of 5 ml according to the method by (10) at 8.00 am and placed in tubes free of anticoagulant to obtain blood serum. The level of triglycerides in the blood serum was measured using a ready-made analysis kit manufactured by the French company Biolabo (32) following the enzymatic analysis method to measure HDL in the blood plasma according to the Warnick and Wood method (32). The level of low-density lipoproteins was estimated by (32). The effectiveness of alanine amino transferase (ALT) in blood serum was measured using a ready-made analysis kit from Syrbio - Paris France while the effectiveness of the aspartate amino transferase (AST) in blood serum was measured by optical spectrometry.

Statistical Analysis: A complete randomized design (CRD) was conducted and the SAS program for statistical analysis (29) was utilized to analyze the data. The means for each treatment were compared utilizing Duncan's polynomial, employing various significance levels to determine meaningful differences between the averages (14).

Results and Discussion

Table 2 shows the effect of adding radish seeds and vitamin E on average egg production over three time periods. In the first period (52-55 weeks), T4 achieved the highest egg production rate (76.6 ± 1.00), significantly superior to all other treatments, followed by the T5 (75.77 ± 0.77), T3 (73.04 ± 1.04), and T2 (73.00 ± 0.39), while the T1 (control) recorded the lowest at 70.10 ± 0.80. In the second period

(56-59 weeks), T4 at 74.40 ± 0.98 continued to outperform the other treatments, followed by T5 (72.00 ± 0.73), T3 (71.60 ± 0.42), and T2 (70.65 ± 0.61), while T1 had the lowest production rate (62.00 ± 1.00). T4 maintained its superiority (77.40 ± 0.94) in the third period (60 - 63 weeks), followed by T5 (76.34 ± 0.59), while T3 (73.70 ± 0.74) and T2 (73.85 ± 0.63) had similar results and significantly outperformed the T1 control treatment (73.30 ± 0.89). The results show a clear positive effect of food additives in improving egg production across all periods.

Table 2: Effect of Adding Radish Seeds and Vitamin E on Egg Production of Broiler Breeders (Mean ± Standard Error).

Diets treatments	Age (Weeks)			Mean
	52 - 55	**56 - 59**	**60 - 63**	
T1 cont.	73.30 ± 0.89 c	70.10 ± 0.80 c	62.00 ± 1.00 c	**68.47 ± 0.77 c**
T2 V. E 300mg	73.85 ± 0.63 b	73.00 ± 0.39 b	70.65 ± 0.61 b	**72.50 ± 0.58 b**
T3 (RS 4g/ kg diet)	73.70 ± 0.74 b	73.04 ± 1.04 b	71.60 ± 0.42 b	**72.78 ± 0.81 b**
T4 (RS 6g/kg diet)	77.40 ± 0.94 a	76.6 ± 1.00 a	74.40 ± 0.98 a	**76.13 ± 0.77 a**
T5 (RS 8g/kg diet)	76.34 ± 0.59 a	75.77 ± 0.77 a	72. ± 0.73 a	**74.70 ± 0.71 a**

Mean values within a column with no common superscript differ significantly (P ≤0.05).

Table 3 shows the effect of adding radish seeds and vitamin E on the average egg weight of broiler breeders over three time periods. In the first period (55-52 weeks), the T4 treatment recorded the highest average egg weight at 75.34 ± 0.53, significantly superior to all other treatments, followed by the T5 treatment (75.39 ± 0.80), the T3 treatment (71.23 ± 0.66), and T2 (70.00 ± 0.41), while the T1 control treatment recorded the lowest at 64.4 ± 1.00. For the second period (59-56 weeks), T4 continued to record the highest egg weight rate (76.20 ± 0.62), outperforming T5 (76.03 ± 0.77), T3 71.23 ± 0.66, and T2 (72.11 ± 0.56), while T1 had the lowest at 66.1 ± 0.86. For the 63 - 60 week period, T4 again had the highest average rate (74.63 ± 0.71), significantly superior to T5 (74.58 ± 0.73), while the T3 (70.53 ± 0.70) and T2 (70.32 ± 0.55) treatments showed close results but outperforming the T1 control treatment average of 64.7 ± 0.93. The results confirm the significant positive effect of food additives on improving the average weight of eggs for all periods.

Table 3: Effect of Adding Radish Seeds and Vitamin E on Average Egg Weight of Broiler Breeders (Mean ± Standard Error).

Diets treatments	Age (Weeks)			Mean
	52 - 55	56 - 59	60 - 63	
T1 cont.	63.6 ± 1.02 c	64.4 ± 1.00 c	66.1 ± 0.86 c	**64.7 ± 0.93 c**
T2 V.E 300mg	68.85 ± 0.63 b	70 .00 ± 0.41 b	72 .11 ± 0.56 b	**70 .32 ± 0.55 b**
T3 (RS 4g/ kg diet)	69.13 ± 0.74 b	71.23 ± 0.66 b	71.23 ± 0.66 b	**70 .53 ± 0.70 b**
T4 (RS 6g/ kg diet)	72.40 ± 0.94 a	75.34 ± 0.53 a	76.20 ± 0.62 a	**74.63 ± 0.71 a**
T5 (RS 8g/ kg diet)	72.34 ± 0.59 a	75.39 ± 0.80 a	76.03 ± 0.77 a	**74.58 ± 0.73 a**

Mean values within a column with no common superscript differ significantly (P ≤0.05).

Table 4 demonstrates that, compared to the other treatments, the T4 group had the highest HDL level (58 ± 2.40), followed by the T5 group (51 ± 3.02), while the control group (T1) had the lowest (41 ± 3.02). In terms of cholesterol, the T1 group had the highest value (290.00 ± 1.40), but T2 (251.06 ± 3.7) and T4 (271.99 ± 3.02) showed substantial declines. In contrast to the control group (189 ± 1.35), LDL reduced dramatically in the T4 group (98 ± 0.99) while the T3 group (115 ± 0.99) showed similar findings. With minor variations from the other treatments, the T5 group had the highest triglyceride levels (241.46 ± 1.79). The results demonstrate that adding radish seeds and vitamin E improves the chemical characteristics of blood, particularly when at higher doses of radish seeds.

Table 4: Effect of Adding Radish Seeds and Vitamin E on Chemical Blood Traits of Broiler Breeds over 63 Weeks (Mean ± Standard Error).

Treatments	Cholesterol mg/dL	Triglycerides mg/dL	HDL mg/dL	LDL mg/dL
T1 cont.	290.00 a ± 1.40	*222.66 ± 3.01	41 c ± 3.02	**189 a ± 1.35**
T2 V.E 300mg	251.06 ab ± 3.7	235.58 ± 4.00	52 b ± 0.99	**120 b ± 2.20**
T3 (RS4g/ kg diet)	273.42 ab ± 1.86	237.09 ± 3.96	50 b ± 1.07	**115 b ± 0.99**
T4 (RS 6g/ kg diet)	271.99 ab ± 3.02	227.37 ± 2.39	58 a ± 2.40	**98 c ± 0.99**
T5 (RS 8g/ kg diet)	280.02 ab ± 3.77	241.46 ± 1.79	51 b ± 3.02	**113 b ± 0.99**
Significance	**0.0001**	**NS**	**0.0001**	**0.0001**

Mean values within a column with no common superscript differ significantly (P ≤0.05).

Figure 1 shows the effect of adding radish seeds and vitamin E on the hatchability of fertilized eggs of Ross 308 flocks in the first period (52-55 weeks). Treatment T4 was superior, recording a hatchability of 77%, followed by T5 (75.2%), while T1 recorded the lowest at 71%. Both T3 and T2 treatments recorded 74% but outperformed treatment T1.

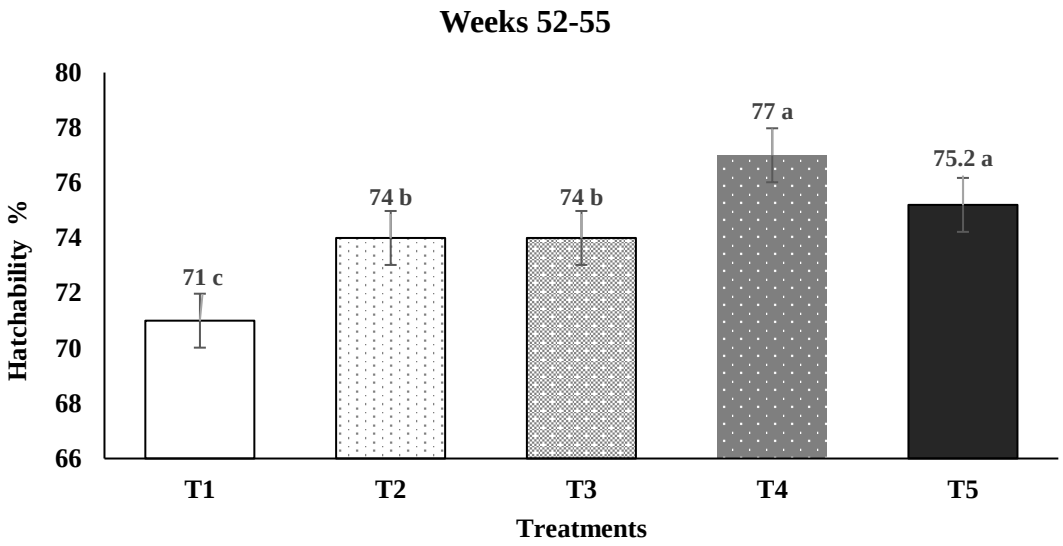

Figure 1: Effect of Adding Radish Seeds and Vitamin E on the Hatchability Rate of Fertilized Eggs of the Broilers in the First Period (52–55 weeks).

The effect of adding radish seeds and vitamin E on the hatchability of fertilized eggs of Ross 308 flocks in the second period (56-59 weeks) are shown in Figure 2. Treatment T4 was superior, recording a hatchability rate of 75%, followed by T5 (74.4%), T3 (74%) and T2 (72%), all of which outperformed the T1 treatment at 69.5%.

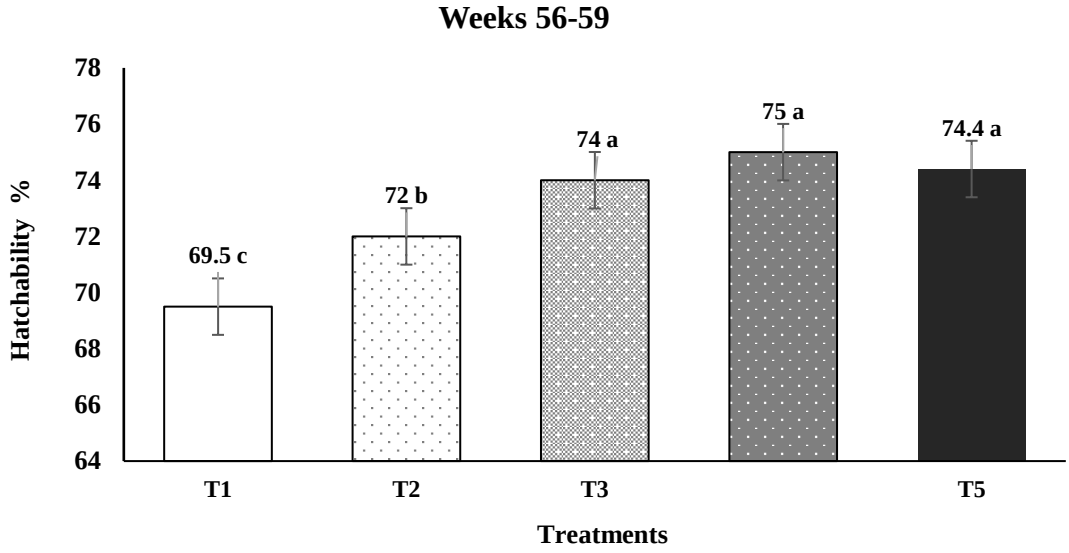

Figure 2: Effect of Adding Radish Seeds and Vitamin E on the Hatchability Rate of Fertilized Eggs of the Broilers in the Second Period (56–59 weeks).

The hatchability rates of fertilized eggs of Ross 308 flocks from adding radish seeds and vitamin E in the third period (60-63 weeks) are shown in Figure 3. Treatment T4 was superior giving a hatchability rate of 75%, followed by T5 (73.8%), T3 (72.1%), and T2 (71%), outperforming the T1 control treatment rate of 63%.

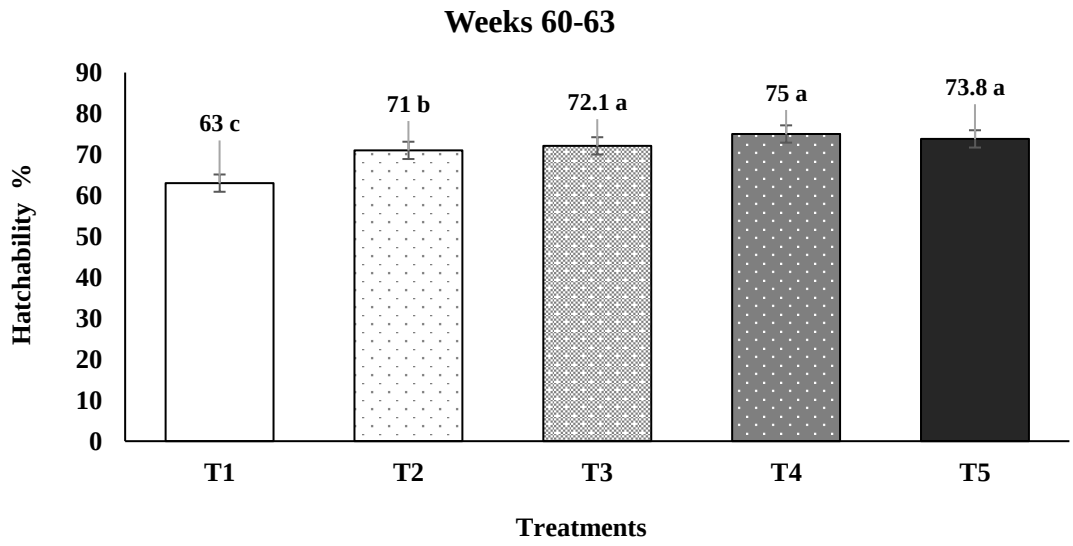

Figure 3: Effect of Adding Radish Seeds and Vitamin E on the Hatchability Rate of Fertilized Eggs of the Broilers in the Third Period (60–63 weeks).

ALT levels (IU/L) in the blood of broilers at 63 weeks were significantly lower ($P<0.01$) for all groups after radish seeds and vitamin E were added (Figure 4). Different treatments were observed for their effect on the broiler blood ALT levels. The T4 group had the lowest ALT, indicating that the fecal microbiome transplant had improved hepatic function. The T5 group displayed lower levels compared to the control group T1, while the T2 group suggested intermediate levels. The results show that radish seeds and vitamin E supplements can improve liver stress and liver function.

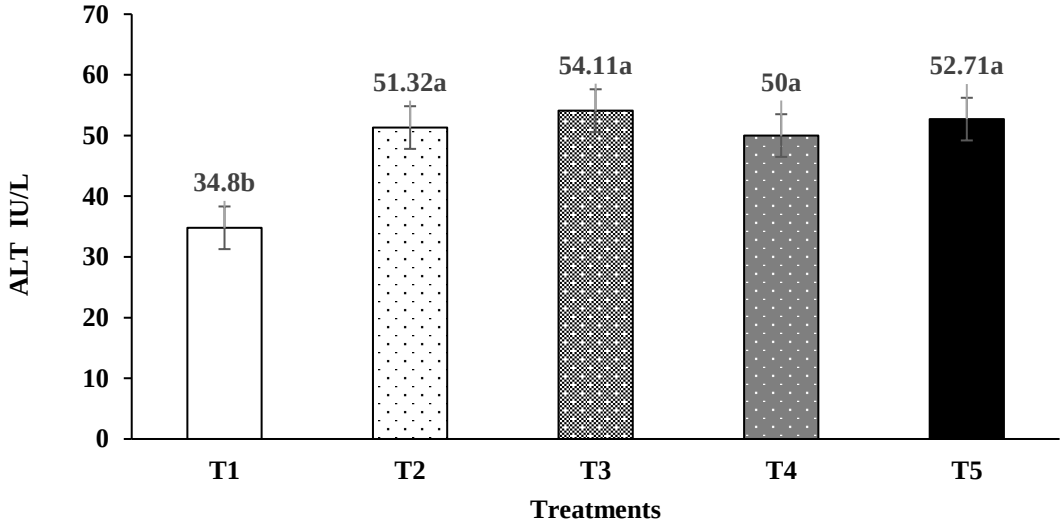

Figure 4: Effect of Adding Radish Seeds and Vitamin E on ALT (IU/L) Blood Traits in Broilers over 63 Weeks.

AST levels in the IU/L of the blood of the broilers after 63 weeks of adding radish seeds and vitamin E supplements are shown in Figure 5. The T4 group had superior AST values over all others. The T1 (control) group registered the highest values indicating greater liver stress, while T2 showed a significant decreased compared

with the control group. This indicates that both radish seeds and vitamin E can potentially enhance liver function in broiler chickens and reduce liver burden.

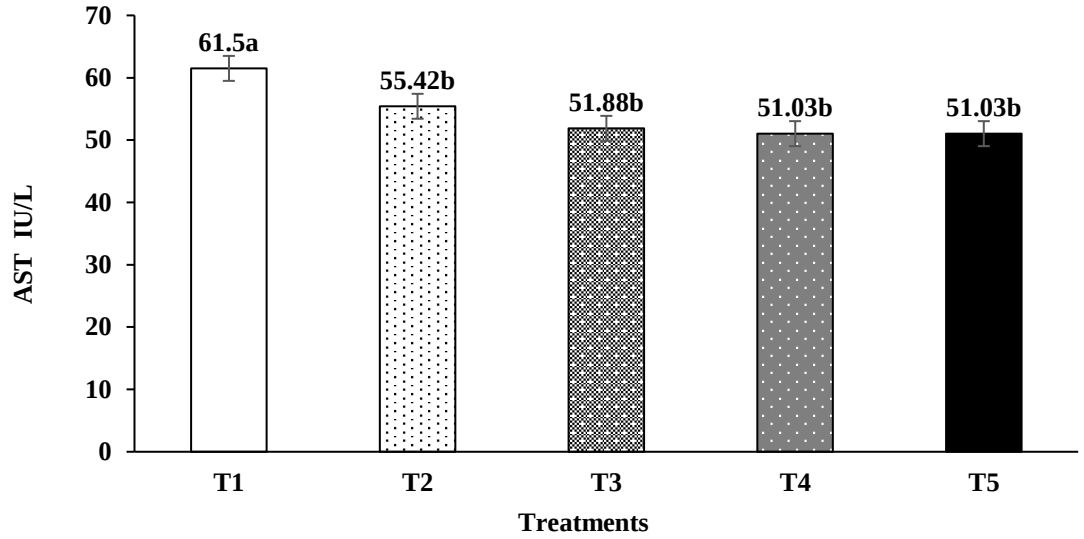

Figure 5: Effect of Adding Radish Seeds and Vitamin E on AST (IU/L) Blood Traits in Broilers over 63 Weeks.

The study results show that vitamin E and radish seeds positively influence the reproductive capability and egg yield of Ross 308 broiler breeders. This enhancement can be attributed to several biochemical and physiological processes pertaining to the reproductive and digestive systems, and increased immunity and health in poultry. The radish seeds contain glucosinolates and flavonoids that are known to increase reproductive hormone levels (e.g., estrogen and progesterone), resulting in improved ovulation rates and egg formation in vivo (14). As a primary compound, glucosinolates transform inside the body into isothiocyanates, which are compounds that stimulate the activity of enzymes that participate in regulating the production of hormones. One of the most important of these enzymes is aromatase (2), which plays a key role in converting androgens into estrogens, and contributes to increasing estrogen levels for the maturation of ovarian vesicles and stimulating ovulation (16). In addition, flavonoids work as antioxidants, which protect ovarian cells from oxidative stress caused by free radicals. They also enhance hormone balance through their effect on hormone receptors, which improves the interaction and synergy between them within the reproductive system. As such, these compounds not only enhance the production of hormones but also ensure the achievement of their highest level of utilization in supporting the reproductive process and thus improving ovulation rates and forming eggs suitable for hatching (37).

Radish seeds contain vital compounds such as folic and ascorbic acids that improve the contents of the inner egg such as protein and fat content, making them suitable for feeding the embryos and better supporting embryonic development. Folic acid promotes the synthesis of amino acids (22), which enhances the construction of proteins, increasing protein levels in eggs, and promoting the quality of the internal egg. This is in addition to its role in the synthesis of nucleic acids (DNA and RNA), which contribute effectively to the process of embryonic development, especially in the early stages (22).

Ascorbic acid (Vitamin C) promotes the absorption of necessary and essential minerals and vitamins such as iron and zinc, which enter into the formation of enzymes necessary for the growth of the embryos. The most important of these is catalase (20), which protects embryo cells from oxidative stress by stimulating the breakdown of hydrogen peroxide into water and oxygen, thereby maintaining the integrity of the embryo cells (38). Furthermore, iron is an essential component in cytochromes which helps in the chain of transport of electrons, an essential process in the production of energy within the mitochondria. The zinc found in the radish seeds contributes to the formation of the enzyme carbonic anhydrase, which regulates the balance of acids and bases within the embryo tissues allowing for high hatchability rates, as occurred in the experimental coefficients (7).

Ascorbic acid also plays a pivotal role in promoting the absorption of calcium in the intestine through vital mechanisms and thus works towards improving the efficiency of calcium receptors such as TRPV6 (21). These are proteins in the intestinal cells responsible for transporting calcium from the intestinal cavity to the inside of the cells through the role of ascorbic acid, which enhances this activity by stimulating the gene expression of these receptors (18). This increases its ability to absorb calcium more efficiently, especially in the presence of a low concentrations of dietary calcium. In addition, it increases the activity of Calbindin-D9k protein inside the intestinal cells, which are transporter proteins that bind to calcium and help transport it inside the cells towards the bloodstream. This process contributes to increasing the amount of calcium absorbed and improving its distribution within the body, thereby promoting other vital processes such as cortex formation and thickening (11).

After calcium is absorbed into the small intestine via active receptors such as TRPV6 and Calbindin-D9k, it is transported into the bloodstream where it binds with transporter proteins such as albumin and globulin to keep its concentration in a soluble and transportable state (26). Once in the cortex (uterine shell gland), it is deposited during the egg white formation (primary site for eggshell formation). Microscopic biological processes begin to deposit calcium in these glands (27). Carbonic anhydrase-enzyme which catalyzes the conversion of carbon dioxide and water into bicarbonate ions enhances calcium deposition in the cortical glands (7). With calcium, these ions combine to form calcium carbonate (CaCO3), the primary structural component of eggshells. Osteopontin and Matrix Gla-protein (MGP) can deliver calcium carbonate as orderly stacked crystals keep building the shell structure and its stiffness (17). Parathyroid hormone (PTH) and calcitriol also control the influx of calcium to the cortical glands, helping to keep a delicate balance of calcium between the blood and the cortical glands. Such an interaction leads to a strong and thick eggshell that reduces their damage and breaking rates during incubation and provides maximum protection for the embryo contained within the egg. Thus, through an amalgamation of absorption, transport and sedimentation, its balanced nature is a significant element of this integrated process, further exemplified by the indispensable role of active chemicals in these phases (27).

The results show that including radish seeds and vitamin E potentially improved the biochemical properties of blood manifested in its highly beneficial role in

reducing cholesterol and LDL levels and increasing HDL levels (19). This reflects the improvements in heart and liver functions if these findings are translated to a series of metabolic processes. Radish seeds include antioxidants such as flavonoids and glucosinols that activate antioxidant enzymes to minimize oxidative stress. For example, glutathione peroxidase and catalase (34) work to reduce the formation of free radicals, which contributes to the protection of liver cells and reduces cellular damage. The lower levels of liver enzymes AST and ALT in the blood indicates an improvement in liver function and reduces damage caused by oxidative stress if the active compounds enhance the activity of detoxification enzymes such as superoxide dismutase and glucose-6-phosphate dehydrogenase (23).

Furthermore, the active compounds in radish seeds and vitamin E affect the regulation of hormonal balance, as they help reduce the levels of the stress-related hormone corticosterone and promote the production of reproductive hormones such as estrogen and progesterone by stimulating the activity of the aromatase enzyme (2). This contributes to improving the production of high-quality eggs through the formation of proteins and fats inside the egg, which support embryonic development and embryo health. Moreover, radish seeds and vitamin E enhance the absorption of minerals such as iron and zinc, which support the formation of enzymes such as carbonic hydrase and cytochrome. This promotes energy production and the balance of acids and bases within the body, thus enhancing the metabolic and health performance of chickens, as well as contributing to higher egg production and overall health improvement (19).

Conclusions

This study showed that broiler breeder output and physiological quality were greatly enhanced when their diets included radish seeds and vitamin E. Their significance as safe and sustainable substitutes for artificial additives is highlighted by these improvements, which included higher egg weight and production, increased hatchability rates, improved blood quality and liver health due to antioxidant properties, and regulation of hormonal balance.

Supplementary Materials:

No Supplementary Materials.

Author Contributions:

Authors S. M. Abdulateef, Z. J. M. Saed, and Th. T. Mohammed prepared the original text, reviewed it, and made edits. The published version of the manuscript has been read and approved by all authors.

Funding:

This research received no financial support.

Institutional Review Board Statement:

The study was carried out in compliance with the protocol approved by the Iraqi Ministry of Higher Education, Department of Animal Production, University of Anbar College of Agriculture.

Informed Consent Statement:

No Informed Consent Statement.

Data Availability Statement:

No Data Availability Statement.

Conflicts of Interest:

The authors declare no conflict of interest.

Acknowledgments:

The Animal Production Department at the College of Agriculture, University of Anbar, Iraq, and the college dean are both acknowledged by the authors for their assistance.

Disclaimer/Journal's Note:

The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of AJAS and/or the editor(s). AJAS and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.

References

1. Abd El-Azeem, N. A., Madkour, M., Hashem, N. M., and Alagawany, M. (2024). Early nutrition as a tool to improve the productive performance of broiler chickens. World's Poultry Science Journal, 80(1): 171-185. https://doi.org/10.1080/00439339.2023.2262443.
2. Abdulateef, S. M., Majid, A. A., Al-Bayer, M. A., Shawkat, S. S., Tatar, A., Mohammed, T. T., and Al-Ani, M. Q. (2021). Effect of aromatase inhibitors on sex differentiation and embryonic development in chicks. Veterinary Medicine and Science, 7(6): 2362-2373. https://doi.org/10.1002/vms3.623.
3. Abdulateef, S. M., Saed, Z. J. M., Mohammed, Th. T., Awad, M. M., Mirzan, N. A., and Mustafa, R. D. (2024). The influence of ovo garlic and tomato extract injections on embryogenesis and neurological traits in chicken embryos. Anbar Journal of Agricultural Sciences, 22(1): 318-330. https://doi.org/10.32649/ajas.2024.183732.
4. Abdulateef, S. M., Atalla, O. K., Al-Ani, M. Q., Mohammed, T. T., Abdulateef, F. M., Abdualmajeed, O. M., and Mahmod, K. (2021). The effect of the electric shock on embryonic development and neurophysiological traits in the chick's embryo. In IOP Conference Series: Earth and Environmental Science, 761(1): 012090. DOI: 10.1088/1755-1315/761/1/012090.
5. Abou El-Maaty, H., Abd El-Aziz, M., El-Diasty, M., and El-Said, E. (2021). Effect of dietary rocket seeds meal and nano-chitosan on performance and related gene expression to growth and lipid profile in broiler chicks. Egyptian Journal of Nutrition and Feeds, 24(1). https://doi.org/10.21608/ejnf.2021.170318.
6. Arisha, M., Attia, A. I., Reda, F. M., Youssef, I. M., Swelum, A. A., Cheng, Y., and Abd El-Hack, M. E. (2024). Consequences of dietary red pepper and radish oils' supplementation on growth, carcass traits, blood indices, digestive enzymes activity and intestinal microbial load of broilers. Journal of Applied Poultry Research, 33(4): 100498. https://doi.org/10.1016/j.japr.2024.100498.
7. Aspatwar, A., Tolvanen, M. E., Barker, H., Syrjänen, L., Valanne, S., Purmonen, S., and Parkkila, S. (2022). Carbonic anhydrases in metazoan model organisms: molecules, mechanisms, and physiology. Physiological reviews, 102(3): 1327-1383. https://doi.org/10.1152/physrev.00018.2021.

8. Bhagwat, V. G., Ellusamy, B., and Paramesh, R. (2021). Evaluation of the effectiveness of phytogenic feed additive on hatchable egg production performance in Cobb 430 Y breeders under field conditions. Veterinary Research Notes, 1(3): 23-23. http://doi.org/10.5455/vrn.2021.a5.
9. Bharati, A. C., Prasad, B., Mallick, S., Masram, D. S., Kumar, A., and Saxena, G. K. (2023). Animal and plant hormone. In Handbook of Biomolecules (pp. 151-175). Elsevier. https://doi.org/10.1016/B978-0-323-91684-4.00028-1.
10. Carpenter, J. W., and Campbell, T. W. (1988). Avian Hematology and Cytology. The Journal of Zoo Animal Medicine, 19(4): p. 244. https://doi.org/10.2307/20094898.
11. Christakos, S., Mady, L. J., and Dhawan, P. (2018). Calbindin-D28K and calbindin-D9K and the epithelial calcium channels TRPV5 and TRPV6. In Vitamin D (pp. 343-359). Academic Press. https://doi.org/10.1016/B978-0-12-809965-0.00021-5.
12. El Shoukary, R. D., and Mousa, M. A. (2018). The impact of some feed additives on behavior, welfare and performance of heat-stressed pigeon squabs. EPH-International Journal of Applied Science, 4(2): 13-21. https://doi.org/10.53555/eijas.v4i2.67.
13. Deshpande, S. P., Rindhe, S. N., Chappalwar, A. M., Londhe, S. V., Munde, V. K., and Deshmukh, V. V. (2023). Effect of Carrot and Radish Powder on Proximate, Sensory and Physico-Chemical Characteristics of Chicken Nuggets. International Journal of Bioresource Science, 10(1): 71-78. https://doi.org/10.30954/2347-9655.01.2023.7.
14. Duncan, D. B. (1955). Multiple range and multiple F tests. biometrics, 11(1): 1-42. https://doi.org/10.2307/3001478.
15. Egorova, T. A. (2023). Glucosinolates in rape and camelina: composition, concentrations, toxicity and anti-nutritive effects in poultry, methods of neutralization - a mini-review. Sel'skokhozyaistvennaya Biologiya, 58(6): 1021-1034. https://doi.org/10.15389/agrobiology.2023.6.1021eng.
16. Fazli, N., Hassanabadi, A., Mottaghitalab, M., and Hajati, H. (2015). Manipulation of broiler chickens sex differentiation by in ovo injection of aromatase inhibitors, and garlic and tomato extracts. Poultry science, 94(11): 2778-2783. https://doi.org/10.3382/ps/pev236.
17. Fu, Y., Zhou, J., Schroyen, M., Zhang, H., Wu, S., Qi, G., and Wang, J. (2024). Decreased eggshell strength caused by impairment of uterine calcium transport coincide with higher bone minerals and quality in aged laying hens. Journal of Animal Science and Biotechnology, 15(1): 37. https://doi.org/10.1186/s40104-023-00986-2.
18. Huang, Q., Yang, R., Wang, Q., Teng, H., Song, H., Geng, F., and Luo, P. (2022). Transcriptome-based insights into the calcium transport mechanism of chick chorioallantoic membrane. Food Science and Human Wellness, 11(2): 383-392. https://doi.org/10.1016/j.fshw.2021.11.018.
19. Kishawy, A. T., Al-Khalaifah, H. S., Nada, H. S., Roushdy, E. M., Zaglool, A. W., Ahmed Ismail, T., ... and Ibrahim, D. (2022). Black pepper or radish seed oils in a new combination of essential oils modulated broiler chickens' performance

and expression of digestive enzymes, lipogenesis, immunity, and autophagy-related genes. Veterinary Sciences, 9(2): 43. https://doi.org/10.3390/vetsci9020043.

20. Li, K., Jiang, L., Wang, J., Xia, L., Zhao, R., Cai, C., ... and Wang, Y. (2020). Maternal dietary supplementation with different sources of selenium on antioxidant status and mortality of chicken embryo in a model of diquat-induced acute oxidative stress. Animal Feed Science and Technology, 261: 114369. https://doi.org/10.1016/j.anifeedsci.2019.114369.
21. Lieben, L., Benn, B. S., Ajibade, D., Stockmans, I., Moermans, K., Hediger, M. A., ... and Carmeliet, G. (2010). Trpv6 mediates intestinal calcium absorption during calcium restriction and contributes to bone homeostasis. Bone, 47(2): 301-308. https://doi.org/10.1016/j.bone.2010.04.595.
22. Liu, Y., Zhi, L., Shen, J., Li, S., Yao, J., and Yang, X. (2016). Effect of in ovo folic acid injection on hepatic IGF2 expression and embryo growth of broilers. Journal of animal science and biotechnology, 7: 1-9. https://doi.org/10.1186/s40104-016-0099-3.
23. Majekodunmi, B. C., Adeleye, O. O., Abatan, M. O., Akamo, A. J., Leramo, O. O., and Abioja, M. O. (2024). Physiological response, blood profile, and liver histology of broiler chickens to oral administration of white radish juice. Egyptian Journal of Agricultural Research, 102(4): 639-684. https://dx.doi.org/10.21608/ejar.2024.286109.1542.
24. Mohammed, T. Th., and Hamad, E. H. (2024). Effect Of Adding Natural Zeolite and Vitamin E To Laying Hans Diets on Some Productive Traits During the Summer Season. Anbar Journal Of Agricultural Sciences, 22(1): 501-516. https://doi.org/10.32649/ajas.2024.183746.
25. Neeteson, A. M., Avendaño, S., Koerhuis, A., Duggan, B., Souza, E., Mason, J., ... and Bailey, R. (2023). Evolutions in commercial meat poultry breeding. Animals, 13(19): 3150. https://doi.org/10.3390/ani13193150.
26. Nys, Y., and Le Roy, N. (2018). Calcium homeostasis and eggshell biomineralization in female chicken. In Vitamin D (pp. 361-382). Academic press. https://doi.org/10.1016/B978-0-12-809965-0.00022-7.
27. Nys, Y., Gautron, J., Rodriguez-Navarro, A. B., and Hincke, M. (2022). Mechanisms and hormonal regulation of shell formation: Supply of ionic and organic precursors, shell mineralization. In Sturkie's avian Physiology, 833-879. https://doi.org/10.1016/B978-0-12-819770-7.00049-9.
28. Oluwagbenga, E. M., and Fraley, G. S. (2023). Heat stress and poultry production: a comprehensive review. In Poultry Science, 102(12): 103141. https://doi.org/10.1016/j.psj.2023.103141.
29. System., S. a S. S. A. (2004). SAS user´s guide. In Statistical.
30. Tabashsum, Z., Scriba, A., and Biswas, D. (2023). Alternative approaches to therapeutics and subtherapeutics for sustainable poultry production. Poultry Science, 102(7): 102750. https://doi.org/10.1016/j.psj.2023.102750.
31. Tainika, B., Abdallah, N., Damaziak, K., Waithaka Ng'ang'a, Z., Shah, T., and Wójcik, W. (2024). Egg storage conditions and manipulations during storage: effect on egg quality traits, embryonic development, hatchability and chick

quality of broiler hatching eggs. World's Poultry Science Journal, 80(1): 75-107. https://doi.org/10.1080/00439339.2023.2252785.

32. Trinder, P. (1969). Determination of glucose in blood using glucose oxidase with an alternative oxygen acceptor. Annals of clinical Biochemistry, 6(1): 24-27. https://doi.org/10.1177/000456326900600108.
33. Tripathi, M. K., and Mishra, A. S. (2007). Glucosinolates in animal nutrition: A review. Animal feed science and technology, 132(1-2): 1-27. https://doi.org/10.1016/j.anifeedsci.2006.03.003.
34. Tsujii, H., Miah, A. G., Takeda, I., and Salma, U. (2017). Dietary effect of selenium-enriched radish sprouts, vitamin E, and Rhodobacter capsulatus on hypocholesterolemia and immunity of broiler. Poultry Science Journal, 5(1): 71-81. https://doi.org/10.22069/psj.2017.12411.1233.
35. Valdez-Baro, O., Jiménez-Ortega, L. A., Cabanillas-Bojórquez, L. Á., Gutiérrez-Grijalva, E. P., and Heredia, J. B. (2024). Food Byproducts as Potential Functional Ingredients for Animal Feeding. In Food Byproducts Management and Their Utilization, 417-452. https://doi.org/10.1201/9781003377801-20.
36. Warnick, G. R., and Wood, P. D. (1995). National cholesterol education program recommendations for measurement of high-density lipoprotein cholesterol: executive summary. The national cholesterol education program working group on lipoprotein measurement. Clinical chemistry, 41(10): 1427-1433. https://doi.org/10.1093/clinchem/41.10.1427.
37. Yang, J. X., Chaudhry, M. T., Yao, J. Y., Wang, S. N., Zhou, B., Wang, M., ... and Li, Y. (2018). Effects of phyto-oestrogen quercetin on productive performance, hormones, reproductive organs and apoptotic genes in laying hens. Journal of animal physiology and animal nutrition, 102(2): 505-513. https://doi.org/10.1111/jpn.12778.
38. Zhu, Y., Li, S., Duan, Y., Ren, Z., Yang, X., and Yang, X. (2020). Effects of in ovo feeding of vitamin C on post-hatch performance, immune status and DNA methylation-related gene expression in broiler chickens. British Journal of Nutrition, 124(9): 903-911. https://doi.org/10.1017/S000711452000210X.