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Full Length Article

Onion (*Allium cepa*) and Sumac (*Rhus coriaria*) Powder as Dietary Supplements for Japanese Quail (*Coturnix japonica*): Effect on Egg Production, Blood Parameters and Antioxidant Activity

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Abstract

This study aimed to evaluate the effect of onion (*Allium cepa* L.) and sumac (*Rhus coriaria* L.) powder on egg production, antioxidant and physiological parameters of Japanese quail (*Coturnix japonica* Temminck & Schlegel, 1849). A total of 2500 quails were used in this study. The quails were randomly assigned into five groups (15 quails/replicate) and all birds were fed and watered *ad libitum* throughout the assay. The control group (D_1) received a basal diet, whereas the treated groups received 5 g/kg (D_2) and 10 g/kg (D_3) onion powder as a supplement to the basal diet, and 5 g/kg (D_4) and 10 g/kg (D_5) of sumac powder as a supplement to the diet. We demonstrated that the supplementation of diets with onion or sumac powder significantly improved quails' egg production, the activity levels of ALT, AST and GSH, and a decrease in MDA level compared to the control. Based on the results, we concluded that dietary supplementation of onion and sumac powder can be appropriate to feed the quails and improve egg production, antioxidant enzyme activity, and serum cholesterol levels.

Keywords: Quail; Herb-based dietary supplement; Feeding; Antioxidant; Egg production

Introduction

In the last decades, the interest in herbs' active components has increased due to the benefits they have on human and animal health (Ahmadian *et al.* 2020). It is well known that the essential oils derived from aromatic plants have antibiotic and antibacterial properties and stimulate the immune system (Alagawany *et al.* 2017), digestion (Mohammed *et al.* 2021), help to lower cholesterol levels (Sabir and Aydin 2017), have antioxidant properties (Aydin and Alcicek 2018) and can also act as growth stimulators (Stankovic 2020).

Onion (*Allium cepa* L.) has a wide range of biological properties, including antioxidant, antimutagenic, and antibacterial properties (Dorrigiv *et al.* 2021). An *et al.* (2015) reported the benefits onion extract has when added to broilers' drinking water, including improved functional performance and decreased lipids profile. Onion seeds are rich in linoleic acid (with levels ranging between 49 and 60%), and are mainly composed of oil (21.86%) and crude proteins (15.70–26.1%) (Yalcin and Kavuncuoglu 2014; Sakhr and El Khatib 2020).

Sumac (*Rhus coriaria* L.), which includes more than 90% of the Anacardiaceae species, is rich in different kinds of compounds, including flavonols, phenolic acids, anthocyanins, and organic acids such as malic and citric (Sakhr and El Khatib 2020). They also contain oleic acid (37.7%), linoleic acid (34.8%), palmitic acid (27.4%) and stearic acid (17%) (Kizil and Turk 2010; Ardalani *et al.* 2016). Several studies showed that small amounts of sumac powder (0.2-0.5%) can improve feed efficiency and reduce plasma lipids when used as a dietary supplement (Kheiri *et al.* 2015). This study determined the effect of onion and sumac powder as dietary supplements on production indicators, serum antioxidants concentration and physiology of Japanese quail.

Materials and Methods

Experimental details and treatments

Experimental details: The quails used in this experiment were provided by the Department of Animal Production, Tikrit University, Iraq, which works on a project to cross flocks of quail to obtain new breeds. 16 weeks-old quails (n = 225) were used in this study. The quail were randomly assigned to one of five groups, and each group had three pins (15 quail per pin) for eight weeks.

Treatments: The control group consisted of a basal diet (D1), whereas the treated groups consisted of the basal diet supplemented with onion powder 5 g/kg (D_2), onion powder 10 g/kg (D_3), sumac powder 5 g/kg (D_4) and sumac powder

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Table 1: Ingredients and chemical composition of the basal diet

Ingredients	Production (%)
Yellow maize*	56.7
Soybean 44%	28
Wheat	2
Vegetable oil	2
Primix	5
Salt	0.3
Di-calcium phosphate	1
Limestone	5
Chemical Composition	100
ME (kcal/kg)	2930.05
Crude Protein (%)	20.48
Phosphor	0.57
Lysine	1.09
Methionine	0.46
Methionine + cysteine	0.77
Calcium	2.28
Crude fibres	3.42

References: Yellow maize: Protein (48%), ME 2440 (kcal/kg)

10 g/kg (D_5). Quails were fed *ad libitum* using adapted equipment; the water and diet for each group were recommended by the (National Research Council 1994) (Table 1). They were kept at a thermo neutral temperature (daytime temperatures ranged between 2°C and 23°C).

Egg production

Egg production per group and pen was recorded weekly, which included measuring egg weight and egg number; with such measures, egg mass was calculated as the egg number × egg weight. Feed intake was recorded and calculated as the loss in grams of feed over seven days (divided by the number of quail days), and feed conversion ratio was recorded weekly as mass divided by the amount of feed.

Blood extraction

Blood samples were collected from three quails from each pin in week eight. Blood samples were taken from the jugular vein and collected into heparinised tubes; serum was isolated and stored at -20°C.

Antioxidant enzyme activities, blood parameters and serum cholesterol quantification

Blood plasma was used to analyse the activity of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) enzymes, using a commercial kit (Biolabo, Franch). Glutathione (GSH) was quantified by spectrophotometric methods at 412 nm, according to Elman's methods. Malonaldehyde (MDA) was analyzed according to Guidet and Shah (1989). Glucose, total proteins, albumin and uric acid were determined using the Spinreact Kit (brand, origin), whereas globulin was determined as the rate between total protein and albumin (Guidet and Shah 1989). Cholesterol and triglycerides were determined using a commercial kit (Biolabo, Franch).

Statistical Analyses

Data coming from the assays were analysed using the software Statistical Analysis System (SAS; v. 9.0, USA) (SAS 2004). Firstly, data were analysed for normality. Then, differences between the groups were assessed using a one-way analysis of variance (ANOVA), followed by Duncan's test (Duncan 1953) at a 95% confidence level. Graph Pad Prism (version 8.0 for windows) was used for graphical analyses (Graph Pad Software, San Diego California, USA).

Results

Egg production

Onion and sumac powder included as supplements in quails' diets significantly affected ($P < 0.05$) all the egg production parameters (Table 2). In general, a significant increase was detected in egg production (%), egg weight (g), egg mass (g/h/d), and cumulative eggs number for both supplements at either concentration compared to the control, during the three weekly periods evaluated. Sumac powder (10 g/kg, D_5) had a statistically significant effect on egg production (90.95%), egg weight (6.36 g), egg mass (12.12 g/h/b) and cumulative eggs number (11.44) in the period (5–8 weeks), respectively. During the first period (1–4 weeks) we found the best value for FCR and feed intake in all treated diets when compared to the control diet over time (1–4 weeks). Treatment D_5 (10 g/kg sumac powder) had the lowest FCR and feed intake ($P < 0.05$) when compared to treatment D_2 (5 g/kg onion powder) and the control. We found similar results in the second period (1–8 weeks) in which 10 g/kg sumac powder supplementation (D_5) presented the best results in all parameters compared to 5 g/kg onion powder (D_2) and control (Table 3).

Liver function, Serum oxidative and Blood biochemistry

Antioxidant activity, blood parameters and serum cholesterol: Onion and sumac powder included as supplements in quails' diets significantly affected ($P < 0.05$) liver enzymes and antioxidant parameters (Fig. 1). The best results were obtained by the addition of the highest dose of sumac powder (10 g/kg), which recorded the highest aspartate aminotransferase (AST) and alanine aminotransferase (ALT) enzymes levels (Fig. 1a, b), the best GSH level and a decrease in the MDA level in quail serum compared to the control group and onion groups (Fig. 1c–d).

Dietary intake of onion powder (5 and 10 g/kg) and sumac powder (5 and 10 g/kg) did not affect the levels of serum uric acid, total proteins, albumin and globulin compared to control (Table 4). Contrarily, the onion and sumac powder supplements at both doses (10 and 5 g/kg) led to a lower serum glucose level compared to the control.

Table 2: Effects of onion and sumac powder on HD (%), egg weight (g), Egg mass and cumulative eggs number of Japanese quail

Treatments*	Parameters			
	HD (%)	Egg weight (g)	Egg mass (g/h/d)	Cumulative eggs number
	1- 4 weeks			
D_1 Control	77.61 ± 1.09 ^{b}	5.43 ± 0.07 ^{b}	10.97 ± 0.08 ^{c}	8.51 ± 0.14 ^{b}
D_2 (5 g/kg OP)	88.09 ± 1.31 ^{a}	6.18 ± 0.09 ^{a}	12.44 ± 0.13 ^{a}	10.96 ± 0.18 ^{a}
D_3 (10 g/kg OP)	90.47 ± 1.10 ^{a}	6.33 ± 0.07 ^{a}	12.19 ± 0.05 ^{ab}	11.00 ± 0.13 ^{a}
D_4 (5 g/kg SP)	89.04 ± 1.00 ^{a}	6.23 ±0.06 ^{a}	12.23 ± 0.08 ^{ab}	10.90 ± 0.16 ^{a}
D_5 (10 g/kg SP)	88.10 ± 1.00 ^{a}	6.21 ± 0.07 ^{a}	12.12 ± 0.06 ^{b}	10.76 ± 0.13 ^{a}
	5-8 weeks			
D_1 Control	79.52 ± 1.09 ^{c}	5.56 ± 0.07 ^{c}	11.72 ± 0.06 ^{c}	9.32 ± 0.13 ^{c}
D_2 (5 g/kg OP)	86.42 ± 1.05 ^{b}	6.05 ± 0.07 ^{b}	12.53 ± 0.07 ^{b}	10.83 ± 0.14 ^{b}
D_3 (10 g/kg OP)	88.09 ± 1.01 ^{ab}	6.16 ± 0.06 ^{ab}	12.63 ± 0.06 ^{ab}	11.12 ± 0.11 ^{ab}
D_4 (5 g/kg SP)	89.28 ± 1.13 ^{ab}	6.24 ± 0.08 ^{ab}	12.81 ± 0.08 ^{a}	11.43 ± 0.14 ^{a}
D_5 (10 g/kg SP)	90.95 ± 1.08 ^{a}	6.36 ± 0.07 ^{a}	12.58 ± 0.04 ^{a}	11.44 ± 0.13 ^{a}
	1-8 weeks			
D_1 Control	78.57 ± 0.51 ^{c}	5.50 ± 0.03 ^{c}	11.35 ± 0.06 ^{b}	8.92 ± 0.07 ^{b}
D_2 (5 g/kg OP)	87.26 ± 0.93 ^{b}	6.11 ± 0.06 ^{b}	12.49 ± 0.03 ^{a}	10.89 ± 0.11 ^{a}
D_3 (10 g/kg OP)	89.28 ± 0.63 ^{ab}	6.25 ± 0.04 ^{ab}	12.41 ± 0.04 ^{a}	11.06 ± 0.07 ^{a}
D_4 (5 g/kg SP)	89.16 ± 0.70 ^{ab}	6.24 ± 0.05 ^{ab}	12.52 ± 0.07 ^{a}	11.16 ± 0.11 ^{a}
D_5 (10 g/kg SP)	89.88 ± 0.73 ^{a}	6.29 ± 0.05 ^{a}	12.35 ± 0.04 ^{a}	11.10 ± 0.10 ^{a}

Means with different letters in the same column differ significantly ($P < 0.05$).
References: letter D in each line states "diet"; OP: Onion Powder; SP: Sumac Powder

Table 3: Effects of onion and sumac powder on feed intake (g/b) and FCR in Japanese quail

Treatments*	Parameters					
	Feed intake (g/bird)			FCR		
	1– 4 weeks	5–8 weeks	1–8 weeks	1–4 weeks	5–8 weeks	1–8 weeks
D_1 Control	36.26 ± 0.53 ^{a}	34.37 ± 0.62 ^{a}	35.31 ± 0.43 ^{a}	4.27 ± 0.10 ^{a}	3.70 ± 0.09 ^{a}	3.40 ± 0.06 ^{a}
D_2 (5 g/kg OP)	31.49 ± 0.47 ^{b}	32.59 ± 0.60 ^{b}	32.04 ± 0.37 ^{b}	2.85 ± 0.03 ^{b}	3.01 ± 0.05 ^{b}	2.95 ± 0.05 ^{b}
D_3 (10 g/kg OP)	30.17 ± 0.55 ^{b}	30.26 ± 0.35 ^{c}	30.22 ± 0.26 ^{c}	2.74 ± 0.05 ^{b}	2.72 ± 0.04 ^{c}	2.74 ± 0.03 ^{c}
D_4 (5 g/kg SP)	29.88 ± 0.60 ^{bc}	28.95 ± 0.36 ^{c}	29.02 ± 0.25 ^{d}	2.68 ± 0.07 ^{b}	2.53 ± 0.04 ^{d}	2.61 ± 0.03 ^{d}
D_5 (10 g/kg SP)	28.88 ± 0.52 ^{c}	28.52 ± 0.40 ^{c}	28.70 ± 0.30 ^{d}	2.69 ± 0.06 ^{b}	2.50 ± 0.05 ^{d}	2.60 ± 0.04 ^{d}

Means with different letters in the same column differ significantly ($P < 0.05$)
References: letter D in each line states "diet"; OP: Onion Powder; SP: Sumac Powder

Table 4: Effects of onion and sumac powder on blood parameters in Japanese quail.

Treatments*	Groups				
	D_1 Control	D_2 (5 g/kg OP)	D_3 (10 g/kg OP)	D_4 (5 g/kg SP)	D_5 (10 g/kg SP)
Glucose (mg/dL)	255.45 ± 8.96^{a}	251.19 ± 8.50^{a}	212.24 ± 9.20^{b}	213.03 ± 5.08^{b}	220.39 ± 5.27^{ab}
Total Protein (g/dL)	2.89 ± 0.30	3.07 ± 0.22	2.57 ± 0.09	3.14 ± 0.29	2.73 ± 0.56
Albumin (g/dL)	1.13 ± 0.15	1.03 ± 0.09	1.04 ± 0.15	1.18 ± 0.11	1.04 ± 0.08
Globulin (g/dL)	1.76 ± 0.25	1.86 ± 0.28	1.53 ± 0.17	1.96 ± 0.21	1.94 ± 0.50
Uric acid (mg/dL)	5.42 ± 0.68	4.79 ± 0.57	4.52 ± 0.63	5.97 ± 0.48	5.59 ± 0.15
Cholesterol (mg/dL)	130.26 ± 3.19^{a}	82.21 ± 5.24^{c}	90.10 ± 2.07^{c}	117.24 ± 3.74^{b}	107.50 ± 10.80^{b}
Triglyceride (mg/dL)	138.68 ± 1.12^{a}	105.65 ± 7.66^{b}	108.24 ± 1.15^{b}	121.51 ± 7.39^{b}	105.65 ± 12.50^{b}

Means with different subscripts in the same column differ significantly ($P < 0.05$)
References: letter D in each column states "diet"; OP: Onion Powder; SP: Sumac Powder

Regarding cholesterol and triglycerides levels in quails' serum, both onion and sumac supplements significantly ($P < 0.05$) affected them (Table 4). The addition of 10 g/kg of sumac powder (D_5) to the quails' diet reduced serum cholesterol and triglyceride levels compared to the control and onion groups.

Discussion

The supplementation of quails' diet with powders obtained from the medicinal plants onion and sumac improved all the egg productivity parameters evaluated and led to a reduction in feed intake with the best FRC value. These results might be explained due to the rich and diverse chemical composition of both herbs since onion and sumac are rich in gallic, benzoic and L-ascorbic acids, as well as flavones, and a variety of minerals such as potassium, calcium, magnesium, and phosphorous (Kheiri *et al.* 2015). Similar results were achieved by Gopi (2014) and Świątkiewicz *et al*. (2018), who found that herbal plants can stimulate digestion in birds, improve liver function, and increase pancreatic digestive enzymes. Thus, it is likely the increased plant planetary, carbohydrate and protein metabolisms in the main organs would accelerate quails' growth and improve egg production. In other studies, Liu *et al.* (2013) and Damaziak *et al.* (2017) showed that synthetic quercetin improved the laying performance of hens.

Moreover, both medicine plants tested in the current study induced a significant increase in the antioxidant

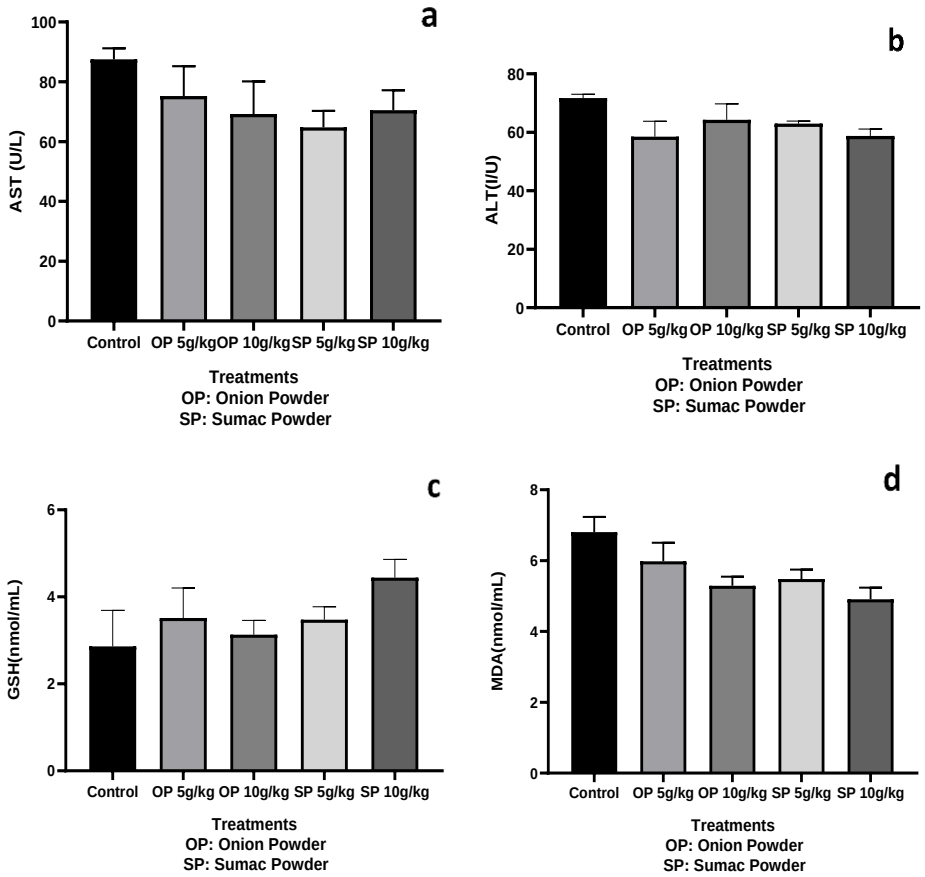

Fig. 1: Effects of onion and sumac powder on antioxidant serum in Japanese quail. **a**) AST activity, **b**) ALT activity, **c**) GSH, **d**) MDA

activity in quails' blood, as denoted by the AST, ALT and GSH and a reduction in MDA, without differences between those fed diets containing 5 or 10 g/kg of onion or sumac powder. This outcome might be explained because these plants are rich in flavonoids and sulfur compounds, as well as a variety of other elements that play an important role as antioxidants, which would contribute to increasing serum GSH levels and decreasing serum MDA, as observed also by Kheiri *et al.* (2015). Particularly, the onion has a high content of polyphenols, glycosides, anthocyanins, allicin, and quercetin (Ye *et al.* 2013), which are purely natural antioxidants and can scavenge free radicals and release electrons or hydrogen atoms, contributing to the antioxidant activity (Rajani *et al.* 2011).

The supplement of quails' diet with onion and sumac powder led to an improvement in lipid profiles with lower levels of cholesterol and triglyceride in the serum. One possible explanation is due to the high levels of bioactive phenolic compounds with antioxidant properties and of flavones and minerals these supplements have. The results showed that the groups fed onion and sumac powder had. Similar results demonstrated that dietary onions effectively reduced serum cholesterol levels and the secretion of cholesterol from the liver while increasing the uptake of high-density lipoprotein in diabetic rats (HDL) (El-Demerdash *et al.* 2005). In addition, Goodarzi and Nanekarani (2014) found that broilers fed with a diet containing 3% onion showed significant decreases in the levels of blood cholesterol and triacylglycerol compared to those fed with the control diet (Zavaragh 2011). According to An *et al.* (2015), the onion effects on lipid metabolism were associated with the activity of sulphur-containing compounds that oxidize free or protein-associated thiol compounds, and NADPH, which is required for lipid synthesis.

Finally, the studied herb-based dietary supplements decreased quails' glucose levels, which might be due to the capacity of onion and its compounds to inhibit the enzymatic breakdown and digestion of starch and others carbohydrates, as well as enzymes involved in glucose metabolism (Vidyavati *et al.* 2010; Barber *et al.* 2021).

Conclusion

Onion and sumac powder significantly improved Japanese quails' egg production and feed efficiency when added to the basal diets, and reduced the feed intake, cholesterol and triglyceride levels, and lipid peroxidation. Thus, onion and sumac powder constitute viable dietary supplements for Japanese quail feeding.

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Author Contributions

AM and AA was coordinator of the research and analyzed and interpreted the data. AA and AA in the study were supervisor of data collection and wrote draft manuscripts, AA, AM and AA was assistants of the collection of data. All authors read and approved the final manuscript.

Conflict of interests

The authors declare no conflict of interest.

Data Availability

Data are available on a reasonable request

Ethics Approval

The study was conducted according to the guidelines of the Declaration of guidelines passed by the institutional ethics committee for the care of animals and were approved by the Animal Ethics Committee of the Department of Animal Production, Tikrit University, Iraq (No.AS-3024P).

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