Adding Gum Arabic powder at different levels to the diet of older laying hens and its effect on lipid levels and oxidation parameters in eggs

Ebrahem Hamza Yasser1 * Nihad Abdul-Lateef Ali 2
1,2Department of Animal Production, College of Agriculture, Al-Qasim Green University, Iraq.
1E-mail address: ebrahemh606@gmail.com
2E-mail address: dr.nihad@agre.uoqasim.edu.iq

Abstract

This study was conducted in the fields of Babylon Governorate, and the field experiment lasted 140 days. The study aimed to Adding Gum Arabic powder at different levels to the diet of older laying hens and its effect on lipid levels and oxidation parameters in eggs. A total of 105 lohmann laying hens were raised at the ages of 65 weeks, 65-68 weeks, 69-72 weeks, 73-76 weeks, 77-80 weeks and 81-84 weeks. 15 groups were distributed into 5 experimental treatments consisting of 21 birds. The treatment included three replicates containing seven birds. The experimental treatments were as follows: Treatment 1: Control treatment. Treatments 2, 3, 4, and 5 added Gum Arabic powder at concentrations of 15, 20, 25, and 30 g/kg feed, respectively. Results showed that Gum Arabic supplementation sig. reduced yolk concentration of cholesterol, triglycerides, low-density lipoproteins (LDL), and very low-density lipoproteins (VLDL) in egg yolks at 0 and 15 days of storage under normal conditions and 15 days of refrigerated storage compared to the first treatment (control), with an improvement in the concentration of high-density lipoproteins (HDL). In addition, the treated groups exhibited significantly lower levels of free fatty acids, peroxide values, and malondialdehyde compared to the control, indicating improved oxidative stability. These findings suggest that Gum Arabic, due to its antioxidant and functional bioactive components, is an effective natural feed additive for enhancing egg quality and shelf life in aged laying hens

Keywords: Keywords: Gum Arabic, lipid profile, oxidative stability, egg storage, laying hen .
***Research paper from PHD thesis for the first author.**

Introduction

Eggs are one of the most important foods for humans due to their rich and balanced nutritional composition. [11]They are a major source of proteins with high biological value, containing all the essential amino acids the body needs for growth and regeneration. Additionally, eggs contain a wide range of vitamins and minerals, making them a complete food that contributes to supporting various bodily functions. The egg industry adheres to strict veterinary health and safety standards to ensure that eggs are free of disease and contaminants. [20] This makes the final product safe and healthy for consumption and ensures the provision of high-quality eggs [18].It is well known that the aging of laying hens leads to a significant decrease in egg production. This decrease is linked to several factors, the most important of which is the increased accumulation of free radicals in the bird's body. [21,17] Free radicals are unstable molecules that are naturally produced during metabolic processes, but their increase leads to cell and tissue damage, which negatively affect production efficiency, exposing it to increased levels of oxidative stress and a decrease in the activity of antioxidant enzymes [9]. This can affect the health of the cells

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responsible for egg production in the ovary, as cell damage and a decline in their efficiency due to oxidative damage leads to a decrease in the productive capacity of the ovary and thus reduces egg production, in addition to a decrease in the immunity of birds [23] This has prompted most researchers and agricultural animal producers to use food additives and bio-alternatives such as herbs, medicinal plants, enhancers, and bio-precursors due to their strong antioxidant activities and nutritional properties that enhance growth and improve the immune and health status, as they contain many active compounds [22] that contribute to reducing the impact of oxidative stress and free radicals. These include: Gum Arabic is a polysaccharide that can be used in poultry diets [11]. It is obtained from Acacia Senegal trees found in Central and West Africa [24]. It is an edible dried secretion and is widely regarded as a safe and natural food additive. It is a natural biomaterial because it contains high molecular weight glycoproteins, which are carbohydrate groups with peptide chains, in addition to containing organic materials, amino acids, and minerals, including calcium [13]. One study showed that adding gum Arabic to laying hens' diets resulted in a significant decrease in serum cholesterol concentrations, triglycerides, and liver enzymes. A significant improvement was also found in the level of albumin, globulin, and calcium in the blood serum [10]. Gum Arabic has anti-inflammatory and antioxidant properties by increasing enzyme activity. Superoxide dismutase, catalase, and glutathione peroxidase in blood serum, as Gum Arabic prevents oxidative stress by activating these enzymes [1]. The antioxidant capacity of Gum Arabic against reactive oxygen species comes from its content of amino acids such as cysteine, tyrosine, histidine, and methionine [26]. Gum Arabic also plays a role in increasing glutathione levels and limits the accumulation of malondialdehyde and mitigates the generation of superoxide radicals. which led to a decrease in oxidative stress [7]. As a result of the above and given the great importance of Gum Arabic, the aim of the current study was to demonstrate the effect of Gum Arabic on egg production indicators, and to demonstrate the evaluation of Gum Arabic in the form of fats and oxidation in egg yolks after storage. and to evaluate the optimal level of adding Gum Arabic powder to feed in terms of its impact on the study criteria.

Materials and Methods

The field experiment of this study, which was conducted in Babylon fields, lasted for 140 days, starting on 26, 10, 2024, and ending on 14, 3, 2025. The study aimed to investigate the effect of adding Gum Arabic powder at different levels to the feed of old laying hens in improving the lipid profile and oxidation parameters in table eggs A total of 105 Lohmann laying hens were reared to 65 weeks of age, with a 2-week introductory period, and divided into 5 groups (65-68, 69-72, 73-76,77-80 and 81-84) weeks. They were divided into 15 replicates in a randomized order and administered according to the standard guidelines described in the Lohmann-Brown manual, with 5 experimental treatments per treatment, 21 birds. Each treatment included three replicates, each containing seven birds. The experimental treatments were as follows: Treatment 1: Control treatment. Treatments 2, 3, 4, and 5 added Gum Arabic powder at concentrations of 15, 20, 25, and 30 g/kg feed, respectively. The chickens were prepared after

being fully vaccinated and fed with the food treatments. After a two week of rearing as a preparatory period and adaptation to the hall before starting the experiment, where no data were collected, the chickens were randomly distributed into 15 replicates, and each replicate had 7 chickens at the age of 65 weeks on the treatments. Pyramid pens (Pens) with a pen area of (2×2) m2 containing (6) batteries, each battery containing (5) cages with dimensions of each cage of (40×40) cm2. The cages were equipped with automatic cage nipple outlets for drinking water, and in each cage (2) nipples were fixed on top of the cage. As for feeding, it was done manually in longitudinal feeders. The hall was equipped with all its requirements during the breeding period. The amount of feed consumed by the chicken was calculated according to the bird (115 g/chicken/day). The lighting system was used: 16 hours of light, 8 hours of darkness, and 4 watts/m2, according to the recommendations in the bird's guide. The temperature in the hall was recorded throughout the experiment daily (at eight o'clock in the morning and evening) using (4) thermometers placed at the ends of the hall and in the middle of the hall, where electric heaters were used to heat the hall. The experiment included the study of the following characteristics: cholesterol, triglycerides, high-density lipoproteins, low-density lipoproteins, very low-density lipoproteins,free fatty acid content, peroxide value, and malondialdehyde. The lipid profile and oxidation parameters of egg yolks stored over two periods (0, 15 under normal conditions and refrigerated) days were measured. A completely randomized design was used to study the effect of different treatments on the studied characteristics. Significant differences between means were compared using Duncan's multiple range test [6], and the ready-made statistical program SAS [27] was used for data analysis.

Table 1: Production feed used in the experiment

Feed material	**(%)**
Yellow Corn	55
Bran	5.5
Soybean Meal (46% Protein)	24
Protein Premix 2.5%	2.5
Vegetable Oil	1.3
Limestone	10.85
Di calcium phosphate (DCP)	50.
Methionine %	0.1
Lysine %	0.05
Salt	0.1
Antitoxin	0.1
Total	100
The Chemical analysis**	
The Representative energy (kilocalorie/kg feed)	2723
Crude protein (%)	16
Calcium (%)	4
Available phosphorus (%)	0.37
Methionine (%)	0.39

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Lysine (%)	0.9
Threonine (%)	0.54
Salt (%)	0.31
Fiber (%)	3.8

Protein premix from the Dutch company Provime, each kg contains: 5.9% crude protein, 3600 kcal metabolized energy/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 meg/kg Vitamin B12.

**Chemical composition calculated based on [16 .[

Results and discussion

Table 2 Cholesterol and Triglycerides illustrates effect of supplementing aged laying hens' diets with different levels of Gum Arabic powder. The statistical analysis indicated that all addition treatments recorded a significant reduction (P≤0.05) in cholesterol concentrations in comparison with the control group in under normal and refrigeration conditions, The highest cholesterol levels were recorded in the control group, reaching 384.63, 464.37, and 385.46 mg/100g in under normal and refrigeration conditions, respectively. The fifth treatment (30 g/kg feed) recorded the lowest cholesterol levels among all groups. As for triglycerides, the third, fourth, and fifth treatments showed a significant decrease (P≤0.05) compared to the control group and the second treatment, which recorded significantly higher triglyceride levels on day 0. At 15 days of storage under both normal and refrigerated conditions, all supplemented groups exhibited significantly lower triglyceride levels compared to the control, with the fifth treatment being the most effective

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Table 2: Adding Gum Arabic powder at different levels to the feed of older laying hens affected the cholesterol and triglyceride concentrations (mg/100g) in the yolk after storing the eggs for periods (0 and 15 days under normal conditions and in refrigeration) (mean ± standard error

*means that there are significant differences between the treatments at the significance level

Treatments	Cholesterol concentration (mg/100g)			Triglyceride concentration (mg/100g)		
	First period days0	Second period: 15 days		First period days0	Second period: 15 days	
		normal conditions	cooling conditions		normal conditions	cooling conditions
First Treatment	384.63 ± 5.68 a	464.37 ± 14.81 a	385.46 ± 4.87 a	92.64 ± 14.79 a	109.20 ± 1.99 a	93.91± 2.16 a
Second Treatment	252.20 ± 22.22 b	285.03 ± 4.33 b	276.86 ± 2.10 b	80.34± 2.80 a	91.66 ± 2.33 b	81.62 ± 3.13 b
Third Treatment	230.20± 5.90 b	261.37± 7.67 c	267.03 ± 8.56 b	68.28 ± 2.97 b	85.60 ± 5.23 b	57.53± 6.56 c
Fourth Treatment	196.33 ± 1.56 c	254.83± 4.01 c	275.26 ± 6.31 b	61.95± 3.27 b	69.43 ± 2.35 c	68.11 ± 5.94 c
Fifth Treatment	190.50± 4.57 c	243.10 ± 9.58 c	245.50 ± 5.20 c	55.50± 0.63 c	59.63 ± 8.54 c	48.21 ± 1.14 d
Significance Level	*	*	*	*	*	*

(P≤0.05).T 1 (control), T2, T3, T4, and T5 treatments: Adding Gum Arabic powder at concentrations of 15, 20, 25, and 30 g/kg feed, respectively.

Table 3 Lipoprotein Fractions (HDL, LDL, and VLDL) shows the effects of Gum Arabic supplementation on high-density lipoproteins (HDL), low-density lipoproteins (LDL), and very low-density lipoproteins (VLDL). The results all treated groups show significantly increased HDL levels (P≤0.05) compared to the control across all storage periods. The fifth treatment consistently yielded the highest HDL concentrations, indicating improved lipid profiles in the egg yolk. On the other hand, LDL and VLDL concentrations were significantly lower (P≤0.05) in all Gum Arabic-treated groups compared to the control during storage at both normal and refrigerated conditions. This indicates the effectiveness of Gum Arabic in reducing unhealthy lipoproteins, thus enhancing the nutritional quality of eggs .

Table 3: Adding Gum Arabic powder at different levels to the diet of older laying hens affects the concentration of high-density lipoproteins, low-density lipoproteins, and very low-density lipoproteins (mg/100g) in the yolk after storing the eggs for periods (0 and 15 days under normal conditions and in refrigeration) (mean ± standard error(

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Treatments	(HDL)High-density lipoprotein (mg/100g)			(LDL) low-density lipoproteins (mg/100g)			(VLDL)very low-density lipoproteins (mg/100g)		
	First period 0 days	Second period: 15 days		First period 0 days	Second period: 15 days		First period 0 days	Second period: 15 days	
		normal conditions	cooling conditions		normal conditions	cooling conditions		normal conditions	cooling conditions
First Treatment	71.24 ± 1.19 d	61.34 ± 6.41 b	50.10 ± 3.15 d	294.87 ± 3.08 a	381.19 ± 13.83 a	316.58 ± 5.10 a	18.52 ± 0.35 a	21.84± 0.39 a	18.78 ± 0.43 a
Second Treatment	82.77± 2.64 c	69.04 ± 3.41 b	79.06 ± 2.46 c	153.37± 21.97 b	197.66 ± 4.57 b	181.48± 2.18 b	16.06± 0.55 b	18.33 ± 0.26 b	16.32 ± 1.02 b
Third Treatment	86.94± 2.91 b c	80.38± 1.13 a	86.83 ± 2.69 b	129.60 ± 6.81 b	163.86 ± 8.37 c	168.70 ± 1.51 c	13.65 ± 0.59 c	17.12 ± 1.04 b	11.50 ± 0.31 c
Fourth Treatment	91.19± 1.43 a b	85.03 ± 2.73 a	93.70 ± 6.36 a b	92.75± 3.23 c	155.92 ± 4.35 c	167.94 ± 4.65 c	12.39± 0.25 c d	13.88 ± 0.47 c	13.62 ± 1.18 c
Fifth Treatment	95.79 ± 3.20 a	86.39 ± 3.06 a	94.56 ± 0.82 a	83.61± 8.78 c	144.79 ± 9.67 c	141.30 ± 3.50 d	11.10± 0.12 d	11.92 ± 1.50 c	9.64± 3.34 c
Significance Level	*	*	*	*	*	*	*	*	*

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means that there are significant differences between the treatments at the significance level (P≤0.05).T 1 (control), T2, T3, T4, and T5 treatments: Adding Gum Arabic powder at concentrations of 15, 20, 25, and 30 g/kg feed, respectively.

The observed improvements in lipid profile are likely attributed to the bioactive compounds in Gum Arabic, especially flavonoids and phenolic compounds, which have been reported to stimulate thyroid function and increase thyroxin secretion. [14]. this enhances cholesterol metabolism and utilization, reducing its accumulation. Additionally, the soluble fiber in Gum Arabic may bind bile acids, reducing cholesterol reabsorption and promoting its excretion [15]. This means that the added factors maintain the stability of the fat in the body, thus reducing the oxidation and rancidity of fats in the egg

yolk. As a result, antioxidants such as astaxanthin, lycopene, and beta-carotene, as well as phenols and flavonoids found in Gum Arabic [12, 26[

The reduction in FFA, PV, and MDA levels highlights the antioxidant potential of Gum Arabic. This may be due to its content of phenolic compounds, carotenoids, vitamin C, and tocopherols, which are known to inhibit lipid oxidation and free radical formation. [7]. that the decrease in low-density lipoprotein (LDL) may be attributed to the phenolic compounds present in Gum Arabic, which have activities that alter cholesterol metabolism in the liver [21]. These phenolic compounds may provide a protective effect against low-density lipoprotein (LDL) oxidation. In addition, phenolic and flavonoid compounds prevent LDL oxidation by inhibiting Coenzyme A (Hydroxy-3-Methylglutaryl-3-CoA), an enzyme that plays an important role in cholesterol synthesis and may have an effect on the composition of fatty acids, cholesterol, LDL, and triglycerides in egg yolk [2.[

We note from Table 4 that adding Gum Arabic powder at different levels to the diet of older laying hens in free fatty acids (FF.A)%, peroxide value (P.V) in mill equivalents/kg, and malondialdehyde (MDA) concentration (Thiobarbituric acid T.B.A) in the yolk after storing the eggs for periods (0 and 15 days under normal conditions and refrigeration) (arithmetic mean ± standard error). All addition treatments recorded a significant decrease ($P \leq 0.05$) in the percentage of fatty acids, peroxide value, and malondialdehyde concentration in the yolk compared to the first treatment (control), which recorded the highest percentage of fatty acids, peroxide value, and malondialdehyde concentration in the yolk during periods (0 and 15 days under normal conditions and refrigeration.(

Table 4: Adding Gum Arabic powder at different levels to the diet of older laying hens in the percentage of free fatty acids (FF.A)%, peroxide value (P.V) milliequivalents/kg, and malondialdehyde concentration (T.B.A) micromol/mol in the yolk after storing the eggs for periods (0 and 15 days under normal conditions and in refrigeration) (mean ± standard error(

Treatments	Free fatty acids %			Peroxide value mEq/kg		Malondialdehyde (µmol/mol)			
	First period 0 days	Second period: 15 days		First period 0 days	Second period: 15 days	First period 0 days		Second period: 15 days	
		normal conditions	cooling conditions		normal conditions	cooling conditions		normal conditions	cooling conditions

First Treatment	0.626 ± 0.006 a	0.915 ± 0.006 a	0.864 ± 0.031 a	0.668± 0.002 a	1.339 ± 0.009 a	1.181 ± 0.002 a	0.337± 0.006 a	0.620 ± 0.020 a	0.551 ± 0.034 a
Second Treatment	0.583 ± 0.005 b	0.746 ± 0.007 b	0.638 ± 0.022 b	0.553 ± 0.005 b	1.047 ± 0.004 b	0.685± 0.005 b	0.211± 0.004 b	0.451 ± 0.013 b	0.421 ± 0.029 b
Third Treatment	0.329 ± 0.004 c	0.607 ± 0.014 c	0.440 ± 0.026 c	0.475± 0.003 c	0.875 ± 0.008 c	0.501± 0.025 c	0.180 ± 0.007 c	0.355 ± 0.032 c	0.282 ± 0.008 c
Fourth Treatment	0.161 ± 0.003 d	0.507 ± 0.025 d	0.390 ± 0.037 cd	0.258 ± 0.006 d	0.614± 0.005 d	0.329 ± 0.038 d	0.146 ± 0.003 d	0.358 ± 0.023 c	0.214 ± 0.026 cd
Fifth Treatment	0.147 ± 0.001 d	0.544 ± 0.009 d	0.334 ± 0.004 d	0.229± 0.004 e	0.616 ± 0.007 d	0.374 ± 0.010 d	0.138± 0.009 d	0.276 ± 0.007 d	0.143 ± 0.027 d
Significance Level	*	*	*	*	*	*	*	*	*

*means that there are significant differences between the treatments at the significance level (P≤0.05).T 1 (control), T2, T3, T4, and T5 treatments: Adding Gum Arabic powder at concentrations of 15, 20, 25, and 30 g/kg feed, respectively.

The results showed a significant decrease in oxidation indicators, including free fatty acids (FFA), peroxide value (PV), and malondialdehyde (TBA) concentration in egg yolk for all treatments adding Gum Arabic powder compared to the first treatment (control). This is believed to be due to the active compounds in Gum Arabic, especially phenols, flavonoids, carotenoids, vitamin C, and tocopherol [5]. as they play an effective role in inhibiting the formation of free radicals Through several mechanisms, including donating electrons or a hydrogen atom to the free radical, making it less reactive, or activating antioxidant enzymes such as glutathione peroxidase and reducing lipid oxidation in egg yolk during storage by acting as strong antioxidants, enhancing the egg preservation process for a longer period. It is also believed that Gum Arabic acts as a preservative membrane based on polysaccharides that prevent evaporation, bacterial infection, and oxidation, thus

naturally and effectively extending the shelf life of eggs [25]. The reason may also be due to the fact that gum arabic improves the condition of the liver and blood circulation, as it improves liver function and the physiological condition of chickens. Gum arabic also works as a natural prebiotic that promotes the growth of beneficial bacteria in the intestines, which leads to improved absorption and metabolic processing of fats [19, 3]. The decrease in malondialdehyde concentration in egg yolk for treatments with Gum Arabic powder compared to the first treatment (control) may be due to the role of active compounds in Gum Arabic, especially phenols and carotenoids, which prevent exposure to oxidative stress through the biochemical functions they perform in living organisms, as they work to inhibit the oxidation of cell membrane lipids and curb free radicals by interrupting the chains of free reactions. [4] Lipid peroxidation is an enzyme-controlled process. Antioxidant enzymes such as superoxide dismutase (SOD) convert superoxide radicals into hydrogen peroxide, which is subsequently degraded by catalase or glutathione peroxidase (GPx). This reaction reduces the accumulation of reactive oxygen species, slows the formation of hydrogen peroxides and subsequently lipid peroxides, limits the formation of malondialdehyde, and keeps oxidative stress levels under control. [10, 8]. These results clearly demonstrate that dietary inclusion of Gum Arabic improves both the lipid profile and oxidative stability of eggs, especially under extended storage conditions. It offers a promising natural solution for enhancing egg quality and shelf life in aged laying hens.

Conclusions

The addition of Gum Arabic powder at various levels to the diets of aged laying hens significantly improved the lipid profile and oxidative parameters of table eggs .These findings highlight the potential of Gum Arabic as a natural antioxidant and functional feed additive for enhancing egg quality and extending shelf life. Its bioactive components, particularly phenolic compounds and amino acids, contribute to its ability to protect lipids from oxidative degradation. Future studies may focus on its long-term effects on laying performance, egg production traits, and consumer safety. Thus, Gum Arabic proves to be an effective dietary supplement for maintaining egg stability and improving the nutritional quality of eggs produced by aging hens.

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