ISSN 1819-1878

Asian Journal of Animal Sciences

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OPEN ACCESS Asian Journal of Animal Sciences

ISSN 1819-1878
DOI: 10.3923/ajas.2017.115.122

Research Article
Hawthorn Leaves and Flowers Addition to Layer Feed on Productivity, Egg Weight and Egg Quality

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Abstract

Background and Objective: Due to the world trend to reduce the use of antibiotics in the treatment of diseases and as growth promoters, there is a need for the use of healthy natural alternatives that are environmentally safe products in order to maintain good production and to improve egg quality and characteristics. Therefore, objective of study was to use hawthorn leaves and flowers as natural alternatives for improving and maintaining the production of egg and its characteristics. **Methodology:** An experiment testing the addition of hawthorn powder to layer hen feed was conducted at Jerash University experimental station. One hundred twenty, of 18 weeks age, Hyline pullets were randomly distributed over three treatments each with four replicates. The three treatments were normal feed (control), feed with 0.1% hawthorn powder and feed containing 0.2% hawthorn powder. **Results:** The results indicated that there was no significant ($p>0.05$) improvement in hen day production percentage. The results also revealed that addition of hawthorn powder to the laying hen feed resulted in more stable egg production, improved egg weight, improved egg shape and eggshell thickness. The results also showed that hawthorn addition decreased the eggshell percentage to total egg weight. Egg yolk weight, egg diameter, egg yolk height, albumen weight and height were improved by adding hawthorn to layer feed. Cholesterol content was reduced. **Conclusion:** Based on the findings of this study it is recommended to add hawthorn dried plant leaves and flowers powder to layer feed for improved and stable egg production, egg weight and egg shape.

Key words: Hawthorn, layer, egg production, egg weight, egg quality, egg yolk color

Received: February 15, 2017 Accepted: April 03, 2017 Published: April 15, 2017

Citation: Moutasem Mohamad Al-Massad, Ali Jaddo Al-Sharafat and Kamel Ina'm Sultan, 2017. Hawthorn leaves and flowers addition to layer feed on productivity, egg weight and egg quality. Asian J. Anim. Sci., 11: 115-122.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Hawthorn (*Crataegus oxyacantha*) is a plant. The leaves, berries and flowers of this plant are used to make medicine. This plant is used for the treatment of some diseases of the heart and blood vessels such as Congestive Heart Failure (CHF), chest pain and irregular heartbeat. It is also used to treat both low blood pressure and high blood pressure, "Hardening of the arteries" (atherosclerosis) and high cholesterol[1]. Hawthorn can be used for several purposes; it can be used as a wild source for resistant root stock in the propagation of some fruit trees as apples, pears as it can tolerate the tough environmental conditions[2], also, it can be used as a forest tree, or as a protective natural farm fence in addition to its high medical value[1]. Hawthorn is considered as a long life tree. It can be found in the wild forests of the mountainous areas. Its leaves are green in color which is similar to buckthorn tree or Jujube tree. Its flowers are white in color producing oval yellowish or black grape like fruits according to its type. The fruits are characterized by their pleasant sweet taste which can be used for medical purposes in addition to the flowers[2].

Fresh hawthorn fruits are used as a source of food as the buckthorn fruits. The fresh fruits of hawthorn are used in curing the nervous heart disturbances resulting from hypertension or associated with menopause[3]. Therefore, it is beneficial for the atherosclerosis cases, heart attacks and helps in restoring blood contents to their normal levels. The useful hawthorn parts are the flowers, leaves, bark and fruits[4,5].

Phenolic compounds, procyanidins (PCs), flavonols and C-glycosyl flavones in hawthorn and hydrolysable tannins in emblic leaf-flower fruits are considered among the major bioactive compounds in these berries. Moreover, hawthorn and fruits are rich in vitamin C, triterpenoids, fruit acids, sugar alcohols and some other components with beneficial effects on the health of human beings[2]. The flavonoids including rutin, apigenin, myricetin, quercetin, naringenin and kaempferol, were identified by high-performance liquid chromatography in the hawthorn extract[6-8].

Egg yolk color is considered the most limiting factor in determining egg quality by the consumer. Poultry farmers are taking egg yolk color into consideration and are eager to achieve the demanded color by the consumer. Egg yolk color is affected by the percentage of yellow corn used in the feed formula and the consumption of green plant parts or grasses by the chicken. As a result of using the modern layer farming and replacing xanthophyll and carotenes rich yellow corn by other available high energy sources ingredients as wheat, barley, oats and triticale for the layer hen feed, this led to the reduction of the egg yolk color for more than 50%[8].

Using feed additives started early in the forties of the last century. The continuous usage of the antibiotics resulted in the production of resistant pathogens that became dangerous to the human health. This led to the prevention of using antibiotics as growth promoters by the European unions in 2006[9]. The various feed additives are considered important products for the assurance of the onset of safe free from diseases, highly efficient poultry production. In general, feed additives enhance growth rates due to better nutrients digestion and absorption in the gut and to the reduction of the amount of energy needed for the digestion processes[10].

For the sake of looking towards the environmentally safe products, avoiding the usage of synthetic pigments, especially in food products that contain eggs as macaroni, mayonnaise, deserts and dry eggs, therefore, the use of natural products as a source of pigmentation for egg yolk in poultry feed became a very important issue nowadays[8]. This study investigated the addition of hawthorn powder to layer feed in order to improve its performance. This area of research is not popular in Jordan. This study will add to the knowledge in the field of egg production.

Therefore, researchers went for the selection of different weeds and medical plants such as hawthorn as alternatives. Most of these resources are natural and can work on enhancing the environment in the digestive tract and posting the immunity through its antibacterial and fungal job[10,11].

The aim of this study was to determine the effect of the addition of dried hawthorn leaves and flowers powder to layer feed on productivity, egg weight and egg quality and egg cholesterol content.

MATERIALS AND METHODS

An experiment was conducted at the experimental poultry farm in the Faculty of Agriculture at Jerash University, Jerash, Jordan. The experiment intended to investigate the effect of adding different levels of hawthorn dried plant leaves and flowers powder to layer feed on the productivity (hen day egg production and egg weight) and the quality of the produced eggs.

One hundred twenty of 18 weeks age Hyline pullets were randomly distributed over three treatments with four replicates per each treatment. The first treatment (T_1) was the control group, given feed without any addition of hawthorn powder. The second (T_2) and the third (T_3) treatments were given feed with the addition of hawthorn powder at the rate of 1 kg per one metric ton and 2 kg per one metric ton of feed (0.1 and 0.2%), respectively as shown in Table 1. The calculated nutrient content of the feed formula is

Table 1: Ingredient composition of layer feed given for three treatments

	Treatments		
Ingredients (%)	T_1	T_2	T_3
Corn	0.625	0.625	0.625
Soybean meal (48%)	0.250	0.250	0.250
Soybean oil	0.010	0.010	0.010
Limestone	0.100	0.100	0.100
Salt	0.003	0.003	0.003
MCP	0.010	0.010	0.010
Premix	0.001	0.001	0.001
DL-methionine	0.001	0.001	0.001
Hawthorn powder	0.000	0.001	0.002

MCP: Monocalcium phosphate

Table 2: Calculated nutrient analysis of laying diet according to NRC Tables (1994)

Nutrients	Contents
ME (kcal kg^{-1})	2790.25
Protein (%)	17.23
Ca (%)	3.61
P (%)	0.34
Lysine (%)	0.90
Methionine (%)	0.38
Meth+Cys (%)	0.67

ME: Metabolizable energy, Meth: Methionine, Cys: Cysteine

shown in Table 2. The feed formula contained 2790 kcal kg^{-1}, ME 17% protein, 3.6% calcium, 0.34% phosphorous, 0.38% methionine and 0.67% lysine as shown in Table 2. The area of each partition was 1.5 m^2 (1.5×1.0 m). Each partition contained ten pullets. The lighting program began with 13 h of light at 18 weeks of age and increased by thirty min weekly till it reached 17 h daily at the age of 26 weeks, then it was fixed till the end of the experiment. Feed was provided according to the recommendation of the producing company (Hyline). The pullets were provided with 105 g per hen daily and *ad libitum* water. The experiment continued for 14 weeks till 32 weeks of age. Eggs were collected daily. Measures and data of egg quality were taken weekly, with measures of production percentage, egg weight, egg diameter, egg albumen height, albumen index (Haugh Units) and eggshell thickness were taken and registered according to the procedure described by Rath *et al.*[12]. Egg yolk color was measured using "Roche Yolk Color Fan". Cholesterol was analyzed using the methodology described by Aderemi *et al.*[13]. The Statistical Package for the Social Sciences (SPSS version 21) was used to analyze the completely randomizes experimental data. The comparison between the means was done using the Least Significant Difference (LSD).

RESULTS

Egg production: There were no significant differences (p>0.05) in Hen Day (HD) production percentage over the whole period of the experiment except at age of 24 weeks indicating no significant effect (either positive nor negative) of adding hawthorn powder to the feed on the productivity of the layer hen as shown in Table 3. But, the HD production was higher than the control in 20-29 weeks but with no significant difference (p>0.05) as shown in Fig. 1. Also, there was an increase in HD production percentage by 2-3% when the hawthorn powder concentration increased from 0.1-0.2% between 20-29 weeks of age. But this increase was not significant (p>0.05). By examining Fig. 1, it could be noticed that the HD production was more stable by adding hawthorn powder to the feed of the laying hen compared to the control curve (T_1).

Egg weight: There was a significant increase ($p \leq 0.05$) in egg weight during the experimental period (20-32 weeks age) as a result of adding hawthorn Powder compared to the control as shown in Table 4.

Egg shape: Egg shape index is defined as the ratio of width to length of the egg:

$$\text{Egg shape} = \frac{\text{Egg width}}{\text{Egg length}} \times 100 \quad (1)$$

and it is an important criterion in determining egg quality[14,15]. There was no significant difference (p>0.05) in Egg shape index as a result of adding 0.1% hawthorn powder compared to the control group (T_1) as shown in Table 5. But the addition of hawthorn powder by 0.2% gave a significant effect ($p \leq 0.05$)) compared to the control (T_1) and the 0.01% hawthorn containing diet (T_2).

Specific gravity of egg: The specific gravity of the egg is equal to egg weight divided by its volume or the equivalent weight of water[12]. The addition of hawthorn powder to layer feed was with no significant effect (p>0.05) on the specific gravity of the egg as shown in Table 5.

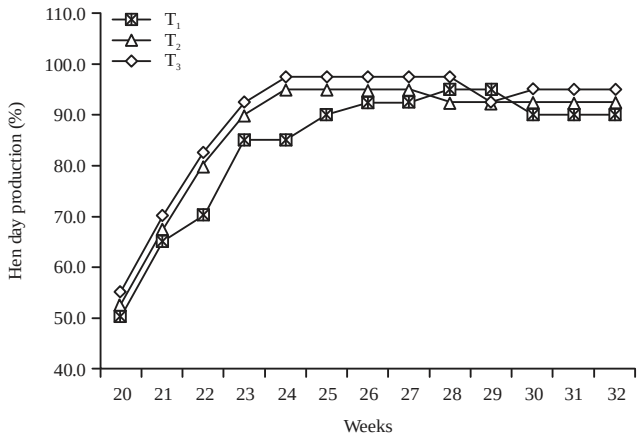

Fig. 1: Effect of adding hawthorn powder on the hen day production

Eggshell weight: There was no significant effect ($p>0.05$) of adding hawthorn powder on the eggshell weight as shown in Table 5. The eggshell is mainly affected by the calcium (Ca) and phosphorus (P) consumption and absorption from the digestive tract. As the addition of hawthorn powder dose not affects Ca and P absorption, it did not show any significant effect ($p>0.05$) on eggshell weight.

Eggshell thickness: There was no significant increase ($p>0.05$) in egg shell thickness as it increased from 0.36 mm to 0.37 and 0.38 mm in T_1, T_2 and T_3, respectively. As compared to the previous result in eggshell weight, the addition of hawthorn powder is not expected to have any significant effect ($p>0.05$) on eggshell thickness.

Eggshell percentage: There is a significant decrease ($p\leq0.05$) in eggshell weight percentage to total egg weight; it decreased from 9.10 to 9.09% when feeding 0.1% hawthorn powder diet shown in Table 5. However, this did not continue to decrease by feeding 0.2% hawthorn powder. This is due to the increase in other egg contents due to the enhancement of egg weight and the remaining of the eggshell weight as it is.

Egg yolk characteristics: The effect adding hawthorn powder to the feed on egg yolk quality including the yolk weight, diameter, height, yolk index and its percentage of the total egg weight is shown Table 6. Treatment T_3 was significantly higher ($p\leq0.05$) in egg yolk weight which reached 16.40 g as compared to the control group with an average of 15.18 g.

Egg yolk diameter increased by adding hawthorn powder. It increased from 40.25 mm for the control group to 41.12 mm for the second treatment, then it increased significantly ($p\leq0.05$), it was 42.2 mm for the third treatment. Egg yolk height increased significantly ($p\leq0.05$) for the second treatment. It increased from 16.78 mm to 17.78 and 17.96 mm for T_1, T_2 and T_3, respectively.

There was a significant increase ($p\leq0.05$) in egg yolk index by the addition of hawthorn powder as compared to the control (T_1) but the increase was higher by using 0.1% hawthorn powder inclusion rate (T_2).

Albumen quality: The albumen weight increased significantly ($p\leq0.05$) from 36.94 g to 37.35 and 38.43 g by the addition of hawthorn powder at the rate of 0.1 and 0.2% as shown in Table 7. The increment in weight was not significant ($p>0.05$) by the addition of 0.02% hawthorn powder as when the means of T_2 and T_3 are compared.

The albumen height increased significantly ($p\leq0.05$) from 7.32 mm to 7.74 and 7.65 mm by adding 0.01 and 0.02% hawthorn powder, respectively (Table 7).

There was no significant difference ($p>0.05$) in the albumen percentage even it was higher for the third treatment (Table 7).

Cholesterol content of egg: There was significant ($p\leq0.05$) reduction in cholesterol content from 10.25 mg g^{-1} to 9.75 and 9.15 mg g^{-1} by adding hawthorn powder to the feed (Table 8). As the quantity of hawthorn powder increased, there was a decrease in cholesterol.

DISCUSSION

Egg production: The HD production was more stable by adding hawthorn powder to the feed of the laying hen

Table 3: Effect of adding hawthorn to layer feed on the hen day egg production percentage through the production period between 20-32 weeks

	Age (weeks)												
Items	20	21	22	23	24	25	26	27	28	29	30	31	32
T_1*	50.00±4.08^a	65.00±2.89^a	70.00±4.08^a	85.00±2.89^a	85.00±2.89^a	90.00±0.00^a	92.50±2.50^a	92.50±2.89^a	95.00±2.89^a	95.00±4.08^a	90.00±4.08^a	90.00±4.08^a	90.00±2.50^a
T_2*	52.50±2.50^a	67.50±2.50^a	80.00±4.08^{ab}	90.00±4.08^a	95.00±2.89^b	95.00±2.89^a	95.00±2.89^a	95.00±2.89^a	92.50±2.50^a	92.50±2.50^a	92.50±2.50^a	92.50±4.79^a	92.50±2.50^a
T_3*	55.00±2.89^a	70.00±4.08^a	82.50±2.50^b	92.50±2.50^a	97.50±2.50^b	97.50±2.50^a	97.50±2.50^a	97.50±2.50^a	97.50±2.50^a	92.50±2.50^a	95.00±2.89^a	95.00±2.89^a	95.00±2.89^a
Mean SE $_{total}$	52.50±1.79	67.50±1.79	77.50±2.50	89.17±1.93	92.50±2.18	94.17±1.49	95.00±1.51	95.00±1.51	95.00±1.51	93.33±1.42	92.50±1.79	92.50±2.18	92.50±1.79
p-value	0.569	0.569	0.083	0.296	0.025	0.100	0.440	0.440	0.440	0.748	0.569	0.687	0.569
Significance	ns	ns	ns	ns	s	ns	ns	ns	ns	ns	ns	ns	ns

*Standard Error of the means. ns: Not significant (p>0.05), s: Significant (p≤0.05), Values having different letters in the same column are significantly different (p<0.05)

Table 4: Effect of adding hawthorn to layer feed on the egg weight through the production period between 20-32 weeks

	Age (weeks)												
Items	20	21	22	23	24	25	26	27	28	29	30	31	32
T_1 (g)*	45.78±0.15^a	46.93±0.08^a	51.80±0.28^a	53.45±0.21^a	54.90±0.08^a	55.95±0.07^a	56.98±0.09^a	57.95±0.09^a	58.73±0.11^a	59.37±0.22^a	60.03±0.13^a	60.48±0.13^a	60.50±0.23^a
T_2 (g)*	46.20±0.13^{ab}	47.38±0.17^a	53.05±0.09^b	54.52±0.23^b	55.73±0.14^b	56.65±0.12^b	59.15±0.25^b	59.43±0.28^b	59.73±0.21^b	59.95±0.16^{ab}	60.20±0.15^a	60.85±0.16^{ab}	61.25±0.19^b
T_3 (g)*	46.40±0.20^b	48.55±0.28^b	54.25±0.10^c	54.95±0.07^{bc}	56.58±0.14^c	57.28±0.13^c	59.48±0.23^{bc}	59.80±0.15^{bc}	60.10±0.11^{bc}	60.30±0.15^b	60.70±0.17^b	61.23±0.11^b	62.20±0.13^c
Average (g) SEM $_{total}$	46.13±0.13	47.62±0.23	53.03±0.32	54.31±0.21	55.73±0.22	56.63±0.17	58.53±0.35	59.06±0.26	59.52±0.19	59.87±0.15	60.31±0.40	60.85±0.12	61.32±0.23
p-value	0.059	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.015	0.028	0.010	0.000
Significance	ns	hs	hs	hs	hs	hs	hs	hs	hs	s	s	hs	hs

*Standard Error of the means. ns: Not significant (p>0.05. s: Significant (p≤0.05), hs: Highly significant (p≤0.01), Values having different letters in the same column are significantly different (p≤0.05)

Table 5: Effect of adding hawthorn powder (leaves and flowers) to layer feed on the external egg characteristics

	Characteristics					
Treatments	Average egg weight (g)	Egg shape index	Specific gravity (g cm^{-3})	Eggshell weight (g)	Eggshell thickness (mm)	Eggshell to total egg weight ratio
T_1 (control)*	60.50±0.23^a	75.49±1.97^b	1.060±0.01^a	5.57±0.18^a	0.36±0.03^a	9.10±0.25^a
T_2 (0. 1%)*	61.25±0.19^b	75.45±1.01^b	1.070±0.02^a	5.63±0.20^a	0.37±0.02^a	9.09±0.34^b
T_3 (0.2%)*	62.20±0.13^c	76.98±1.57^a	1.050±0.14^a	5.67±0.27^a	0.38±0.04^a	9.09±0.27^b

*Values represent the standard error of the means (SEM), Values having different letters in the same column are significantly different (p≤0.05)

Table 6: Effect of adding hawthorn powder to layer feed on the yolk characteristics

	Characteristics				
Treatments	Average yolk weight (g)	Yolk diameter (mm)	Yolk height	Yolk index	Yolk weight percentage
T_1 (control)*	15.18±0.15^a	40.25±0.27^a	16.78±0.23^a	0.41±0.02^a	24.83±0.25^a
T_2 (0.1%)*	16.40±0.22^b	41.12±0.28^a	17.78±0.21^b	0.43±0.01^b	25.02±0.23^b
T_3 (0.2)*	15.97±0.15^b	42.10±0.34^b	17.96±0.56^b	0.42±0.02^b	25.44±0.22^b

*Values represent the mean and standard error of the means (MSE), Values having different letters in the same column are significantly different (p≤0.05)

Table 7: Effect of adding hawthorn powder on albumen quality

Treatments	Average albumen weight (g)	Albumen height (mm)	Albumen (%)	Haugh unit (HU)
T_1 (control)*	36.94±0.14[a]	7.32±0.21[a]	60.42±0.38	84.66±1.53[a]
T_1 (0.1%)*	37.35±0.21[b]	7.47±0.19[b]	60.36±0.21	85.18±1.31[b]
T_2 (0.2)*	38.43±0.14[b]	7.65±0.30[c]	61.20±0.32	86.02±1.25[b]

*Values represent the mean and Standard Error of the Means (MSE), Values having different letters in the same column are significantly different ($p \leq 0.05$)

Table 8: Effect of adding hawthorn powder on the egg yolk cholesterol content

Treatments	Egg yolk cholesterol content (mg g^{-1})
T_1 (control)	10.25±0.14[a]
T_2 (0.1%)	9.75±0.21[b]
T_3 (0.2%)	9.15±0.14[c]

Values having different letters in the same column are significantly different ($p \leq 0.05$)

compared to the control curve (T_1). This result could be attributed to the presence of the antioxidant and anti-inflammatory compounds content of hawthorn. This result is not in consistent with the result obtained by Saki *et al.*[16] who concluded that egg production was not significantly affected ($p \leq 0.05$) by adding hawthorn to layer hen feed but the result is consistent with that of Cabuk *et al.*[17]. The difference in results may be attributed to the fact that hawthorn as feed additive might improve nutrient digestibility, enhance activities of digestive enzymes and modulate gut micro biota that can cause an increase in birds' performance.

Egg weight: Addition of hawthorn powder to layer hen feed result in significant increase ($p \leq 0.05$) in egg weight. This result is consistent with the result obtained by Ghasemi *et al.*[18] who had found a significant effect ($p \leq 0.05$) of adding medical herbs to laying hen feed. Both results may be attributed to the presence of the antioxidants that caused an enhancement in egg weight and prevented the deterioration of nutrients absorbed from digestive tract.

Egg shape: Addition of hawthorn powder by 0.02% resulted in significant effect ($p<0.05$) on egg shape index compared to the control (T_1). This result is in consistent with the result obtained by Zhao *et al.*[19], who demonstrated changes in egg shape. These results could be attributed to the presence of antioxidant and anti-inflammatory compounds in hawthorn that caused a reduction in the occurrence of ovary inflammation that may cause some defects in the egg shape.

Eggshell percentage: Addition of hawthorn powder resulted in a decrease ($p<0.05$) in eggshell weight percentage to total egg weight. This result is in consistent with the result obtained by Zhao *et al.*[19]. The results of Zhao *et al.*[19] study and the results of this study could be attributed to the increase in other egg contents due to the enhancement of egg weight and the remaining of the eggshell weight as it is.

Egg yolk: There was an increase in egg yolk index by the addition of hawthorn powder as compared to the control (T_1) but the increase was higher by using 0.1% hawthorn powder inclusion rate (T_2). This result may be explained by the presence of flavonoids (a natural source of pigment) in hawthorn[20].

Albumen: The albumen weight increased as a result of adding hawthorn powder to layer hen feed. This increase is expected due to the presence of the previously mentioned antioxidants in the hawthorn powder. This result is not consistent with the result obtained by Yalcin *et al.*[20] who reported that no significant effects ($p \leq 0.05$) were obtained by supplementation of hawthorn powder on albumen index.

The albumen quality is measured in Haugh units. The Haugh unit is a measure of egg protein quality based on the height of its egg white albumen. The test was introduced by Raymond Haugh. The results showed an increase in Haugh units due to the addition of 0.1% hawthorn as compared by the control but the increase in this measurement was not significant ($p>0.05$). This result is consistent with the results of Yalcin *et al.*[20]. This increase in this study as well as Yalcin *et al.*[20]. study is expected due to the presence of the previously mentioned antioxidants (flavonoids and phenolic compounds) in the hawthorn powder and due to the increase in albumen weight.

Cholesterol content of the egg: A reduction in cholesterol by the addition of hawthorn powder is noticed. This result agreed with the work of Saki *et al.*[16], who used a phytogenic mixture of garlic, marigold, fennel seeds and thyme. Both results could be attributed to the presence of flavonoids and phenolic compounds in the powder as compared to the therapeutic trials made on human being. The flavonoids and polyphenolic compounds are responsible for the reduction of blood cholesterol. Hawthorn is used for the treatment of hypercholesterolemia in human being[7].

CONCLUSION AND RECOMMENDATION

The results of the study revealed that addition of hawthorn powder to the laying hen feed resulted in improved egg weight, improved egg shape and improved eggshell thickness. The results also revealed that hawthorn addition

decreased the eggshell percentage to total egg weight. Egg yolk weight, egg diameter, egg yolk height, albumen weight and height were improved. Cholesterol content was reduced. Based on the findings of this study it is recommended to add hawthorn dried plant leaves and flowers powder (HP) to layer feed at the rate of 2 kg ton^{-1} as it gave better results than 1 kg ton^{-1}. There is a need for farther investigation about each constituent of the hawthorn powder in order to find the main compound responsible for each positive effect in this experiment.

SIGNIFICANCE STATEMENTS

Productivity of layer hens and egg characteristics are largely affected by inclusion of feed additives. This study could provide information on the issues related to the impact natural feed additives on layer poultry performance. Hawthorn could be successfully used as feed additive in layer nutrition. Further, this study would also be a review on the importance of natural plants to be used as feed additives to enhance the performance of livestock. This study would be beneficial to poultry producers in planning for feed combinations of their flocks as this study would provide the necessary information on the different benefits of hawthorn addition to layer hen. This would expectedly heighten the awareness of the poultry producers and the decision makers in poultry industry to benefit from natural feed additives. To the future researchers, this study can provide baseline information on the recent status of using hawthorn as feed additive to layer hens.

ACKNOWLEDGMENTS

The authors wish to express their deep sense of gratitude to the Faculty of Agriculture as well as to the Deanship of Scientific Research at Jerash University for their support and cooperation.

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