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Determination of mineral content and antimicrobial activities of sumac (*Rhus coriaria* L.) grown under Kilis ecological conditions (Turkey)

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Abstract

In this study, it was aimed to determine the antimicrobial activity of sumac (*Rhus coriaria* L.) fruits naturally grown in Kilis region and frequently used in the food of the people and to make antibiograms of the used pathogens.

The antimicrobial activity of ethanol, methanol, water and petroleum ether extracts of Sumac (*Rhus coriaria* L.) fruits was investigated. The antimicrobial effect of the obtained extracts was tested on *Escherichia coli, Staphylococcus aureus, Pseudomonas* spp., Bacterial strains and *Penicillium thomi* and *Aspergillus parasiticus* fungi according to disk diffusion method. Antibacterial effects of extracts of *Rhus coriaria* L. fruits with different solvents on different test microorganisms were measured by disc diffusion method.

In the study, it was determined that the bacteria used were susceptible / resistant to various antibiotic discs, and that the ethanol extract from the microorganisms used had a maximum effect of 33 mm on the *S. aureus* strain. Methanol extracts (10-30 mm) of the fungi used were found to be more effective. It has been observed that petroleum ether extracts do not act against the microorganisms used.

In general, it has been determined that there is antimicrobial property and protective effect against microorganisms as a natural product. Sumac is a natural food substance abundantly consumed in the region according to other regions. Consideration of commercial dimensions around the world is considered to be an important source of income in the development of our country.

Keywords: *Rhus coriaria;* Antimicrobial activity; Micro and macro elements; Kilis; Turkey

1 Introduction

Medicinal and aromatic plants have been interesting for human use from prehistoric times to the present. In addition to the economic value chain for developing countries; The importance and demand for medicinal and aromatic plants also increased in the context of herbal-based medicines, health products, pharmaceuticals, food additives and cosmetics (Iqbal, 2013; Pushpangadan, 2013; Yaldiz and Kulak, 2014; Scotti et al., 2014; Udupa, 2016). It is known that the biological activities and competencies of plants existing in nature are related to secondary metabolites. In addition, it is known that in addition to significant changes in the metabolites of the plant depending on the developmental periods and collection times of the plant, the interaction of abiotic factors such as environmental, chemical and physical conditions with the biotic factors such as viruses, bacteria and fungi is also significantly affected. Therefore, analyzes on the biological activity and component contents of different ecotypes and chemotypes of the same plant species are performed (Scotti et al., 2014; Mohmod and Mohtar, 2014; Khan et al., 2016; Akgunlu et al., 2016).

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In recent years, the prevalence of widespread antibiotic resistant pathogen microorganisms requires new alternative antimicrobial agents. Natural herbal products offer new antimicrobial agents and many new drug components have been isolated from plants (Nascimento et al., 2000; Obeidat et al., 2012). Plants collected and consumed by humans have fewer side effects than synthetic or semi-synthetic pharmaceutical agents. Numerous preliminary studies have been conducted to identify potent antimicrobial agents (Molla et al., 2010; Kang et al., 2011; Obeidat et al., 2012). Scientific studies have been increasing recently to determine the mineral composition of some food and medicinal plants (Koca et al., 2009; Şekeroğlu and Koca, 2010; Özkan et al. 2010; Şekeroğlu, 2011; Tunçtürk et al., 2011; Şekeroğlu et al., 2012; Yaldiz et al., 2014).

2 Material and method

2.1 Material

In this study, *Rhus coriaria* L. (Anacardiaceae) plant fruit collected from Kilis province was used. The study material consisted of fruit samples grown naturally in Kilis 7 Aralık University central campus in autumn 2010. The collected samples were brought to the laboratory and the species were extracted from the fruit and leaf samples. Species identification was made with the help of the obtained data and available literature (Davis, 1967; Tanker et al., 2007; Yıldız and Aktoklu, 2010).

2.2 Plant fruit extraction with soxhlet

The plant fruit samples obtained from the field study were brought to the laboratory before they were identified and allowed to dry under appropriate conditions (room temperature). The dried *Rhus coriaria* L. fruit samples were pulverized with a mechanical blender according to aseptic conditions and 5 g cartridges were prepared for extraction in Soxhlet apparatus. The prepared cartridges were extracted with 200 ml of solvent for 12 hours. Ethanol, methanol water and petroleum ether were used as solvent in the extraction. The extracts were evaporated to 2 ml in a rotary evaporator. The extracts thus prepared were stored at +4 °C until use.

2.3 Preparation of antibiotic discs of extracts

It is absorbed from the essential oils or sample extracts extracted by suitable methods by micro pipette into empty sterile 6 mm diameter discs (Schleicher & Shüll No: 2668, Germany). It is impregnated with 0.1–100 µl of essential oils and 20, 25, 30 µl or 50 µl of extracts. Sometimes this amount can reach up to 150-200 µl. For comparison, standard antibiotic discs are used as controls (Tendencia, 2004; Mahon ve Lehman, 2022).

2.4 Types of microorganisms used

Test Microorganisms: Bacterial samples were obtained from Kilis 7 Aralık State Hospital Microbiology Laboratory and microfungus strains were obtained from Kilis 7 Aralık University, Faculty of Science and Letters, Biology Laboratory. *Escherichia coli, Pseudomonas* spp., *Staphylococcus aureus* bacteria and *Aspergillus parasiticus, Penicillum thomi* fungus strains were used in the study.

2.5 Disc diffusion method

Disc diffusion method was used to determine antimicrobial activity (Cavaleri et al. 2005; CLSI, 2012; Balouiri et al. 2016; Mahon ve Lehman, 2022). The prepared extracts were impregnated with micropipettes to 10 µl of empty sterile 6 mm diameter Whatman papers. Mueller Hinton Agar (Merck) and Sabouraud Dextrose Agar (Merck) were used as the medium.

2.6 Analysis of Sumac samples by ICP-OES

0.3 g of the ground samples were taken and wet burning process was performed in the microwave system. Then, micro and macro elements were analyzed by ICP-OES. For example, ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrophotometers), a technique applied to both solid and liquid samples, was used to determine element content. The ICP-OES technique has recently come to the fore as a high accuracy and precision technique used to determine the trace element content of natural samples (Domínguez-González et al., 2010; Kabata-Pendias, 2010). The elements of interest in each sample as micro elements; Fe, Zn, Cu and K, P, Ca, Mg and Na values were examined as macro elements. ICP-OES analysis was performed with Perkin Elmer Optima 2100 DV model in three readings to determine the absolute concentrations. ICP-OES device quality controls were calibrated using standard reference materials. Results are expressed as means for analysis.

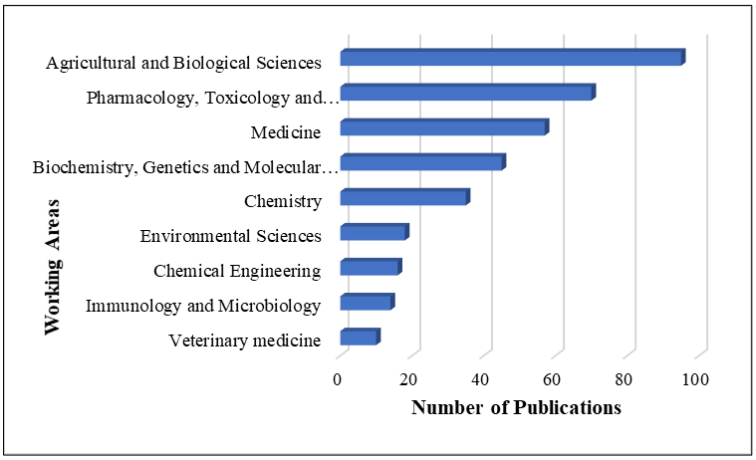
3 Results and discussion

Fruit part of *Rhus coriaria* L. plant samples were included in the study. Fruit samples were extracted with ethanol, methanol, petroleum ether and water to determine inhibition concentrations against different microorganisms. Also, antibiotic resistance of microorganism strains were investigated. The micro and macro element contents of the obtained fruit samples were analyzed.

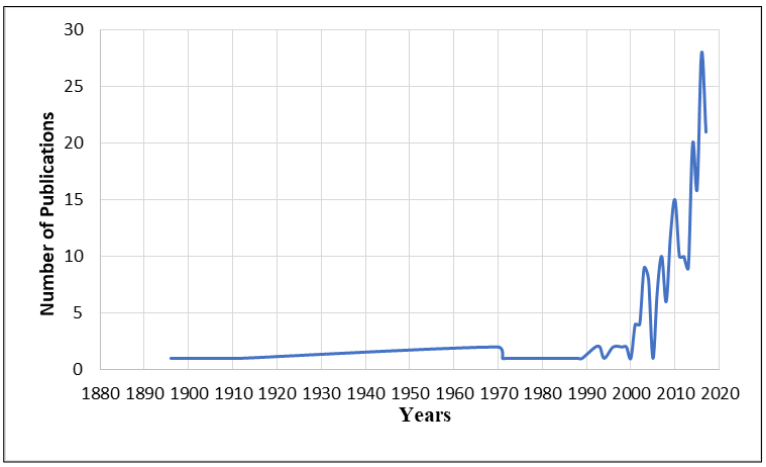
3.1 Systematic Evaluation of Scientific Studies on Sumac (*Rhus coriaria* L.)

The bibliometric and systematic evaluation of the sumac plant was made by using Vosviewer 1.6.8 program. For this purpose, the studies on sumac plant were taken from SCOPUS database. SCOPUS database has been chosen because it is one of the most reliable and largest scientific databases (Kulak, 2018).

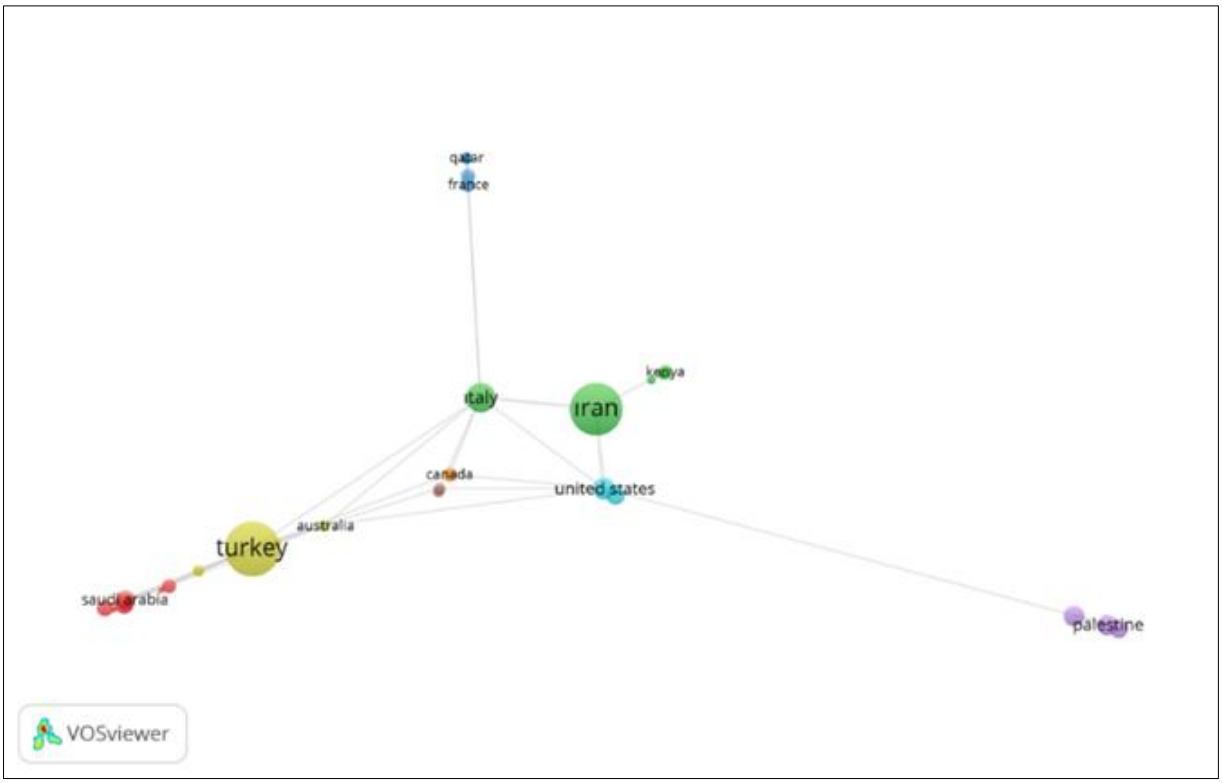
The detailed information on the time, place and thematic changes of the studies carried out on the Sumac plant are as follows. According to years sumac plant; agricultural and biological sciences, engineering sciences, pharmacology and toxicology sciences, chemical and chemical engineering. It is seen that the most studies are done in agricultural and biological sciences. This in order; Pharmacology, toxicology and pharmaceutical, medical, biochemistry, genetic and molecular biology, chemical and chemical engineering and environmental sciences. The first publication about Sumac plant was published in 1896. This work; It is about the color substances of Sicilian sumac (*Rhus coriaria* L.) and was published by Perkin and Allen (1896). The majority of publications is addressing Turkey and Iran. The most commonly used terms in the studies on Sumac plant were found to be: antimicrobial activity, ethnobotany, public health, antioxidant, liver protective role, diabetes, tannin, flavonoid and plant extract. These results show that the studies on sumac plant are at the beginning level. It is seen that there are no molecular, biochemical and genetic studies related to sumac species which are distributed in nature and located in different geographies (Fig. 1).



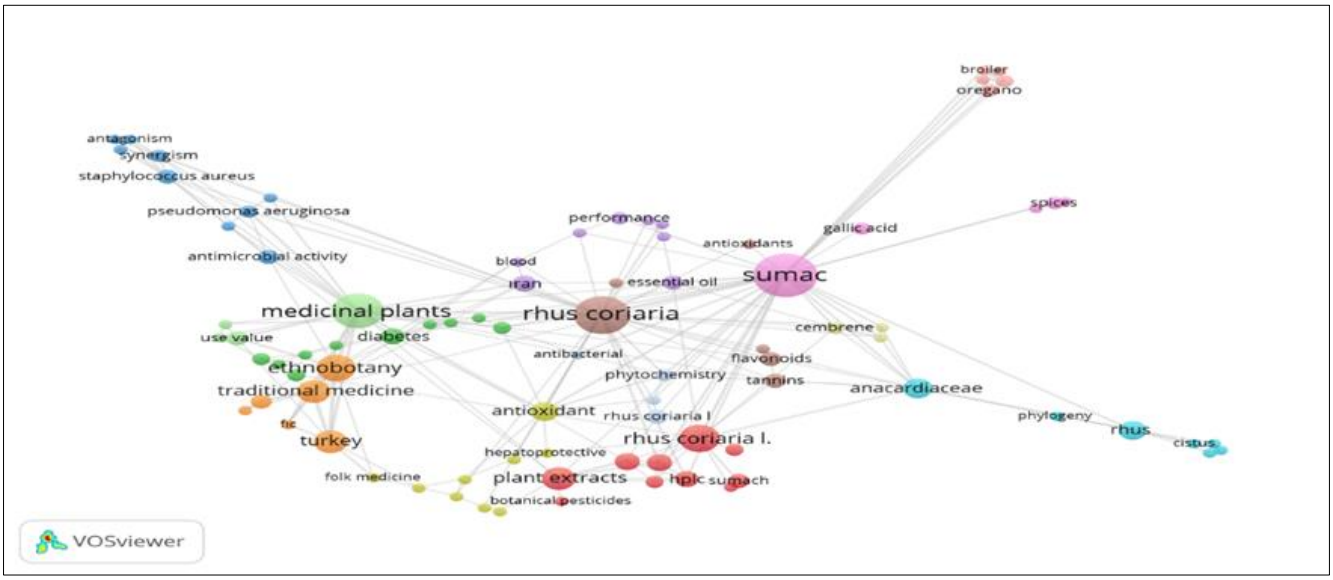
a. Evaluation of the number of publications in different fields of study



b. Variation of the number of publications on Sumac plant by years



c. Countries that publish on Sumac and their interactions



d. The most commonly used terms in the Sumac work

Figure 1 Systematic evaluation of scientific studies on Sumac (*Rhus coriaria* L.)

3.2 Results of Antimicrobial Activity of *Rhus coriaria* L. Extracts

In this study, ethanol, water, petroleum ether and methanol extracts of *Rhus coriaria* L. fruits were isolated from bacteria and fungi (*Escherichia coli, Pseudomonas* spp., *Staphylococcus aureus* bacteria and *Aspergillus parasiticus, Penicillium thomi* fungus strains). it is given (Fig 2). When the antimicrobial activities of the extracts of fruit samples in different organic solvents against test microorganisms were examined, it was observed that the most effective extract was ethanol extract of *Rhus coriaria* L. It is reported that ethanol extract gives positive results in disc diffusion method applications (Benedict and Brady, 1972).

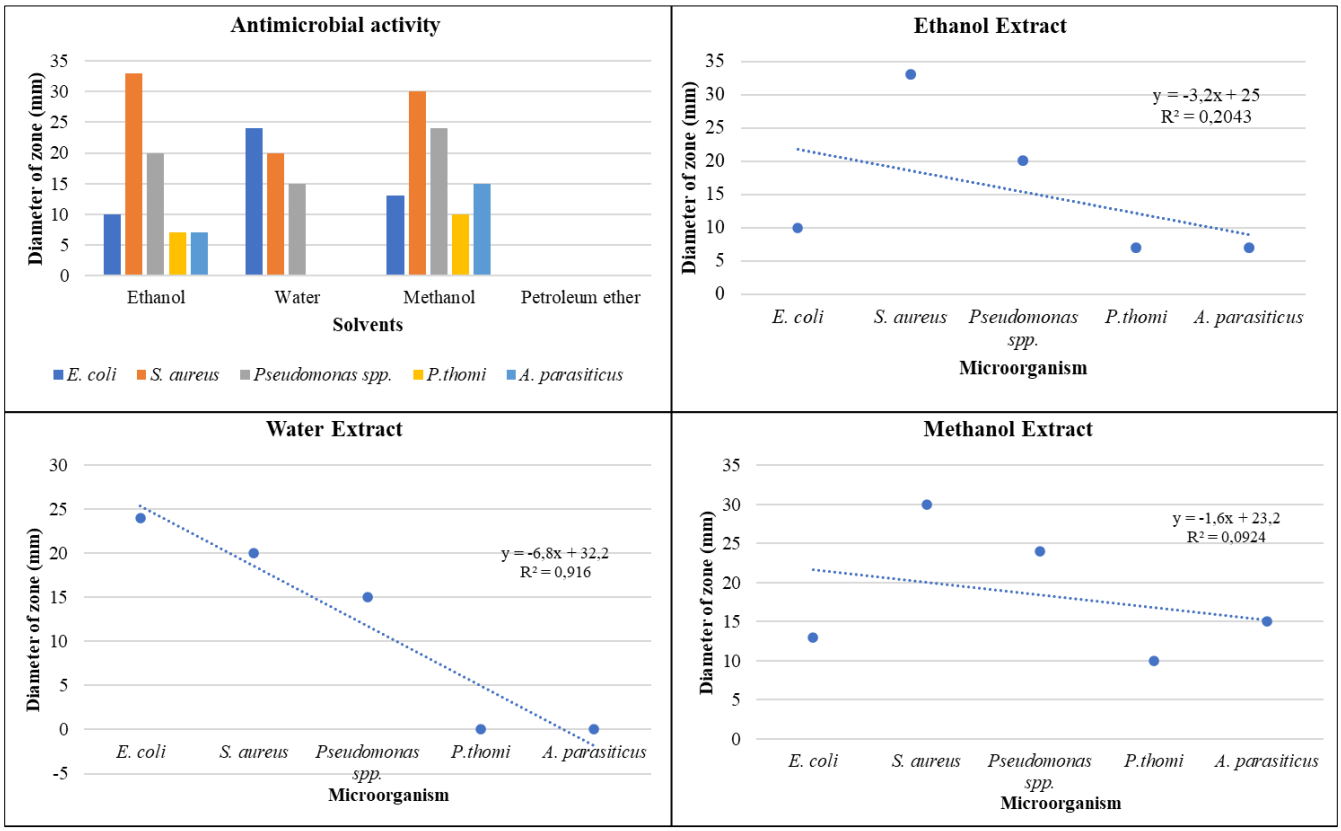


Figure 2 Antimicrobial activity results

For *Escherichia coli, Pseudomonas* spp., *Staphylococcus aureus* strains, the diameters of inhibition zones were measured for 24 hours. In addition, different antibiotic discs were tested on bacteria (Table 1). According to antibiotic disc findings for *Escherichia coli* strain, ampicillin (10 mcg) was found to be resistant to antibiotics. In our study, it was determined that, as an alternative, a natural product against this strain and the aqueous form of sumac extracts could be used.

Pseudomonas spp. antibiotic disc findings were found to be resistant to Ceftazidime, Cefepime and Meropenem antibiotics. It is contemplated that the extracts of Sumac samples obtained with different solvents will be usable for this strain. It is also possible to be used in alternative medicine because it is a natural product and gradually decreases the sensitivity to antibiotics. When antibiotic disc findings for *Staphylococcus aureus* strain were examined, only two of the antibiotic discs used in the study were found to be resistant to Clindamycin and Erythromycin.

Table 1 Antibiogram concentration results

Antibiotic discs/ *E. coli*	**Const.**	**Effect**	**Value (mm)**
Amoxicilin/Clavulanic acid	25 mcg	Sensitive	≥ 20
Cefuroxime	30 mcg	Sensitive	≥ 18
Ceftriaxone	30 mcg	Sensitive	≥ 21
Cefepime	30 mcg	Sensitive	≥ 16
Ceftazidime	30 mcg	Sensitive	≥ 18
Cefixime	5 mcg	Sensitive	≥ 19
Gentamicin	10 mcg	Sensitive	≥ 15
Trimethoprim/ sulphamethoxazole	1.25 mcg	Sensitive	≥ 16

Ofloxacin	10 mcg	Sensitive	≥ 22
Cephazolin	30 mcg	Sensitive	≥ 18
Meropenem	10 mcg	Sensitive	≤ 19
Cefoxitin	30 mcg	Sensitive	≥ 18
Aztreonam	30 mcg	Sensitive	≥ 22
Imipenem	15 mcg	Sensitive	≥ 16
Ampicillin	10 mcg	Resistant	< 11
Antibiotic discs/*Pseudomonas* spp.	**Const.**	**Effect**	**Value (mm)**
Cefepime	30 mcg	Resistant	≥ 16
Ceftazidime	30 mcg	Resistant	≤ 14
Tobramicin	10 mcg	Sensitive	≥ 15
Gentamicin	10 mcg	Sensitive	≥ 15
Ticarcillin	75 mcg	Sensitive	≥ 15
Piperacilin Tazobaktam	100 mcg	Sensitive	≥ 18
Imipenem	15 mcg	Sensitive	≥ 16
Aztreonam	30 mcg	Resistant	≤ 15
Meropenem	10 mcg	Sensitive	≤ 19
Antibiotic discs/ *S. aureus*	**Const.**	**Effect**	**Value (mm)**
Vankomicin	30 mcg	Sensitive	≥ 12
Gentamicin	10 mcg	Sensitive	≥ 15
Trimethoprim/ Sulphamethoxazole	1.25 mcg	Sensitive	≥ 16
Clindamicin	5 mcg	Resistant	≤ 14
Eritromicin	15 mcg	Resistant	≤ 13
Penicillin G	10 mcg	Sensitive	≥ 29
Teicoplanin	30 mcg	Duyarlı	≥ 14

3.3 Analysis of Sumac Samples with ICP-OES

In this study, Ca, K, Mg, Na, P, Fe, Zn and Cu contents of sumac pericarp and nuclei were investigated. (Table 2). Calcium (Ca) has an important function in plant growth metabolism and especially in the permeability of the cell membrane and stabilization of tissues (Özen and Onay, 2007). In this study, the content of Ca in sumac nuclei was determined as 3495 mg / kg. In the sumac plant Ca contents were determined in different studies as follows; 3661 ppm (Ozcan and Haciseferogullari, 2004); 3155 mg / kg (Kossah et al., 2009a); 3098 mg / kg (Kossah et al., 2009b). It was determined that the results obtained within the scope of the study were consistent with the literature.

Potassium (K) regulates osmotic pressure in plants and controls the mechanism of opening and closing of stomata. Although it activates some enzymes, it also takes part in the synthesis of starch (Özen and Onay, 2007). The K value obtained in this study was determined as 11420 mg / kg. Again in the sumac plant potassium content 7963 ppm (Ozcan and Haciseferogullari, 2004), 7441 mg / kg (Kossah et al., 2009a) and 5576 mg / kg (Kossah et al., 2009b). The findings obtained in our study were found to be quite high compared to the values given in the literature.

Magnesium (Mg) in the basic structure of chlorophyll, which is thought to give green color to plants, is a necessary mineral for the activation of many enzymes. It is also involved in protein synthesis (Ozen and Onay, 2007). In our study, magnesium values were determined as 935 mg / kg. 835 ppm (Özcan and Haciseferogullari, 2004), 605 mg / kg (Kossah et al., 2009a) and 871 mg / kg (Kossah et al., 2009b) values are the values given in the literature and are close to our findings.

The excess of sodium (Na), which is not absolutely necessary in the growth mechanism of plants, has a negative effect on plant growth, causing the products to be of qualitative and quantitative lower values, but a certain level of sodium content is required for the normal vital functioning of the plant. The value obtained in this study was 120.8 mg / kg. Sodium contents of sumac fruits collected and analyzed from different locations are as follows: 114 ppm (Özcan and Haciseferogullari, 2004), 101 mg / kg (Kossah et al., 2009a) and 183 mg / kg (Kossah et al., 2009b). The values obtained in our study are similar to those determined in the literature.

The phosphorus (P) content we determined in the sumac fruit was 2043 mg / kg, but it was found to be very high compared to the values obtained in other studies (1243 ppm-Özcan and Haciseferogullari, 2004; 327 mg / kg- Kossah et al., 2009a; and 1032 mg / kg- Kossah et al., 2009b).

As in other nutrients and functional elements, iron (Fe) content was determined as 75, 51 mg / kg and it was found to be much lower than the values obtained in current studies (144 ppm-Özcan and Haciseferogullari, 2004; 174 mg / kg-Kossah. et al., 2009a; and 180 mg / kg-Kossah et al., 2009b).

Zinc (Zn), which is vital for the activation of enzymes in other microelements but which is vitally important, is determined as 14.02 mg / kg in our study. These values are partially similar to those given in the literature (10.93 ppm-Özcan and Haciseferogullari, 2004; 55.74 mg / kg- Kossah et al., 2009; and 17.20 mg / kg- Kossah et al., 2009) . Copper (Cu) value determined in our study is 0.00856 mg / kg. However, this value is much lower than the results given in the literature (3.73 ppm-Özcan and Haciseferogullari, 2004; 42.68 mg / kg-Kossah et al., 2009a and 9.56 mg / kg-Kossah et al., 2009b).

Table 2 Sumak sample mineral content findings

Elements	**Result**	**Unit**
Iron (Fe)	75.51	mg/kg
Sodium (Na)	120.8	mg/kg
Zinc (Zn)	14.02	mg/kg
Copper (Cu)	0.00856	mg/kg
Phosphorus (P)	2043	mg/kg
Potassium (K)	11420	mg/kg
Calcium (Ca)	3495	mg/kg
Magnesium (Mg)	935	mg/kg

4 Conclusion

It has been found that it has antimicrobial properties in general and has a protective effect against microorganisms as a natural product. Sumac is a natural food which is consumed abundantly in the region compared to other regions. Considering the commercial dimensions of the world is thought to be an important source of income for the development of our country.

It is hoped that the sumac fruits, which are used abundantly by the people in daily meals in the Kilis region, are evaluated in different sectors and their culture is made in the environment because of the suitability of the growing conditions and the studies to be an important livelihood for the public.

As a result;

- According to the effect of the strains used, the sumac extracts which are considered as suppressing antibacterial properties are chemotherapeutic, antibacterial, etc. It is hoped that it can be used as.
- Ethanol and methanol extracts were found to give better results. It has been found that it has no effect against microorganisms in petroleum ether extracts.
- It is thought that Sumac plant can be used as food preservative additive and it will contribute to extend shelf life of foods.

- The commercial availability of extraction in different extracts in which antimicrobial and antifungal activity is determined may be considered.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

There is no conflict of interest.

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