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MASTER OF SCIENCE (MSc) DEGREE THESIS

**THE EFFECT OF SUMAC WATER ADDITION ON YIELD
PERFORMANCE AND SURVIVAL RATE IN BROILERS**

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ÖZET

Yüksek Lisans Tezi

ETLİK PİLİÇLERDE SUMAK SUYU KATKISININ VERİM PERFORMANSI VE YAŞAMA ORANINA ETKİSİ

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Bu çalışma, sumak bitkisi suyunun içirilerek ve inhalasyon yoluyla verilmesinin etlik piliçlerde verim performansı ve bağışıklık düzeyine katkısını belirlemek amacı ile yapılmıştır. Bu amaçla 240 adet Ross 308 etlik civciv günlük olarak bir kuluçkahaneden temin edilerek, 3*2 deneme modelinde (3 sumak seviyesi 2 adet verilme yolu içme suyu ve buhar ile) civcivler rastgele olarak her biri 10 civciv içeren 4 tekerrürlü 6 farklı deneme grubu oluşturulmuştur. Piliçlere içme suyunda üç farklı seviyede (0, 5 ve 10 g/litre) sumak suyu içirilerek ve inhalasyon yoluyla verilmiştir. Denemenin 35. gününde içme suyu yolu ile Newcastle (NDV) ve İnfeksiyöz bronşit (IBV) hastalığı için aşı uygulaması yapılmış ve bağışıklık cevabı için antikor titreleri belirlenmiştir. Çalışma 42 gün devam etmiştir. Denemeler sırasında canlı ağırlık kazancı, yem tüketimi ve yemden yararlanma oranlarını belirlemek için 10, 24 ve 42. günlerde ölçümler alınmıştır. Kesimler 42 günde yapılmış ve iç organlar tartılmış, karkas değerleri belirlenmiş ve bazı hematolojik testler ve lipid profili de incelenmiştir. İçme suyu veya inhalasyon ile sumak verilmesinin etlik piliçlerin besi performansını önemli ölçüde etkilemediği görülmüştür. Sumak suyu, etlik piliçlerin serumundaki lipid profilini, özellikle kolesterolü düşürmede etkili olmuş, karkas parçalarında etkili olmamış ve karkas randımanı az bir miktar düşmüştür. Ayrıca, etlik piliçlerin NDV ve IBV'sine karşı antikor üretimi inhalasyon ile bir dereceye kadar iyileşmiştir. Jejunum morfolojisi ise önemli düzeyde iyileşmiş ve villus yüksekliği artmış ise de istatistiksel olarak anlamlı olmamıştır.

ANAHTAR KELİMELE: Broiler, sumak, korona virüs, buhar soluma, enfeksiyon.

ABSTRACT

MSc Thesis

THE EFFECT OF SUMAC WATER ADDITION ON YIELD PERFORMANCE AND SURVIVAL RATE IN BROILERS

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The current research aimed to determine the impact of drinking sumac plant water and giving it via inhalation on yield performance and survival rate in broilers. For this purpose, 240 Ross 308 broiler chicks were taken daily from a hatchery and 6 groups were formed in a 3*2 trial model (3 sumac level, 2 delivery ways with drinking water and steam). Groups were divided into 4 replications and 10 chicks were distributed to each group. Birds were supplemented with three different levels (0, 5, and 10 g/litter) of sumac both in drinking water and via inhalation. This duration of experiment was 42 days. In order to determine body weight, increased weight, the feed intake, and feed conversion ratio, during the experiments the weight of the chicks and leftover were weighted on days 10, 24, and 42. After slaughtering internal organs were weighed, the carcass characteristic were measured, haematological tests and lipid profile were done as well as measuring Newcastle Disease Virus (NDV) antibody titers and infectious bronchitis antibody titers (IBV). The main results of present paper that supplementation of sumac in the drinking water or as a inhalation didn't significantly Influence the performance of broiler chickens in terms of growth as a result of sumac supplementation. Sumac was effective in reducing the lipid profile particularly cholesterol in the serum of broiler chickens. The dressing percentage was slightly decreased by sumac supplementation without any effect on the carcass parts. In addition, the antibody production against NDV and IBV of broiler chickens was improved to some extent. Jejunum morphology was clearly improved thereby increasing the villi height however it was statistically not significant.

KEY WORDS: Broiler, sumac, coronavirus, steam inhalation, diseases.

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1. INTRODUCTION

Birds are typically maintained in close quarters with high stocking densities in the broiler industry, placing them at danger of disease transmission. Antibiotics, growth boosters and anti-coccidial medicines, among other potentially harmful feed additives, are commonly used to improve growth rates, prevent illnesses, and reduce losses in poultry farms. It is stated that antibiotics in broiler feed and antimicrobial resistance in animal and human germs can rise as a result of this (Van den Bogaard et al., 2001; Thapaliya et al., 2017). Bird's nutritional requirements alter throughout time and each kind of diet probably can be matched for a certain time period.

It is noticed that during the production phase some diet modifications are required, and this has been more obvious during daytime (Waldroup et al., 1993). Nutritionists have devised a variety of feeding plans in order to boost broiler production efficiency (Shariatmadari, 2012). As a result, there is a considerable consumer demand for farm animal diets that are antibiotic-free (Rahnama et al., 2017). Recently, initiatives have been made to employ medicinal herbs as alternatives to antibiotics and synthetic growth boosters (Chacher et al., 2017). The scientific literature has only a few research on the impact of these supplements on the performance of broilers. Broiler chicken meat consumption has increased due to its low cost, simplicity of processing, variety and high nutritional content. Chicken meat is soft and fine-fibred, with a lot of high-quality protein and lipids that are readily available. It also contains a low amount of cholesterol (Grabowski and Kijowski, 2004).

Broiler birds that grow quickly are usually butchered around 6 weeks of age, when they have reached their optimal body weight, dressing percentage, breast muscle content, feed conversion and feather maturity. Chickens are also reared till 4-5 weeks of age for some consumed, particularly in the food services business. Chickens are being butchered at a higher rate than ever before, their bodies are utilized to manufacture poultry products when they are 12-15 weeks old and weigh 3-4 kg. (Grabowski and Kijowski, 2004) .

For improving bird health many medical herbals are used as an additive from them sumac. It is first found in Asia and is belonging to the family of Anacardiaceae. Flavanols like myricetin, quercetin and kaempferol can be found in sumac fruits (Mehrdad et al., 2009) In addition, found different sorts of organic acids in sumac including citric acid, malic acid, phenolic acid, tartaric acids, anthocyanins and hydrolysable tannins (Ozcan and Haciseferogullari, 2004). Sumac is used in traditional medicine as a herbal treatment for its analgesic, anorectic, antidiarrheal, antihyperglycemic properties and antiseptic (Rayne and Mazza, 2007). Some researchers have written on the positive effects of sumac in poultry diets (Gulmez et al., 2006; Kheiri et al., 2015). Quail chosen sumac for only 2–4% of their diet found that approximately 55% of the sumac seeds were undigested when goes through the Quail digestive system (Nestler and Bailey, 1944). In broilers, however, Low levels of sumac supplementation (0.2–0.5 % of the nutrition) enhanced feed conversion ratio, the shape of intestine and plasma cholesterol, while increasing abdominal fat and high-density lipoprotein (Golzadeh et al., 2012; Kheiri et al., 2015). Furthermore, Increased Newcastle Disease titers and the replacement of *E. coli* in the gastrointestinal tract by lactobacilli, have been noted by Kheiri et al., (2015). However, when sumac was added to the diet of layers at a concentration of 0.5 percent, egg weight was confirmed to be decreased (Gumus et al., 2018). Cakmak et al., (2017) Treatments were organised in a factorial manner using the levels of sumac powder (0.0, 0.75, and 1.5 g/kg feed). At the end of the study, there was a significant relationship between stocking density and dietary sumac powder supplementation for only body weight and abdominal fat pad variables (P0.05).

In the broiler sector, birds are usually kept with high stocking densities, putting them at risk of disease transmission. Reducing diseases is from priorities to reduce losses in poultry farms. Many studies have been done using of herbal and plants which have medicinal properties to decrease illnesses. Sumac (*Rhus coriaria*) is one of them that is an anti-inflammatory, antifungal, antioxidant and antimicrobial feed supplement. Fruits of the sumac provide a broad range variety of benefits for poultry productivity. It is clear that the main problem experiencing poultry farms are diseases. This leads to huge losses in poultry farms. Wherefore the current study

aims to identify the impact of drinking sumac plant water and giving it via inhalation on yield performance and survival rate in broilers. The major objectives of this project are to identify the impact sumac water and sumac water vapour on broiler and to measure survival rate within the treatments as well as monitoring disease resistance of broiler to sumac water and sumac water vapour.

1.1. Hypothesis

In the last two years, with the development of the covid-19 epidemic in the world, herbal extracts that contribute to the development of the immune system have become the focus of attention. Like all other immune systems, both innate and adaptive responses occur in the gut against pathogenic microbes. The intestinal epithelium consists of four cell lineages originating from a common stem cell: absorbent enterocytes, mucus-producing cells, hormone-producing enteroendocrine cells, and antimicrobial peptide-producing Paneth cells. It has been stated that extracts of some aromatic plants such as sumac significantly increase the muscularis, mucosa, total intestinal length and serosa in the intestinal environment. Due to the high content of active compounds in sumac that possess antioxidant and antibacterial effect, it proposed that sumac supplementation may reduce the lipid, improve the growth performance of broilers and enhance their resistance to disease.

2. REVIEW LITERATURE

2.1. Background

Natural selection has produced modern chicken breeds over billions of years, which has been supplemented with artificial selection for commercial purposes. Since domestication, the most progress in chicken genetics has come at the end of the 20th century, following the introduction of large-scale agribusiness (Schmidt et al., 2009). This is due to advancements shown in quantitative genetics and the economic accomplishment of its implementation (Siegel et al., 1997).

Broilers raised today will reach market weight in sixty % fewer duration than broilers raised forty years ago. Nonetheless, modern broilers' cardiac capability and pulmonary is quite similar to that of older broiler strains, forcing their cardiopulmonary system to operate at or near its physiological maximum (Lorenzoni and Ruiz-Feria, 2006). The lungs' capacity often does not fulfill the oxygen requirements of fast development. In extreme circumstances, when ambient temperature rises or low, this impairs the ability to control the energy balance (Luger et al., 2003). Animal feeding is particularly significant, with feed accounting for up to nearly 80% of total livestock production costs (Mottet et al., 2017). Each step in the process should have a clear target in mind on how to improve feed quality and manage feed costs in animal production and work toward that goal on a daily basis.

When antibiotics in feed are banned or restricted, in the past decade, the attentions has increased on different natural products including bioactive products extracted from herbs and medicinal plants as animal growth promoters (Qureshi et al., 2017). Therefore, since the 1990s, there is a big demand on plant-based performance promoters. For example, the EU's essential oil sales reached 90 tons in 1996, but it is expected to reach 600 tons in just 10 years (Greathead, 2003). Sumac and its extracts have anti-bacterial, anti-fibrosis, anti-fungal, anti-inflammatory, hypoglycemic,

leukopenia, anti-tumor and anti-oxidant properties in many medicinal plants. Shows the potential as a feed ingredient (Janbaz et al., 2014). For a long time sumac used as a plant of medicine for humans as well as for food preservation (Fazeli et al., 2007). Nevertheless, there is a paucity of information on sumac's use in animal feed, especially for poultry.

Sumac (*Rhus coriaria*) is an anti-inflammatory, anti-fungal, antioxidant, and anti-microbial feed supplement. The fruits of sumac provide a wide variety of benefits for poultry productivity. In Arab nations, sumac is a common spice. While it is used as a powder, it is a fruit in its natural state. Sumac is the common name for the spice made from the *Rhus coriaria* plant, which comes from the Anacardiaceae family and the genus *Rhus*. The Arabic word "summaq," that means "dark red," is assumed to be the source of sumac's etymology (Abu-Reidah et al., 2014). Some say it comes from of the Syriac term "Sumaga," meaning "red" (Raodah et al., 2014).

2.2. The Life of Broiler Chickens

Broilers or broiler chickens are chickens that produce meat. Consumer demand for low-cost poultry meat has fueled the development of the broiler industry. The weight of the pectoral muscle has been increased by breeding for developmental characteristics and better nutrition. To gain weight rapidly, commercial broiler chicks are intended to develop very quickly. Chickens intended for meat processing have two distinct stages in their lives. They're hatched and are transferred to a grow-out field at the age of one day. They'll stay here until they gain enough weight to be killed. Some important information will be given about the life and management of broilers.

2.2.1. The hatchery

The eggs of the parent bird (breeder bird) utilized to generate meat chickens are incubated. The eggs are kept in the incubator under ideal atmospheric conditions and at precisely controlled temperatures. The chicks are able to hatch after 21 days and

are then transported to the field. During the first few weeks of life, chicks need extra heat and humidity. Temperature from (32°C to 34°C), with a humidity levels from (60% to 70%) are needed for newly hatched chicks (de Jong et al., 2017).

2.2.2. Transport of chicks

Chicks are taken to the field from the hatchery in transport modules (or chick boxes) when they are a day old. Chicks are dropped into transport boxes or modules as they ride through a conveyor belt. The chicks are vaccinated with subcutaneous vaccinations and/or spray during this phase (Breytenbach, 2005). There are several scientific recommendations that specify the ideal climatic conditions for transporting day-old chicks (temperature, ventilation, etc.) (Mitchell et al., 2004). Newly hatched chicks, unlike older birds, are unable to control their body temperatures, making them particularly vulnerable to heat stress throughout transportation. For a short time after hatching, newly born birds have been supported by water and energy stored in the yolk reservoirs and as the time to first water and feed access rises, chick survivability decreases dramatically (Mitchell et al., 2004).

2.2.3 Vaccination

Within a few weeks broiler chickens reach to slaughter weight. This leaves no time for the immune system to mature. Therefore, chicks have been vaccinated against many diseases. The source of infection (such as Salmonella) can also be transmitted from breeder to chicks via eggs (vertical transmission). As a result, the breeder hen should also be vaccinated. Before transportation as mentioned above the chicks are vaccinated with subcutaneous vaccinations and/or spray if Marek's disease vaccination is not performed in-ovo, it is injected at hatch (Breytenbach, 2005). The most widely used vaccinations are those infectious and transmittable including the virus causes bronchitis, the virus of Newcastle disease, Marek's disease, coccidiosis, bursal disease and birds pneumovirus (Breytenbach, 2005). Vaccines are often administered by drinking water, spray, *in vitro* fertilization, or injection (the most

common subcutaneous route). For respiratory vaccines, it is recommended to use spray vaccination, which is the most reliable vaccination method.

2.2.4. Slaughter

Globally, the most common method applied for killing and/ stunning the poultry is electrical and gas method (EFSA, 2004).

2.2.4.1. Electrical systems

The chicken hung upside down with a metal key with its paws was stunned by the amazing device of a charged waterbath and was cut into the throat by an automatic knife, causing blood loss (exsanguination). Broilers may be electrically immobilized (ie, paralyzed but conscious) or unable to faint effectively (due to individual differences in electrical resistance), but they are completely aware of and feel the pain of having their throats cut (Hindle et al., 2010).

2.2.4.2. Controlled atmosphere systems (CAS)

The chickens in the transport box is transported through the tunnel, where (CO₂), inert gas (nitrogen/argon) or a combination of such gases is gradually increased. Multiphase CO₂CAS system kills the poultry via exposing them to a mixture of gas that contains 40 percent of Carbone dioxide, the higher concentration (>55 percent) then applied to kill the birds. An optimal option can be a mixture of CO₂ (30%) and other chemicals including inert gas and possibly oxygen so that to reduce the negative impact of the gas on the birds (Gerritzen et al., 2013).

Carbon dioxide causes rapid unconsciousness by directly depressing the central nervous system. Carbon dioxide, on the other hand, is toxic to poultry (If the levels are higher than 20 percent). It is being thought that inert gases such as argon and nitrogen are to be unproblematic during inhalation process, however having in large quantities can cause bird's death as these gases will lead to minimize the Oxygen

level in the body of birds. Although less traumatic to birds than CO₂, inert gas CAS takes more time to death them and chickens have also been observed flapping their wings vigorously after losing consciousness, causing carcass harm (Gerritzen et al., 2000).

2.2.4.3. Low atmospheric pressure stunning (LAPS)

Low Atmospheric Pressure Stunning is a more recent technique which simulates the physiological consequences of rising to high altitudes. While still allowing for regulated slow decompression. The air chamber in the container of chickens is steadily depleted oxygen, causing the chickens to lose consciousness due to a lack of oxygen. According to current research, LAPS can be equivalent to other CAS approaches in terms of welfare. However, more can be done by researches to see if birds have acute pain or anxiety between the starts of the LAPS mechanism and the start of unconscious (Mackie and McKeegan, 2016).

2.3. Sumac Plant (*Rhus coriaria*)

2.3.1. Sumac's use in history

Sumac has long been utilized as a source of traditional and natural medicines in culinary cultures around the world. For a long time, the use of plants in spices and flavoring compounds has been the mainstream of indigenous therapies. For ages, Sumac is being used as a spice in cooking. The Greek doctor Pedanius Dioscorides (40-90 AD) wrote about the health benefits of sumac in the encyclopedic "De Materia Medica" ("Medical Problems") two thousand years ago (Quest, 2006). The pressing of *R. coriaria* fruits to obtain the essential oils is a process that dates back to ancient Rome and is still used in some cuisines today. Based on the type of sauce you make, the oil will be mixed with vinegar or olive oil. Nonetheless, *R. coriaria*'s therapeutic virtues have been known since antiquity. Sumac, for example, was once employed in folk medicine to treat chronic symptoms of stroke, as documented in Canon of Medicine for Avicenna (Ibn-Sina) (Zargaran et al., 2013). Surprisingly,

sumac in Palestine and Iran refers to the plant's pure ground fruit epicarps, whereas in the Turkey, uses the salt crystals to crushed the entire fruit (Mirhadi et al., 2011). It's a popular culinary spice in Mediterranean, particularly in fish and meat recipes (Nasar-Abbas et al., 2004). Pulverized sumac seeds are used in salads and other dishes in the culinary world (Kizil and Turk, 2010). A growing body of evidence suggests that incorporating sumac into water or food can have health benefits for animals and humans (Chakraborty et al., 2009) .

2.3.2. Structural description of the sumac parts

The shrub *Rhus coriaria* L. is between 3-4 meters in length, with the leaves shape of pinnate. It has 6-8 pairs of oval leaflets shape varying in sizes and has a white flora at the end of the inflorescence. When ripe, the fruits are villose, reddish drupes and globose, they contain essential oils, tannins, anthocyanins, fixed oil and various organic acids in one seed. Essential oils, sugar, gallic acid, wax and (bi)flavonoid are all found in the leaves (Ünver and Özcan., 2010). Weight (0.20 g), length (4.70 mm), volume (19.50 mm³), geometric diameter (3.64 mm), thickness (2.64 mm) and sphericity (0.77) are physical properties. The moisture content of *R. coriaria* fruits was measured to be 4.79 percent. Static friction (0.48-0.68), porosity (68.50%), density (304.25 kg/m³), bulk projected area (0.16 cm³) and terminal velocity (3.50 m/s) of the fruits were all determined at the same moisture content (Özcan and Haciseferogullari, 2004).

2.3.3. Physical characteristics of *Rhus coriaria*

The leaves of the sumac tree are spiraled and the fruit is contained within each cluster. The crimson fruits are closely clustered onto a 5–30 cm inverted cone-shaped spike. Sumac bobs are dense clusters of crimson drupes formed by tiny small spheres firmly packed together (Figure 1).



Figure 2.1. Sumac leaves and fruit (Adopted from Sakhr, 2019)

Sumac powder is made from sun-dried drupes that have been pulverized into a crimson powder (Abu-Reidah et al., 2014). In an analysis conducted by the Faculty of Agriculture at the Selcuk University, Turkey, the immediate physical parameters of the plant with the content of moisture 4.79 percent were determined promptly after arriving, as well as the dimensional features of these fruits (Table 1). Before designing tools for collecting, handling, processing, transporting and storing sumac fruit, understand the physical characteristics of the plant it is necessary (Özcan and Haciseferogullari, 2004). The physical characteristics of a fruits were assessed (Table 1).

Table 2.1. *Rhus coriaria* dimensional and physical attributes (Özcan and Haciseferogullari, 2004)

Length (mm)	4.72 ± 0.030
Width (mm)	3.90 ± 0.028
Thickness (mm)	2.64 ± 0.025
Weight (g)	0.018 ± 0.001
Mean diameter (mm)	3.64 ± 0.023
Volume (mm ³)	19.49 ± 0.442
Sphericity	0.773 ± 0.003
Projected area (cm ²)	0.164 ± 0.005
Bulk density (kg/m ³)	304.25 ± 1.364
Porosity (%)	68.52 ± 0.578
Terminal velocity (m/s)	3.52 ± 0.128
Coefficient of static friction	
Iron sheet	0.532 ± 0.036
Galvanized iron sheet	0.482 ± 0.022
Plywood	0.607 ± 0.068
Rubber	0.675 ± 0.334

2.3.4. The composition of the sumac plant and its uses

Sumac's name comes from genus *Rhus coriaria*, which is a member of the Anacardiaceae family in the Sapindales order, which includes 81 types and more than 800 species. The *Rhus* spp. are found worldwide in temperate climates and subtropical particularly in southeastern Anatolia, Africa, the West Asia and

Mediterranean region. The name comes from the Syriac word "sumaga" which means "red" (Wetherilt and Pala, 1994). *R. coriaria* was found to be high in tannins, (iso) flavonoids and terpenoids, with 211 compounds according to a study that looked at sumac for phenols and other phytochemicals (Abu-Reidah et al., 2015). Plant compounds found in *R. coriaria* include tannic acid, gallic and ellagic, as well as quercetrin, isoquercetin, myricitrin, quercetin, myricetin and avicularin (Duke et al, 2002; Janbaz et al., 2014). The sour taste of the ground plant (pH 2.5) comes from the malic acids and citric found in its juice. The sumac used to treat many diseases such as indigestion, anorexia, hemorrhages, dysentery, diarrhea, toothaches and hyperglycemia, among other conditions (Shabbir, 2012). Various researches have shown that sumac has antiviral characteristic against HIV (Janbaz et al., 2014).

2.3.4.1. Physiochemical analysis of *Rhus coriaria*

Sumac is a blooming shrub that grows wild in Lebanon's rural areas or in orchards. The scientific name of the sumac is *Rhus coriaria*. It is belonging to the Sapindales order's Anacardiaceae family (Asgarpanah and Saati, 2013). It grows in temperate and subtropical climes. It is especially popular in Africa, the Mediterranean region and Western Asia (Abu-Reidah et al., 2014). There are about 250 species of the genus *Rhus*, which can be found all over the world. Syrian sumac is the name given to it in the Middle East, which encompasses Lebanon, Syria, Palestine and Jordan (Raodah et al., 2014). Sumac reproduces both by underground rhizomes (new roots that proliferate) and by seed (Abu-Reidah et al., 2014). There have been a lot of studies done on *Rhus coriaria* has showed a number of promising substances that could be used in the food sector as well as in homeopathy. These molecules are important in enhancing human health and the economy for a diversity of reasons, such as prevent of oxidation processes and the treatment of bacterial and fungal diseases.

2.3.4.2. Chemical composition of the plant sumac (*Rhus coriaria*)

In an effort to analyze and identify chemical components in sumac, researchers in Iran found 191 compounds in *Rhus coriaria*, which were classified as:

“78 hydrolysable tannins

59 flavonoids

9 anthocyanins

2 isoflavonoids

2 terpenoids

1 diterpene, 38 other unidentified compounds (Ardalani et al., 2016)”

In order to classify, establish and isolate the ingredients from sumac fruit and its leaves, different extracts have been used. Some researchers used aqueous extracts, others were using isolated alcoholic extractors and some others using lipid to extract sumac ingredients. Sumac fruits have the largest proportion of hydrolyzable tannins, following by flavonoids (Ardalani et al., 2016). This is an indication of the fruit's antioxidant characteristic and ability. Other unidentified compounds follow hydrolysable tannins, which account for nearly 20 percent of the fruit's mass. *Rhus coriaria* should be studied further so that to classify and isolate these compounds. There are anthocyanins, terpenoids, isoflavonoids and diterpenes after that (Ardalani et al., 2016). Sumac fruit has a 2.6 percent protein, 7.4 percent fat, 14.6 percent fiber and 1.8 percent ash content, according to a report on the chemical properties of mature fruits (Table 2). According to a calorimetric analysis, 100g of sumac fruit contains 147.8 kca. (Özcan and Haciseferogullari, 2004).

Table 2.2. Chemical composition of the sumac plant by (Özcan and Haciseferogullari, 2004; Raodah et al., 2014)

Properties	References		
	Ozcan haciseferogullari (2004)	and	Raodah et al. (2014)
Moisture (%)	10.6 (fresh)		2.43 (dried)
Crude oil (%)	7.4		18.74
Crude protein (%)	2.6		4.69
Crude fiber (%)	14.6		ND
Carbohydrate (%)	ND		71.21
Crude energy (kcal\100g)	147.8		ND
Ash (%)	1.8		2.93
Water soluble extract (%)	63.8		ND
Acidity (%)	4.6		ND
PH	3.7		3.02

2.3.4.3 Mineral composition of *Rhus coriaria*

Potassium, calcium, magnesium, and phosphorus are the most abundant minerals in sumac fruit. Other minerals such as zinc, boron, sodium, aluminum and iron have been found in sumac (Özcan and Haciseferogullari, 2004). Sumac is a natural approach to increase your intake of nutrients like calcium and potassium (Özcan and Haciseferogullari, 2004). The highest concentration of potassium found to be 7963 ppm in sumac and followed by phosphorus 1238 ppm and calcium 3661 ppm. On the other hand, it was found that 0.03 ppm of cadmium was almost undetectable, followed by 0.47 ppm of selenium. Sumac on the other hand, had the lowest selenium level of all the plants examined, while basil had the most (Ozkutlu et al., 2011).

2.3.4.4. Vitamins Content of the Sumac plant (*Rhus coriaria*)

There are very limited studies conducted on the vitamins content analysis of the sumac plant. In a comparison study conducted in China on the differences between Chinese and Syrian sumac, several of the vitamins found in *Rhus coriaria*

were identified ascorbic acid, cyanocobalamin B12, pyridoxine B6, riboflavin B2, Thiamin B1, biotin and nicotinamide are the major vitamins present in sumac. The most abundant vitamin was pyridoxine, which was followed by thiamine, ascorbic acid and riboflavin (Kossah et al., 2010).

2.3.5. Health benefits prebiotic dosage of sumac

In folk traditional medicine Arabic Palestinian medicinal herbs, this plant was used to treat liver disease stroke, cancer, hypertension, diarrhea, eczema, dysentery, hematemesis, ophthalmia, stomach ache, aconuresis, teeth, diuresis, atherosclerosis, diabetes, measles, smallpox, gum diseases, headaches and animal bites (Ali-shtayeh et al., 2008). *R.coriaria* also has hepatoprotective properties, anti-bacterial, anti-fungal, anti-ischemic, anti-oxidant, hypouricemic, hypoglycemic and anti-septic properties all of which confirm its traditional use (Fi et al., 2011;Özcan, 2003) .

2.4. The effects of Sumac Plant (*Rhus coriaria*) on Broiler Chickens

There are a lot of proof that sumac feed improves broiler performance, notably in terms of FCR and growth (Kheiri et al., 2015). After broiler chickens were fed sumac fruits powder in the food in different diet level starting from 2.5 gram per kilogram to 5 grams per kilogram, weight increase and feed efficiency were dramatically increased. Earlier research had found that supplementing with 7 g/kg had a negative impact on FCR (Golzadeh et al., 2012;Ghasemi et al., 2014). 0.1 percent sumac dramatically boosted both carcass percentages and live weight gain in broilers, according to a study Feed intake was substantially reduced in broiler chickens fed 3 or 7 grams of sumac powder per kilogram of body weight, while weight gain was unaffected; thus, feed conversions was increased (Toghyani and Faghan, 2017). According to Kheiri et al., (2015) there was a decrease in abdominal fat, Depending Golzadeh et al., (2012) when sumac added to the feed of chickens, they had more abdominal fat. Mazloom, (2011) According to the findings, using sumac in broiler diets improved efficiency, blood biochemical testing and carcass traits had no impact on immunological measures. Shirzadi et al., (2020) showed data

that diet supplemented with 0.2 percent sumac substantially increased broiler chicken body weights but had no effect on feed conversion ratio and feed intake. Sumac's active ingredients (especially cinnamaldehyde and ugenol) can help chickens absorb nutrients more efficiently, eventually the growth is increased (Ghasemi et al., 2014). Langhout, (2000) indicated that herbal floras may help poultry digest their food, while (Shirzadi et al., 2020) DM digestion was substantially increased in poultry fed sumac diet supplemented. Furthermore, there were major increase in ileal ether extracts and gross energy digestion in supplement diet chickens compared to control birds, but no difference in ash digestion or crude fiber (Shirzadi et al., 2020).

Sumac oils has the potential to improve poultry output by improving digestion and liver production (Kheiri et al., 2015). When chickens feeding sumac were compared with the control, the muscularis, mucosa, total gut length and serosa all dramatically increased. Ghasemi et al., (2014) indicated that crypt depth, villus height, goblet cell number width and epithelium layer were all impacted by the usage of sumac extraction in poultry diet. (Golzadeh et al., 2012) Intestinal villi height was reduced when sumac extract was added to the diet, while goblet cell number and epithelial layer thickness were increased significantly. (Shirzadi et al., 2015) compared to chickens feeding the control diet, villus height, ratio of crypt depth and the height of villus were heavily higher in chickens fed sumac-supplemented diets. Kheiri et al., (2015) there were advances in liver function and a rise in pancreas digesting enzyme secretion. Sumac supplementation will improve carbohydrate and protein metabolism in the main organs, resulting in a faster rate of growth for these parts. According to some researchers attribute enhance bird performance to sumac's antioxidant and other characteristics, which might promote digestive enzyme excretion, feed digestibility and hence broiler development (Mazloom, 2011). Sumac products have also been discovered to also have antibacterial, hypoglycemic properties and antioxidant (Rayne and Mazza, 2007). Sumac has roughly 50 times the antioxidant effect of vitamins E and C, according to research. Sumac contains phenolic chemicals that can prevent lipid peroxidation, as well as scavenged hydroxyl radicals and superoxide anions (Ferk et al., 2007; Rubya et al., 1995), and

boost the activity of detoxification enzyme like glutathione-S-transferase (Piper et al., 1998). Golzadeh et al., (2012) reported the high sumac supplementing (10 g/kg) has a negative impact on feed intake and FCR. This could have something to do with the polyphenolic chemicals found in sumac. These deleterious impacts of phenol chemicals has been linked to their effect on availability nutritional. Sumac has also been discovered to be a main source of tannin (Kosar et al., 2007). Tannin consumption is linked to decreased feed intake and appetite, as well as poor nutrient absorption, growth in chicken and feed efficiency (Nyachoti et al., 1996) . Tannin is strong kidney and liver toxin may induce bone diseases in poultry, as well as pathological changes in tissues at different levels, esophageal irritations, necrosis in crop, duodenum and gizzard (Marzo et al., 2002).

Sumac contains high proposition of healthy active compounds that could be used as an additive supplementation in the drinking water or as an inhalation with great antioxidant and antibacterial effect. It is hypothesised that sumac may improve the digestion and overall performance of broilers and increase the antibody production of broiler chickens.

3. MATERIAL and METHOD

3.1. Study Location

The study was carried out at the Department of Animal Production in poultry houses, College of Agriculture, Duhok University, Duhok city, Iraq The procedure of this trial was agreed by the Animal Ethic committee of the College of Agricultural Engineering Sciences, University of Duhok (Approval No: AEC 15112020).

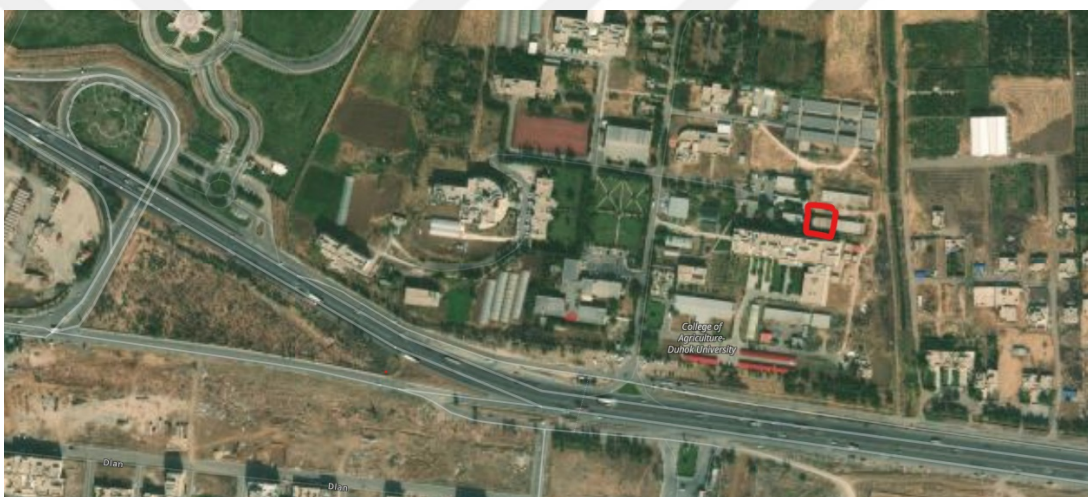


Figure 3.1. Study location

3.2. Experimental Design and Bird Management

In a feeding trial, a total of 240-day-old Ross 308 broiler chicks were generously obtained from hatchery. Then the chicks raised in poultry farm College of Agricultural and Engineering Sciences, University of Duhok from 10\11\2020 to 22\12\2020, this period included only field experimental. The chicks randomly allocated to 6 different treatments of 4 replications, 10 birds per a replicate. Birds were supplemented with three different levels (0, 5 and 10 g/liter) of sumac in either drinking water or as an inhalation. Chicks were reared in floor pens (100 × 100cm) bedded with wood shaving (Figure 3.1.). Two phase feeding were adopted in this experiment: a starter diets from 1 to 24 days, while grower diets from 25 to 42 days.

All of the diets were formulated to meet the needs for Ross 308 broiler chickens (Tables 3.1.). The room temperature progressively decreased from 35 °C in d 1 to 22 °C $\pm$ 1 °C at 42 days. Birds vaccinated against Infectious bronchitis and Newcastle at day 32 to measure the antibody titers against these diseases. Across the duration of experiment, 18 hours of lighting provided in each day, excluding the first week in which 23 hours of lighting were provided. Water and feed were provided *ad libitum*. On d 10, 24 and 42, the birds and feed leftover weighed to measure the weight gain, body weight, feed conversion ratio and feed intake. Mortalities recorded as they occurred, then feed per gain corrected for mortality.



Figure 3.2. General view of the cages

Table 3.1. Ingredient and nutrient composition of the starter and grower diets

Ingredients	Starter (1-24 day)	Grower (25-42 day)
Wheat	59.70	65.50
Protein concentration	5.80	4.00
Soybean meal	28.00	22.97
Vegetable oil	2.70	4.00
Limestone	1.22	1.20
Dicalcium phosphate	0.90	0/90
DL-methionine	0.15	0.15

Table 3.1. (continue)

L-lysine	0.15	0.15
¹ Enzyme	0.20	0.20
Salt	0.30	0.25
Vit.Premix	0.80	0.60
Anti.fungul	0.08	0.08
Total	100.00	100.00
Calculated Chemical Composition %		
Crude protein	23.37	21.18
Energy Kcal/kg	3021.10	3147.74
Fat	3.80	5.12
Linoleic acid	1.73	2.40
Crude fiber	2.65	2.60
Methionine	0.73	0.63
Lysine	1.58	1.37
Tryptophan	0.32	0.30
Meth. + Cystine	0.96	0.82
Threonine	0.80	0.73
Arginine	1.44	1.30
Ca	1.15	1.02
Available P	0.62	0.55
Na	0.36	0.29
Cl	0.24	0.21

¹Enzyme = Xylanase, Amylase, Protease and Phytase

Sumac (*Rhus coriaria*) that used in the experiment was analyzed laboratory. The chemical properties (phenolic acid, moisture, ash, total nitrogen and protein) of sumac were determined according procedure described by AOAC (AOAC., 1990).

The Table 4 shows the main results of chemical analysis of sumac (*Rhus coriaria*).

Table 3.2. Chemical composition of local sumac (*Rhus coriaria*)

Some ingredient for sumac seed	Value
Fruit moisture, %	8.67
Ash, %	1.23
Protein, %	2.06
Total nitrogen (N ₂)	0.33
Phenolics in sumac juice*	
Catechinhydrate, Ppb	954.32
Syringicacid, Ppb	117.84
Resveratrol_Ppb	157.25
Fumaric Acid, Ppb	8538
Gallic Acid, Ppb	91179
Caffeic, Ppb	28.31
Hydroxycinamic, Ppb	119.29
Hydroxyben, Ppb	32.91
Salisilikasid, Ppb	57.23
Phloridzindyhrate, Ppb	137.94
Myricetin, Ppb	63.9
Ellagicacid, Ppb	25079.55
Quercetin, Ppb	210.17
Luteolin, Ppb	12.4

*: Analysis of some phenolics in sumac juice were done by using a Triple Quadrupole LC/MS/MS [LCMS-8030]. In addition, Shimadzu LCMSMS-8030 and Inertsil ODS 4 as devices; 2um, 2.1X 50mm column was used.

3.3. Collection and Processing of Samples

3.3.1. Visceral organs and carcass characteristics

On day 42, two birds were chosen at random from each cage and slaughtered by cervical dislocation (Figure 4). The visceral organs were weighed after the abdominal cavity was opened. The mass per unit of body weight was used to calculate the relative organ weight (g/kg of body weight). The carcass was measured and the relative weight of its pieces (breast, drumsticks and thighs) was computed as a mass per unit of carcass.



Figure 3.3. Visceral organs and carcass characteristics

3.3.2. Serum biochemical parameters

Two birds from each cage are slaughtered then blood samples (approximately 5 ml) collected from the jugular vein into non-heparinized tubes. Subsequently, after centrifuging the blood for 15 minutes, the serum was extracted and stored in the refrigerator for analysis (Figure 3.4.). Colorimetric enzymatic methods were utilized to assess serum biochemical parameters such as albumin, total protein, high-density lipoprotein, low-density lipoprotein, triglycerides and cholesterol using the procedures described in the used commercial kits (Randox laboratories limited, United Kingdom).



Figure 3.4. Blood collection

3.3.3. The activity of enzymes in the serum

The concentration of Aspartate aminotransferase (AST) and Alanine aminotransferase (ALT) in serum is determined spectrophotometrically following the procedure described in the commercial kit using.

3.3.4. Antibody titers

After the harvesting of serum, the antibody titers against infectious bronchitis (IBV) and Newcastle Disease Virus (NDV) measured, at 42d after the regarding vaccine injection at day 32, by using hemagglutination-inhibition test (Cunningham, 1971). For this test, two-fold serial dilutions of heat-inactivated (at 56_°C) serum were made in U-bottom micro titer plates with phosphate-buffered saline (PBS) (0.01 mol/L; pH 7.4) for totally antibody.

3.3.5. Jejunum histology

Jejunal tissue samples were collected, flushed with buffered saline, and placed in 10% buffered formalin. After embedding in paraffin wax and sectioning, the sliced samples were stained with eosin and haematoxylin (Figure 3.5.). Prepared tissue samples were captured at 10× zoom using a digital camera under microscope (Dino-Eye-Microscope Eye-piece Camera). Dino-eye program was used to determine the morphometric indices. The image was digitized and the villi height of villi (from the tip of the villi to the junction of villi with crypts) and depth of crypt (from the villi/crypt junction to the muscular junction) was measured in 7 to 10 of well-orientated villi for all jejunal section.



Figure 3.5. Jejunal tissue collection and measurement

3.4. Statistical Analysis of Data

All data were analyzed using Minitab version 17's General Linear Models (GLM) method for the main impact of sumac level in water or as an inhalation, as well as their interactions. Duncan's multiple range analysis was used to determine the differences between mean values.

4. RESULT and DISCUSSION

4.1. Result

4.1.1. Growth performance

At day 10 there was no significant impact ($P>0.05$) of the experimental factors on the feed intake of broiler chicks, although there were slight differences in means in some cases (Table 4.1.). For example, it was observed that application of inhalation methods increased the feed intake compared to water method, but statistically the increase was not significant. Regarding the interaction, no significant interaction was found between experimental factors ($P>0.05$), demonstrating that birds consumed feed similarly to sumac levels using both administration methods. In spite of slight increase in means when applying inhalation, again statistically these trends were non-significant ($P>0.05$). There was no significant response ($P>0.05$) of weight gain and body weight of broilers to sumac levels. However, weight gain ($P<0.01$) and body weight ($P<0.01$) responded significantly to administration methods. Birds that received the sumac as an inhalation were significantly heavier and gained more weight than those received it as in their drinking water. Regarding the interaction, the interaction effects of experiment factors on both weight gain and body weight were found to be non-significant ($P>0.05$). That means both weight gain and body weight at each sumac levels were responded highly when applied sumac in the form of inhalation than in the form of water drinking (Table 4.1.). The FCR was increased significantly ($P<0.05$) by rising levels of sumac regardless to the administration method. The administration method of sumac had no significant impact ($P>0.05$) on the FCR of 10 days old chicks. However, the interaction effect of experiment factor on Feed conversion ratio (FCR) was not significant ($P>0.05$), indicating that the FCR was higher in birds at the highest level of sumac in either drinking water or as an inhalation, however the better FCR was detected in the control groups.

Up to 24 days, there was no significant impact ($P>0.05$) of the experiment factors and their interaction ($P>0.05$) on the feed intake of broiler chickens (Table 4.2.). Despite the existence of slight differences in means in some cases especially when changing the levels of sumac, these values were not statistically different. Birds that were inhaled the sumac inhalation tended to have the higher body weight and weight gain than those that were received the sumac in their drinking water, but again statistically there trends were not significant. However, FCR was increased significantly ($P<0.05$) by rising levels of sumac indicating the better FCR in the control group than those that were received the sumac in either drinking water or as an inhalation.

When assessed over the 42 days of experimental period, it was observed that there was significant effect of administration methods ($P<0.05$) on feed intake, while the effects of levels of sumac and the interactive effect of experimental factor on feed intake were found to be non-significant ($P>0.05$) (Table 4.2.). Feed intake significantly decreased ($P<0.05$) in chickens that were inhaled the sumac inhalation than those that were received it as in their drinking water. Body mass index was found to be highly significant. ($P<0.05$) by administration methods. Body weight and weight gain were significantly higher at broilers that received sumac in drinking water compared to those received sumac by inhalation. Neither the level of sumac nor the interaction of the experimental factors had any significant impact on the weight gain and body weight of broilers. Feed conversion ratio of 42 day old broilers were not affected by the experimental factors and their interaction ($P>0.05$).

Table 4.1. impact of the level and the administration method of sumac on the productive performance of broiler chicks at day 10

Administration method	Level g/liter	FI, g	BW, g	WG, g	FCR, kg/kg BW
In water	0	307.3	317.7	263.8	1.16
	5	311.7	305.4	251.4	1.19
	10	306.4	310.8	257.2	1.18
Inhalation	0	324.0	326.8	273.8	1.18
	5	319.2	325.1	272.0	1.17
	10	321.3	314.4	261.4	1.22
SEM		3.441	1.604	1.615	4.954
Level	0	315.7	322.3	268.8	1.17 ^b
	5	315.5	315.2	261.7	1.18 ^{ab}
	10	313.9	312.6	259.3	1.20 ^a
Administration method	Water	308.5	311.3 ^b	257.5 ^b	1.18
	Inhalation	321.5	322.1 ^a	269.1 ^a	1.19
Source of variation					
Administration method		0.074	0.003	0.002	0.326
Level		0.974	0.063	0.070	0.041
Adm. method × Level		0.847	0.145	0.140	0.097

a,b – mean in the same column not sharing the same subscript are different significantly, FI=feed intake, BW= body weight, FCR=feed conversion ratio, WG= weight gain. SEM= standard error of means

Table 4.2. Impact of the level and the administration method of sumac on the productive performance of broiler chicks at day 24

Administration method	Level g/liter	FI g	BW g	WG g	FCR kg/kg BW
In water	0	1622.5	1352.5	1300.0	1.25
	5	1622.5	1337.5	1282.5	1.26
	10	1630.0	1342.5	1287.5	1.26
Inhalation	0	1607.5	1370.0	1312.5	1.22
	5	1635.0	1392.5	1340.0	1.22
	10	1642.5	1342.5	1287.5	1.27
SEM		6.009	6.305	6.328	4.876
Level	0	1615.0	1361.3	1306.3	1.23 ^b
	5	1628.8	1365.0	1311.3	1.24 ^b
	10	1636.3	1342.5	1287.5	1.27 ^a
Administration method	Water	1625.0	1344.2	1290.0	1.25
	Inhalation	1628.3	1368.3	1313.3	1.24
Source of variation					
Administration method		0.785	0.071	0.082	0.065

Table 4.2. (continue)

Level	0.363	0.319	0.296	0.027
Administration method × Level	0.569	0.219	0.178	0.110

a,b – mean in the same column not sharing the same subscript are different significantly, FI=feed intake, BW= body weight, FCR=feed conversion ratio, WG= weight gain. SEM= standard error of means

Table 4.3. Impact of the level and the administration method of sumac on the productive performance of broiler chicks at day 42

Administration method	Level g/liter	FI g	BW g	WG g	FCR kg/kg BW
In water	0	4612.5	3147.5	3097.5	1.49
	5	4662.5	3170.0	3115.0	1.49
	10	4645.0	3115.0	3062.5	1.51
Inhalation	0	4662.5	3100.0	3042.5	1.53
	5	4365.0	3005.0	2952.5	1.47
	10	4360.0	2850.0	2800.0	1.55
SEM		32.196	35.592	35.204	0.011
Level	0	4637.5	3123.6	3070.0	1.51
	5	4513.75	3087.5	3033.8	1.48
	10	4502.5	2982.5	2931.3	1.53
Administration method	Water	4640.0 ^a	3144.2 ^a	3091.7 ^a	1.49
	Inhalation	4462.5 ^b	2985.0 ^b	2931.7 ^b	1.52
Source of variation					
Administration method		0.013	0.038	0.036	0.377
Level		0.193	0.268	0.274	0.219
Administration method × Level		0.068	0.473	0.498	0.512

a,b – mean in the same column not sharing the same subscript are different significantly, FI=feed intake, BW= body weight, FCR=feed conversion ratio, WG= weight gain. SEM= standard error of means

4.1.2. The relative weight of visceral organs

There were no important effects ($P>0.05$) of experimental factors and their interaction on relative weight of small intestine (Table 4.5.). The relative weight of small intestine was increased in birds that were inhaled with sumac compared to those that were received it in their drinking water, but this increase was not statistically significant (Table 4.5.). There was a significant effect ($P<0.05$) of the interaction among the experiment factors on gizzard weight. This interaction revealing that the higher gizzard weight in chickens that inhaled with highest level of sumac compared to other experimental groups. The relative weight of spleen was increased significantly ($P<0.05$) in chickens that were inhaled the sumac inhalation than those that had sumac by drinking water (Table 4.5.). A significant ($P<0.05$) interaction has been uncovered among the experiment factors indicating the higher relative weight of spleen in chickens that were inhaled with the highest level of sumac compared to other experiment groups. The interaction of the experimental factors tends ($P<0.07$) to decrease the relative weight of bursa in birds that were inhaled with the higher level of sumac. There were important effects ($P>0.05$) of experimental factors and their interaction on liver relative weight in birds. Although, the interaction of the experiment factors indicated the higher liver relative weight in birds that were inhaled with pure water preceded by those that were received the highest level of sumac in the drinking water, this difference was not statistically significant. The relative weight of liver was also increased in birds that were inhaled with sumac than those that were drinking it, but again this increase was not statically different.

4.1.3. Serum lipid profile

The serum lipid profile of chickens was not impacted by the treatments except for the triglycerides which were commonly higher ($P<0.05$) in chickens that were inhaled with sumac solution than those that were received it in the drinking water.

4.1.4. Serum chemistry

In general, serum biochemistry was not affected by the treatment. However, only the level of creatinine in the serum was almost doubled ($P < 0.05$) in birds that were inhaled with sumac solution than those that were received it in the drinking water (Table 4.6.). However, the interaction of the experimental factor tended to increase the albumin to globulin in the serum of chickens that were received the highest level of sumac in their drinking water, but this increase was not statistically significant ($P > 0.05$).

Table 4.4. Impact of the level and the administration method of sumac on the relative weight of internal organs of chickens

AD ¹	Level g/liter	S. int ² g	Gizz ³ , g	Spleen g	Bursa g	Liver g	Heart g
In water	0	4.50	2.61 ^{ab}	0.13	0.163	2.050	0.502
	5	4.09	2.50 ^{ab}	0.10	0.115	2.133	0.569
	10	3.99	2.32 ^b	0.11	0.173	2.831	0.560
Inhalation	0	4.42	2.28 ^b	0.11 ^b	0.174	2.99 ^b	0.557
	5	4.50	2.62 ^{ab}	0.13 ^{ab}	0.145	2.17 ^{ab}	0.529
	10	4.53	2.87 ^a	0.17 ^a	0.110	2.438 ^a	0.454
SEM		0.072	0.056	5.785	8.121	0.051	0.015
Level	0	4.46	2.44	0.20	0.168	2.024	0.530
	5	4.29	2.56	0.11	0.130	2.153	0.550
	10	4.27	2.59	0.14	0.142	2.135	0.507
AD ¹	Water	4.20	2.47	0.11 ^b	0.150	2.005	0.544
	Inhalation	4.49	2.59	0.14 ^a	0.143	2.202	0.513
AD ¹		0.063	0.311	0.044	0.680	0.071	0.326
Level		0.514	0.526	0.262	0.175	0.55	0.546
AD ¹ × Level		0.214	0.017	0.020	0.072	0.036	0.123

a,b – mean in the same column not sharing the same subscripts are different significantly,

¹AD=administration method, ²S.int=small intestine, ³Gizz=Gizzard, SEM= standard error of means

Table 4.5. Impact of the level and the administration method of sumac on the serum lipid profile of chickens

AD ¹	Level g/liter	Chol ² mg/dl	Trig ³ mg/dl	HDL ⁴ mg/dl	LDL ⁵ mg/dl
In water	0	106.25	44.50	73.00	24.25
	5	107.75	41.00	74.25	25.25
	10	109.25	34.00	77.25	25.25
Inhalation	0	119.75	57.75	77.25	30.75
	5	112.75	59.25	78.00	23.25
	10	109.75	59.25	69.00	29.00
SEM		2.235	4.121	1.647	0.801
Level	0	113.00	51.13	75.13	27.50
	5	110.25	50.13	76.13	24.25
	10	109.50	46.63	73.13	27.13
AD ¹	Water	107.75	39.83 ^b	74.83	24.92
	Inhalation	114.08	58.75 ^a	74.75	27.67
AD ¹		0.174	0.034	0.980	0.104
Level		0.800	0.897	0.754	0.222
AD ¹ × Level		0.497	0.838	0.192	0.116

a,b – mean in the same column not sharing the same subscripts are different significantly,

¹AD=administration method, ²Chol=cholesterol, ³Trig=triglycerides, ⁴HDL=high density lipoproteins,

⁵LDL=low density lipoproteins, SEM= standard error of means

Table 4.6. Impact of the level and the administration method of sumac on serum chemistry of broiler chickens

AD ¹	Level g/liter	Creatinine mg\dl	² T. protein g\dl	Albumin g\dl	Globulin g\dl	A/G ³
In water	0	0.048	3.093	1.125	1.950	0.579
	5	0.083	2.990	0.975	2.025	0.484
	10	0.035	2.918	1.100	1.800	0.609
Inhalation	0	0.080	3.248	1.175	2.075	0.563
	5	0.138	2.978	1.050	1.925	0.548
	10	0.093	3.130	1.025	2.125	0.484
SEM Level		0.011	0.069	0.034	0.045	0.014
	0	0.064	3.170	1.15	2.013	0.571
	5	0.110	2.984	1.012	1.975	0.516
	10	0.064	3.024	1.062	1.963	0.565
AD ¹	Water	0.055 ^b	3.000	1.066	1.925	0.558
	Inhalation	0.103 ^a	3.118	1.083	2.042	0.532
Source of variation						
AD ¹		0.044	0.406	0.809	0.217	0.382
Level		0.176	0.528	0.273	0.898	0.327
AD ¹ × Level		0.881	0.793	0.635	0.192	0.051

a,b – mean in the same column not sharing the same subscripts are different significantly.

¹AD=administration method; ²T.protein=total protein; ³A/G=albumin/globulin ratio; SEM=standard error of means

4.1.5. The level of liver enzymes and digestive enzymes in the serum

In general, no significant effect of experimental factors and their interaction ($P>0.05$) was observed on studied enzymes in the serum of chickens, although there are a few differences in means in some cases (Table 4.7.). The interaction effect of the experimental factors on AST indicating that chickens receiving the medium level (0.5g) of sumac in the drinking water had the greatest level of AST comparison to the other experiment groups, but this effect was not statistically significant (Table 4.7.). The level of ALT was slightly increased in chickens that were received the highest level of sumac regardless to the administration method, but again this increase was not statistically significant. However, the lower level of ALT was noticed in birds that received the medium level (5 g) of sumac. The interaction effect of the experimental factors on creatine kinase was shown the higher creatine kinase level in the serum of birds by rising levels of sumac in the drinking water, although the effect was not significant ($P>0.05$). Moreover, the level of lipase was increased in the serum of birds that were offer drinking water containing sumac than those that were inhaled with it.

Table 4.7. Impact of the level and the administration method of sumac on the level of some enzymes in the serum of chickens

AD ¹	Level g/liter	² AST U/L	³ ALT U/L	⁴ ALP U/L	Amaylase U/L	⁵ CK U/L	Lipase U/L
In water	0	403.25 ^b	10.25 ^a	1606.75	259.0	34216.8 ^b	11.00 ^{ab}
	5	841.50 ^a	7.75 ^{ab}	1246.25	569.0	69579.8 ^a	12.25 ^a
	10	633.75 ^{ab}	9.25 ^{ab}	1862.00	675.0	67985.5 ^a	12.00 ^a
inhalati on	0	508.25 ^{ab}	7.75 ^{ab}	1696.50	356.5	48947.0	12.25 ^a
	5	396.25 ^b	6.50 ^b	1673.25	454.0	29384.3	8.25 ^{ab}
	10	597.50 ^{ab}	10.00 ^a	1311.50	346.0	50331.8	7.00 ^b
SEM Level	0	48.866	0.413	165.30	85.211	44.744	0.677
	5	455.750	9.000 ^{ab}	1651.63	307.75	41581.9	11.625
	10	618.875	7.125 ^b	1459.75	511.50	49482.0	10.250
AD ¹	Water	615.625	9.625 ^a	1586.75	510.50	59158.6	9.500
	Inhalati on	626.167	9.0833	1571.67	501.0	57260.7	11.7500
Source of variation							
AD1		0.215	0.243	0.973	0.507	0.126	0.073
Level		0.320	0.060	0.891	0.543	0.299	0.446
AD1× Level		0.084	0.295	0.486	0.602	0.066	0.158

a,b – mean in the same column not sharing the same subscripts are different significantly.

¹AD=administration method; ²AST =aspartate aminotransferase; ³ ALT =alanine aminotransferase;

⁴ALP=alkaline phosphatase; ⁵CK=creatine kinase; SEM=standard error of means

4.1.6. Antibody production against newcastle disease (NDV) and infectious bronchitis (IBV)

It was found that there was a significant effect ($P<0.05$) of administration methods on antibody production against IB, while the effect of sumac levels and the interaction between experimental factors was found to be non-significant ($P>0.05$) (Table 12). As a single factor, the effect of the administration method of sumac was significant on the antibody production against IB revealing the higher ($P<0.05$) antibody production against IB in birds that were inhaled the sumac inhalation than those on the drinking water containing sumac. Since IB virus is from the coronavirus family, it causes damage to the lungs. Although the addition of sumac to the drinking water improved the antibody profile against IB comparing to the control group, this improve was not statistically significant. Probably the inhalation method could be expected to be more effective against this virus and at least one support mechanism might have worked here. There were no significant impacts of the experiment factors and their interaction on the antibody production against ND in broiler chickens.

However, it can be observed that the antibody production against ND increased by rising levels of sumac in the drinking water. Whereas, in contrast it decreased by rising levels of sumac as an inhalation comparing to the control group that was inhaled with water, but again these differences were not statistically significant.

4.1.7. Jejunum morphology

The effect of sumac on the jejunum histology is presented in (Table 13). There was no significant impact of the experiment factors and their interaction on the jejunum morphology of broiler chickens. However, although not significant, longer villi were detected in birds that were inhaled with the medium level (5 gm/L) preceded by those received the higher level of sumac in their drinking water. Villi height in-significantly increased by rising levels of sumac regardless to the administration method.

4.1.8. Carcass yield and the relative weight of carcass parts

Carcass yield was significantly decreased ($P<0.05$) by rising levels of sumac regardless to the administration method (Table 14). The relative weight of breast decreased insignificantly ($P>0.05$) in birds that were inhaled with sumac compared to those that were received the sumac in their drinking water. However, the relative weight of drumsticks increased significantly ($P<0.05$) in birds that were on the drinking water containing sumac compared to these that were inhaled with sumac.

Table 4.8. Impact of the level and the administration method of sumac on antibody production against IB and ND of broiler chickens

Administration method	Level g/liter	Infectious Bronchitis	Newcastle Disease LD ₅₀
In water	0	877.75	4550.50
	5	2014.50	6298.00
	10	1091.00	6223.75
Inhalation	0	3373.50	8305.75
	5	2034.25	5607.50
	10	2687.50	3914.50
SEM		21.575	58.134
Level	0	2125.63	6428.13
	5	2024.38	5952.75
	10	1889.25	5069.13
Administration method	Water	1327.75 ^b	5690.75
	Inhalation	2698.42 ^a	5942.58
Administration method		0.005	0.831
Level		0.905	0.633
Administration method × Level		0.087	0.116

a,b – mean in the same column not sharing the same subscripts are different significantly.
SEM=standard error of means

Table 4.9. Impact of the level and the administration method of sumac on jejunum histomorphology of broiler chickens

Administration method	Level g/liter	Villous height mm	Crypt depth Mm	¹ V/C
In water	0	1409.01	167.83	9.44
	5	1368.47	181.06	9.01
	10	1490.47	181.27	8.44
Inhalation	0	1332.28	200.81	6.72
	5	1513.48	168.93	9.13
	10	1400.24	182.59	7.67
SEM		31.829	9.326	0.586
Level	0	1370.64	184.32	8.079
	5	1440.97	174.99	9.071
	10	1445.36	181.93	8.051
Administration method	Water	1422.65	179.72	8.964
	Inhalation	1415.33	184.11	7.837
Source of variation				
Administration method		0.910	0.697	0.350
Level		0.571	0.915	0.725
Administration method × Level		0.260	0.607	0.606

¹V/C=villous height/crypt depth, SEM=standard error of means

Table 4.10. Impact of the level and the administration method of sumac on carcass yield and the relative weight of carcass parts of broiler chickens

Administration method	Level g/liter	Carcass,%	Breast,%	Thighs,%	¹ Drum,%
In water	0	74.7	30.5	11.1	8.5
	5	73.4	30.9	10.9	8.3
	10	73.9	31.1	11.4	8.3
Inhalation	0	76.6	30.8	11.5	9.1
	5	73.6	29.3	11.6	8.9
	10	73.4	28.8	11.2	8.8
SEM		0.357	0.311	0.114	0.073
Level	0	75.7 ^a	30.7	11.3	8.8
	5	73.5 ^b	30.1	11.2	8.6
	10	73.6 ^b	30.0	11.3	8.5
Administration method	Water	74.0	30.9	11.1	8.3 ^b
	Inhalation	74.5	29.6	11.4	8.9 ^a
Source of variation					
Administration method		0.494	0.072	0.206	0.001
Level		0.041	0.612	0.935	0.397
Administration method × Level		0.363	0.258	0.292	0.940

a,b – means in the same column not sharing the same subscripts are significantly different. ¹Drum= drumsticks; SEM=standard error of means

4.2. Discussion

4.2.1. Growth performance

In general, there was no significant impact of sumac on the productive performance in broiler chickens. Although not significant, but birds that were received sumac reduced feed intake, weight gain, body weight and poorer FCR than control groups regardless to the administration method. The current study's findings were consistent with those of Mohammadi et al., (2011) who discovered that nutritional sumac powder had no impact on broiler performance. When sumac powder was added to broiler meals raised at varied stocking densities, similar results were achieved (Cakmak et al.,2017). Furthermore, according to Sabir and Aydin, (2017) the body weight of the chickens eating sumac supplemented meals was identical to that of the controls birds. According to Alishah et al., (2012) no significant variations in body weight gain or FCR in chickens eating varying amounts of sumac.

However, Toghyani and Faghan, (2017) found adding powder of sumac to the diets of broiler chicks improved their FCR significantly. Mansoub, (2011) found that Varying sumac levels had a profound effect on broiler feed intake, feed conversion ratio, live weight and weight gain. According to Ghasemi et al., (2014) varied levels of sumac extract (1, 2 and 3 percent of diet) showed substantial effects on feed intake. Lee et al., (2003) indicated that an increase in feed efficiency in broilers eating a diet supplemented with sumac extracts. The active components in sumac (cinnamaldehyde and eugenol) cause increased feed consumption efficiency, leading to higher growth, according to Ghasemi et al., (2014). However, in the current research this impact was not found. Different findings in the literature might be explained by experimental conditions, the level and the offering way of sumac to the birds. However, to authors' point of view, in general the effects of medical plants including sumac are more pronounced in birds that are exposed to health or management challenge or stress. However, in the current study birds were reared under normal and standard rearing condition. Thus, sumac was not effective in introducing a change in the broiler performance compared to the control.

The current research demonstrated that chickens that were received sumac in their drinking water were heavier, gained more weight and had better FCR than those that were inhaled with sumac vapour. This could be attributed to the elevated level of humidity in inhaled birds that may negatively impact on the growth performance of birds.

4.2.2. The relative weight of visceral organs

In the current research the relative weight of some internal organs including gizzard, spleen, liver and bursa were affected by the interaction. This effect was dose depended in which the highest level of sumac was dominant. The relative weight of gizzard and spleen increased whereas that of bursa and liver decreased with the highest level of sumac as an inhalation. Herbs have the potential to stimulate the digestive system in poultry, increasing the action of digestive enzymes and improving the operation of internal organs, especially the liver (Langhout, 2000).

This would improve the metabolism of important nutrients, such as carbohydrates and proteins, in the major organs, perhaps improving their function and increasing their development rate.

This corresponded to the results of Kheiri et al., (2015) who found nutritional sumac increased the relative weight of the spleen and gizzard while decreasing the weight of the bursa in female broiler chickens. Sumac consumption raised gizzard weight and lowered liver weight in broilers, according to (Mansoub, 2011). In contrast (Cakmak et al., 2017) found that nutritional supplementation of sumac powder had no impact on the internal organ weights of chickens. Similar findings have been reported by (Mohammadi et al., 2011) who found that dietary sumac had no impact on the relative weight of internal organs in chickens.

4.2.3. Serum lipid profile, chemistry and enzymes

Although not significant, however the serum lipid profile including (cholesterol, triglycerides and HDL) slightly decreased by rising levels of sumac. In the current study, the hypo-lipidemic effect of sumac was more pronounced when it was offered to the birds in the drinking water. Sumac is a well-known fat-lowering plant that has long been used to control blood lipid levels (Mohammadi S., 2010; Akbari-Fakhrabadi et al., 2018). Sumac's hypolipidemic impact has been thoroughly researched and proven in the literature (Hajmohammadi et al., 2018) . Sumac has the ability to lower LDL levels and total cholesterol in both adolescents and adults (Asgary et al., 2018; Sabzghabae et al., 2014). This could be related to the presence of polyphenols with high resin capabilities, which could reduce fat absorption in the gastrointestinal system (Beretta et al., 2009). Sumac also includes phenol acids and flavonoids such as gallic acid, methyl gallate, quercetin and kaempferol among other things (Shabana et al., 2011). Polyphenols have been demonstrated to diminish intestinal cholesterol absorbed and even boost bile acid secretion by inhibiting reverse cholesterol transport (Choi et al., 2007). Sumac had no impact on the levels

of the remaining serum biochemical measures (globulin, albumin, total protein and albumin/globulin ratio).

4.2.4. The level of AST, ALT and some digestive enzymes in the serum

In the present study the level of serum AST, ALT, amylase and alkaline phosphatase was almost same in all experimental groups and the treatment had no significant effects on their levels. This corresponded to the results of Cakmak et al., (2017) on the serum content of AST and ALT in broiler given diets with varying levels of sumac. However, Shata, (2017) discovered that increasing the amount of sumac in Japanese quail diets reduced the levels of AST and ALT.

4.2.5. Antibody production against IBV and NDV

In the current study although statistically not significant but the effect of sumac on the production of antibodies against IBV and NDV depended on the administration method of sumac rather than the level of it. This was obvious when the antibody production against IBV and NDV increased by inhalation of sumac inhalation. Rising levels of sumac in the drinking water. However, the antibody production against the mentioned diseases decreased in birds that were inhaled the sumac inhalation. This could be related to the nature and the site of infection of these viruses. It's well-known that both IBV and NDV invade the respiratory system more than any other parts of the body. Thus, in the present study the antimicrobial properties of sumac were more pronounced when it was inhaled over the birds. Therefore, decreasing the production of antibodies could be attributed to the direct interaction of sumac inhalation with the defense mechanism of the respiratory system. This would decrease the possibility of respiratory infections without over stimulation of the immune system. However, in regards to the administration methods in general aspect inhalation of inhalation regardless to the treatments increased the humidity providing the favorable environment of such viruses to grow. This corresponded to the results of Ahmadian et al., (2020) who found that increasing the amount of sumac in broiler diets greatly boosted antibody production

against NDV. However, Toghyani and Faghan, (2017) found that dietary sumac powder had no influence on NDV antibody production in broiler chicks.

4.2.6. Jejunum histomorphology

In the current research, there was no significant impact of sumac on the jejunum morphology of broiler chickens. Although not significant the effect of sumac to improve the morphology of jejunum was clear. This was evidenced by longer villi as the level of sumac increased. The function and physical structure of the intestinal villi in broilers may be affected by herbal plants (Rafiee et al., 2014). Longer villi may reflect increased absorption and nutritional utilization, resulting in improved digestive performance (Samanya and Yamauchi, 2002). In addition, the presence of biological active substances and some growth boosters in herbs may influence brush border enzymes and nutrient use. This is accomplished by decreasing intestinal mucosal inflammation, increasing villus height and improving digestive enzyme release and absorption in the gastrointestinal system. The use of sumac extract has been shown to impact intestinal properties such as crypt depth, villus height, villus width, goblet cells and epithelial layer (Ghasemi et al., 2014). This was in contrast to Kheiri et al., (2015) who discovered deeper intestinal crypts in female broiler chickens as a result of dietary sumac.

4.2.7. Carcass yield

In the present study, the carcass yields significantly decreased by 1% when the sumac level increased regardless to the administration method. However, carcass parts including breast meat, thighs and drumsticks were not affected. This corresponded to the results of Ahmadian et al., (2020) who discovered that increasing sumac levels in broiler diets reduced the dressing percentage. Although abdominal fat was not examined in this investigation, the drop in dressing % could be related to the reduction in abdominal fat that was validated by Ahmadian et al., (2020) when sumac was added to broiler diets

5. CONCLUSIONS and RECOMMENDATIONS

5.1. Conclusions

The findings reported in this research show supplementation of sumac in the drinking water or as an inhalation did not significantly affect the growth performance of chickens. There was a general reduction in the body weight, feed intake and weight gain as a result of sumac supplementation. As it was hypothesized sumac was effective in reducing the lipid profile particularly cholesterol in the serum of broiler chickens. The dressing percentage was slightly decreased by sumac supplementation without any effect on the carcass parts. That would indirectly attribute to the hipolipidimic effect of sumac. In addition, the antibody production against ND and IB of broiler chickens was improved to some extent. Jejunum morphology was clearly improved thereby increasing the villi height however, it was statistically not significant.

5.2. Recommendations

Further investigations are needed to detect the perfect level of sumac and the proper delivery way as a means of increasing production and physiology of broiler chickens. The effect of sumac would be more pronounced if birds were subjected to a disease challenge. In addition, comparison of sumac in water, via inhalation and as powder in diet is in need as well as comparing with other medicinal herbs.

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