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EFFECT OF DIETARY SUMAC SEED POWDER AS ANTIOXIDANTS AND GROWTH PROMOTER ON EGG PRODUCTION PERFORMANCE AND BLOOD OF JAPANESE QUAIL LAYING

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SUMMARY

The effect of various levels of sumac seed powder (SSP) as antioxidant and growth promoter on laying performance, egg production, egg quality, some plasma concentration and reproductive performance of Japanese quail was investigated using 180 birds in 9 weeks of age, randomly assigned to four dietary treatments (0.0, 1.5, 2.0 and 2.5% SSP) with 45 birds per treatment and 3 replicates (10 hens and 5 cocks each). The results obtained can be summarized as follows: At the overall periods quail fed 2% SSP recorded significant the highest ($p \leq 0.05$) feed consumption compared with 2.5% SSP, while, all levels of SSP recorded the best values of feed conversion ratio compared to the control group. Also, egg production %, egg number, egg weight and egg mass/hen/day for SSP treatments were significantly ($p \leq 0.05$)increased than those fed control diet. Sumac seed powder supplements significantly ($p \leq 0.05$) increased albumin height, internal quality unit, color yolk, shell% and yolk / albumin ratio. However, albumin% and shell thickness were significantly decreased compared with control group. Also, most levels of SSP had improved the blood hematological parameters such as white blood cells, hemoglobin, red blood cells and mean corpuscular hemoglobin concentration feeding especial birds fed 1.5 and 2% SSP compared to the control group. The birds fed 1.5% SSP recorded significantly ($p \leq 0.05$) the highest value for globulin and improved A/G ratio compared with other treatments. The plasma lipid profile, liver enzymes and total lipid were significantly reduced ($p \leq 0.05$) but increased total antioxidant capacity and by supplementation SSP. Reproductive performance significantly ($p \leq 0.05$)improved by feeding SSP. In conclusion, the data obtained showed that the diet supplemented with the sumac seed powder (1.5, 2.0 and 2.5%) for Japanese quail laying improved egg performance, egg quality, most of the blood hematological, blood biochemical parameters and reproductive performance.

Keywords: *Sumac seed, growth performance, egg, blood, reproductive performance, Japanese quail*

INTRODUCTION

Synthetic growth enhancers and supplements in poultry nutrition are expensive and possess adverse effects in bird and human. Sub-therapeutic levels of antibiotics given to poultry as growth enhancer may result to the development of antibiotic-resistant bacteria, which are hazardous to animal and human health. Meanwhile, the use of organic supplements such as probiotics and herbs, are generally believed to be safer, healthier, and less subject to hazards. Thus, herbs and herbal products are incorporated in livestock feeds and water instead of synthetic products in order to stimulate or promote effective use of feed nutrients which result in more rapid gain, higher production and better feed efficiency Portugaliza and Fernandez (2012).Moreover, Herbs contain active substances that can improve digestion and metabolism and have antibacterial and immunostimulant activities in animals (Sabra and Mehat 1990).

Salih and Gurbuz (2015) found that there are so many advantages of using herbs than antibiotics. Phytogenic feed additives may have the potential to promote production performance and productivity and thus, add to the set of non-antibiotic growth promoters such as organic acids and probiotics. Antibiotics can't be used during laying period of chickens due to residual effect in eggs. Farmers can easily use in their layer, broiler and parent stock without any residual effect. Even these herbs can be used during the laying period. Sparks (2006) reported that medicinal herbs have been used since a very long time. Medical herbs feed additives including sumac is good alternative to replace antibiotic growth promoters.

Rhus coriaria commonly known as sumac is a flowering shrub which belongs to *Anacardiaceae* family and it grows widely distributed in subtropical temperate regions throughout the world, especially in Asian countries and Africa countries. Sumac is used as an herbal remedy in traditional medicine because of its assumed analgesic, anti diarrheal, antiseptic, anorectic, and anti hyperglycemic properties (Rayne and Mazza, 2007). Sumac possesses pharmacological functions including antibacterial, antifungal, antioxidant and hypoglycemic activities. It could be suggested that flavonoids, aromatic components and xanthones might be useful in the development of new drugs to treat various diseases. The present results suggested a possibility that these compounds can be further developed as a potential disease-curing remedy (Asgarpanah and Saati, 2014). Sumac seeds are rich in vit. B and gallic, benzoic and L-ascorbic acids **(**Abas, 2009). The seeds are a very good source of flavones, such as quercetin, myricetin and kaempferol (Mehrdad *et al*. 2009). Phenols and glycosides of *R. coriaria* rich in anthocyanins and hydrolysable tannins, gallic acid, anthocyanin fraction contained cyanidin, peonidin, pelargonidin, petunidin and dolphinidin glucosides and coumarates. Phenolic compounds are secondary metabolites in the plant material responsible for sumac's antioxidant effect. Although the antioxidant property of sumac has been established (Kosar *et al*.,2007). Onkar *et al*. (2011) revealed that the seeds of sumac are rich in phenolic compounds and the isolated aromatic compounds showed antifungal activity *against candida albicans* and *aspergillus flavus*. Gurbuz and Salih (2017) found that contents of chemical composition of sumac seed, total phenolic (2.46%) and total flavonoid (4.81%). The animal experiments have shown that *R. coriaria* also has caused protection in inner organs. Supplementation of the drinking water (0.02 g/kg per animal) has decreased the formation of oxidized DNA bases in colon, liver, lung and lymphocytes; also after gamma-irradiation pronounced effects have been observed (Chakraborty *et al.* 2008).

Mansoub (2011), Golzadeh, *et al.* (2012), Kheiri *et al*. (2015) and Gurbuz and Salih (2017) reported that when used sumac powder in broiler or laying hens diets increased the HDL, reduces the total cholesterol, very low LDL and plasma fasting blood sugar. Also, Shata and El-Moustafa (2017) found that quail fed sumac seed powder(1.5,2 and 2.5%) had the heaviest ($P \leq 0.05$) BW, FC**,** total antioxidants capacity, better, HDL, FCR and improve the immune response as compared to the control. The AIT**,** AST, cholesterol, LDL, glucose and the population of *E. coli* of the control were higher than the birds fed sumac. While, Arpášová *et al*. (2014) found that FC, FCR, egg production, egg mass and egg weight were not significantly influenced with oregano oil or sumac addition on laying hens diets.

The present study was conducted to evaluate the effect of four levels of dietary sumac seed powder as antioxidants on productive, performance, egg quality and some blood constituents in laying Japanese quail.

MATERIALS AND METHODS

The present experiment was carried out at El–Fayoum Poultry Farm, Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture, Egypt.

Experimental birds and design:

Hundred and eighty Japanese quail birds at 9 weeks of age (120 females and 60 males) were randomly distributed into four experimental groups, each group contained 45 birds(30 females and 15 males), each one was subdivided into 3 replicates with 15 birds per each(10 females and 5 males). All experimental groups had nearly similar average body weight and fed for 20 weeks. Birds in all groups were kept under the same environmental and managerial conditions. Feed and water were supplied ad libitum throughout the experimental period lasted for 12 weeks. Basal diet formulated to cover nutrient requirements (Table 1) according to Egyptian Feed Composition Table (2001). The experimental design was included four tested treatments as follows: the first treatment received a control diet (0.0% SSP), while treatments 2,3 and 4 received diets containing 1.5,2 and 2.5% SSP, respectively. All groups received mashed diets containing similar metabolizable energy and crude protein percent (20% CP and 2900 Kcal).

Egg performance:

Data collection procedure. Egg production measurements (EP%), feed consumption (FC) were calculated. Eggs were collected daily at 9:00 am and the egg number (EN) was recorded on individual basis. The egg weight (EW) was recorded individually. Feed conversion ratio was calculated as gram feed consumption divided by gram egg mass per hen per day according to EL-Husseiny *et al*. (2008).

Egg quality:

Thirty eggs from each treatment were collected and used for measuring quality traits. The yolk color degree was determined using the Roche color fan, the reafter, the proportion of each of the three egg components was calculated as a percent of the total egg weigh. Internal quality unit (IQU) was calculated according to the equation derived by Kondaiah *et al*.(1983) as follows: IQU=100 log(H+4.18- 0.8989*W $^{0.6674}$). Where H = albumen height in mm and W = egg weight in g.

Blood parameters:

At the end of the experiment two blood samples were collected from the brachial vein (one into heparinized tube for separate plasma and the other one into unheparinized tube for separate serum) of three birds/treatment. Fresh blood samples were used for determination of hemoglobin (Hb), red blood cell count (RBCs) and white blood cell count (WBCs) according to Clark *et al*. (2009). Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration were calculated. Plasma was immediately separated by centrifugation for 10 minutes at 3200 rpm. Some plasma criteria as total protein(g/dl), albumin(g/dl), globulin, (g/dl), total lipids, cholesterol (HDL- LDL),total antioxidants capacity and liver enzymatic activity (ALT and AST) were determined using commercial kits.

***Reproduction performance**:*

At the last month of the experiment one hatch was conducted to determine hatchability parameters. On day 17 “the end of incubation period” were used 60 eggs from each treatment. Unhatched eggs were broken to determine unfertile eggs, dead and deformed (Abnormalities) embryos. Fertility, hatchability, dead and deformed embryos percent were calculated.

Statistical analyses:

Obtained data were statistically analyzed using linear models procedure described in SAS users guide (SAS, 1999). Differences among means were tested using Duncan’s multiple range test (Duncane’s,1955).One – way analysis model was applied for experiment: $Y_{ij} = \mu + T_i + E_{ij}$ Where: Y_{ij} = Observations, μ = The overall mean, Ti = Effect of ith treatments (0.0, 1.5, 2.0 and 2.5% SSP), E_{ij} = Experimental error

Table (1): Composition and calculated analysis of experimental diets.

Ingredient	Different levels of SPP%			
Sumac seed powder(SSP)	0.0	1.5	2	2.5
Yellow corn	55.9	52.39	51.2	50.1
Soybean meal 44%	28.59	29.49	29.89	30.09
Corn gluten meal 60%	5.0	5.0	5.0	5.0
Soya oil	2.6	3.7	4.0	4.4
Dicalcium phosphate	1.21	1.22	1.21	1.21
Limestone	5.78	5.78	5.78	5.78
NaCl	0.35	0.35	0.35	0.35
Premix* (V&M)	0.3	0.3	0.3	0.3
DL. Methionine	0.07	0.07	0.07	0.07
NaHCO3	0.1	0.10	0.1	0.1
Choline chloride 60%	0.1	0.10	0.1	0.1
Total	100	100	100	100
Calculated values %				
CP%	20	20	20	20
ME. KCal/Kg	2900	2900	2900	2900
Ca %	2.50	2.50	2.50	2.50
Avail. P %	0.35	0.35	0.35	0.35
Methionine %	0.45	0.45	0.45	0.45
Lysine %	1.0	1.0	1.0	1.0
Meth. + cyst.	0.75	0.75	0.75	0.75

**Each 3 kg contains: 15000.000 IU Vit. A, 4000.000 IU Vit. D3, 50000 mg Vit. E, 4000 mg Vit. K3,3000mgVit. B1, 8000mg Vit. B2, 5000mg Vit. B6,16000mg pantothenic acid, 20mg Vit. B12, 2000mg folic acid,4500mg niacin, 200 mg biotin, 7500 mg zinc, 500000mg choline,15000mg copper,150mg cobalt,1000mg iodine,150mg selenium,100000mg manganese, 30000mg iron and carrier Ca Co 3 add to 3 kg.*

RESULTS AND DISCUSSION

Feed consumption and feed conversion ratio:

The diets prepared using sumac seed powder (SSP) were well accepted by the birds and there were no visible side effects. Effect of feeding dietary inclusion levels of 0.0, 1.5, 2 and 2.5% SSP on feed consumption (FC) and feed conversion ratio(g feed/ g egg) of Japanese quail laying hens at experimental periods are given in Table 2. The data showed that SSP levels did not significantly affect feed consumption at periods 1 and 3, while, feed consumption at period 2 significantly increase ($P \leq 0.05$)with quail laying hens fed 1.5 and 2%SSP compared to the control group. At the overall periods birds fed 2%SSP recorded significantly higher (($P \leq 0.05$) FC compared to 2.5%. The reduced in the amount of feed consumption with hens fed 2.5% SSP could be due be sumac rich in hydrolysable tannins and organic acids. Results obtained are in harmony with those obtained by Mansoub (2011) who found that using different levels of sumac (0.75,1.0,1.5 and 2%) had significant effects on feed intake in broiler compared to the control group. Zavaragh (2011) showed that 2% garlic, 2% sumac and 2% garlic + sumac powder improved ($p<0.05$) feed intake of Japanese quails compared to the control group. Also, Golzadeh *et al*. (2012) who showed that feed intake of 10g sumac was significantly higher than that of the control and 2.5g sumac/kg birds ($p< 0.05$).

Table (2). Effect of dietary sumac seed powder (SSP) at different levels on feed consumption and feed conversion ratio in Japanese quail.

Treatment	FC	FCR	FC	FCR	FC	FCR	FC	FCR
	Period 1		Period 2		Period 3		Overall	
Control	32.73	4.33 ^{a}	30.15 ^{b}	3.17	32.21	3.35	31.70 ^{ab}	3.61 ^{a}
SSP 1.5	29.84	3.32 ^{b}	34.37 ^{a}	3.21	31.37	2.97	31.86 ^{ab}	3.17 ^{b}
SSP 2.0	29.55	3.09 ^{b}	34.66 ^{a}	3.13	34.13	3.09	32.78 ^{a}	3.10 ^{b}
SSP 2.5	29.95	3.06 ^{b}	31.10 ^{ab}	2.76	29.92	2.70	30.32 ^{b}	2.84 ^{c}
SEM	±1.32	±0.21	±1.18	±0.18	±1.96	±0.23	±0.67	±0.07

a, b, c Means in the same column with different superscripts are significantly different ($p \leq 0.05$)
FC=feed consumption (g/hen/day)   FCR=feed conversion ratio(g feed /g egg

The same observation was noted by Valiallahi *et al*. (2014) who revealed that feed intake had significantly ($P<0.05$) increased in treatments (0.02% sumac powder, 0.02% ajwain powder and 0.02% virginiamycin powder) compared to the control group. Also, Shata and El-Moustafa (2017) found that feed consumption had significantly ($P \leq 0.05$)) increased and better FCR in treatments (1.5,2 and 2.5% SSP) as compared to the control. The present results are not in agreement with the report of Sharbati *et al*. (2013) who found that no significant differences between the treatments for feed intake when used different levels of 0, 0.25, 0.5 and 1% sumac seed powder or 100 mg/kg alpha tocopherol acetate (Vitamin E) of broiler. Arpášová *et al*. (2014) found that the feed consumption and feed conversion ratio were not significantly influenced with oregano oil or sumac addition on laying hens diets. Also, Kheiri *et al*. (2015) reported that 0.02 % sumac powder or 0.02 % dried whey powder had significantly ($P<0.05$) reduced feed intake compared to the control. On the other hand, hens fed diets supplemented with all levels of SSP had significantly the best feed conversion ratio (g feed/g eggs)($P \leq 0.05$) when compared with those fed control diet during 1 and overall period. However, hens fed diets supplemented with all levels of SSP numerically improved FCR compared to the control group during periods 2 and 3 (Table 2). Finally, adding of all levels of SSP to the diet improved the FCR in the laying hens especially 2.5% followed by 2 and 1.5 %SSP. The reduced feed consumption and increased egg production resulted in better feed conversion ratio with sumac addition on laying hens diets.

Egg production traits:

Egg production traits are shown in Table (3). Supplementation all levels of sumac seed powder to quail laying hens diets significantly($P \leq 0.05$)increased egg number/hen/day (En/h/d) and egg mass/hen/day(EM) especially level 2.5% followed by 2 except 1.5 %SSP than those fed control diet at periods 1,2,3 and overall period, while, hens fed 2.5% SSP recorded significantly higher (($P \leq 0.05$) in egg weight (EW) compared to the control group at periods 1,3 and overall period. On the other hand, the egg production (EP %) significantly ($P \leq 0.05$) increased when fed 2 and 2.5% SSP compared to the control group at periods 1 and 2, but at period 3 the level 2% significantly (P≤0.05) increased compared to the control group. At the overall period the laying hens fed all levels of SSP significantly increased compared to the control group. *Rhus coriaria* are rich in oils, fatty acids and minerals, suggesting that they could be valuable for using in foods. The oil includes oleic, linoleic, palmitic and stearic acids(Kizil and Turk 2010). Also, these medicinal plants have active components -which are often called photobiotic or botanical- are secondary metabolites in medicinal plants with positive effects on animal health and productivity (Ghazaghi *et al.,* 2014).It could be the reason for the results of increasing egg production by using all levels of SSP. These results are not in agreement with the report of Arpášová *et al*. (2014) who found that the egg production, egg mass and egg weight were not significantly influenced with oregano oil or sumac addition on laying hens diets.

Table (3). Effect of dietary sumac seed powder (SSP)at different levels on egg production in Japanese quail

Treatment	EN/h/d	EM	EW	EP%	EN/h/d	EM	EW	EP%
			Period 1				Period 2	
Control	0.59[b]	7.61[b]	13.01[b]	59.05[b]	0.71[b]	9.61[b]	13.52	70.95[b]
SSP 1.5	0.68[ab]	8.98[a]	13.33[ab]	67.38[ab]	0.78[ab]	10.72[ab]	13.65	78.51[ab]
SSP 2.0	0.71[a]	9.56[a]	13.38[ab]	71.43[a]	0.80[a]	11.10[a]	13.84	80.28[a]
SSP 2.5	0.73[a]	9.87[a]	13.68[a]	72.14[a]	0.82[a]	11.29[a]	13.80	81.77[a]
SEM	±0.03	±0.36	±0.14	±2.64	±0.03	±0.42	±0.19	±2.55
			Period 3				Overall	
Control	0.72[b]	9.71[b]	13.37[b]	72.62[b]	0.68[b]	8.97[b]	13.30[b]	67.54[b]
SSP 1.5	0.77[ab]	10.58[ab]	13.70[ab]	77.25[ab]	0.74[a]	10.09[a]	13.56[ab]	74.38[a]
SSP 2.0	0.81[a]	11.06[a]	13.71[ab]	80.67[a]	0.77[a]	10.57[a]	13.65[ab]	77.46[a]
SSP 2.5	0.78[ab]	11.08[a]	14.20[a]	78.01[ab]	0.77[a]	10.75[a]	13.89[a]	77.31[a]
SEM	±0.02	±0.33	±0.18	±2.21	±0.02	±0.26	±0.15	±1.65

a, b, c Means in the same column with different superscripts are significantly different (p≤0.05), EN/h/d=Egg number/hen/day, EM=Egg mass/hen/day, EW=egg weight(g), EP%=egg production%

Egg quality:

The results of egg quality among the different treatment groups are presented in Table 4. Egg shape index percentage (ESI%), yolk index percentage (YI%)and egg surface area (ESA) were insignificantly affected by different treatments. Supplementation of 2.5% SSP significantly increased (P≤0.05)internal quality unit (IQU)compared to control group,1.5 and 2.0 % SSP supplementation were equality effective on IQU. The increased of internal quality unit with treatments containing sumac go to increased egg weight and albumin height compared to the control group. While, shell thickness was significant increased ((P≤0.05) when laying birds fed control group compared to 2%SSP.However, both 1.5and 2.5%SSP supplementation were equally effective on egg shell thickness. The lower of egg shell thickness with laying fed sumac may be due to increasing egg rate of laying that depressed shell quality. On the other hand, the yolk colour values were significantly(P≤0.05)increased and linearly with the inclusion level of SSP. Laying fed 2 and 2.5%were significantly (P≤0.05) increased compared to the control group. Sumac seed is rich in phenols, carotenoids, vit. E and C that are dark in colour and they tended to provoke a fair acidification as a good source for yolk pigments.

Table (4). Effect of dietary sumac seed powder (SSP) at different levels on egg quality in Japanese quail

Treatment	Egg shape index%	Yolk index%	Internal quality unit	Shell thickness(mm)	Yolk color	Egg surface area
Control	81.46	48.93	66.41[b]	0.250[a]	4.9[b]	24.63
SSP 1.5	79.79	49.70	68.39[ab]	0.243[ab]	5.13[ab]	25.20
SSP 2.0	81.17	48.63	70.91[ab]	0.240[b]	5.33[a]	24.52
SSP 2.5	81.34	48.17	73.25[a]	0.243[ab]	5.40[a]	25.02
SEM	±0.93	±0.58	±1.94	±0.003	±0.11	±0.24

a, b, c Means in the same column with different superscripts are significantly different (p≤0.05)

Egg components:

Egg components parameters are shown in Table 5. Supplementing hens diet with 1.5 and 2.5% SSP recorded significantly (P≤0.05)increased of egg weight compared to2% SSP. While, there were no effects due to treatments on yolk weight (g), yolk %, yolk height, and albumen weight %. Results revealed that yolk diameter was significantly (P≤0.05)increased by supplementation 2.5% compared with the other levels and control group. Laying fed control group recorded significantly (P≤0.05) increased on albumin % compared to1.5 and 2%. However, laying quail hens fed 2 and 2.5% SSP recorded significantly (P≤0.05) higher albumin height compared to the control group. Results of egg shell % and yolk % / albumen % ratio were higher for all treatments compared to control group. Generally, the increased of most egg quality and components parameters with laying fed SSP compared to the control may be containing sumac on antioxidant, essential oils, medicinal properties, minerals such as (Ca, K, Mg, P, Se, Zn, Fe…) and vit. such as (A,B,C,K and E).

Table (5). Effect of dietary sumac seed powder (SSP)at different levels on egg components in Japanese quail.

Treat.	Egg wt (g)	Yolk				Albumin			Shell	yolk% / albumin %
		%	ht (mm)	diameter	wt (g)	%	wt (g)	ht (mm)	%	
Control	**13.45[ab]**	**29.45**	**12.13**	**25.13[b]**	**3.96**	**62.37[a]**	**8.32**	**5.39[b]**	**8.68[b]**	**0.472[b]**
SSP 1.5	**13.71[a]**	**30.46**	**12.56**	**25.27[b]**	**4.18**	**60.65[b]**	**8.32**	**5.82[ab]**	**8.88[ab]**	**0.502[a]**
SSP 2.0	**13.02[b]**	**30.06**	**12.19**	**24.97[b]**	**3.94**	**60.56[b]**	**8.03**	**5.98a[a]**	**9.34[a]**	**0.496[ab]**
SSP 2.5	**13.57[a]**	**29.33**	**12.59**	**26.13[a]**	**3.98**	**61.53[ab]**	**8.35**	**6.35a[a]**	**9.14[ab]**	**0.477[ab]**
SEM	**±0.15**	**±0.58**	**±0.16**	**±0.18**	**±0.10**	**±0.45**	**0.13**	**±0.17**	**±0.17**	**±0.013**

a, b, c Means in the same column with different superscripts are significantly different (p≤0.05)

Biochemical parameters:

Hematological parameters:

Hematological parameters as shown in Table (6), revealed some changes in its indices. A consistent and significant (P≤0.05) increase in leukocytic (WBCs) and hematocrite, hemoglobin and red blood cells(RBCs) were observed in quail laying hens treated with 2% SSP as compared to other treatments. The increase in WBCs may be as a result of the ability of the plant to cause some degree of improvement in immunity. This observation supports previous studies where sumac has been to cause significant increase in white blood cell count.

Table (6). Effect of dietary sumac seed powder (SSP)at different levels on blood hematological parameters in Japanese quail.

Treat.	WBCs (10 3/mm3	Hemoglobin (g/dl)	Red blood cells (RBCs)	Hematocrite %	MCV	MCH	MCHC
Control	250.23 b	14.43c	2.98bc	42.90 b	144.69 a	49.20 b	34.08 b
SSP 1.5	255.73 b	16.43 b	3.34ab	44.53 b	133.66 b	49.27 b	36.89 a
SSP 2.0	262.87a	18.50 a	3.51 a	49.83 a	142.87 a	53.05 a	37.13 a
SSP 2.5	235.63c	14.87c	2.84c	40.13c	141.30 a	52.29 a	37.04 a
SEM	±1.70	±0.54	±0.12	±0.82	±2.21	±0.69	±0.77

a, b, c Means in the same column with different superscripts are significantly different (p≤0.05)
WBCs= white blood cell count, MCV= Mean Corpuscular Volume, MCH= Mean Corpuscular Hemoglobin, MCHC= Mean Corpuscular Hemoglobin Concentration.

The decrease in HB indicates the seed some particular dose can precipitate some degree of anemia especially if used over a long period of time. On the other hand, 1.5%SSP decreased (P≤0.05) the MCV as compared to other treatments or control group. But, quail laying hens fed on 2 and 2.5 % SSP recorded significantly (P≤0.05) increased the MCH compared to 1.5% or the control group. The highest values of MCHc were recorded in all levels of SSP as compared to control group.

Blood constituents:

Plasma biochemical parameters could be used as indicators for the nutritional and physiological status of experimental quail laying hens. The results of the estimated blood plasma parameters of quail laying hens as affected by dietary SSP are presented in Table (7). It is obvious that dietary supplementation of all levels of SSP. This could be due to the significantly (P≤0.05) increase in the plasma concentration of globulin level and significantly (P≤0.05)lower of albumen and A/G achieved by the supplemented 2% SSP compared to the other treatments and control group. Total serum protein has been reported as an indication of the protein retained in the animal body (Esonu *et al*., 2001). The relatively greater total serum protein content of broilers receiving dietary SSP might be an indication of the good protein content and/or quality of the sumac seed powder.

The current results indicated that 2% SSP may improve the immune response. Globulin level has been used as an indicator of immune responses and source of antibody production. Griminger (1986) stated that high globulin level and low A/G ratio signify better disease resistance and immune response. On the other hand, laying of 2 and 2.5% SSP had significantly (P≤0.05)higher values of plasma total antioxidant capacity compared to those fed 1.5% SSP or control group. This is may be due to sumac containing antioxidant enzymes.

Table (7). Effect of dietary sumac seed powder (SSP)at different levels on blood in Japanese quail.

Treatment	Plasma protein profile				Total antioxidants capacity (mmol/l) TAC
	Total protein	Albumin	globulin	A/G	
Control	4.52	1.37 [a]	3.15 [b]	0.44[a]	0.150[b]
SSP 1.5	4.50	1.22 [a]	3.28 [b]	0.37 [a]	0.177 [b]
SSP 2.0	4.68	0.69 [b]	3.98 [a]	0.18 [b]	0.244 [a]
SSP 2.5	4.66	1.30 [a]	3.36 [b]	0.39 [a]	0.227 [a]
SEM	±0.07	±0.05	±0.09	±0.02	±0.01

a, b, c Means in the same column with different superscripts are significantly different (p≤0.05),
A/G=Albumin/globulin, TAC=total antioxidants capacity(mmol/l)

Similar results have been obtained by Shata and El-Moustafa(2017) who showed that quail chicks fed sumac seed powder had significantly higher (P≤0.05) total antioxidants capacity, total protein and globulin and better A/G as compared to the control.

Data of blood parameters laying hens fed the experimental diets containing different levels of SSP are presented in Table 8. It is evident that dietary 1.5 and 2% SSP % recorded significantly (P≤0.05)lower cholesterol level compared with those fed 2.5% SSP or the control group. The current results showed that birds fed all levels of SSP recorded significantly (P≤0.05) the highest values of HDL and the lowest values of LDL compared with the control group. Serum total lipids were significantly decreased for the groups fed different levels of SSP as compared to the control . These results agree with those obtained by Mansoub (2011), Zavaragh (2011)and Shata and El-Moustafa(2017) who showed that the serum total cholesterol and LDL concentration were significantly reduced, while HDL was significantly increased in treatment containing sumac compared to the control (P≤0.05).

Table (8). Effect of dietary sumac seed powder (SSP)at different levels on plasma lipid profile and liver enzymes in Japanese quail.

Treatment	Plasma lipid profile				Liver enzymes	
	Cholesterol	HDL	LDL	Total lipid	AST	ALT
Control	129.42 [a]	68.37 [c]	61.04 [a]	856.67 [a]	86.00 [a]	41.67 [a]
SSP 1.5	104.88 [b]	72.58 [bc]	32.30 [b]	770.67 [b]	81.33 [ab]	32.67 [b]
SSP 2.0	107.03 [b]	75.00 [b]	32.03 [b]	769.33 [b]	79.00[bc]	27.00 [c]
SSP 2.5	121.55 [a]	85.18 [a]	36.37 [b]	543.33 [c]	74.33[c]	38.67 [a]
SEM	±2.55	±1.80	±2.19	±14.64	±1.49	±1.15

a, b, c Means in the same column with different superscripts are significantly different (p≤0.05).

Also, Golzadeh *et al*. (2012) found that total cholesterol of birds fed 5g and 10g sumac/kg was significantly lower than that of the control and 2.5g ($p< 0.05$). Moreover, no significant difference between the treatments for plasma the HDL and LDL than those of the other treatments ($p<0.05$). Valiallahi *et al*.(2014) revealed that blood total cholesterol and LDL decreased significantly at 0.02% sumac, while HDL significantly increased compared to the other treatments. Also, Kheiri *et al*.(2015) found that the serum concentration cholesterol of chicks decreased significantly by sumac and whey powder feeding. While, LDL level decreased significantly, HDL levels increased in the sumac group compared to the control. Gurbuz and Salih (2017) found that supplementation sumac (10,20 and 30g/kg)or ginger power (10,20 and 30 g/kg)in hens diets significantly increased HDL and decreased LDL and cholesterol levels in the blood of hens. On contrary,Sharbati *et al*. (2013) found that the blood total protein of sumac or vit. E fed birds was lower than that of control birds ($P<0.05$).None of blood cholesterol, triglyceride and hemoglobin was affected by dietary treatments.

From Table (8), all levels of SSP were decreased liver enzymes (AST,ALT). This result pointed out that birds could tolerate the addition of SSP up to 2.5% without any deleterious effects on kidney and liver functions. The main reason of cholesterol and triglyceride decrease in blood of chicks is substances like carvacrol and thymol which are present in herbs such as these herbal. The hypocholesterolemic action of sumac is possibly related to its polyphenolic components. Polyphenols have been shown to depress the reverse-cholesterol transport, reduce the intestinal cholesterol absorption and increase bile acid excretion (Tebib *et al*., 1994). These substances have effect on cholesterol and triglyceride and decrease these harmful parameters in blood (Zargari, 2011). These results agree with those obtained by Shata and El-Moustafa(2017) who found that quail chicks fed sumac seed powder had lowest ($P\leq0.05$)ALT and AST compared to the control.

Reproduction performance:

The effect of feeding dietary inclusion of sumac seed powder 0.0, 1.5, 2.0 and 2.5% on fertility, hatchability, clear, embryonic mortality and deformed percentages of Japanese quail laying hens are presented in Table 9. The fertility and hatchability (based on total eggs set) were significantly increased by increasing the levels of SSP compared to control group. Also, the hatchability (based on fertile eggs set) was increased by using all levels of SSP compared to control. Also, the experimental diets contained 2% SSP resulted in a significant increase the hatchability of fertile egg % as compared to the control diet. Significant differences were observed on clear % between all levels SSP and the control group. The hens fed 2.5% recorded significantly ($P\leq0.05$) the lowest value (1.67%) followed by those fed 2%SSP (6.67%) and 1.5%SSP (8.33%), then the control group which recorded the highest clear% (20.00%). In respect of dead embryonic mortality, it was significantly decreased ($P\leq0.05$) by 2% SSP with exception the diet contained 1.5%SSP. On the other hand, data in Table (9) indicated no significant differences between hens fed all levels of SSP on deformed % compared to the control group.

Table (9). Effect of dietary sumac seed powder (SSP)at different levels on hatchability parameters in Japanese quail.

Treatment	Fertility%	Hatch.t. egg%	Hatch.f. egg%	Clear%	Dead %	Deformed%
Control	80.00^{c}	66.67^{c}	83.66^{b}	20.00^{a}	8.33^{ab}	5.00
SSP 1.5	91.67^{b}	78.34^{b}	86.63^{ab}	8.33^{b}	10.00^{a}	3.33
SSP 2.0	93.33^{b}	83.33^{a}	89.44^{a}	6.67^{b}	6.67^{b}	3.33
SSP 2.5	98.33^{a}	85.00^{a}	86.40^{ab}	1.67^{c}	8.33^{ab}	5.00
SEM	±1.44	±1.26	±1.33	±0.87	±0.58	±0.62

a, b, c Means in the same column with different superscripts are significantly different ($p\leq0.05$).
Hatch.t. egg%: hatchability per total eggs ; Hatch.f. egg%: hatchability per fertile eggs

The improved fertility and hatchability may be due to containing sumac seed minerals such as selenium, zinc and vitamins such as B,C and E. Also, the increase in the productive performance of hens fed sumac seed due to those medicinal properties herbs sumac seed could be attributed to their essential oils content.

CONCLUSION

Supplementation of 1.5, 2.0 and 2.5% of sumac seed powder had significantly improved feed consumption and feed conversion ratio of laying Japanese quail. Also, improved egg production performance, egg quality, most hematological parameters, blood constituents and reproductive performance. And lower cholesterol levels in the blood. In general, the best levels 2.0 and 2.5%.

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تأثيرالتغذيةعلى مسحوق بذور السماق كمضاد أكسدة ومنشط للنموعلى إنتاج البيض والدم في السمان اليابانى البياض

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تم دراسة تأثير مستويات مختلفة من مسحوق بذور السماق كمضاد أكسدة ومنشط للنمو على الأداء الإنتاجى وانتاج البيض وجودة البيض وبعض قياسات الدم والأداء التناسلى على السمان الياباني باستخدام 180 طائر عمر 9 أسابيع ، والتي تم توزيعها عشوائيا إلى 4 معاملات غذائية (0.0، 1.5، 2.0 و 2.5٪) 45 طائر لكل معاملة و 3 مكررات (10 دجاجات و 5 ديك في كل منهما). يمكن تلخيص النتائج التي تم الحصول عليها على النحو التالي: في الفترات الكلية سجلت نسبة 2٪ زيادة معنوية فىإستهلاك العلف مقارنة مع 2.5٪، في حين أن جميع مستويات بذور السماق سجلت أفضل القيم فى الكفاءة التحويلة للأعلاف مقارنة مع مجموعة الكنترول. أيضا كانت نسبة إنتاج البيض، وعدد البيض، ووزن البيض، وكتلة البيض / الدجاجة / يوم فى معاملات السماق أعلى معنويا عن الكنترول. إضافة بذور السماق الى العلائق أدى الى زيادة معنوية فى ارتفاع البياض وحدة الجودة الداخلية، لون الصفار والنسبة المئوية للقشرة ونسبة الصفار / للبياض. ومع ذلك انخفض معنويا نسبة الألبومين وسمك القشرة مقارنة مع مجموعة الكنترول. أيضا، فإن معظم مستويات السماق حسنت من صفات الدم الهيماتولوجية مثل خلايا الدم البيضاء والهيموجلوبين وخلايا الدم الحمراء ومتوسط تركيزالهيموجلوبين وبخاصة عند تغذيةالطيور على 1.5 و 2٪ سماق مقارنة مع مجموعة الكنترول. سجلت تغذية الطيورعلى 1.5 ٪ أعلى قيمة للجلوبيولين وتحسين نسبة A / G مقارنة مع المعاملات الأخرى،حدث إنخفاض معنوى فىنسبةالدهون في الدم وإنزيمات الكبد والدهون الكلية ولكن زادت مضادة الأكسدة الكلية باضافة السماق.تحسن الأداء التناسلى بشكل ملحوظ ($p \leq 0.05$) عندالتغذية على بذور السماق .في الختام،أظهرت البيانات التي تم الحصول عليها أن إضافة مسحوق بذورالسماق بنسب (1.5، 2.0 و 2.5٪) للسمان الياباني البياض حسن منإنتاج البيض،وجودة البيض،ومعظم صفات الدم الهيماتولوجية ،صفات الدم الكيموحيوية والأداءالتناسلي.

الكلمات الدالة: *بذورالسماق،جودةالبيض،الدم،القياسات الفسيولوجية،السمان الياباني البياض*