Evaluation of the addition of psyllium seed powder (*Plantago ovata*) to the laying hens diet for improving the lipid profile and oxidation parameters in stored eggs

Ola Mahdi Abed[1] Nihad Abdul–Lateef Ali[2]

[1,2]Department of Animal Production, College of Agriculture, Al-Qasim Green University, Al-Qasim, Babil 51001, Iraq

Corresponding author: Ola Mahdi Abed

[1]E-mail: ola.mahdi1986@agre.uoqasim.edu.iq

[2]E-mail: dr.nihad@agre.uoqasim.edu.iq

Abstract

This study was conducted in a field located at Al-Wardia area in Babylon Province. The experiment was lasted for 16 weeks from 20/11/2023 until 10/3/2024, to study the effect of adding different levels of Plantago ovata seed powder to the diet of laying hens on the lipid profile and oxidation parameters of stored eggs. 105 white Lohmann layer hens were used at the age of 65 weeks. The feed was provided according to the Lohmann white layer managements guide. Chickens were randomly distributed into five experimental treatments (21 birds for each treatment), each treatment included three replicates with seven hens in each replicate. The treatments were as follows: Treatment 1: Control group without any additions, Treatment 2: basic diet with 10 gm of psyllium seed powder added / kg feed, Treatment 3: basic diet with 15 gm of psyllium seed powder added / kg feed, Treatment 4: basic diet with 20 gm of psyllium seed powder added / kg feed and Treatment 5: basic diet with 25 gm of psyllium seed powder added / kg feed. All the experimental treatments showed a significant decrease ($p \leq 0.05$) in the concentration of cholesterol, triglycerides, low-density lipoproteins (LDL) and very low-density lipoproteins (VLDL) in the yolk when the eggs stored for the periods 0, 15 and 30 days with a significant improvement ($p \leq 0.05$) in the concentration of high-density lipoproteins (HDL) for all supplemented treatments compared to the first treatment (control). The supplemented treatments recorded a significant improvement ($p \leq 0.05$) in the concentration of glutathione, catalase, and superoxide dismutase enzymes and a significant decrease ($p \leq 0.05$) in the concentration of malondialdehyde in the yolk compared to the control treatment.

Keywords: Laying hens, Plantago ovata seeds, lipid profile, oxidation parameters

Introduction

Medicinal plants and their extracts have gained increasing importance at the present time in poultry nutrition, the essence of which lies in the value of their nutritional products and their positive impact on human health [1], in addition to the fact that medicinal plants improve the productive performance of poultry [2]. The widespread use of synthetic antibiotics and growth promoters in animal feed has been

banned by the European Union since 2006. This ban has played an important role in encouraging researchers to find efficient alternatives such as medicinal plants. The purpose of using antibiotics is known to protect animals from diseases, but microorganisms have developed resistance to these antibiotics over time. Therefore, the research trend has been widely directed towards using medicinal plants and herbs in animal feed as an alternative to synthetic antibiotics and promoters [3]. Plantago ovata is one of these important medicinal plants that can be used as feed for ruminants and poultry [4]. The seeds of this plant contain many active compounds that have benefits for animal health and productivity [5]. The biologically active compounds present in its seeds have a remarkable antimicrobial and antioxidant effects and also act as an antiparasitic in broiler chickens [6-9]. On the other hand, it is important in removing free radicals, which prevents meat pigments from oxidation and results in improving the properties and color of meat [4]. The composition of Plantago ovata seeds, rich in fatty acids, amino acids, minerals, vitamins and other useful elements [10], contributes to increasing the nutritional value of meat as well as its contribution to the organic production of meat and eggs [11]. Egg consumption has doubled in the past decades [12], resulting in a significant increase in the demand for laying hens. However, keeping up with this huge increase in consumption faces many challenges. Producers, for example, suffer from a decline in production as chickens aged, which leads to economic losses for the producers. On the other hand, the digestive system of laying hens is also affected, as the weakness of the mucosal cells in the intestinal walls and the shortening of the villi result in a decrease in the efficiency of nutrition associated with a decrease in the absorption of nutrients and a decrease in calcium and phosphorus in the bloodstream [13].

In order to overcome these challenges and due to the great importance of Plantago Ovata seeds, the aim of the current study was to determine the best proportions added to the feed and to study their effect on the lipid profile and oxidation parameters in stored eggs.

Materials and Methods

This study was conducted in a field located at Al-Wardia area, Babylon province, for the period from 20/11/2023 until 10/3/2024, to study the effect of adding different levels of psyllium seed powder (Plantago ovata) to the feed of laying hens on the fat content and oxidation indicators of the eggs produced in day 0, 15, and 30 of the storage period 105 white Lohmann laying hens aged 65 weeks were used in this experiment. Hens were prepared after being fully vaccinated and fed with experimental treatments diet) after week of preparation(adaptation) period to the hall before the start of the experiment. Chickens were randomly distributed at the age of 66 weeks to the treatments in a hall. The hall was equipped with all its requirements during the breeding period and the flock was fed based on the diet shown in Table (1). The experiment included five treatments and each treatment included three replicates with (7) chickens in each replicate. The amount of feed consumed by the chicken was calculated according to what is in the Lohmann White Breeding Guide and the experiment lasted 16 weeks. Psyllium seed powder was mixed with the feed manually until the feed became completely homogeneous.

The experiment included five treatments as follows: The first treatment: a control group free

of any additions. The second treatment: a basic feed with 10 g of psyllium seed powder added / kg of feed. The third treatment: a basic feed with 15 g of psyllium seed powder added / kg of feed. The fourth treatment: a basic feed with 20 g of psyllium seed powder added / kg of feed. The fifth treatment: a basic feed with 25 g of psyllium seed powder added / kg of feed. The experiment included studying the following characteristics: The lipid profile in the yolk includes: Cholesterol in egg yolk, Triglycerides in the yolk, High-density lipoproteins, Low-density lipoproteins and Very-low-density lipoproteins. The Estimation of oxidation parameters in yolk includes: Glutathione, Catalase enzyme, Superoxide dismutase enzyme and Lipid peroxide MDA.

The lipid profile and oxidation parameters in yolk were measured over three storage periods (0, 15 and 30 days) and the experimental data were analyzed using a completely randomized design (CRD) to study the effect of the studied treatments on the different characteristics, and the averages were compared using Duncan's multiple range test to find significant differences between them [14], and the statistical program SAS [15] was used in the statistical analysis.

Table 1. Feed ingredients used in the experiment

Material	**Concentration**
Yellow corn (%)	36.5
Wheat (%)	12
Barley (%)	12.83
Soybean (44% protein) (%)	25.92
Protein [1] (%)	2.5
Limestone (%)	9.25
Vegetable oil (%)	1.0
Sum.	100
Chemical composition [2]	
Energy (kilocalorie/kg feed)	2700
Crude protein (%)	17
Crude fiber (%)	3.68
Calcium (%)	4.13
Phosphorus (%)	0.42
Methionine + cysteine %	0.71
Lysine (%)	0.92
Dietary Cation-Anion Balance (mg/kg)	202.43
Choline (%)	0.17
Folic acid (mg/kg)	0.54
Glycine (%)	0.73

Glycine + serine (%)	1.58
Histidine (%)	0.45
Isoleucine (%)	0.71
Leucine (%)	1.41
Lysine (%)	0.92
Methionine (%)	0.42
Cysteine (%)	0.29
Phenylalanine (%)	0.82
Tyrosine (%)	0.70
Phenylalanine + Tyrosine (%)	1.52
Threonine (%)	0.64
Tryptophan (%)	0.25
Valine (%)	0.80
Arginine (%)	1.07

[1)] Protein concentrate from the Dutch company Profimi. Each kg contains: 5.9% crude protein, 3600 representative energy calories/kg, 6.4% calcium, 5.7% phosphorus, 6.5% sodium, 4000 mg/kg iron, 2800 mg/kg zinc, 600 mg /kg copper, 8.35 mg cobalt, 60 mg/kg iodine, 10 mg/kg selenium, 5.9% methionine, 1.5% lysine 5.9% methionine with cysteine, 1200 mg/kg niacin, 400,000 IU vitamin A, 140,000 IU vitamin D3, 2000 mg/kg E, 100 K, 90 mg/kg vitamin B1, 160 ppb vitamin B2, 200 mg/kg vitamin B6 and 1000 mg/kg vitamin B12.
[2)] The analysis of the entering feed materials was used to calculate the chemical composition [16].

Results and discussion

Table 2 shows the effect of adding psyllium seed powder (Plantago ovata) to the feed of white Lohmann laying hens on the concentration of cholesterol (mg/100g) and triglycerides (mg/100g) in the stored egg yolk, where it is noted that the first treatment (control) recorded the highest concentration for cholesterol in the yolk after storing the eggs for three different periods (0, 15 and 30 days) and with a significant difference ($p \leq 0.05$) from the second, third, fourth and fifth addition treatments, which recorded the lowest concentration of cholesterol in the egg yolk.

Regarding, the concentration of triglycerides, the addition treatments recorded the lowest concentration of triglycerides in the yolk after storing the eggs for different periods (0, 15 and 30 days) and with a significant difference ($p \leq 0.05$) from the first treatment (control), which recorded the highest concentration of triglycerides during the three storage periods, reaching 86.14, 95.45 and 95.23 (mg/100 g), respectively.

Table 2. Effect of adding psyllium seed powder (Plantago ovata) to the diet of white Lohmann laying hens on the concentration of cholesterol (mg/100 g) and triglycerides (mg/100 g) in the yolk after storing the eggs for periods (0-15-30) days (mean ± SE)

Treatments	Cholesterol (mg/100g)			Triglyceride (mg/100g)		
	Day 0	Day 15	Day 30	Day 0	Day 15	Day 30
T1 (control)	381.13 ^{a} ± 1.42	381.80 ^{a} ± 3.21	439.33 ^{a} ± 1.99	86.14 ^{a} ±1.45	95.45 ^{a}± 2.34	95.23 ^{a} ± 2.03
T2	228.80 ^{b} ± 1.82	223.27 ^{b} ± 1.30	242.27 ^{b} ± 1.82	63.46 ^{b} ± 2.56	81.06 ^{b} ±1.86	64.63 ^{b} ±1.73
T3	215.10 ^{c} ± 1.72	223.70 ^{b} ± 2.29	238.97 ^{b} ± 3.14	51.57 ^{c} ± 1.23	61.98 ^{c} ± 3.42	48.97 ^{c} ± 4.46
T5	187.80 ^{d} ± 3.78	221.93 ^{b} ±1.51	222.23 ^{c} ± 1.94	38.18 ^{d} ± 6.49	53.45 ^{cd} ± 6.72	39.27 ^{d} ± 2.37
T5	181.40 ^{d} ± 6.33	208.83 ^{c} ± 2.05	224.77 ^{c} ± 4.95	28.11 ^{d} ± 5.62	49.26 ^{d} ± 1.12	42.80 ^{cd} ±3.02
Significant level	*	*	*	*	*	*

*: There are significant differences between treatments at a significance level of (P≤0.05). T1: control (without addition), T2, T3, T4 and T5 feed with psyllium seed powder of 10, 15, 20 and 25 g/kg, respectively.

Table 3 shows the effect of adding psyllium seed powder to the diet of white Lohmann laying hens on the concentration of high-density lipoproteins, low-density lipoproteins and very low-density lipoproteins (mg/100 g) in egg yolk after storing the eggs for periods of 0, 15 and 30 days. As for the concentration of high-density lipoproteins in the first storage period of 0 days, the results indicate that all addition treatments recorded a significant improvement ($p \leq 0.05$) compared to the first treatment (control) which recorded the lowest concentration of these proteins, while the fifth treatment recorded the highest concentration. In the second (15 days) and third (30 days) periods after storage, the significant improvement ($p \leq 0.05$) continued in all addition treatments for the concentration of high-density lipoproteins compared to the first treatment (control), which recorded the lowest concentration of 57.93 and 55.80

(mg/100 g), respectively, while the fourth and fifth treatments recorded the highest concentration of these proteins in the above two periods, followed by the second and third treatments. As for low-density lipoproteins, it is noted from the results of the statistical analysis that the first treatment (control) recorded the highest concentration of low-density lipoproteins after storing eggs for the periods 0, 15 and 30 days, reaching 299.80, 304.78 and 364.48 (mg/100g), respectively, with a significant difference ($p \leq 0.05$) from the addition treatments, which recorded the lowest concentrations of low-density lipoproteins. Regarding the very low density lipoproteins, the addition treatments recorded the lowest concentration of these proteins with a significant difference ($p \leq 0.05$) from the first treatment (control) which recorded the highest concentration of very low density lipoproteins during the three storage periods 0, 15 and 30 days and reached 17.22, 19.08 and 19.05 (mg/100g) respectively.

Table 3. Effect of adding psyllium seed powder (Plantago ovata) to the feed of white Lohmann laying hens on the concentration of high density lipoproteins, low density lipoproteins and very low density lipoproteins (mg/100g) in the yolk after storing the eggs for the periods (0-15-30) days (mean ± standard error)

Treatments	High-density lipoprotein (HDL) (mg/100g)			low-density lipoproteins (LDL) (mg/100g)			very low-density lipoproteins (VLDL) (mg/100g)		
	Day 0	Day 15	Day 30	Day 0	Day 15	Day 30	Day 0	Day 15	Day 30
T1 (control)	64.10^{b}± 1.36	57.93^{c} ± 1.35	55.80^{c} ±1.42	299.80^{a} ± 2.65	304.78^{a} ± 5.63	364.48^{a} ± 2.09	17.22^{a} ± 0.40	19.08^{a} ± 0.47	19.05^{a}± 0.41
T2	75.84^{c} ± 1.49	68.10^{b} ± 0.65	1.19^{b} ± 65.57	140.27^{b} ± 2.59	138.96^{b} ± 1.83	163.77^{b} ± 2.47	12.69^{b} ± 0.14	16.21^{b} ± 0.77	12.93^{b} ± 0.35
T3	82.11^{bc} ± 4.79	78.10^{a} ± 3.76	2.17^{b} ± 66.62	122.67^{c} ± 1.38	133.20^{b} ± 3.11	162.56^{b} ±0.92	10.31^{c} ± 0.12	12.39^{c} ± 0.68	9.79^{c} ± 0.89
T4	85.02^{ab}± 3.14	81.37^{a}± 0.55	1.71^{a} ± 75.90	95.14^{d} ± 3.63	129.87^{b} ± 6.04	138.48^{c} ± 2.46	7.63^{d} ± 0.71	10.69^{cd} ± 0.54	7.85^{d} ± 0.47
T5	92.68^{a}± 3.35	83.23^{a} ± 0.54	2.04^{a} ± 75.37	83.10^{d} ± 9.42	115.75^{c} ± 2.24	140.84^{c} ± 5.73	5.62^{e} ± 0.86	9.85^{d} ± 0.22	8.56^{cd} ± 0.20
Significant level	*	*	*	*	*	*	*	*	*

*: There are significant differences between treatments at a significance level of (P≤0.05). T1: control (without addition), T2, T3, T4 and T5 feed with psyllium seed powder of 10, 15, 20 and 25 g/kg, respectively.

Adding flavonoids to the poultry diet improves the fat content of eggs by reducing cholesterol and triglyceride levels [17]. Flavonoids present in psyllium seeds reduce the total carbohydrate and glucose content by inhibiting the glycosidic bonds of sugar molecules that are involved in the synthesis of cholesterol, which affects the conversion of Acetyl CoA to cholesterol in the liver [18]. Since cholesterol is involved in the synthesis of sex hormones, increasing the concentration of estrogen can reduce the level of cholesterol in the blood, which may affect the supply of cholesterol for the synthesis of egg yolk [19]. The significant improvement in the lipid profile in the addition treatments compared to the control treatment by reducing the concentration of cholesterol, triglycerides, low-density lipoproteins, and very low-density lipoproteins and increasing the concentration of high-density lipoproteins may be attributed to the presence of vitamin C in psyllium seeds [20], which plays a fundamental role in the metabolism of acids, in addition to its effectiveness in stabilizing fats and protecting them from oxidation and rancidity, and also contributes to preventing the oxidation of lipoproteins [21]. Or the reason for the improvement in the fat profile in egg yolk in psyllium seed treatments may be due to its content of omega-3 and 6 acids [22], which work to reduce the deposition of fat in the yolk by increasing the metabolism of fats inside the liver and consuming them for energy instead of depositing them inside the chicken body, which in turn works to reduce the concentration of fats in the yolk, which leads to an improvement in the physiological condition [23].

The results of the statistical analysis in Table 4 indicated the effect of adding psyllium seed powder (Plantago ovata) to the feed of white Lohmann laying hens on the oxidation parameters of glutathione concentration, catalase enzyme, superoxide dismutase enzyme, and malondialdehyde concentration Aldehyde (micromoles/mol) in the yolk after storing eggs for periods 0, 15 and 30 days (mean ± standard error). The results of the study on the concentration of glutathione during the first period of storage (0 days) showed a significant improvement ($p \leq 0.05$) for the second, third, fourth and fifth addition treatments compared to the first treatment (control) which recorded the lowest concentration of glutathione reaching 26.50 (micromoles/mol), while in the second period of storage (15 days), all addition treatments continued to enhance with a significant improvement ($p \leq 0.05$) in the concentration of glutathione where the fourth and fifth treatments recorded the highest concentration of glutathione reaching 50.80 and 51.77 (micromoles/mol) respectively followed by the second and third treatments, while the first treatment (control) recorded the lowest concentration reaching 20.32 (micromoles/mol). Regarding the third storage period (30 days), all addition treatments were significantly superior ($p \leq 0.05$) compared to the first treatment (control) which recorded the lowest concentration of glutathione reaching 13.40 (micromol/mol), while the fourth and fifth treatments recorded the highest concentration reaching 49.00 and 45.37

(micromol/mol), respectively. Considering the concentration of the catalase enzyme in egg yolk, it is noted that in the first storage period (0 days), all addition treatments recorded a significant improvement ($p \leq 0.05$) compared to the first treatment (control), as the fourth and fifth treatments recorded the highest concentration of this enzyme, while the first treatment (control) recorded the lowest concentration of it reaching 31.73 (micromol/mol). In the second (15 days) and third (30 days) storage periods, the significant improvement in the concentration of the catalase enzyme continued for all addition treatments. Compared to the first treatment (control), which also recorded the lowest concentration of this enzyme during these two periods. The results of the concentration of the enzyme superoxide dismutase in egg yolk in the first period (0 days) of storage indicate that the second, third, fourth and fifth addition treatments recorded a significant improvement ($p \leq 0.05$) compared to the first treatment (control), as the fifth treatment recorded the highest concentration of the enzyme, reaching 71.68 micromol/mol, while the first treatment (control) recorded the lowest concentration of this enzyme, reaching 39.72 micromol/mol. On the other hand, in the second and third periods (15 and 30 days) of storage, there was a significant superiority ($p \leq 0.05$) for all addition treatments, as the fourth and fifth treatments recorded the highest enzyme concentration, followed by the second and third treatments. The first treatment (control) recorded the lowest concentration, reaching 31.42 and 27.03 (micromol/mol) during these two periods, respectively. While the results of the statistical analysis in the same table for the concentration of malondialdehyde in egg yolk showed that the first treatment (control) recorded the highest concentration of the compound in the three storage periods (0, 15 and 30 days) with a significant difference ($p \leq 0.05$) from all addition treatments amounting to 0.036, 0.059 and 0.066 (micromol/mol) respectively, while the fifth treatment recorded the lowest concentration of malondialdehyde during these periods amounting to 0.021, 0.020 and 0.027 (micromol/mol) respectively.

Table 4. Effect of adding psyllium (Plantago ovata) seed powder to the diet of white Lohmann laying hens on the oxidation parameters of glutathione concentration, catalase enzyme, superoxide dismutase enzyme, and malondialdehyde concentration in the yolk after storing the eggs for periods (0-15-30) days (mean ± standard error)

Treatments	Glutathione in egg yolk (µmol/mol)			Catalase enzyme in egg yolk (µmol/mol)			superoxide dismutase in egg yolk (µmol/mol)			malondialdehyde in egg yolk (µmol/mol)		
	Day 0	Day 15	Day 30	Day 0	Day 15	Day 30	Day 0	Day 15	Day 30	Day 0	Day 15	Day 30
T1 (control)	26.50^{c} ± 1.25	20.32^{d} ± 1.20	13.40^{c} ± 0.84	31.73^{c} ± 0.64	26.40^{e} ± 1.81	25.00^{c} ± 0.93	39.72^{d} ± 2.13	31.42^{d} ± 1.55	27.03^{e} ± 1.02	0.036^{a} ± 0.004	0.059^{a} ± 0.002	0.066^{a} ± 0.001
T2	35.97^{b} ± 1.41	27.81^{c} ± 2.02	28.87^{b} ± 5.41	57.83^{b} ± 0.86	41.27^{d} ± 0.45	40.80^{b} ± 4.21	52.95^{c} ± 0.80	44.16^{c} ± 2.01	36.47^{d} ± 0.90	0.026^{b} ± 0.002	0.044^{b} ± 0.001	0.053^{b} ± 0.003
T3	41.21^{b} ± 5.73	41.44^{b} ± 0.54	33.03^{b} ± 4.75	62.97^{b} ± 4.80	48.63^{c} ± 0.72	48.63^{b} ± 4.21	59.75^{b} ± 2.64	53.32^{b} ± 5.17	45.70^{c} ± 0.55	0.027^{b} ± 0.002	0.030^{c} ± 0.002	0.036^{c} ± 0.001
T4	61.18^{a} ± 1.51	50.80^{a} ± 1.09	49.00^{a} ± 1.86	79.73^{a} ± 2.37	62.73^{b} ± 0.64	59.27^{a} ± 2.23	64.65^{b} ± 2.36	66.57^{a} ± 0.57	53.30^{b} ± 1.80	0.024^{b} ± 0.001	0.022^{d} ± 0.003	0.030^{cd} ± 0.001
T5	65.47^{a} ± 2.25	51.77^{a} ± 3.72	45.37^{a} ± 2.34	80.50^{a} ± 2.76	70.63^{a} ± 4.02	66.37^{a} ± 1.51	71.68^{a} ± 0.55	66.27^{a} ± 1.43	58.47^{a} ± 2.57	0.021^{b} ± 0.001	0.020^{d} ± 0.001	0.027^{d} ± 0.004
Significant level	*	*	*	*	*	*	*	*	*	*	*	*

*: There are significant differences between treatments at a significance level of (P≤0.05). T1: control (without addition), T2, T3, T4 and T5 feed with psyllium seed powder of 10, 15, 20 and 25 g/kg, respectively.

The reason for the improvement in the psyllium seed treatments in the concentration of glutathione, superoxide dismutase and catalase, which are major antioxidants that protect cells from reactive oxygen species, as each enzyme plays an integral role in adjusting the redox balance [24]. The decrease in the concentrations of these antioxidants and the increase in the concentration of malondialdehyde in the egg yolk of the first treatment (control) during the three storage periods and the increase in the concentration of these antioxidants and the decrease in the concentration of malondialdehyde in all addition treatments may be due to the seeds containing many active compounds that act as natural antioxidants that support the oxidation system within the body. The most important of these compounds are flavonoids, phenols and sugars, as phenolic compounds work to reduce cellular oxidative stress by inhibiting the action of free radicals and thus restricting their action in damaging cell membranes, in addition to enhancing the oxidation system and that the unsaturated fatty acids in the egg yolk are exposed to fat oxidation due to the length of the chain during storage period and high ambient temperature [25], and in order to delay the oxidation of fats in poultry products, the chicken diet should be supplemented with natural antioxidant compounds [26] and that fat oxidation is the main mechanism for the decrease in egg yolk fat [27] as the biomarker of fat oxidation is malondialdehyde, which is the most effective measure of oxidative stress, and its increase is generally considered a pathological condition, so stress indicators should be reduced by consuming foods containing natural antioxidants [28]. The phenolic compounds work to restrict and inhibit the malondialdehyde compound and form more stable compounds [29] as fat oxidation can lead to increased production and accumulation of free radicals or reactive oxygen species directly or by reducing the cell's ability to eliminate reactive oxygen species, which causes oxidative stress in cells [30]. Or perhaps the reason for the improvement in the concentrations of the studied antioxidants is due to the role of vitamin E found in psyllium seeds [31, 32, 33], as when the concentrations of antioxidants decrease, lipid peroxidation increases in tissues and plasma, leading to damage to cell membranes, and vitamin E is the main fat-soluble antioxidant that breaks the chain of lipid peroxidation reactions, and through its activity in quenching free radicals, it breaks the spread of the chain and thus ends the attack of free radicals at an early stage, and such an effect of vitamin E on polyunsaturated fatty acids of biofilms. The presence of vitamin E in the diet of laying hens through its presence in psyllium seeds leads to enhancing the antioxidant capacity in eggs [34, 35,36,37].

Conclusions

Adding different levels of psyllium seed powder as a natural antioxidant to the diet of laying hens improved the lipid profile, glutathione, catalase and superoxide dismutase concentrations, reduced the level of malondialdehyde in the yolk and protected it from oxidation after storing the eggs for three different periods of time.

Acknowledgment: The authors are grateful to the college of agriculture, Al-Qasim Green University.

References

[1] Zheng M; Mao P; Tian X and Meng L. 2019. Growth performance, carcass characteristics, meat and egg quality, and intestinal microbiota in Beijing-you chicken on diets with inclusion of fresh chicory forage. Ital J Anim Sci. 18(1): 1310–1320.

[2] Pliego, Alberto Barbabosa; Masoomeh Tavakoli; Ameer Khusro; Alireza Seidavi; Mona M. M. Y. Elghandour; Abdelfattah Z. M. Salem; Ofelia Márquez-Molina and Raymundo Rene Rivas-Caceres. 2020. Beneficial and adverse effects of medicinal plants as feed supplements in poultry nutrition: a review, Animal Biotechnology, DOI: 10.1080/10495398.2020.1798973

[3] Selaledi AL; Hassan MZ; Manyelo TG; Mabelebele M. 2020. The current status of the alternative use to antibiotics in poultry production: an African perspective. Antibiotics. 9(9):594–612.

[4] Redoy MR; Shuvo AA; Cheng L and Al-Mamun M. 2020. Effect of herbal supplementation on growth, immunity, rumen histology, serum antioxidants and meat quality of sheep. Animal. 14(11):2433–2441.

[5] Yap KH; Yee G; Candasamy M; Md S; Majeed A and Bhattamisra S. 2019. Effect of catalpol on liver glucose homeostasis in high fat diet/low dose streptozotocin-induced type 2 diabetes mellitus. Br J Pharmacol. 176:3051–3052.

[6] Ferrazzano GF; Cantile T; Roberto L; Ingenito A; Catania MR, Roscetto E; Palumbo G; Zarrelli A and Pollio A. 2015. Determination of the in vitro and in vivo antimicrobial activity on salivary Streptococci and Lactobacilli and chemical characterization of the phenolic content of a Plantago lanceolata infusion. Biomed Res Int. 2015:286817.

[7] Pena-Espinoza M; Valente AH; Thamsborg SM; Simonsen HT; Boas U; Enemark HL; Lopez-Munoz R and Williams AR. 2018. Antiparasitic activity of chicory (Cichorium intybus) and its natural bioactive compounds in livestock: a review. Parasit Vectors. 11(1):475–489.

[8] Boamah V; Agyare C; Odoi H and Dalsgaard A. 2016. Practices and factors influencing the use of antibiotics in selected poultry farms in Ghana. J Antimicrobiol. 2(2):120–128.

[9] Hammami S; Debbabi H; Jlassi I; Joshi RK and Mokni RE. 2020. Chemical composition and antimicrobial activity of essential oil from the aerial parts of Plantago

afra L. (Plantaginaceae) growing wild in Tunisia. S Afr J Bot. 132: 410–414.

[10] Romero-Baranzini, A.L.; Rodriguez, O.G.; Yanez-Farias, G.A.; Barron-Hoyos J.M. and Rayas-Duarte, P. 2006. Chemical, Physicochemical, and Nutritional Evaluation of Plantago (Plantago ovata Forsk). Cereal Chemistry, 83: 358-362. https://doi.org/10.1094/CC-83-0358

[11] Li Chang Xing; Dhanasikar Santhi; Abdul Ghaffar Shar; Muhammad Saeed; Muhammad Asif Arain; Akhtar Hussain Shar; Zohaib Ahmed Bhutto; Mohib Ullah Kakar; Robina Manzoor; Mohamed E. Abd El-Hack; Mahmoud Alagawany; Kuldeep Dhama and Mo Chen Ling. 2017. Psyllium Husk (Plantago ovata) as a Potent Hypocholesterolemic Agent in Animal, Human and Poultry. International Journal of Pharmacology, 13: 690-697.

[12] Zaheer, K. 2015. An Updated Review on Chicken Eggs: Production, Consumption, Management Aspects and Nutritional Benefits to Human Health. Food and Nutr. Sci. 6:1208 – 1220.

[13] Foley, Josephine. 2021. The Effects of Different Feed Supplements on Performance Parameters, Egg Measurements, and Eggshell Integrity in Older White Leghorn Laying Hens. Theses and Dissertations in Animal Science. 215. https://digitalcommons.unl.edu/animalscidiss/215

[14] Duncan, D. B. 1955. Multiple range and multiple F-tests. Biometrics 11, l - 42.

[15] Statistical Analysis System SAS. Statistical. Ninth Edition. USA, Cary, N.C. SAS Institute, Inc. 2012.

[16] Amy Batal and Nick Dale. 2016. Feed stuffs Ingredient Analysis, Edition Prepared by Amy Batal and Nick Dale ; Sanderson Farms; University of Georgia, Athens, Ga.

[17] Sudhanya Nath and Aravindkumar K. 2021. Role of Flavonoids in Poultry Nutrition. Acta Scientific Veterinary Sciences 3.12: 88-91

[18] Zhang BW; Li X; Sun WL; Xing Y; Xiu ZL; Zhuang CL and Dong YS. 2017. Dietary Flavonoids and Acarbose Synergistically Inhibit α-Glucosidase and Lower Postprandial Blood Glucose. J Agric Food Chem. 2017 Sep 27;65(38):8319-8330. doi: 10.1021/acs.jafc.7b02531. Epub 2017 Sep 15. PMID: 28875706.

[19] Prapassara Kan;ai, Vorasak Patchimasiri; Soontaranee Tongyai; Arunee Engkagul and Chanin Tirawattanawanich. 2004. The Effects of White Kwao Krua (Pueraria Mirifica) on Serum Lipid Profile, EggYolk Cholesterol Levels, and Egg Production in Laying Hens. Agriculture and

Natural Resources 38 (5). Bangkok, Thailand: 78-83. https: //li01.tci-thaijo.org/index.php/anres/ article/view/243215

[20] El-Dreny, E.; Shaheen, M. and Shaban, H. 2023. Anti-obesity Influence of Psyllium (Plantago ovate) and Chia (Salvia hispanica L.) Seeds on Rats Fed a High-Fat Diet, *Food Technology Research Journal*, 1(3), pp. 20-31. doi: 10.21608/ftrj.2023.300612

[21] Spitzer, V. 2007. Vitamin basics. The facts about vitamins in nutrition. DSM Nutritional products. 3rd ed., printed in Germany.

[22] Cowley, J.M.; O'Donovan, L.A. and Burton, R.A. 2021. The composition of Australian Plantago seeds highlights their potential as nutritionally-rich functional food ingredients. *Sci Rep* 11, 12692.

[23] Qassim, Al-Hassan A.; Luma K. Bandr and Firas M. Alkalani. 2022. Effect of Using Avocado and Chia Oil and their Mixture in Meat Broiler Diets on Some Physiological and Microbial Characteristics of Blood Plasma. NeuroQuantology.20(4):233-234.

[24] Lim'on-Pacheco, J. and Gonsebatt, M.E. 2009. The role of antioxidants and antioxidant-related enzymes in protective responses to environmentally induced oxidative stress. Mutat. Res., 674, 137–147.

[25] Martino, G.; Haouet, M.N.; Marchetti, S.; Grotta, L. and Ponzielli, V. 2014. Effect of vitamin E supplementation on egg yolk quality and oxidative stability. Asian J. Agric. Food Sci., 2, 248–254.

[26] Xie, T.; Bai, S.P.; Zhang, K.Y.; Ding, X.M.; Wang, J.P.; Zeng, Q.F.; Peng, H.W.; Lu, H.Y.; Bai, J. and Xuan, Y. 2019. Effects of Lonicera confusa and Astragali radix extracts supplementation on egg production performance, egg quality, sensory evaluation, and antioxidative parameters of laying hens during the late laying period. Poult. Sci. 2019, 98, 4838–4847.

[27] Goliomytis, M.; Orfanou, H.; Petrou, E.; Charismiadou, M.; Simitzis, P.; Deligeorgis, S. 2014. Effect of hesperidin dietary supplementation on hen performance, egg quality and yolk oxidative stability. Braz. J. Poult. Sci., 55, 98–104.

[28] Tsikas, D. 2017. Assessment of lipid peroxidation by measuring malondialdehyde (MDA) and relatives in biological samples: Analytical and biological challenges. Analytical biochemistry, 524: 13-30.

[29] Zamora, R.; Alcon, E. and Hidalgo, F. J. 2023. Malondialdehyde trapping by food phenolics. Food chemistry, 417: 135915.

[30] Cano-Gutiérrez, G.; Acevedo-Nava, S.; Santamaría, A.; Altamirano Lozano, M.; Cano-Rodríguez, M.C. and Fortoul, T.I. 2012. Hepatic megalocytosis due to vanadium inhalation: Participation of oxidative stress. Toxicol. Ind. Health, 28, 353–360.

[31] Shahid, M.S.; Zhou, S.; Nie,W.; Wang, L.; Lv, H. and Yuan, J. 2022. Phytogenic Antioxidants Prolong n-3 Fatty Acid-Enriched Eggs' Shelf Life by Activating the Nrf-2 Pathway through Phosphorylation of MAPK. Foods 2022, 11, 3158. https://doi.org/10.3390/foods11203158

[32] Wen Jiang; Licong Zhang and Anshan Sha. 2013, The effect of vitamin E on laying performance and egg quality in laying hens fed corn dried distillers grains with solubles, Poultry Science, Volume 92, Issue 11, Pages 2956-2964, ISSN 0032-5791, https://doi.org/10.3382/ps.2013-03228.

[33] Zhao, H.; Chen, Y.; Wang, S.; Wen, C., and Zhou, Y. 2021. Effects of dietary natural vitamin E supplementation on laying performance, egg quality, serum biochemical indices, tocopherol deposition and antioxidant capacity of laying hens. Italian Journal of Animal Science, 20(1), 2254–2262.

[34] Al-Jebory HH, Al-Saeedi MKI, Ajafar M, Nihad Abdul-Lateef Ali .2024. Impact of melatonin on improving productive traits of broiler exposed to environmental stress. Adv. Anim. Vet. Sci. 12(4): 775-781.

[35] Galib A. Al-Kaissy; Hasan S.A. Jawad; Nihad Abdul-Lateef Ali and Ihsan H. Al-Timimi.2023. Protein Replacers in Poultry Diets. Revis Bionatura .8 (2) 78. http://dx.doi.org/10.21931/RB/CSS/2023.08.02.78 .

[36] Hamzah Merzah, L. and Abdul-Lateef Ali, N.2022. Effect of Adding Different Levels of Maca Root (Lepidium Meyenii) to the Diet on the Productive Performance of Broilers Exposed to Oxidative Stress. Archives of Razi Institute, Vol. 77, No. 4 (2022) 1357-1364 .

[37] Layth Hamzah Merzah and Nihad Abdul-Lateef Ali.2023. Different Diets of Maca Roots (Lepidium meyenii) Affect Several Physiological Blood Characteristics of Broiler Chickens Under Oxidative Stress. IOP Conf. Series: Earth and Environmental Science.1: 9 .