



**T.R.**

**KAHRAMANMARAŞ SÜTÇÜ İMAM UNIVERSITY**  
**GRADUATE STUDIES IN SCIENCE AND TECHNOLOGY**

**THE USE OF SUMAC (*Rhus coriaria L.*) AS A FEED  
ADDITIVE IN JAPANESE QUAIL DIET**

**PAYAM SADIK SABIR**

**M.Sc. Degree Thesis**  
**ANIMAL SCIENCE**

**KAHRAMANMARAŞ - TURKEY 2014**

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**PAYAM SADIK SABIR**

**Thesis submitted in candidature for  
the degree of Master in Department of  
ANIMAL SCIENCE**

**KAHRAMANMARAŞ – TURKEY 2014**

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I hereby declare that all information in the thesis has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

PAYAM SADİK SABİR

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**SUMAK'IN (*Rhus Coriaria L.*) JAPON BILDİRCİNLERİNİN RASYONLARINDA  
YEM KATKI MADDESİ OLARAK KULLANIMI**

**(YÜKSEK LİSANS TEZİ)**

**PAYAM SADIK SABİR**

**ÖZ**

Sumak (*Rhus Coriaria L.*) içerdiği esansiyel amino asitler, vitaminler ve mineraller nedeniyle hep araştırmaların ilgi odağı olmuştur. Bu tez çalışması, Sumakın Japon bildircinlerinde (*Coturnix coturnix japonica*) vücut ağırlığı, yem tüketimi, yumurta ağırlığı, yağ asitleri ve kolesterol kompozisyonu gibi parametreleri üzerine etkilerinin araştırılması amacıyla yapılmıştır. İlk denemede, 7 günlük 180 adet Japon bildircini rastgele üç gruba ayrılarak (4 tekerrür) % 0, % 0,5 veya %1.5 sumak içeren rasyonlarla 5 hafta beslenmişlerdir. *Ad libitum* olarak beslenen bildircinler çalışmada beşinci haftanın sonunda, her tekerrürden 4 bildircin kesilerek karkas ağırlığı ile iç organ ağırlıkları ölçülmüştür. Göğüs, bacak, ve kanatlar vücuttan ayrılarak tartılmıştır. Rasyona 1% oranında sumak eklenmesi vücut ağırlığı ile karaciğer ağırlığının önemli şekilde azalmasına neden olmuştur.

İkinci denemede, 7 haftalık 84 yumurtlayan bildircin rastgele 4 gruba (3 tekerrür/ grup) ayrılarak %0, %0.25, %0.5 veya %1 sumak içeren rasyonla 48 gün boyunca beslenmişlerdir. Yumurtalar günlük olarak toplanmış ve ağırlıkları tartılmıştır. Denemenin son haftasında tekerrür başına 3 yumurta yağ asidi için toplanmıştır. Kolesterol analizi için ise grup başına 3'er yumurta rastgele seçilmiştir. Diyete %0.5 sumak eklenmesi, yumurta sarısı renginin azalmasına neden olmuştur. Rasyonlara sumak eklenmesi kontrol grubuna kıyasla Japon bildircinlerinde vücut ağırlığının azalmasına neden olmuştur. Yine rasyonda kullanılan sumak, yumurta yağ asitlerini önemli bir şekilde etkileyerek özellikle tekli doymamış yağ asitlerinde istenen artışa ve doymuş yağ asitlerinde azalmaya neden olmuştur.

**Anahtar Kelimeler:** Sumak, karkas performansı, yumurta sarısı yağ asidi kompozisyonu, yumurta kolesterolü, Japon bildircini

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# THE USE OF SUMAC (*Rhus Coriaria L.*) AS A FEED ADDITIVE IN JAPANESE QUAIL DIET

(M.Sc. THESIS)

PAYAM SADIK SABIR

## ABSTRACT

Sumac, growing in no agriculturally viable region, contains some imperative essential amino acids, vitamins and minerals. The objective of the present study was to investigate the impact of the sumac (*Rhus coriaria L.*) as a feed additive on body weight, feed intake, egg properties such as egg fatty acid profile and cholesterol content in Japanese quail (*Coturnix coturnix japonica*). Two experiments were conducted. In the first experiment, one hundred and eighty 7 days old Japanese quail were randomly assigned into three groups (4 replicates, 15 birds/ replicate) and fed a diet supplemented with 0, 0.5, or 1.0 % sumac for 5 weeks. The birds received water and feed *ad libitum* during the study. At the end of the fifth week of the study, 4 birds per replicate were killed and eviscerated body and internal organ weights were measured. Breast, legs, and wings were separated from the body and weighed. The results showed that adding 1% sumac to the diet led to decrease body weight and liver weight from one week to five weeks of age.

In the second experiment, 84 laying quails at 7 weeks of age were randomly assigned into 4 groups (3 replicates/each group) and fed a diet supplemented 0, 0.25, 0.5 or 1.0% sumac for 48 days. Eggs were collected and weighed daily. At the end of the last week, 3 eggs per replicate were collected for fatty acid analysis. Also for yolk cholesterol analysis, 3 eggs per group were separated. Some eggs were checked for egg parameters such as yolk and albumen weight, shell weight, yolk color, and Haugh unit. The results refer to a decreasing degree of yolk color by adding 0.5% sumac to the diet. Also results showed decreasing final body weight by adding different level 0.25, 0.5, and 1 % of sumac to the diet. Use of sumac significantly decreased saturated fatty acid (mainly C14:0, C16:0 and C18:0) and increasing mono-saturated fatty acids (mainly C16:1, n-7 and C18:1,n-9). Supplementation of sumac did not affect cholesterol levels in the egg yolk.

**Keywords:** Sumac, body performance, yolk fatty acid, yolk cholesterol, Japanese quail.

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Page number: 45

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## CONTENTS

	<b><u>Page No</u></b>
ÖZ .....	i
ABSTRACT .....	ii
ACKNOWLEDGMENT .....	iii
LIST OF CONTENTS .....	iv
LIST OF TABLES .....	vii
1. INTRODUCTION .....	1
1.1. Sumac.....	1
1.2. Japanese Quail.....	2
1.3. Objectives Of The Study.....	3
2. LITERATURE REVIEW .....	4
2.1. Compound Of Sumac.....	4
2.1.1. Minerals in sumac .....	5
2.1.2. Fatty acid, amino acid, and organic acid in sumac .....	6
2.1.3. Vitamins in sumac.....	10
2.1.4. Anti-oxidant and anti-microbial activity of sumac .....	11
2.1.5. Effect of sumac on poultry .....	12
3. MATERIAL AND METHOD.....	14
3.1. Source Of Sumac .....	14

**Page No**

3.2. Experiment 1 .....	15
3.2.1. Experimental design .....	15
3.2.2. Preparing feed .....	15
3.2.3. Live body weight and body weight gain .....	16
3.2.4. Feed intake and feed conversion ratio .....	16
3.2.5. Body parts weight .....	16
3.2.6. Mortality and live ability % .....	16
3.3. Experiment 2 .....	17
3.3.1. Experimental design .....	17
3.3.2. Housing and equipment's .....	17
3.3.3. Preparing feed .....	17
3.3.4. Egg production ratio .....	19
3.3.5. Egg mass .....	19
3.3.6. Feed intake .....	19
3.3.7. Feed conversion ratio .....	19
3.3.8. Egg parameter measurements .....	20
3.3.9. Average egg weight .....	20
3.3.10. Hough unit .....	20
3.3.11. Egg shell weight .....	20
3.3.12. Egg yolk color index .....	21

	<b><u>Page No</u></b>
3.3.13. Analyze fatty acids and cholesterol in the egg.....	21
3.4. Statistical analyses .....	21
4. RESULT AND DISCUSSION .....	22
4.1. Experiment 1 .....	22
4.1.1. Effect of different levels of sumac on quails body weight gain .....	22
4.1.2. Effect of different levels of sumac on feed intake in growing quail .....	23
4.1.3. Effect of different levels of sumac on quails feed conversion ratio .....	24
4.1.4. Effect of different levels of sumac on quails body parts weight.....	25
4.2. Experiment 2 .....	27
4.2.1. Effect of different levels of sumac on feed intake in laying quail .....	27
4.2.2. Effect of different levels of sumac on quails egg parameters .....	28
4.2.3. Effect of different levels of sumac on quail's hen day egg production .	28
4.2.4. Effect of different levels of sumac on egg weight .....	29
4.2.5. Effect of different levels of sumac on laying quails body weight and body weight gain .....	30
4.2.6. Effect of different levels of sumac on laying quails feed conversion .....	31
4.2.7. Effect of different levels of sumac on laying quails egg mass .....	33
4.2.8. Effect of different levels of sumac on cholesterol content and fatty acid composition in quail's egg .....	34
5. CONCLUSION.....	38
6. REFERENCES .....	39

## LIST OF TABLES

	<b><u>Page No</u></b>
Table 1. Chemical composition of sumac .....	4
Table 2. Mineral contents of sumac .....	5
Table 3. Fatty acid composition of sumac fruits that planted in Syria .....	8
Table 4. Amino acid profiles of sumac fruits that planted in Syria .....	9
Table 5. Organic acid content in sumac fruits that planted in Syria .....	10
Table 6. Vitamin content of sumac fruits that planted in Syria .....	10
Table 7. Nutrient compounds of sumac .....	14
Table 8. The nutrients that contain in the feed and the value of them that used. ....	18
Table 9. Effect different levels of sumac on quail's weekly body weight gain. ....	23
Table 10. Effect different levels of sumac on quail's feed intake. ....	24
Table 11. Effect different levels of sumac on quails feed Conversion .....	25
Table 12. Effect of different levels of sumac on quails Body measure. ....	26
Table 13. Effect of different levels of sumac on laying quail's feed intake .....	27
Table 14. Effect of different levels of sumac on quails egg parameter .....	28
Table 15. Effect of different levels of sumac on quails Hen day egg production .....	29
Table 16. Effect of different levels of Sumac on quails Egg weight. ....	30
Table 17. Effect of different levels of sumac on laying quails body weight and body weight gain .....	31
Table 18. Effect of different levels of sumac on laying quails feed conversion .....	32
Table 19. Effect of different levels of sumac on laying quails Feed conversion .....	33
Table 20. Effect of different levels of sumac on Egg mass.....	34
Table 21. Effect of different levels of sumac on fatty acid compsiton and cholesterol content .....	36

## **1- INTRODUCTION**

### **1.1. Sumac**

Sumac is the common name of the genus *Rhus coriaria L.* of a perennial edible plant, which contains over 250 individual species in the family Anacardiaceae. The word of “Sumac” is derived from the Aramaic word “Sumaqa” which means red (Ahmadian et al., 2008). It is a shrub or small tree, 0.5 - 3.0 m in height, with densely brownish tomentose young branches. The fruit is globose, villose and reddish drupe when ripe. These plants are arbors that grow in temperate and tropical regions worldwide. In general, sumac can grow in no agriculturally viable regions, and has a long history of use by indigenous people for medicinal and other purposes. This suggests potential for commercializing these plants without competing for food production land uses (Wyk and Wink, 2004). It is used in pharmaceutical and cosmetic preparation, food coloring or preservations, veterinary practices and leather processing technologies (Zargari, 1996). It contains many compounds that are useful economically in medicine (Eftekhar et al., 2001). Aside from some studies on sumac as an antioxidant, anti-hyperglycemias, and an ant hyperuricemic agent, many articles have been recently published on antimicrobial activities of sumac because of the advent of new microbial resistances and the need to find new antimicrobial agents (Ahmadian et al., 2008). Fazeli et al., (2006) reported that sumac has a considerable antimicrobial effect on skin bacteria.

Also sumac contains flavonoid compounds (Lee, et al., 2002) and the extracts of the plant have been shown to have antioxidant (Bozan, et al., 2003), free radical scavenging (Candan and Sokmen, 2004), antimicrobial (Abbas, et al., 2004) and hypoglycemic (Giancarlo, et al., 2006) biological activities. Guozhong, and Hongzhang, (2011) reported that this genus offers promise as a natural source of commercial flavonoids. As well as it used as antibacterial, antidiarrheal, antispasmodic, antiviral, astringent, candidicide, hepatoprotective, antigastric, anti-inflammatory, antioxidant, antiulcer, fungicide, cyclooxygenase-inhibitor and lipoxygenase inhibitors due to their contents of ellagic acid, gallic acid, quercetin, isoquercitrin, myricetin and tannic acid (Duke et al., 2003).

## 1.2. Japanese Quail

The Japanese quail belongs to the order Galiformes, genus *Coturnix*, and species *japonica*. The scientific designation for Japanese quail is *Coturnix japonica*, different from the common quail (*Coturnix coturnix japonica*). The Japanese quail is found in Japan, Korea, Eastern China, Mongolia and Sakhalin as migrating birds. The plumage color of the wild type is predominantly dark cinnamon brown. However, adult females have pale breast feathers that are speckled with dark colored spots. Adult males have uniform dark rust red feathers on the breast. Sex differences in plumage color appear about 3 weeks of age, but not at 0 – 2 weeks of age. The eggshell color of the wild quail is white, flesh tint, light brown or speckled blue and/or brown. The size, shape and color pattern on the eggs vary considerably among females. These differences in egg color have been proposed as a means of identifying hens.

The Japanese quail is only one of many animals domesticated by the Japanese. The first record of wild Japanese quail appeared in the eighth century in Japan. Thereafter, several records of wild Japanese quail were found in several areas in Japan. The Japanese quail was semi domesticated during the sixteenth century as a singing bird. Within the period from 1907 to 1941, the Japanese quail was selected for increased egg production. In 1941, about 2 million Japanese quail was kept. However, the majority of these domesticated quail was lost during the Second World War. After the war, the Japanese quail egg industry was rebuilt from the few remaining domesticated birds, possibly with the addition of domesticated lines from Korea, China, Taiwan and quails captured in the wild. Japanese quail is now farmed mainly for egg production in Japan. In Europe, they are selected for increased body weight for meat production. The body weight of meat quail is 2 – 3 times heavier than that of the egg production type (Mizutani, 2003).

As well as its small body size (80 - 300 g) and consequent low maintenance cost, in addition to its short generation interval, disease resistance and high egg production make this species an excellent laboratory animal. Japanese quail is also the smallest avian species produced for meat and eggs, and has been extensively studied (Kayang et al., 2004). Although not yet accepted as a food source worldwide, quail is becoming increasingly important in various countries. In the Philippines, the rich taste of quail eggs has caused demand to surpass supply (Amoah and Martin, 2010). Quail products are popular as conventional food in countries such as France, Italy, Greece, Japan and China,

and interest is growing with them as a dietetic food rich in vitamins and minerals, particularly for children and the elderly (González, 1995).

### **1.3. Objectives Of The Study**

The purpose of the present study is to investigate the effect of the sumac (*Rhus coriaria L.*) on body performance and laying performance as a feed additive in growing and laying Japanese quails, respectively. One of the objectives of the present study was to investigate the effect of sumac (*Rhus coriaria L.*) on body performance, feed intake or feed conversion ratio in growing Japanese quail. Another objective of the study was to investigate the effect of sumac on egg production, fatty acid composition and cholesterol content in the quail's egg.

## 2. LITERATURE REVIEW

### 2.1. Compound Of Sumac

Moisture, protein, ash, fiber and oil contents of fruits are affected mainly by the varieties of species and the growth conditions. These findings may be useful as dietary information which requires prior knowledge of the nutritional composition of sumac fruit used as condiment. The consumption of sumac fruit is rising around the world due to the increasing popularity of natural products. Future studies could include amino acids and vitamin contents of the sumac fruits (Özcan, 2004).

The analyses of sumac fruits showed this composition: moisture, oil, protein, fiber, ash and water-soluble extract in (Table 1).

Table 1. Chemical composition of sumac (*Rhus coriaria L.*) fruits (Özcan and Haciseferogullari, 2004)

Properties	Values
Moisture (%)	10.6±1.1
Crude oil (%)	7.4±1.6
Crude protein (%)	2.6±0.2
Crude fiber (%)	14.6±0.4
Crude energy (Kcal/100 g)	147.8±7.3
Ash (%)	1.8±0.4
Water-soluble extract (%)	63.8±4.2
Acidity (%)	4.6±0.2
pH	3.7±0.3

### 2.1.1. Minerals in sumac

The mineral content of sumac fruits grown in Turkey was determined by inductively coupled plasma atomic emission spectrometer (ICP-AES). Potassium, calcium, magnesium and phosphorus were found to be predominant elements in sumac fruits. The knowledge of the nutritional properties and the mineral content of sumac fruit may be useful as dietary information, (Özcan, and Haciseferogullari, 2004).

Table 2. Mineral contents of sumac fruits. (Özcan, and Haciseferogullari, 2004)

Minerals Values	(ppm)
Al	125.47±11.04
B	25.72±1.86
Ba	0.52±0.12
Ca	3661.57±25.71
Cd	0.03±0.01
Cr	1.03±0.07
Cu	3.73±0.14
Fe	144.53±3.76
K	7963.35±47.85
Li	1.40±0.13
Mg	855.95±17.63
Mn	10.49±1.32
Na	114.06±3.65
Ni	1.07±0.03
P	1238.74±37.82
Pb	0.52±0.03
Se	0.47±0.02
V	6.43±0.67
Zn	10.93±0.84

The concentrations of minerals are given in Table 2. Potassium, calcium, magnesium and phosphorus were the predominant elements in the sumac fruits, followed by Al, Fe, Na, B and Zn. Potassium content in sumac fruits (7963.4 ppm) is higher than that in most of the other fruits. In terebinth fruit it is about 801.88 mg/Kg (Ozcan, 2004), in sumac skin–7600 ppm (Özcan, 2004), and in orange varieties – 1011 mg/ L to 1364 mg/L (Topuz et al., 2004). Potassium content of sumac fruits was lower than that of blackthorn fruits (Marako et al., 2004). Copper, iron and zinc are essential elements for the human body and their daily requirement for adults is 2-3 mg, 18 mg and 15 mg, respectively (Clydesdale and Francis, 1985). Calcium is the major component of bone and assists in tooth development (Brody, 1994). Mg, Fe and P levels are essential, too. Other inorganic elements which contribute to the biological processes, but which have not been established as essential, are barium, bromine, cadmium, lead and lithium (Macrae et al., 1993). Cadmium and lead are best known for their toxicological properties. Decreasing of these toxic element contents is an advantage (Macrae et al., 1993). Implied that sumac could contribute partially to the overall daily dietary intake of those elements. Data on sumac fruit mineral content have not been reported in the literature, (Gül et al., 1988).

### **2.1.2. Fatty acid, amino acid, and organic acid in sumac**

Fatty acids have three major physiological roles; first, they are building blocks of phospholipids and glycolipids. These amphipathic molecules are important components of biological membrane. Second, fatty acid derivatives serve as hormones, and intracellular messengers. Third, fatty acids are fuel molecules. They are stored as triacylglycerols, which are uncharged esters of glycerol. Animals are unable to convert fatty acids into glucose. Specially, acetyl CoA cannot be converted into pyruvate or oxaloacetate (Stryer, 1988).

A source of dietary monounsaturated fatty acids (MUFA) and their inclusion in monogastric diets can be particularly valuable to increase the degree of unsaturation of intramuscular fat without the negative effect of lipid oxidation associated with dietary polyunsaturated fatty acids. There is increasing evidence that dietary monounsaturated fatty acid enrichment has a positive effect on cardiovascular health, decreasing low-density lipoprotein cholesterol but not high-density lipoprotein cholesterol in blood plasma, and decreasing the susceptibility of low-density lipoprotein to oxidation (Grundy, 1986), (Roche, 2001).

Fatty acid composition of pericarp and seed of grown wild *Rhus coriaria L.*, from ten different regions of Turkey, was determined. Fatty acid analysis was carried out by gas chromatography (GC). The main fatty acids of pericarps were oleic (33.78-52.57%), palmitic (16.99-29.76%), linoleic (11.60-21.91%) and linolenic (0.33-1.33%) acids. In addition, linoleic (49.35-60.57%), oleic (24.58-32.05%), palmitic (8.32-13.58%), stearic (1.57-3.03%) and linolenic (0.46-0.74%) acids were established as major fatty acids of sumach seeds (Ünver, 2010).

Mavlyanov et al., (1997) reported that fruits of sumac (*Rhus coriaria L.*) contain flavonols, phenolic acids, hydrolysable tannins, anthocyanins and organic acids. Brunke et al., (1993) pointed out that the fruits of sumac contain malic, citric and tartaric acids. (Brunke et al., 2006) also pointed out that more than 120 substances could be identified in sumac. Main constituents are terpene hydrocarbons, oxygenated terpenes as well as farnesyl acetone, hexahydrofarnesylacetone and aliphatic aldehydes. Galic acid, protocatechonic acid, p-OH-benzoic acid and vanilic acid were determined and evaluated by (Kosar et al., 2007).

Sumac contains malic and citric acids in high concentrations (5.02-14.24%), (Wetherlit and Pala, 1994). Sumac also contains gallic acid (3, 4, 5-trihydroxybenzoic acid) which is a polyphenol natural organic acid found in sumac as active substance. It is also found both in free and as part of tannins. A strong protective effect was observed with gallic acid which is very rapidly absorbed in the gastrointestinal tract of humans; it showed that gallic acid is 50 times more protective than the vitamins C and E, (Ferk et al., 2007). It is also known that gallic acid has anti-oxidant, anti-inflammatory, anti-microbial and radical scavenging activities (Kim et al., 2006). Gallic acid has a scavenging activity by donating hydrogen to a radical, while itself oxidizes to quinone, which is stable, it can also combine with copper and iron metal ions, which can induce the radical production via the Fenton reaction. Hynes et al., (2001) showed that the complex between ferric ions and gallic acid can result in the oxidation of gallic acid to hydroxyquinone and the reduction of ferric ions to ferrous ions.

Table 3. Fatty acid composition of sumac fruits that produced in Syria (% total fatty acid) (Kossah, et al., 2011).

<b>Fatty acid</b>	<b>Fatty acid profile of sumac (%)</b>
<b>C14:0</b>	0.36 ± 0.07
<b>C16:0</b>	27.41 ± 0.55
<b>C16:1 (n-7)</b>	0.68 ± 0.23
<b>C18:0</b>	2.92 ± 0.37
<b>C18:1 (n-9)</b>	36.95 ± 0.28
<b>C18:1 (n-6)</b>	30.38 ± 0.54
<b>C18:1 (n-3)</b>	1.27 ± 0.15
<b>ΣUFA</b>	69.28 ± 1.20
<b>ΣSFA</b>	30.69 ± 0.99

Data are means of three determinations ± SD.

ΣUFA = Total Unsaturated fatty acids

ΣSFA = Total saturated fatty acid.

Table 4. Amino acid profiles of sumac fruits that produced in Syria (mg/g protein). (Kossah, et al., 2011).

<b>Amino acid content</b>	<b>mg/g protein</b>
Essential amino acids	
Leucine	1.25 ± 0.16
Iso Leucine	0.63 ± 0.08
Lysine	0.98 ± 0.02
Phenylalanine	0.75 ± 0.13
Threonine	0.70 ± 0.08
Methionine	0.15 ± 0.07
Valine	0.71 ± 0.06
Tryptophan	0.51 ± 0.18
Non-essential amino acids	
Arginine	1.09 ± 0.10
Histidine	0.68 ± 0.08
Cysteine	0.18 ± 0.04
Aspartic acid	1.70 ± 0.34
Glutamic acid	2.45 ± 0.15
Serine	0.93 ± 0.17
Glycine	0.60 ± 0.26
Alanine	0.96 ± 0.26
Tyrosine	0.51 ± 0.33
Proline	1.43 ± 0.27

Data are means of three determinations ± SD.

Table 5. Organic acid content in sumac fruits that produced in Syria (mg/kg) (Kossah et al., 2011).

<b>Organic acid content</b>	<b>mg/kg</b>
Malic acid	1568.04 ± 0.05
Citric acid	56.93 ± 0.35
Tartaric acid	2.15 ± 0.13
Fumaric acid	3.40 ± 0.46

Data are means of three determinations ± SD.

### 2.1.3. Vitamins in sumac

Sumac have a high percentage of vitamins like B6 (Pyridoxine), C (Ascorbic acid), B1 (Thiamin) and B2 (Riboflavin), table (6). (Kossah et al., 2011).

Table 6. Vitamin content of Sumac fruits that produced in Syria (mg/kg) (Kossah et al., 2011).

<b>Vitamin content</b>	<b>mg/kg</b>
Thiamine	30.65 ± 0.57
Riboflavin	24.68 ± 0.42
Pyridoxine	69.83 ± 0.31
Cyanocobalamin	10.08 ± 0.24
Nicotinamide	17.95 ± 0.28
Biotin	4.32 ± 0.23
Ascorbic acid	38.91 ± 0.27

Data are means of three determinations ± SD.

## 2.2. Antioxidant And Antimicrobial Activity Of Sumac

Nowadays, there are a lot of reports indicating the positive effects of herbs like anti-coccidal, anti-oxidant, anti-fungi and etc. (Zavaragh, 2011). Some of medical effects of herbs are related to their secondary metabolites such as phenols, essential oils, saponins etc. (Ipu, 2006). Kosar et al., (2007) found that demonstrate that sumac can be used as a natural antioxidant.

Herbs have been used for the control of certain type of some disease for years because of availability, easy usage, and non-side effects. Many herbs have a long history of use even prehistoric use, in preventing or treating human and animal diseases. Aromatic plants have been used traditionally in therapy of some diseases worldwide for a long time. Research on the use of herbal mixtures in bird's diets has produced inconsistent results (Fritz, 1993). Approximately 80% of domestic animals have been fed synthetic compounds for the purpose of either medication or growth promotion (Lee, at el., 2001). Recently, the concerns about possible antibiotic residues and antibiotic resistance have aroused great caution in the usage of antibiotics in the animal industry. Research indicated that sumac is effective against both gram positive and negative bacteria, but it is more effective on gram positive than gram negative microorganisms (Ahmadian-attari, 2007).

As well as Candan and Sokmen, (2004) suggested that the methanolic extracts of sumac fruits have considerable antioxidant activity against free radicals and lipid peroxidation in vitro, a fact that may encourage in vivo studies. The hypoglycaemic efficacy of sumac extract was investigated through inhibition of a glycoside hydrolase: alpha-amylase. Ethyl acetate extract of sumac may have an interest in the treatment and prevention of hypoglycemia, diabetes and obesity (Giancarlo et al., 2006).

Much more relevant studies has been done on the antioxidant effect of sumac and its derivatives, such as the extract (Ozcan and Akgul, 1995; Ozcan, 2003).

AL-Saltany (2010) reported that the sumac, *R.coriaria* has antibacterial and antifungal activities *in vitro*. Phytochemicals in *R. coriaria* are being used as antibacterial, anti-diarrheic, anti-dysenteric, antiseptic, antispasmodic, antiviral, hepatoprotective, hepatotonic, protisticide, analgesic, antigastric, anti-inflammatory, antioxidant, antiulcer, fungicide etc. (Nash, 2007).

Organic solvent extracts of *R.coriaria* (petroleum ether, ether, acetone, ethanol and methanol) exhibited a broad antibacterial spectrum against Gram positive, Gram- negative, acid fast and spore forming bacteria. The most sensitive test organisms were the Gram positive (Staphylococci, Streptococci and Corynebacteria), sporeformers (*Bacillus* species) and acid bacteria (*Mycobacterium phlei*). The least sensitive organisms were the gram negative bacteria (*Salmonella*, *Shigella*, *Brucella*). (Pesek, 2000).

### **2.3. Effect Of Sumac On The Poultry**

Antibiotics are growth promoters with high rate of usage in the poultry industry; they improve growth and the yield of feed. But since the societal concerns about antibiotic resistance and the possibility of transferring some of these antibiotics to the human by using these checks, there are some benefits in the usage of these growth promoters. Since then the scientists have been trying to find alternatives, and one the best option is herbs and their drivens.

There are a lot of advantages in using medicinal plants in the food such as easy usage, non-side effects, no waste particulars in the target body and etc. Several compounds like, enzymes, organic acids, probiotics, and phytogetic are used to improve the performance (Patterson, 2003). Some authors state significant positive effects on broiler performance (Ertas, 2005), (Peric, 2008), whereas another group of authors established no influence on gain, feed intake or feed conversion. (James, 1992).

Mustafa, (2012) showed that giving a diet supplemented with 1.0% and 1.5% sumac to the broiler had a significant increase ( $p<0.01$ ) in total protein, total globulin and high density lipoprotein (HDL) in the blood while significantly induces ( $p<0.01$ ) in low density lipoprotein (LDL), blood serum cholesterol, glucose and uric acid as compared with 0.5% and control. Mustafa (2012) also showed a significant increase ( $p<0.01$ ) in the percentage of *B. fabricius* and spleen relative weights and the titer of (HI, IBD and IBV), and in total duodenum, jejunum and ileum (villi height and crypts) by increasing 1.5% of sumac as compared with 1%, 0.5% of sumac and the control, as well as Mustafa (2012) found that using 1.5, 1, 0.5 % of sumac are significantly increased ( $p<0.05$ ) in *Lactobacillus* counts, while showed induces ( $p<0.05$ ) in *E.coli* and *Enterococcus* as compared with the control.

In the results of (Zavaragh, 2011) we can see that the amount of daily feed intake, the carcass and Liver percentage was observed, in this group that used 2% of sumac for Japanese quails higher than the control group.

The results of (Mansoub, 2011) that was the highest percent of breast, thigh and HDL were observed by using 2% of sumac than 0.75%, 1%, and 1.5%, and the lowest percent of abdominal fat and LDL was observed by using 1.5% of sumac than the 0.75%, 1%, and 2%. The results are evidence that the using of sumac in broiler feeds has significant effects on performance, carcass traits and blood biochemical without having any significant effects on immunity parameters.

When we look at the study of (Abas, 2009) that used sumac for the broiler, in the results of this study we can see that using 1% of sumac in broiler nutrition cause to decrease cholesterol levels in the blood and cause to increase value of lymphocyte. Also in this study show higher values of carcass weight percentage by using 1% of sumac than the using 2% and control group, but it show that Mg content in the tibia bone by using 2% of sumac higher than 1% of sumac and control.

### 3. MATERIALS AND METHODS

#### 3.1. Source Of Sumac

In this study, sumac (*Rhus coriaria* L.) was purchased a local company in the Akre city in Iraq. The local name of this type of sumac is Dostaky Sumac. Sumac fruits were smashed and analyzed in our laboratory (Table 7).

Table 7. Nutrient composition of Sumac

Properties	Values
Protein %	3.73
Crude Oil %	18.55
Dry matter	94.52
Minerals (mg)	
Ca	0.34589
Cr	0.00022
Cu	0.00083
Fe	0.03536
K	0.89816
Mg	0.14982
Mn	0.00106
Na	0.04619
P	0.24926
Zn	0.00238

## **3.2. Experiment 1**

### **3.2.1. Experimental design**

One hundred and eighty 7 d-old Japanese quail (*Coturnix coturnix japonica*) chicks were randomly assigned into three groups (4 replicates per group, 15 birds/replicate) and fed for 6 weeks on a diet supplemented with 0, 0.5, or 1.0 % sumac. The birds will receive water and feed *ad libitum* during the study. At the end of the 5th week of the study, four birds per each replicate were killed (two male and two female) and eviscerated body and internal organ weights were measured. Breast, legs, liver, heart, and wings were separated from the body and weighed.

The dietary Sumac for each treatment as following:

A= Control group fed the standard diet (S.D).

B= Birds fed S.D including 0.5% Sumac.

C= Birds fed S.D including 1% Sumac.

### **3.2.2. Preparing feed**

For this experiment a commercial diet containing 2900 Mcal/kg and 20% CP was supplemented with the sumac at the levels of 0, 0.5 or 1 % and fed to quail chicks for 27 days.

**Productive performance traits:**

**3.2.3. Live body weight (LBW) and body weight gain (BWG).**

At one week old and at the end of each week, birds were weighted by a digital balance. The weight gain was calculated by using this equation:

$$\text{Weight gain (g)} = \text{B.W at the end of the week} - \text{B.W at the beginning of the week.}$$

**3.2.4. Feed intake (FI) and feed conversion ratio (FCR).**

Feed intake in each replicate was measured and recorded weekly and feed conversion ratio was calculated by the following equation (Naji, 2006).

$$\text{Feed conversion ratio} = \frac{\text{FI during a feeding period}}{\text{Weight gain during the same period}}$$

**3.2.5. Body parts weight**

At the end of study 4 birds killed 4 birds per replicate (2 male and 2 female) and body parts were measured and recorded.

**3.2.6. Mortality% and liveability%**

In this study mortality was recorded daily for each replicate and calculated by the following equation (Ahmad and Sharma, 1992):

$$\text{Mortality \%} = \frac{\text{Number of dead birds}}{\text{Total number of birds}} * 100$$

And the liability percentage was calculated by the equation below:

$$\text{Liveability \%} = 100 - \text{mortality \%}$$

### **3.3. Experiment 2:**

#### **3.3.1. Experimental design**

In the second experiment, the female quails at 7<sup>th</sup> week (49 days) of age were assigned into 4 groups (3 replicates/ group). Each group contained 21 birds (7 birds per replicate) and fed a diet supplemented 0, 0.25, 0.5, or 1 % sumac for 48 days. Eggs were collected and weighed daily. After three weeks of feeding sumac, three eggs per each replicate (12 eggs per group) were checked for egg parameters such as yolk and albumen weight, height of albumen, shell weight, egg weight, yolk color and Haugh unit. At the end of the study, 2 eggs per each replicate were collected and checked for yolk cholesterol level. For egg yolk fatty acid analysis, three eggs per group were collected and sent to the laboratory.

The dietary Sumac for each treatment as following:

A= Control group quails fed the standard diet (S.D).

B= birds fed S.D include 0.25% Sumac.

C= birds fed S.D include 0.5% Sumac.

D= birds fed S.D include 1% Sumac.

#### **3.3.2. Housing and equipment's**

Quails were randomly assigned in to replicates in the groups, and placed in to the one of the floors in the cages. Daily photoperiod was 15 hours during the laying period.

#### **3.3.3. Preparing feed:**

In this experiment a basal diet containing 2900 Mcal/kg and 20% CP was prepared and sumac was supplemented at the levels of 0, 0.25, 0.5, or 1 %. During the study these diets were given to the quail's ad libitum.

Table 8. The nutrients that contain in the feed that used and the value of them.

<b>Nutrients</b>	<b>% as fed</b>
<b>Corn grain</b>	60.00
<b>Soybean meal (48% CP)</b>	25.85
<b>Calcium carbonate</b>	5.31
<b>DCP</b>	2.06
<b>Lysine</b>	2.22
<b>DL-Methionine</b>	0.21
<b>Vegetable oil</b>	3
<b>NaCl</b>	0.35
<b>Vitamin</b>	1
<b>Diet SUM</b>	100

Basal diet contained 2900 Mcal/kg metabolic energy and 20% crude protein (CP).

**Egg production and quality traits:**

Egg production and total egg weights were recorded daily.

**3.3.4. Egg production ratio:**

Hen Day Egg Production (H.D) of quails in all treatments weekly was calculated as the following equation (Al- Zubaidi, 1986):

$$\text{Hen Day Egg Production (H.D) \%} = \frac{X}{Y * Z} * 100$$

X = the number of eggs produced during a certain period.

Y = length of time in days for the same period.

Z = number of chickens at the end of the period.

**3.3.5 Egg mass:**

Egg mass calculated by the following equation:

Rate of egg mass (g) = Accumulative number of eggs \* average weight of the egg.

**3.3.6. Feed intake (FI):**

Feed intake (g / hen / day) by calculating the feed remaining at the end of weeks of feed provided at the beginning of the week during egg production.

Feed consumption was recorded on a replicate basis on weekly intervals.

$$\text{Average daily feed intake (g / hen)} = \frac{\text{Amount of feed intake (g)}}{\text{Number of birds per replicate * length of time in days}}$$

**3.3.7. Feed conversion ratio (FCR):**

Feed conversion ratio was calculated on a weekly basis for every group in the study. The FCR was expressed as kilograms of feed consumed per kilogram of egg consumed.

FCR calculated as in both of these two equations:

$$\text{FCR (g feed / g eggs)} = \frac{\text{Feed intake (g / bird)}}{\text{Egg mass (g / bird)}}$$

$$\text{FCR (g feed/egg)} = \frac{\text{Feed intake (g / bird)}}{\text{Accumulative number of eggs (egg/bird)}}$$

### 3.3.8. Egg parameters measurements:

To measure internal and external quality of eggs to the four treatments in this experiment by broken 3 eggs from each replicate in the treatments were on a flat glass dish and measured the following qualities:

Egg weight (g), shell weight (g), yolk weight (g), albumin weight (g), high of albumen (mm), yolk color, Haugh unit, egg width (mm), egg length (mm), thickness of shell (mm), yolk diameter (mm), high of yolk (mm), length of albumin (mm)

### 3.3.9. Average egg weight:

Eggs were weighted individually and recorded each day.

### 3.3.10. Haugh unit:

Haugh was unit measured by the following equation (Nesheim *et al.*, 1979):

$$\text{Haugh Unit} = 100 \text{ Log } (H + 7.57 - 1.7^{w^{0.37}})$$

As:

H = albumen height (mm)

w = egg weight (g)

### 3.3.11. Egg shell weight:

The egg shell weighed a digital balance in all replications of the four treatments.

### 3.3.12. Egg yolk color index:

Nine egg yolks in each treatment bring close to Yolk Color Fan that composed of (1-15) color grading, the Yolk Color Fan put close to the yolk than record the number of colors that's close to the yolk in each treatment.

### 3.3.13. Analyze fatty acids and cholesterol in egg:

The yolk cholesterol concentration (mg cholesterol / g of egg yolk) was determined in the filtered samples by UV spectrophotometer using commercial kits.

## 3.4. Statistical Analyses

For the statistical design and data analyses, a completely randomized experimental design, with 3 treatments with 4 replicates for Experiment 1 and 4 treatments with 3 replicates for Experiment 2 was applied. The data in each experiment were subjected to ANOVA procedures appropriate for a completely randomized design and the significance of differences between the means estimated using Duncan test (Duncan's new multiple range test). Probability level of  $p < 0.05$  was considered. All statistical analyses were performed using the software SAS program. (SAS, 2003, Version 9.1)



## **4. RESULTS AND DISCUSSION**

### **4.1. Experiment 1**

#### **4.1.1. Effect of different levels of sumac on quail's body weight gain (BWG):**

Table (9) refers to the effect of Sumac on weekly and final body weight gain (BWG). The dietary supplementation in body weight gain for all treatments showed non-significant effect ( $p>0.05$ ), but for total of body weight gain had a significant effect ( $p>0.05$ ). Using 1% of sumac in the group C decreased body weight, which mean total body weight gain less than group A (control) and group B (0.5% sumac).

The results showed agreement with findings by Zavaragh (2011) for weekly body weight gain that used 2% sumac in the quail's diet. However, the total body weight gain from the first day of feeding sumac until 35 days of age, we can see it's not agreeing with result of Zavaragh (2011). Also in a study conducted in chickens by Abas and Horniakova (2009) that used diet supplemented with 0.5 or 1 % sumac showed similar results with a present study that used the same ratio of sumac. However, it is non-agreed with (Mansub, 2011) when used 0, 0.75, 1, 1.5 or 2 % of sumac. Also (Golzadeh et al., 2012) did not find any significant effect on the total body weight gain when they used 0, 0.25, 0.5, 1% of sumac for the broiler.

Because of Sumac contains flavonoid compounds (Lee et al., 2002) and the extracts of the plant have been shown to have antioxidant (Bozan et al., 2003), due to contain gallic acid and tannic acid (Duke et al., 2003). These acids lead to decomposition fat in the body, thus, feeding high level of sumac gradually cause to decrease the body weight gain. The decreasing body weight gain may be related to the polyphenolic compounds of sumac. These negative effects of phenol compounds have been related to their influence on the availability of some nutrients. Sumac was reported as a rich source of tannin (Kosar et al., 2006). Moreover, tannins decrease the protein digestibility through their action on the brush border membrane of the small intestine, where enzymatic activity is mainly located (Marzo et al., 1990). The formation of an insoluble tannin-protein complex has been reported in the gastrointestinal tract by dietary supplementation of tannic acid (Tamir & Alumot, 1970).

Table 9. Effect of different levels of sumac on quail's weekly and total body weight gain

<b>Group</b> <b>BW gain</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>S.L.</b>
<b>Week 1</b>	25.52 ± 2.40	27.91 ± 1.50	27.45 ± 0.75	N.S
<b>Week 2</b>	31.84 ± 2.10	32.54 ± 1.41	29.77 ± 0.97	N.S
<b>Week 3</b>	39.16 ± 1.78	42.65 ± 3.02	35.98 ± 2.57	N.S
<b>Week 4</b>	39.74 ± 2.53	34.24 ± 4.64	25.69 ± 5.20	N.S
<b>Total BW gain</b>	136.26 ± 3.80 <sup>a</sup>	137.24 ± 4.15 <sup>a</sup>	118.89 ± 7.48 <sup>b</sup>	*

A= Control B = 0.5% sumac C= 1% sumac

<sup>a-b</sup> Means within rows with different superscripts differ significantly at ( $p \leq 0.05$ )

L.S.= level of significant N.S.= non-significant  $p > 0.05$

± Standard Error. \* =  $p \leq 0.05$

No. of birds in week 1: group A was 56, group B was 58, and group C was 60 birds

No. of birds in week 2: group A was 56, group B was 58, and group C was 60 birds

No. of birds in week 3: group A was 56, group B was 58, and group C was 60 birds

No. of birds in week 4: group A was 54, group B was 58, and group C was 58 birds.

#### 4.1.2. Effect of different levels of sumac on feed intake in growing quail

Table (10) refers to the effect of Sumac on weekly and total feed intake; from seven days of age until 35 days of age. The dietary supplementation in all treatments showed non-significant effect ( $p > 0.05$ ). Group B and group C had the same result with the control group. The highest feed intake was recorded in group A and then group C then group B respectively.

Zavaragh (2011) showed that diet supplemented with 2% of sumac increased feed intake significantly compared to the control. However, the result of the present study was agreed with the result of Mansub (2011) when 0.75, 1, 1.5 and 2 % of sumac were added to broiler diet. In that study, feed intake was not changed by inclusion of sumac in the diet. Also the present study was agreed with Abas and Horniakova (2009) showing that 0.5 or 1 % of sumac supplementation did not influence feed intake. Golzadeh et al. (2012) showed that using 1% of sumac in feed had significant effect on broiler feed intake, but using 0.25% and 0.5% did not have any significant effect on broiler feed intake.

Table 10. Effect of different levels of sumac on quail's feed intake

<b>F.I.</b> \ <b>Group</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>S.L.</b>
<b>week1</b>	102.77 ± 5.13	88.31 ± 7.26	91.15 ± 5.09	N.S
<b>week2</b>	126.54 ± 12.57	127.96 ± 3.06	135.80 ± 14.47	N.S
<b>week3</b>	153.77 ± 5.08	140.36 ± 15.12	146.48 ± 8.46	N.S
<b>week4</b>	150.05 ± 14.89	137.99 ± 5.41	124.28 ± 8.69	N.S
<b>Total Feed Intake</b>	523.13 ± 18.47	494.61 ± 23.42	498.70 ± 21.64	N.S

A= Control B = 0.5% sumac C= 1% sumac

L.S.= level of significant N.S.= non-significant  $p>0.05$ . ± Standard Error

No. of birds in week 1: group A was 56, group B was 58, and group C was 60 birds

No. of birds in week 2: group A was 56, group B was 58, and group C was 60 birds

No. of birds in week 3: group A was 56, group B was 58, and group C was 60 birds

No. of birds in week 4: group A was 54, group B was 58, and group C was 58 birds.

#### 4.1.3. Effect of different levels of sumac on quail's feed conversion (FCR)

Table (11) refers to the effect of sumac on weekly and average of feed conversion; at first week until 5 weeks. The dietary supplementation in all treatments showed non-significant effect ( $p>0.05$ ). Treatment (B) and treatment (C) had the same result with treatment (A) that it was the control group. The highest feed conversion was recorded in group C (4.43), which was greater than group A (3.92), and group B (3.71).

This result is in agreement with the (Zavaragh, 2011) that found Sumac did not have any significant effect ( $p>0.05$ ) in feed conversion when he was feeding quails 2% of sumac. Also Mansub (2011) noticed the different level of sumac 0.75, 1, 1.5 and 2 % did not show any significant effect on feed conversion of broiler. Also the result of the present study was agreed with (Abas and Horniakova, 2009) that they used 0.5 & 1 % of sumac for males and females of broiler. But Golzadeh et al., (2012) showed that using 1% of sumac in feed had significant effete on broilers feed conversion ratio, but using 0.25% and 0.5% did not have any significant effect on broilers feed conversion ratio.

Table 11. Effect of different levels of sumac on feed conversion ratio (FCR) in quails

Group FCR	A	B	C	S.L.
Week 1	4.13 ± 0.40	3.22 ± 0.41	3.37 ± 0.23	N.S
Week 2	4.10 ± 0.69	3.97 ± 0.25	4.62 ± 0.61	N.S
Week 3	3.71 ± 0.27	3.35 ± 0.45	4.09 ± 0.14	N.S
Week 4	3.76 ± 0.19	4.32 ± 0.71	5.61 ± 1.47	N.S
Feed Conversion during period study	3.92 ± 0.13	3.71 ± 0.28	4.43 ± 0.56	N.S

A= Control B = 0.5% sumac C= 1% sumac

L.S.= level of significant N.S.= non-significant  $p>0.05$

± Standard Error.

No. of birds in week 1: group A was 56, group B was 58, and group C was 60 birds

No. of birds in week 2: group A was 56, group B was 58, and group C was 60 birds

No. of birds in week 3: group A was 56, group B was 58, and group C was 60 birds

No. of birds in week 4: group A was 54, group B was 58, and group C was 58 birds

#### 4.1.4. Effect of different levels of sumac on quail's body parts weight:

Body parts weight values of tribal groups are presented in tables 12. The results in table (12) showed that adding sumac to the diet just had a significant effect ( $p<0.01$ ) on the weight of the liver in quail. Sumac was caused decreasing weight of the liver in the treatment C, but it did not have any significant effect ( $p>0.05$ ) on net body weight, breast weight, back weight, wing weight and leg weight. This decreasing in liver weight due to supplemental protein in quails (Azadeganmeher et al., 2007).

The liver is closely associated with the digestive tract, as the organ responsible for metabolism and synthesis from absorbing nutrients (Shane, 2006). This result is not agreeing with the (Zavaragh, 2011) found non-significant effect ( $p>0.05$ ) in weight of Liver when he was fed quails 2% of sumac and he did not find any significant effect on weight of carcass too that it was in agreed with the president study. Also (Mansub, 2011)

noticed the different level 0.75, 1, 1.5 or 2 % of Sumac did not have any significant effect on the Breast and Lievre weight of broiler chickens. Herbal planet including sumac could stimulate the digestive system in birds, improve the function of liver and increase the pancreatic digestive enzymes. Enhancement of the metabolism of herbal plant, carbohydrates and proteins in the major organs would increase growth rates of these organs (Mellor, 2000). There is a possibility of antimicrobial herbs made a remarkable decrease in the amount of intestine microbial colony and this prevented from lysis of amino acids and they used in the formation of proteinic tissues and increased the breast percentage (Lee et al., 2001). Also decrease livers weight due to supplemental protexin (it's a blend of live viable microbes which benefits the host animals by improving the intestinal microbial balance) in broilers.

Table 12. Effect of different levels of sumac on quail's body measure

<b>Group</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>S.L.</b>
<b>Net Body Weight</b>	135.43 ± 4.85	132.38 ± 5.54	124.94 ± 3.67	N.S
<b>Breast Weight</b>	39.07 ± 1.84	38.31 ± 1.65	34.81 ± 1.37	N.S
<b>Back Weight</b>	27.21 ± 1.15	27.00 ± 1.41	25 ± 1.29	N.S
<b>Wings weight</b>	10.36 ± 0.39	10.13 ± 0.51	10.63 ± 0.46	N.S
<b>Legs Weight</b>	27.64 ± 1.08	26.56 ± 1.31	24.24 ± 0.81	N.S
<b>Liver Weight</b>	3.93 ± 0.22 <sup>a</sup>	3.94 ± 0.23 <sup>a</sup>	3.06 ± 0.14 <sup>b</sup>	**

A= Control B = 0.5% sumac C= 1% sumac

<sup>a-b</sup> Means within rows with different superscripts differ significantly at ( $p \leq 0.01$ )

L.S.= level of significant N.S.= non-significant ( $p > 0.05$ )

± Standard Error. \*\*  $p \leq 0.01$ .

No. of birds in week 1: group A was 56, group B was 58, and group C was 60 birds

No. of birds in week 2: group A was 56, group B was 58, and group C was 60 birds

No. of birds in week 3: group A was 56, group B was 58, and group C was 60 birds

No. of birds in week 4: group A was 54, group B was 58, and group C was 58 birds.

## 4.2. Experiment 2:

### 4.2.1. Effect of different levels of sumac on feed Intake in laying quail:

Table (13) refers to the effect of Sumac on weekly and total feed intake in layer quail; from 49 days of age until 97 days of age. The dietary supplementation in all treatments showed non-significant effect ( $p>0.05$ ). There was not any different in feed intake when quails fed on different ratio of sumac 0, 0.25, 0.5, or 1 %.

Zavaragh (2011) when he fed 2% of sumac for quails showed it had a significant effect ( $p\leq 0.05$ ) on feed intake and they consumed more feed than control. However, the result of the present study was agreed with the result of Mansub (2011) when 0.75, 1, 1.5 and 2 % of sumac were used for the broiler and no significant effect on feed intake was observed. Also the present data was agreed with Abas and Horniakova (2009) that 0.5 or 1 % of sumac as a diet was used for male and female broilers from the first day until 40 days of age. However, Golzadeh et al. (2012) showed that use of 1% of sumac in the feed had significant effect on broiler feed intake, compared to the diets supplemented with control, 0.25% or 0.5% sumac supplemented diets.

Table 13. Effect of different levels of sumac on laying quail's feed intake

<b>Group</b> <b>FI</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>S.L.</b>
<b>Week1</b>	28.39 ± 0.75	27.77 ± 0.71	24.48 ± 2.09	29.29 ± 1.01	N.S
<b>Week2</b>	27.53 ± 3.04	29.94 ± 0.66	25.82 ± 3.23	29.61 ± 0.67	N.S
<b>Week3</b>	27.39 ± 2.04	29.65 ± 1.38	29.28 ± 1.59	29.81 ± 1.21	N.S
<b>Week4</b>	29.95 ± 1.92	31.70 ± 1.04	31.03 ± 2.06	35.21 ± 1.35	N.S
<b>Week5</b>	29.62 ± 4.08	34.18 ± 0.85	34.28 ± 1.95	32.54 ± 0.41	N.S
<b>Week6</b>	30.05 ± 1.33	31.79 ± 0.32	29.67 ± 0.87	31.58 ± 1.93	N.S
<b>Week7</b>	27.67 ± 2.05	28.34 ± 1.23	27.43 ± 3.24	32.48 ± 1.14	N.S
<b>Total FI</b>	1404.16 ± 98.48	1493.50 ± 24.57	1413 ± 71.91	1543 ± 31.64	N.S

A= Control B= 0.25% sumac C=0.5% sumac D=1% sumac

L.S.= level of significant N.S.= non-significant ( $p>0.05$ ). ± Standard Error. No. of birds was 21 birds for all groups from the starting study until the end of the study.

#### 4.2.2. Effect of different levels of sumac on quail's egg parameters:

The results in table (14) showed that adding different levels of Sumac to the layer quail's diet on egg parameters. The degree of yolk color decreased by adding 0.5% of sumac ( $p < 0.01$ ) from 49 days of age to 97 days of age. At the same time in group D (1% of sumac) did not show any change in yolk color. The differences of yolk color among the groups (B, C, and D) may be related to some environmental effects. Different levels of sumac did not show any significant effect ( $p > 0.05$ ) on other egg parameters such as shell weight, yolk weight, albumin weight, high of albumin and Hough unit.

Table 14. Effect of different levels of sumac on egg parameters

Group Egg Parameters.	A	B	C	D	S.L.
Shell Weight	1.61 ± 0.06	1.56 ± 0.04	1.63 ± 0.06	1.52 ± 0.04	N.S
Yolk Weight	3.57 ± 0.15	3.67 ± 0.18	3.74 ± 0.08	3.81 ± 0.08	N.S
Albumin Weight	6.34 ± 0.23	6.24 ± 0.23	6.43 ± 0.12	6.61 ± 0.16	N.S
High of Albumin	4.87 ± 0.18	4.83 ± 0.20	4.40 ± 0.25	4.71 ± 0.12	N.S
Yolk Color	10.22 ± 0.28 <sup>a</sup>	10.33 ± 0.17 <sup>a</sup>	9.33 ± 0.24 <sup>b</sup>	10.44 ± 0.29 <sup>a</sup>	**
Hough Unit	91.68 ± 1.05	91.45 ± 1.13	88.82 ± 1.17	90.54 ± 0.75	N.S

A= Control B= 0.25% sumac C=0.5% sumac D=1% sumac

<sup>a-b</sup> Means within rows with different superscripts differ significantly at ( $p \leq 0.01$ )

L.S.= level of significant N.S.= non-significant ( $p > 0.05$ )

± Standard Error.

No. of birds was 21 birds for all groups from the starting study until the end of the study.

#### 4.2.3. Effect of different levels of sumac on quail's hen day egg production (HD)

The effect of different levels of sumac on quail's hen day egg production showed in table (15). No significant effects were found among groups (B, C, D, and control) on hen day egg production for each week between groups and during the study too.

Sumac has been reported as a rich source of tannin (Kosar et al., 2006). Even tannins have a negative effect on protein digestibility through producing a complex protein (tannin

protein) in the gastrointestinal tract (Marzo et al., 1990; Tamir & Alumot, 1970), but this effect did not influence egg production.

Table 15. Effect of different levels of sumac on quails hen day egg production (HD)

Group HD	A	B	C	D	S.L.
W1	86.40 ± 2.46	87.07 ± 2.46	70.07 ± 9.53	82.31 ± 1.36	N.S
W2	91.84 ± 3.54	86.40 ± 5.57	80.61 ± 5.30	85.04 ± 7.85	N.S
W3	87.76 ± 8.25	91.16 ± 3.79	85.03 ± 5.93	82.99 ± 6.49	N.S
W4	85.72 ± 6.56	89.80 ± 5.40	87.08 ± 1.80	90.48 ± 1.80	N.S
W5	92.52 ± 4.46	91.16 ± 4.77	90.48 ± 2.46	88.44 ± 1.18	N.S
W6	91.16 ± 4.76	89.12 ± 4.76	86.40 ± 2.46	93.88 ± 1.18	N.S
W7	89.68 ± 4.42	89.68 ± 7.05	84.92 ± 11.53	92.07 ± 1.59	N.S
HD during the study	89.29 ± 4.50	89.20 ± 4.66	80.74 ± 2.98	87.89 ± 1.51	N.S

A= Control B= 0.25% sumac C=0.5% sumac D=1% sumac

L.S.= level of significant N.S.= non-significant ( $p > 0.05$ )

± Standard Error.

No. of birds was 21 birds for all groups from the starting study until the end of the study.

#### 4.2.4. Effect of different levels of sumac on egg weight:

Table (16) refers that sumac were having a significant effect ( $p \leq 0.05$ ) or ( $p \leq 0.01$ ) on egg weight from 49 days of age to 97 days of age. At the first and seventh week we did not have any significant effect for all groups. But at the second, third, fourth, fifth and sixth week we had a significant effect between groups including a control group. Adding 0.25% of sumac to diet during the study increased egg weight and was significant ( $p \leq 0.05$ ) or ( $p \leq 0.01$ ) with group A, C and D. The higher egg weight during the study period was recorded in group B (11.70 g) and the less egg weight was recorded in group A that it was control group was (11.43 g).

Egg weight is among the most important parameters not only for consumers, but for egg producers as well, due to the economic benefit and market requirement.

Table 16. Effect of different levels of sumac on quail's egg weight

Group Egg weight	A	B	C	D	Effect
W1	11.07 ± 0.16	11.11 ± 0.13	10.82 ± 0.14	10.91 ± 0.12	N.S
W2	11.20 ± 0.12 <sup>b</sup>	11.59 ± 0.09 <sup>a</sup>	11.14 ± 0.17 <sup>b</sup>	11.42 ± 0.11 <sup>ab</sup>	*
W3	11.31 ± 0.10 <sup>ab</sup>	11.63 ± 0.09 <sup>a</sup>	11.02 ± 0.14 <sup>b</sup>	11.41 ± 0.12 <sup>a</sup>	**
W4	11.32 ± 0.15 <sup>b</sup>	11.76 ± 0.10 <sup>a</sup>	11.69 ± 0.12 <sup>a</sup>	11.72 ± 0.10 <sup>a</sup>	*
W5	11.66 ± 0.13 <sup>b</sup>	11.72 ± 0.10 <sup>b</sup>	12.13 ± 0.12 <sup>a</sup>	11.66 ± 0.10 <sup>b</sup>	**
W6	11.71 ± 0.12 <sup>b</sup>	12.15 ± 0.11 <sup>a</sup>	11.88 ± 0.13 <sup>ab</sup>	11.71 ± 0.10 <sup>b</sup>	*
W7	11.60 ± 0.15	11.96 ± 0.12	11.58 ± 0.12	11.71 ± 0.11	N.S
Average of Egg weight	11.43 ± 0.05 <sup>b</sup>	11.70 ± 0.04 <sup>a</sup>	11.50 ± 0.05 <sup>b</sup>	11.51 ± 0.04 <sup>b</sup>	**

A= Control B= 0.25% sumac C=0.5% sumac D=1% sumac

<sup>a - b</sup> Means within rows with different superscripts differ significantly at ( $p \leq 0.05$ ) or ( $p \leq 0.01$ )

L.S.= level of significant N.S.= non-significant ( $p > 0.05$ )

± Standard Error. \* ( $p \leq 0.05$ ). \*\* ( $p \leq 0.01$ )

No. of birds was 21 birds for all groups from the starting study until the end of the study.

#### 4.2.5. Effect of different levels of sumac on laying quails body weight and body weight gain

Table (17) shows effect different levels of Sumac on layer quails body weight from 49 days of age to 97 days of age. At the beginning of the experiment the essential body weight of birds was not-significant differences between groups. As it is shown in table (18) the body weight of birds has been changed during the study period and it was significant ( $p \leq 0.01$ ). At the end of the study period body weight of birds in group A decreased by 6.38 g. However, the final body weight decreased in group B, C and D. That's mean using sumac by different levels cause for increasing body weight in the layer Japanese quail.

A rich source of minerals, fats, and protein in sumac, gave abundant evidence that supports the value of sumac in preventing diverse helping to address common ailments such as digestive irregularity and enhancing reproductive performance in both males and females (Dawson, 2008).

The improvements of body weight and body weight gain are due to the active materials (Cinnamaldehyde and ugenol) which found in sumac, causing greater efficiency in the utilization of feed, resulting in enhanced growth. These results could be attributed to the effect of sumac powder on improving feed utilization probably due to its anti-bacterial effect on gut micro flora (Ahmadian-attari, 2007). Also these results contribute to the improving of performance and digestibility coefficients. The positive improvement of these values may relate to fatty acids in sumac which may have an effect on muscle protein synthesis and protein deposition through a prostaglandin depend mechanism (Palmer, 1993).

Table 17. Effect of different levels of Sumac on body weights in laying quails

<b>Group</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>S.L.</b>
<b>BW</b>					
<b>Initial Body weight</b>	251.38 ± 4.48	255.33 ± 5.14	240.57 ± 4.26	258.05 ± 6.18	N.S
<b>Body weight of the end</b>	245.0 ± 5.36 <sup>b</sup>	274.86 ± 6.29 <sup>a</sup>	256.62 ± 5.73 <sup>b</sup>	277.67 ± 4.59 <sup>a</sup>	**
<b>Body weight Gain</b>	- 6.38 ± 5.94 <sup>b</sup>	19.52 ± 2.31 <sup>a</sup>	14.05 ± 5.88 <sup>a</sup>	19.62 ± 3.71 <sup>a</sup>	**

A= Control B= 0.25% sumac C=0.5% sumac D=1% sumac

<sup>a-b</sup> Means within rows with different superscripts differ significantly at ( $p \leq 0.01$ )

L.S.= level of significant N.S.= non-significant ( $p > 0.05$ )

± Standard Error. \*\* ( $p \leq 0.01$ )

No. of birds was 21 birds for all groups from the starting study until the end of the study.

#### 4.2.6. Effect of different levels of sumac on laying quails feed conversion:

Table (18) and (19) show effect different levels of Sumac on weekly and final Feed Conversion ratio on layer quails from 49 days of age to 97 days by using both of two roles (FCR = FI/ egg numbers) and (FCR = FI/ egg mass). The results showed that adding sumac to diet as dietary supplementation did not affect the feed conversion for layer quails. And no significant differences ( $p > 0.05$ ) were found between groups and control based on both two roles.

This result is in agreement with the (Zavaragh, 2011) that found Sumac did not have any significant effect ( $p > 0.05$ ) in feed conversion when he was feeding quails 2% of sumac.

Also Mansub (2011) noticed the different level of Sumac 0.75, 1, 1.5 and 2 % did not show any significant effect on feed conversion of broiler. Also the result of the present study was agreed with (Abas and Horniakova, 2009) that they used 0.5 & 1 % of sumac for males and females of broiler. But (Golzadeh et al., 2012) showed that using 1% g/kg of sumac in feed had significant effect on broilers feed conversion ratio but using 0.25 and 5 g/kg did not have any significant effect on broilers feed conversion ratio.

Table 18. Effect of different levels of Sumac on laying quails feed conversion, by using (FCR=FI/egg numbers)

<b>Group</b> <b>FCR</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>Effect</b>
<b>W1</b>	32.86 ± 0.22	31.90 ± 0.39	35.82 ± 4.36	35.64 ± 1.85	N.S
<b>W2</b>	29.81 ± 0.27	35.06 ± 3.19	32.19 ± 3.49	35.61 ± 4.48	N.S
<b>W3</b>	31.34 ± 0.70	32.77 ± 2.98	34.70 ± 2.74	36.23 ± 2.44	N.S
<b>W4</b>	35.03 ± 0.90	35.70 ± 1.25	35.70 ± 2.75	38.92 ± 1.32	N.S
<b>W5</b>	31.73 ± 3.05	37.80 ± 2.97	37.88 ± 1.79	36.83 ± 0.90	N.S
<b>W6</b>	33.01 ± 0.62	35.93 ± 2.41	34.45 ± 1.99	33.64 ± 2.00	N.S
<b>W7</b>	30.77 ± 0.81	32.25 ± 4.14	33.75 ± 6.37	35.33 ± 1.76	N.S
<b>FCR</b>	32.08 ± 0.75	34.45 ± 2.45	34.93 ± 1.38	36.03 ± 1.44	N.S

A= Control B= 0.25% sumac C=0.5% sumac D=1% sumac

L.S.= level of significant N.S.= non-significant ( $p > 0.05$ ). ± Standard Error.

No. of birds was 21 birds for all groups from the starting study until the end of the study.

Table 19. Effect of different levels of Sumac on laying quails feed conversion, by using (FCR=FI/egg mass)

<b>Group</b> <b>FCR</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>S.L.</b>
<b>W1</b>	3.10 ± 0.13	2.98 ± 0.10	3.30 ± 0.43	3.24 ± 0.43	N.S
<b>W2</b>	2.79 ± 0,20	3.12 ± 0.17	2.97 ± 0.20	3.34 ± 0.42	N.S
<b>W3</b>	2.88 ± 0.14	2.74 ± 0.17	3.37 ± 0.35	3.26 ± 0.30	N.S
<b>W4</b>	3.00 ± 0.14	3.09 ± 0.06	3.10 ± 0.17	3.37 ± 0.17	N.S
<b>W5</b>	2.79 ± 0.15	3.21 ± 0.17	3.12 ± 0.09	3.23 ± 0.12	N.S
<b>W6</b>	2.86 ± 0.05	2.83 ± 0.14	2.78 ± 0.14	2.74 ± 0.18	N.S
<b>W7</b>	2.51 ± 0.02	2.67 ± 0.29	2.90 ± 0.52	3.01 ± 0.11	N.S
<b>FCR</b>	2.85 ± 0.04	2.95 ± 0.12	3.07 ± 0.05	3.17 ± 0.18	N.S

A= Control B= 0.25% sumac C=0.5% sumac D=1% sumac

L.S.= level of significant. N.S.= non-significant ( $p>0.05$ ). ± Standard Error.

No. of birds was 21 birds for all groups from the starting study until the end of the study.

#### 4.2.7. Effect of different levels of sumac on quail's egg mass:

Table (20) refers to the effect of different levels of Sumac on quail's weekly and final egg mass. There was no significant effect of sumac on egg mass from 48 days of age to 97 days of age in the treated groups compared to the control group.

Table 20. Effect of different levels of sumac on quails Egg mass

Group Egg mass	A	B	C	D	S.L.
W1	9.17 ± 0.32	9.33 ± 0.31	7.66 ± 1.20	9.08 ± 0.31	N.S
W2	9.83 ± 0.60	9.62 ± 0.30	8.70 ± 0.93	9.10 ± 0.88	N.S
W3	9.60 ± 1.09	10.85 ± 0.26	8.84 ± 0.81	9.30 ± 0.94	N.S
W4	10.06 ± 1.07	10.28 ± 0.54	10.01 ± 0.12	10.47 ± 0.18	N.S
W5	10.52 ± 0.98	10.66 ± 0.31	10.97 ± 0.39	10.09 ± 0.27	N.S
W6	10.52 ± 0.65	11.28 ± 0.45	10.71 ± 0.23	11.52 ± 0.08	N.S
W7	9.44 ± 0.70	9.22 ± 0.64	8.42 ± 1.03	9.26 ± 0.09	N.S
Egg Mass	9.88 ± 0.75	10.18 ± 0.33	9.33 ± 0.29	9.83 ± 0.32	N.S

A= Control B= 0.25% sumac C=0.5% sumac D=1% sumac

L.S. = level of significant N.S. = non-significant ( $p > 0.05$ ). ± = Standard Error.

No. of birds was 21 birds for all groups from the starting study until the end of the study.

#### 4.2.8. Effect of different levels of sumac on cholesterol content and fatty acid composition in quail's egg:

Table (21) refers to the effect of different levels of sumac on fatty acid and cholesterol contain in Japanese quail egg from 49 days of age to 97 days of age. Sumac had a significant effect ( $p \leq 0.01$ ) on the ratio of total saturated fatty acid (SFA). By increasing the ratio of sumac in the diet gradually decreased total saturated fatty acid in the egg yolk. The most obvious decreasing of C14:0 was found in group D (30.43) compared to the control group (34.74). But the results did not show any significant effect of C15:0 and C17:0 between groups.

Results in the table (22) showed sumac had significant on total MUFA, by decreasing levels of sumac to the diet in group B, C, and D gradually decrease the ratio of MUFA. Some types of MUFA such as C16:1 and C20:1n9 did not show significant effect by adding sumac to the diet. C14:1 and C24:1 decreased and showed significant effect by adding sumac to the diet. However increasing sumac in the diet C18:1n9c as a type of MUFA increased gradually from (50.82%) in the control group (58.31%) in group D

Also adding sumac to the diet had a significant effect on the ratio of PUFA in the egg. By adding sumac gradually in group B, C, and D decreased ratio PUFA. Group C was more affected compared to group B and C which decrease by (4.92%).

Finally adding sumac to the diet did not record significant effect on the level of cholesterol in the quail's egg.

Monounsaturated fatty acids (MUFA) in the food have a positive impact on the degree of unsaturation of intramuscular fat without having a negative effect on lipid oxidation. It has been reported that dietary monounsaturated fatty acid enrichment has a positive effect on cardiovascular health through decreasing low-density lipoprotein cholesterol in the blood but it does not affect high-density lipoprotein cholesterol in blood plasma. Also (MUFA) decrease the susceptibility of low-density lipoprotein to oxidation (Grundy, 1986; Roche, 2001).

The amount and type of fat in the hen diet modifies the fatty acid composition of lipid in the egg (Guenter et al., 197; Hargis et al., 1991), and body tissues (Menge, 1971; Watkins, 1988; Phetteplace and Watkins, 1989). In this study fatty acid in the diet reflected that fatty acid composition in egg.

Sumac has anti-oxidant activity, but in our study the level of cholesterol in the egg did not decrease, it may relate to environmental factors such as mild heat stress

Table 21. Effect of different levels of sumac on fatty acid composition and cholesterol content in quail's egg.

<b>Group</b> <b>F.A.</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>S.L.</b>
<b>% SFA</b>	34.74 ± 0.18 <sup>a</sup>	32.46 ± 0.56 <sup>b</sup>	32.46 ± 0.56 <sup>b</sup>	30.43 ± 0.80 <sup>c</sup>	**
<b>C14:0</b>	0.54 ± 0.02 <sup>a</sup>	0.38 ± 0.01 <sup>c</sup>	0.46 ± 0.04 <sup>b</sup>	0.37 ± 0.01 <sup>c</sup>	**
<b>C15:0</b>	0.02 ± 0	0.02 ± 0.01	0.02 ± 0	0.02 ± 0	N.S
<b>C16:0</b>	25.69 ± 0.26 <sup>a</sup>	24.18 ± 0.10 <sup>b</sup>	24.46 ± 0.42 <sup>b</sup>	24.09 ± 0.20 <sup>b</sup>	**
<b>C17:0</b>	0.08 ± 0.01	0.08 ± 0.01	0.07 ± 0	0.07 ± 0.01	N.S
<b>C18:0</b>	8.34 ± 0.17 <sup>a</sup>	7.81 ± 0.53 <sup>a</sup>	7.34 ± 0.21 <sup>a</sup>	5.88 ± 0.49 <sup>b</sup>	**
<b>% MUFA</b>	55.39 ± 0.29 <sup>c</sup>	59.52 ± 0.30 <sup>b</sup>	61.69 ± 0.74 <sup>a</sup>	62.87 ± 0.90 <sup>a</sup>	**
<b>C14:1(n-7)</b>	0.08 ± 0 <sup>a</sup>	0.05 ± 0 <sup>b</sup>	0.05 ± 0 <sup>b</sup>	0.05 ± 0 <sup>b</sup>	**
<b>C16:1(n-7)</b>	4.34 ± 0.34 <sup>ab</sup>	3.65 ± 0.28 <sup>ab</sup>	3.53 ± 0.18 <sup>b</sup>	4.90 ± 0.20 <sup>a</sup>	N.S
<b>C18:1(n-9)</b>	50.82 ± 0.20 <sup>c</sup>	55.70 ± 0.06 <sup>b</sup>	57.98 ± 0.91 <sup>a</sup>	58.31 ± 0.10 <sup>a</sup>	**
<b>C20:1(n-9)</b>	0.09 ± 0.01	0.07 ± 0.01	0.10 ± 0.01	0.08 ± 0.01	N.S
<b>C24:1(n-9)</b>	0.07 ± 0.01 <sup>a</sup>	0.05 ± 0 <sup>b</sup>	0.03 ± 0 <sup>c</sup>	0.03 ± 0 <sup>c</sup>	**
<b>% PUFA</b>	9.51 ± 0.35 <sup>a</sup>	7.56 ± 0.20 <sup>b</sup>	4.59 ± 0.47 <sup>d</sup>	5.79 ± 0.16 <sup>c</sup>	**
<b>C18:2(n-6)</b>	8.18 ± 0.12 <sup>a</sup>	6.09 ± 0.37 <sup>b</sup>	4.01 ± 0.41 <sup>c</sup>	5.16 ± 0.10 <sup>a</sup>	**
<b>C18:3(n-3)</b>	0.13 ± 0.01 <sup>a</sup>	0.08 ± 0.01 <sup>b</sup>	0.06 ± 0.01 <sup>b</sup>	0.08 ± 0.01 <sup>b</sup>	**
<b>ΥC18:3(n-6)</b>	0.16 ± 0.02 <sup>a</sup>	0.10 ± 0.01 <sup>b</sup>	0.07 ± 0.01 <sup>b</sup>	0.09 ± 0.01 <sup>b</sup>	**
<b>C20:3(n-6)</b>	0.09 ± 0.01	0.07 ± 0.01	0.10 ± 0.01	0.08 ± 0.01	N.S
<b>C20:4(n-6)</b>	0.05 ± 0.01 <sup>a</sup>	0.04 ± 0 <sup>b</sup>	0.02 ± 0 <sup>c</sup>	0.02 ± 0 <sup>c</sup>	**
<b>C22:6(n-3)</b>	0.84 ± 0.17 <sup>a</sup>	1.06 ± 0.15 <sup>a</sup>	0.31 ± 0.03 <sup>b</sup>	0.42 ± 0.04 <sup>b</sup>	**
<b>Total FA</b>	99.64 ± 0.11 <sup>a</sup>	99.53 ± 0.06 <sup>a</sup>	98.52 ± 0.43 <sup>b</sup>	99.09 ± 0.16 <sup>ab</sup>	**
<b>Cholesterol (mg/100g)</b>	600.85 ± 15.17	578.19 ± 10.53	587.0 ± 11.0	593.82 ± 16.92	N.S

A= Control B= 0.25% sumac C=0.5% sumac D=1% sumac

\*\* ( $p \leq 0.01$ ) ± = Standard Error.

L.S. = level of significant N.S. = non-significant ( $p > 0.05$ )

C14:0	=	Myristic acid.
C14:1	=	Tetradecenoyl carnitine.
C15:0	=	Pentadecanoic acid.
C16:0	=	Palmitic acid.
C16:1	=	Palmitoleic acid.
C17:0	=	Margaric acid.
C18:0	=	Stearic acid.
C18:1n9c	=	Oleic acid Methyl ester.
C18:2n6c	=	Linoleic acid Methyl ester.
C18:3n3	=	Linolenic acid Methyl ester.
gC18:3n6	=	Gama-linolenic acid Methyl ester.
C20:1n9	=	Ecosenoic acid Methyl ester.
C20:3(n-6)	=	Dihomogamma-linolenic acid.
C24:1(n-9)	=	Nervonik acid.
C22:6(n-3)	=	Docosahevaenoic acid.
C20:4(n-6)	=	Arachadonic acid.

## **5. CONCLUSION**

Sumac as herb contains many compounds that are useful in medicine. It has some important activities such as anti-microbial, antiviral, and anti-oxidant. Supplementation of 1% of sumac to the diet of Japanese quail decreased body weight from 7 days of age to 35 days of age.

Sumac supplemented to the laying hens' diet has a significant effect on egg weight. By adding 0.25% of sumac to the Japanese quail diet increased egg weight significantly. Finally adding sumac by different levels such as 0.25, 0.5 or 1% decrease saturated and polyunsaturated fatty acid in the egg and increase the total of monounsaturated fatty acid gradually in the egg.

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