The Use of Different Additions of Folic Acid on Productive Performance of Laying Japanese Quail

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Abstract

This study aimed to determine the effect of using different folic acid supplements (0, 4, 8, and 12) mg/kg of feed on the nutrition of laying quail hens. Ninety-six eight-week-old white Japanese quail hens were used and divided into four treatments, each with four replicates (cages) of six hens. The study lasted two months.

At the end of the study period, the results showed significant differences (P ≤ 0.05) in egg weight, yolk percentage, and yolk diameter, favoring the fourth treatment. The albumen percentage was also significantly higher in the third treatment, while the egg width was significantly higher in the second and fourth treatments. No significant differences (P ≤ 0.05) were recorded among the other studied traits. The highest net profit (in Iraqi dinars/g of eggs) and the highest net profit margin compared to total costs (%) were observed in the third treatment, while the lowest were in the fourth treatment.

Keywords: folic acid, quail, egg indices, laying performance.

Introduction

In recent years, many countries around the world have paid close attention to poultry and its products, as they are an important source of food security for their populations **[18]** **[24]**. The increase in the world's population has led to rising demand for food, including animal protein, which is primarily provided through poultry products such as eggs and meat **[32]**. This change was one of the main reasons for the significant development of the poultry industry, especially in developing countries **[16]**. Researchers agree that poultry eggs are distinguished by their unparalleled protein content, which contains all essential amino acids, as well as high-quality fats, vitamins, and minerals **[10]** **[23]** **[30]** The egg industry has responded quickly to the search for new technologies to use eggs The challenge is to secure enough food to meet the needs of these growing numbers while preserving and sustaining natural resources **[25]**. Quail birds utilize lower-energy feed more efficiently compared to other poultry species **[4]**. beyond their traditional nutritional value, such as eggs fortified with omega-3 and selenium **[8]**. Just as omega-3 and selenium-fortified eggs have found a niche in the specialty egg market, it is only natural that eggs fortified with folic acid could also carve out their own niche market **[5]**.

The National Research Council **[26]** has also addressed poultry feed folic acid requirements. It has been shown that fortifying laying hens' diets with folic acid increases its content in the eggs produced **[13]** **[31]** **[34]**.

Folic acid is a water-soluble vitamin B9 that the body cannot synthesize **[20]**. It is also known as polyglutamyl, folacin, pteroyl monoglutamate, or vitamin B9 **[14]** **[35]**.Folic acid is primarily composed of pteroylglutamic acid **[37]**. The biologically

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active form of folic acid after digestion and absorption is 5-methyltetrahydrofolate **[3]**

Folic acid is essential in poultry diets as it participates in numerous metabolic reactions and is particularly important as a methyl donor in metabolic pathways. Adding folic acid to the diets of laying quail increases the amount of 5-methyltetrahydrofolate in egg yolks. This enhances the role of folic acid in the remethylation of homocysteine to methionine. Homocysteine is converted to methionine via two pathways. The first pathway involves the transfer of a methyl group from 5-methyltetrahydrofolate to homocysteine, resulting in methionine, which represents the largest portion of the methylation cycle in the body. The second pathway involves the remethylation of betaine to dimethylglycine and ultimately to methionine **[19] [31]**.

Folic acid participates in the synthesis of purines and pyrimidines, nitrogenous bases that serve as building blocks in nucleic acids, as well as in the metabolism of amino acids such as serine, glycine, histidine, methionine, choline, and thiamine **[6] [11] [28]**. It has a positive effect on antioxidant activity, thyroid hormones, anti-inflammatory activity, gene expression, and immune response **[27] [33]**. It is essential in the methylation cycle and in preventing the oxidation of proteins and DNA by free radicals **[2]** .

Folic acid also contributes to the formation of proteins, enzymes, and some vitamins, and it enhances the digestion, absorption, and metabolism of absorbed nutrients, thus increasing their utilization. It also improves the morphology of the small intestine by increasing the depth and height of the villi, improving the intestinal lining, and promoting the growth of beneficial bacteria. Folic acid, a water-soluble vitamin B9, is crucial for various bodily functions and cannot be synthesized by the body **[20]**. It's also referred to as polyglutamyl, folacin, pteroyl monoglutamate, or simply vitamin B9 **[14] [35]**. The chemical structure of folic acid is primarily based on pteroylglutamic acid **[37]**, and after being digested and absorbed, it becomes biologically active as 5-methyltetrahydrofolate **[3]**

In poultry diets, folic acid is indispensable as it plays a key role in various metabolic reactions. It functions significantly as a methyl donor in metabolic pathways, particularly in laying quail, where adding folic acid can enhance the levels of 5-methyltetrahydrofolate found in egg yolks. This process aids in remethylating homocysteine into methionine, utilizing two principal pathways: the methyl group transfer from 5-methyltetrahydrofolate directly to homocysteine and the remethylation of betaine to dimethylglycine, eventually leading to methionine **[19] [31]**.

Folic acid is also involved in synthesizing purines and pyrimidines, which are vital components of nucleic acids, and it influences amino acid metabolism, including serine, glycine, histidine, methionine, choline, and thiamine **[6] [11] [28]**. Additionally, it enhances antioxidant activity, influences thyroid hormones, exhibits anti-inflammatory properties, and plays a role in gene expression and immune response **[27] [33]**. Its function in the methylation cycle also contributes to protecting proteins and DNA from oxidative damage by free radicals **[2]**.

Beyond metabolic functions, folic acid assists in forming proteins, enzymes, and some vitamins, while improving nutrient digestion, absorption, and metabolism—this leads to better utilization of absorbed nutrients. Furthermore, it promotes a healthier morphology of the small intestine by increasing villi depth and height, enhancing the intestinal lining, and encouraging the growth of beneficial bacteria, which assist in synthesizing vitamins like thiamine, riboflavin, and biotin **[21] [22] [36]**.

Crucially, folic acid is vital for developing the oviduct in poultry, an d its supplementation in feed can boost egg production **[17] [29]**. This vitamin positively affects egg weight, internal quality, and even increases shell thickness and strength **[15] [9]**

Given its numerous beneficial roles, folic acid has garnered significant attention from nutrition specialists, making it a focal point. Poultry requirements for this vitamin are affected by several factors, including breed, age, production stage, diet, folic acid levels, and flock management practices **[12]**. This study aimed to determine the effect of adding different levels of folic acid to quail diets on production performance and egg quality, as well as to investigate the effect of its addition on certain blood parameters. Poultry requirements for this vitamin are influenced by several factors, including breed, age, production stage, diet, folic acid levels, and flock management practices **[12]** . **[7]** reported that adding folic acid to the diets of laying hens at different levels significantly increased egg production, egg mass, and egg weight, and improved the feed conversion ratio. These effects, in turn, improved the productive characteristics and quality of the eggs, resulting in folate-enriched eggs. We conclude that moderate levels represent an effective nutritional strategy for producing folate-enriched eggs, aiming to meet part of human dietary needs and to enhance the health benefits of eggs as a functional food source.

This study aimed to determine the effect of adding different levels of folic acid to quail diets on production performance and egg quality, as well as to investigate the effect of its addition on certain blood parameters

Material and Methods

This research was carried out at the poultry farm of the Animal Production Department, College of Agriculture and Forestry, University of Mosul, Iraq. Over a period of 60 days, 96 white-laying female quail, each 8 weeks old, were utilized. The quail were randomly assigned to four experimental treatments, with each treatment consisting of four replicates of six females.

The study involved the addition of four levels of folic acid to their diet: 0, 4, 8, and 12 mg/kg of feed. These treatments were formulated to contain one percent of crude protein, totaling 20.01%, and met all the nutritional requirements of the birds based on the guidelines from NRC (1994) Table No. 1. Throughout the duration of the study, the female birds had ad libitum access to both feed and water. They were housed in wooden cages measuring 50×50×50 cm (length, width, and height, respectively), each equipped with a feeder and a waterer. The birds were managed under a veterinary and preventive health program, overseen by the veterinary unit in the department. Additionally, all necessary administrative supplies for raising laying quail were adequately provided.

Studied traits:

Eggs were collected daily and weighed. Random egg samples were taken periodically to study certain qualitative characteristics, including feed intake and remaining feed, to determine consumption rates. The amount of water consumed by the birds was measured using a 2000 ml drinking water tank, and the remaining water was measured using a graduated container with 10 ml increments. Finally, the birds were weighed twice, at the

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beginning and end of the study, to determine changes in body weight.

The study examined several characteristics, including: total number of eggs, daily egg production (%), egg weight, egg mass, albumen, yolk, and shell ratio, shell thickness, feed consumption rate, feed conversion efficiency, energy conversion efficiency, protein consumption rate, protein conversion efficiency, water consumption rate, water conversion efficiency, water-to-feed ratio, final body weight, change in body weight, variable and fixed costs, total costs, total revenue, net profit (Iraqi dinars/g of eggs), net profit margin compared to total costs, and profit rank per gram of eggs. The data in the study were statistically analyzed using a completely randomized design (CRD) for a simple one-factor experiment. The significance of the differences between the means was tested, and the standard error of the means was found by analyzing the data according to the ready-made statistical program SAS (SAS, 2003). Eggs were collected daily and weighed. Random egg samples were taken periodically to study certain qualitative characteristics, including feed intake and remaining feed, to determine consumption rates. The amount of water consumed by the birds was measured using a 2000 ml drinking water tank, and the remaining water was measured using a graduated container with 10 ml increments. Finally, the birds were weighed twice, at the beginning and end of the study, to determine changes in body weight.

Table 1: Components of the experimental diet and its calculated chemical analysis: *

Ingredients	percentage (%)
Soybean meal	20
Yellow corn	31
Wheat	27
Protein concentrate**	7
Wheat bran	6
Sunflower oil	2.5
Limestone	5
Dicalcium Phosphate	1
Table Salt	0.25
Vitamins and Minerals	0.25
Total	100
Chemical composition	
Metabolic energy kcal/kg	2903
Crude protein %	20.01
Ether extract %	2.27
Crude fiber %	3.40
Ash %	2.60
Soluble carbohydrates %	59.82
Calcium %	2.60
Available phosphorus %	0.44
Lysine %	1.06
Folic acid mg/kg	1.05

*Calculated chemical analysis of feed ingredients and nutritional requirements of laying quail in the study (NRC, 1994).

**The protein concentrate used in the study was Wafi, of Dutch origin, containing the following:

Metabolizable energy 2200 kcal/kg, crude protein 40%, crude fat 5%, crude fiber 2%, calcium 9%, available phosphorus 4%, lysine 4.5%, methionine 3.7%, linoleic acid 2%.

Results and Discussion

The statistical analysis results in Table 2 showed significant differences ($P \leq 0.05$) in egg weight (g/egg) during the 60-day rearing period, favoring the fourth treatment (12 mg folic acid/kg feed) compared with the control treatment. This treatment recorded an average egg weight of 10.92 g. These results are consistent with those of **[7]** and Al-Shamary and Jameel, but differ from those of **[1]**

However, this table indicates no significant differences ($P \leq 0.05$) in any of the other traits listed: total number of eggs (eggs/hen), total egg mass (g eggs/hen),

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and daily egg production rate (HDD). (%), These results agreed with those of the researcher [31].

Table 2. Effect of using different folic acid supplements on some quantitative characteristics of Japanese quail eggs(Mean ± SE)

Treatments	Characteristics Egg weight (g/egg)	Total number of eggs (eggs/hen)	Total egg mass (g eggs/hen)	Daily egg production rate (H.D.) (%)
First treatment: 0 mg folic acid/kg feed	9.38 b ±0.49	47.88 ±2.56	451.92 ±45.3	79.79 ±4.27
Second treatment 4 mg folic acid/kg feed	10.38 ab ±0.26	44.38 ±4.67	464.27 ±57.3	73.96 ±7.78
Third treatment 8 mg folic acid/kg feed	10.38 ab ±0.48	51.13 ±3.84	526.72 ±31.6	85.21 ±6.40
Fourth treatment 12 mg folic acid/kg feed Fourth	10.92 a ±0.34	39.75 ±4.89	432.41 ±52.50	66.25 ±8.15

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Table 3 shows significant differences ($p \leq 0.05$) in some of the studied traits, namely the percentage of white and yolk (%), yolk diameter, and egg width (mm). For the percentage of yolk and yolk diameter, these differences confirmed the superiority of treatment four. As for the percentage of white, the significant differences ($p \leq 0.05$) favored treatments one and three..

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These results, with significant differences ($p \leq 0.05$), demonstrated the superiority of treatments two and four in egg width..

As for the rest of the results in Table 3, they did not prove any significant differences between the experimental treatments for the traits of shell percentage (%), shell thickness (mm), yolk height (mm), thick albumen height, thin albumen height (mm), and egg length (mm).

Table 3. Effect of using different folic acid supplements on some qualitative characteristics of Japanese quail eggs(Mean ± SE)

	Characteristics									
Treatments	Albumen percentage (%)	Yollient percentage (%)	Shell percentage (%)	Shell thickness (mm)	Yollient height (mm)	Yollient diameter (mm)	Thick albumen height (mm)	Light albumen height (mm)	Egg length (mm)	Egg width (m)
First treatment: 0 mg folic acid/kg feed	51.73 a ±1.05	33.75 b ±1.13	14.52 ±0.83	0.20 ±0.010	9.46 ±0.33	23.61 b ±0.76	4.14 ±0.19	2.92 ±0.12	30.32 ±0.65	23.8 b ±0.33
Second treatment 4 mg folic acid/kg feed	50.18 ab ±0.35	35.94 ab ±0.47	13.89 ±0.31	0.20 ±0.013	10.41 ±0.32	24.66 ab ±0.24	4.00 ±0.14	2.95 ±0.29	31.68 ±0.42	24.80 a ±0.17
Third treatment 8 mg folic acid/kg feed	52.08 a ±0.87	34.17 b 0.77	13.75 ±0.31	0.20 ±0.011	10.36 ±0.50	24.46 ab ±0.35	4.37 ±0.25	2.99 ±0.25	31.60 ±0.60	24.57 ab ±0.13
Fourth treatment 12 mg folic acid/kg feed	48.79 b ±0.46	40.02 a ±3.01	14.41 ±0.34	0.21 ±0.016	10.29 ±0.24	25.37 a ±0.45	4.11 ±0.40	2.66 ±0.21	31.65 ±0.40	25.07 a ± 0.35
Fourth										

The results in Table 4 did not show any significant differences ($p \leq 0.05$) in any of the studied traits: feed intake (g feed/female), feed conversion ratio (g feed:g egg), energy intake (kcal/female), energy conversion ratio (kcal:g egg), crude protein intake (g protein/female), and crude protein conversion ratio (g protein:g egg)

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Table 4. Effect of using different folic acid supplements on some Feed intake rate of Japanese quail(Mean ± SE)

Treatments	Characteristics Feed intake rate (g feed/female)	Feed conversion ratio (g feed : g eggs)	Energy intake rate (kcal/female)	Energy conversion ratio (kcal : g eggs)	Protein intake rate (g protein/ female)	Protein conversion ratio (g protein : g eggs)
First treatment: 0 mg folic acid/kg feed	1276.65 ±25.31	2.89 ±0.24	3706.11 ±73.47	8.40 ±0.69	255.46 ±5.06	0.58 ±0.049
Second treatment 4 mg folic acid/kg feed	1276.20 ±33.26	2.95 ±0.53	3704.81 ±96.54	8.55 ±1.56	255.37 ±6.65	0.59 ±0.108
Third treatment 8 mg folic acid/kg feed	1470.60 ±161.33	2.88 ±0.52	4269.15 ±468.35	8.36 ±1.51	294.27 ±32.28	0.58 ±0.103
Fourth treatment 12 mg folic acid/kg feed	1319.25 ±28.82	3.19 ±0.39	3829.79 ±83.70	9.27 ±1.13	263.98 ±5.77	0.64 ±0.078
Fourth						

The results in Table 5 indicate a significant decrease ($p \leq 0.05$) in water consumption (ml water/female) in favor of the third treatment (8 mg folic acid/kg feed) compared to all experimental treatments. This may be due to the increased folic acid consumption of the females in this treatment, especially since these birds consumed the highest feed intake. As shown in the previous table (Table 4), the of the other traits in this table. The results for the remaining traits in this table did not show any significant differences at the probability level ($p \leq 0.05$). These traits are water conversion efficiency (ml water's egg), water consumption-to-feed ratio (ml water: g feed), initial body weight, final body weight, and change in body weight (g/female.

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Table 5. Effect of using different folic acid supplements on Water consumption rate and Change in body weight (g/female)of Japanese quail eggs(Mean ± SE)

Treatments	Characteristics					
	Water consumption rate (ml water/female)	Water conversion efficiency (ml water:g egg)	Water consumption:feed consumption ratio	Initial body weight (g/female	Final body weight (g/female)	Change in body weight (g/female)
First treatment: 0 mg folic acid/kg feed	3245.70 a ±69.66	7.38 ±0.71	2.54 ±0.06	168.50 ±3.08	205.50 ±3.08	37.00 ±5.43
Second treatment 4 mg folic acid/kg feed	3407.25 a ±174.94	7.98 ±1.74	2.68 ±0.15	166.92 ±0.69	206.88 ±2.58	39.96 ±2.16
Third treatment 8 mg folic acid/kg feed	3942.00 b ±154.00	7.61 ±0.72	2.75 ±0.22	167.50 ±3.17	215.17 ±5.10	47.67 ±7.69
Fourth treatment 12 mg folic acid/kg feed Fourth	3432.00 a ±139.10	8.33 ±1.12	2.61 ±0.15	167.88 ±2.08	210.27 ±2.10	42.39 ±2.21

The economic analysis presented in Table 6 explores the production costs associated with 1 gram of Japanese quail eggs. Notably, the first treatment had the lowest variable cost at 1.935 Iraqi dinars (IQD) per gram, a result of its reduced feed consumption compared to most other treatments, aside from the second treatment. Conversely, the fourth treatment exhibited the highest variable cost of 2.456 IQD per gram.

When examining fixed costs, the third treatment also stood out with the lowest cost at 2.038 IQD per gram, while the fourth treatment recorded the highest fixed cost at 2.700 IQD per gram. Total costs mirrored these trends, with the lowest total cost at 4.174 IQD per gram for the third treatment and the highest at 5.156 IQD per gram for the fourth treatment. It's important to note that total revenue

remained consistent across all transactions at 10 IQD per gram of eggs, based on a wholesale price of 1200 IQD for a tray of 12 quail eggs.

In terms of net profit, the third treatment outperformed the others, yielding profits of 5.826 IQD per gram, followed by the second treatment at 5.561 IQD, the first at 5.525 IQD, and the fourth at 4.844 IQD per gram. This demonstrates how the third treatment managed to maintain the lowest total costs, while the fourth saw the highest costs. Net profit is determined by deducting total costs from total revenue.

The rankings of net profit percentages relative to total costs reflected a similar pattern, with the third treatment leading and the fourth last. The superior performance of the third treatment can be attributed to its efficiency in maintaining lower total costs, which was influenced by achieving a higher egg mass ratio.

Table 6: Effect of using different folic acid supplements on some Economic Variables of Japanese quail eggs (Mean ± SE)

Treatments	Characteristics						
	Variable Costs (Feed Costs) (Iraqi Dinar/g of Eggs)	Total Costs (Iraqi Dinar/g of Eggs)	Total Revenue (Iraqi Dinar/g of Eggs)	Daily egg production rate (H.D.) (%)	Fixed Costs (Iraqi Dinar/g of Eggs)	Net Profit Ratio compared to Total Costs (%)	Profit Rank
First treatment: 0 mg folic acid/kg feed	1.935	2.540	4.475	10	5.525	123.46	3
Second treatment 4 mg folic acid/kg feed	1.993	2.446	4.439	10	5.561	125.28	2
Third treatment 8 mg folic acid/kg feed	2.136	2.038	4.174	10	5.826	139.58	1
Fourth treatment 12 mg folic acid/kg feed	2.456	2.700	5.156	10	4.844	93.95	4

At the time of this study, the exchange rate was 1400 Iraqi dinars to the US dollar.The price of 1 g of animal feed was 0.685, 0.725, 0.765, and 0.805 Iraqi dinars for the five transactions, respectively.

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