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Research Article/Araştırma Makalesi

Effects of antioxidant and physicochemical properties on antimicrobial activity of sumac (*Rhus coriaria* L.) plant spices which are collected from the southeastern anatolia region of Turkey

Türkiye'nin güneydoğu anadolu bölgesinden toplanan sumak (Rhus coriaria L.) bitki baharatlarının antioksidan ve fizikokimyasal özelliklerinin antimikrobiyal aktivitelerine etkisi

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ABSTRACT

The current work aimed to determine the effects of antioxidant and physicochemical properties of sumac fruits on its antimicrobial activity. Samples collected from Mardin and Diyarbakır provinces which are located in Turkey's Southeastern Anatolia were used and the results were compared among each other. Samples taken from Diyarbakır and Mardin were analysed separately, and they exhibited high antioxidant activities. Analyzes were performed on the aqueous extracts of the collected samples. The highest rate in the determination of total phenolic substance content by the Folin-Ciocalteu method was observed in the first sample collected from Diyarbakır Çermik and this value was recorded as 82.2 mg gallic acid g^{-1} sumac. The highest total flavonoid content (7.55 mg catechin g^{-1} sumac) and inhibition value (75.7 % DPPH) were also observed in the same sample. On the other hand, the sample obtained from Bismil, showed a strong antimicrobial effect by affecting the highest zone area among the six samples which also had a 72.3% DPPH inhibition value and 54.6 (mg gallic acid g^{-1} sumac) total phenolic content value. It has been observed that the antimicrobial effect is directly proportional to the antioxidative values.

Key Words: Rhus coriaria, Antioxidant, Antimicrobial, Phenolic, Flavonoid

ÖZ

Mevcut çalışma, sumak meyvelerinin antioksidan ve fizikokimyasal özelliklerinin antimikrobiyal aktivitesi üzerindeki etkilerini belirlemeyi amaçlamıştır. Türkiye'nin Güneydoğu Anadolu bölgesinde yer alan Mardin ve Diyarbakır illerinden toplanan örnekler kullanılmış ve sonuçlar kendi aralarında karşılaştırılmıştır. Diyarbakır ve Mardin'den alınan örnekler ayrı ayrı analiz edilmiş ve yüksek antioksidan aktivite sergilemiştir. Toplanan örneklerin sulu ekstraktları üzerinde analizler yapılmıştır. Folin-Ciocalteu yöntemi ile toplam fenolik madde içeriğinin belirlenmesinde en yüksek oran Diyarbakır Çermik'ten alınan ilk örnekte gözlenmiş ve bu değer 82,2 mg gallik asit g^{-1} sumak olarak kaydedilmiştir. En yüksek toplam flavonoid içeriği (7.55 mg kateşin g^{-1} sumak) ve inhibisyon değeri (%75.7 DPPH) aynı örnekte gözlenmiştir. Bismil'den alınan numune ise %72.3 DPPH inhibisyon değeri ve 54.6 (mg gallik asit g^{-1} sumak) toplam fenolik içerik değeriyle altı numune arasında en yüksek zon alanını etkileyerek güçlü bir antimikrobiyal etki göstermiştir. Antimikrobiyal etkinin antioksidatif değerlerle doğru orantılı olduğu gözlemlenmiştir.

Anahtar Kelimeler: Rhus, Coriaria, Anioksidan, Antimikrobiyal, Fenolik, Flavanoid

Introduction

Sumac is a common name for a genus (*Rhus*) that is one of the individual plant species of the Anacardiaceae family. These plants are found in temperate and tropical regions around the world, often grown in agricultural capacity areas, and have a long history of use by indigenous people for medicinal and other uses. (Akgul and Ayar, 1993). The word sumac has passed into our language from the word summak, which means "the plant whose dark red seeds are used as spice and dye raw materials" in Arabic. The origin of the word is summaqa, which means red in Syria (Basoglu and Cemeroglu, 1984). Spices have had an impact on the cultural lives, religious behaviors, policies and economies of societies throughout history. Spices used to flavor foods have the ability to protect them with their antimicrobial and antioxidant effects (Yikmis et al., 2017). Turkey has a very important and rich vegetation in terms of available plant diversity. Due to the rich vegetation and aromatic properties of these plants in Turkey, different parts of various plants are widely used as spices (Karanki, 2013). Sumac is red in color, with hairy leaves, which can be propagated by seed or cuttings (Akgul and Ayar, 1993). Its leaves contain plenty of tannins. The fruit turns green at first and then red (Tanker et al., 2007). When examined as a spice, it has a purplish color close to red and a sour taste with a unique smell. It contains 10-20% oil and 0.02-0.03% essential oil (Brunke et al., 1993). Organic acids such as malic, citric, tartaric and their salts also contain coloring agents. It gets its unique smell from its essential oil (Akgul and Ayar, 1993).

Candan and Sökmen (2004), compared the methanol extract of sumac pericarp against the antioxidant and free radical scavenging effects of curcumin, ascorbic acid and tannin in their study. It was reported that the extract is rich in antioxidants and has a strong free radical scavenging effect, and an antioxidant effect wasn't found that could be caused by ascorbic acid. In addition, they emphasized that the antioxidant activity of sumac has not yet been clarified on the basis of components and that new research should be done to support this. Ökmen and Uğur (2011), investigated the antimicrobial activities of 44 streptomycetin isolated from different soil samples where sumac plants were grown in Ankara and Adana (Turkey). A total of 12 strains, including multiple antibiotic resistant strains of staphylococcus aureus, staphylococcus epidermidis and stenotrophomonas maltophilia, were used, and 36% of the isolates showed antimicrobial activity on the tested microorganisms. Of the active isolates, 81% showed antibacterial activity on gram positive and 25% on gram negative bacteria. 69% of the isolates showed anticandidal activity. Sixteen isolates inhibited the growth of s.aureus strains at varying rates. It was determined that 3 of these isolates had high activity against methicillin-resistant s.aureus (MRSA). It was observed that none of the isolates showed antibacterial activity on multi-antibiotic resistant s. maltophilia (MU64).

Two main types of sumac grows in Turkey. These are Derice Sumac (*Rhuscoriaria* L.) (It is also referred to as Syrian sumac in some sources) and Dyer Sumac (*Rhuscotinus* L.) (Oncu, 1951). After its fruits are dried, *R. coriaria* is ground with a certain amount of table salt and used as a spice. The aim of current study is to determine the antioxidant, antimicrobial and physicochemical properties of sumac plant spice, which is widely used in Diyarbakır and Mardin regions and which is widely spread as a plant, and to show their relationship with each other. For this purpose, samples of sumac *(Rhuscoriaria* L.) collected from the city center and villages of Diyarbakır's Eğil, Hazro, Hani, Bismil, Çermik and Kulp districts and Mardin's Savur, Mazıdağı, Midyat and Derik districts were used and their properties were compared among each other.

Materials and Methods

The main material of this study is sumac specimens (*Rhuscoriaria* L.) which grows wild in

the natural environment and collected as fruits. The chemicals used in the study were supplied from Merck (Germany) and Sigma-Aldrich (USA). Samples were collected in August-September 2019 and each sample was taken from where it belongs. The name and codes of samples taken from South Eastern Anatolia of Turkey are given in Table 1.

Table1. Codes and names of samples collected from the regions

Sample Code	Name	Sample Code	Name
1	Hazro	12	Mazidagi 2
2	Eğil	13	Kulp 1
3	Hani	14	Kulp 2
4	Bismil	15	Derik
5	Mardin M1	16	Lice
6	Mardin M2	17	Midyat 1
7	Çermik 1	18	Midyat 2
8	Çermik 2	19	SavurSicva
9	Çermik 3	20	Savur 1
10	Çüngüş	21	Savur 2
11	Mazidagi 1	22	Savur 3

Preperation of sumac extract

Extraction for antioxidant analysis

Sumac samples were used in a laboratory environment by grinding the household flour mill and separating the pericarp and seeds from fruits (Kossah et al., 2009). The collected sumacs were coded according to the areas taken and cleaned by separating from wood parts and cores. The dark red colored pericarp parts, which were considered as spice after separation, were ground in a mill. To determine the antioxidant analyses, a 10 g of ground sumac was taken and kept in 100 ml distilled water for 1 hour, then it was extracted by centrifugation (Mazaheri at al., 2017).

Extraction for antimicrobial analysis

A 200 grams of ground sumac sample obtained from samples taken from Midyat, Kulp, Hazro, Mazıdagi, Bismil and Çermik was added to 1000 mL distilled water and refluxed for 1 hour at 100 ° C. The extracts were then filtered through Whatman (no2) filter paper using Buchner funnel to separate the sumac particles. The filtrates were concentrated under vacuum in a rotary evaporator, lyophilized and dried six different sumac extracts were stored in sealed bottles at 4 °C until analysis. All tests were performed in triplicate and results were given as mean values ± standard deviation of three replicates.

Physicochemical analysis

In physicochemical analysis, pH, humidity, ash, acidity and particle size of the sumac samples were determined. To determine acidity, 95 g of water was placed on 5 g of sumac, which was separated from the seeds and ground, and then left for three hours. A 15 ml of the filtrate was taken and titrated with 0.1 N NaOH. Results were calculated in terms of citric acid equivalent. In order to determine the pH of the samples, it was made with a pH meter using the filtrate used in acidity analysis. For moisture determination, sumac samples were weighed as 5 grams, placed in petri dishes, kept in an oven at 103 °C for 2 hours (when it reached constant weighing), and then weighed. To determine the ash content, a 2 g of sample was weighed into crucibles and ignited with alcohol, and then kept at 550 °C for 2 hours. Water was dropped on it and burned for 1 hour again and the weighings were taken. The size of the sumac grains was measured using calipers (Basoglu and Cemeroglu, 1984).

Antioxidant analysis

The application of organic and aqueous solvents while extracting is the most common method of extracting antioxidant compounds from plant tissues. Antioxidant compounds play an important role in preventing damage caused by free radicals. Therefore, antioxidant compounds of natural and synthetic origin are used. Various methods are used to evaluate the antioxidant capacity of herbal products and

foods.These methods can be examined under two groups as methods based on electron transfer (ET) and hydrogen atom transfer (HAT) reactions. Electron transfer(ET) assays measure the reducing ability of the substrate (antioxidant) while hydrogen atom transfer assays measure the hydrogen donating ability of the substrate. ET-based methods include the total phenols assay by Folin-Ciocalteu reagent (FCR), trolox equivalence antioxidant capacity (TEAC), ferric ion reducing antioxidant power (FRAP), "total antioxidant potential" assay using a Cu (II) complex as an oxidant, and DPPH method (Albayrak et al., 2010).In this study, total phenolic content(based on Folin-Ciocalteu reagent (FCR)) , total flavonoid substance and DPPH free radical scavenging activity of the samples were examined as antioxidative analyses.

Dpph (diphenyl-1-picrylhydrazyl)

The DPPH methodology, which can be measured spectrophotometrically and has a strong purple color, was developed by Brand-Williams et al. (Brand-Williams et al., 1995). DPPH analysis is one of the spectrophotometric methods used in antioxidant activity measurement (Sharma and Bhat, 2009). The DPPH radical is one of the few stable organic nitrogen radicals. It is dark violet in color. UV-vis absorption maximum is 515 nm (Albayrak et al, 2010). This method is based on the scavenging of the DPPH radical by antioxidants due to a redox reaction. The methanolic DPPH solution turns dark violet and the decrease in absorbance is measured by UV-vis spectrophotometer. Alternatively, the antioxidant reduction ability can be evaluated by electron spin resonance. The more discoloration in the methanolic DPPH solution, the greater the decrease in the absorbance of the reaction mixture, hence high radical scavenging capacity. When the DPPH solution is mixed with a substance that can give off a hydrogen atom, it turns into a reduced form with the disappearance of the purple-violet color. The effect of DPPH scavenging was estimated using the following formula:

$$The\ effect\ DPPH\ scavenginginhibition(\%) = \left(Acontrol - \frac{Asample}{Acontrol}\right) \times 100 \quad (1)$$

Where *Acontrol* was the control absorbance and *Asample* was the sample absorbance (Zhu et al., 2010).

Total phenolic content

Phenolic compounds are aromatic structures containing one or more hydroxyl groups. Many polyphenols contain more than one hydroxyl group, some of which are methylated or glycosylated. It is estimated that there are about 8000 kinds of phenolic substances found in plants. The total phenolic matter analysis method was proposed by Singleton and Rossi in 1965 and later developed by different practitioners. Folin-Ciocalteu reagent (Folin Phenol Reagent or Folin-Denis reagent) is a mixture of phosphomolybdate and phosphotungstate reagent used for the colorimetric determination of phenolic and polyphenolic antioxidants (Singleton and Rossi, 1965). The method measures the amount of material tested to inhibit the oxidation of the reagent (Vinson and Hontz, 1995). However, it is known that this reagent does not only measure the total amount of phenolic compound and will also react with all reducing agents present in the sample. Therefore, there is controversy that the reagent measures not only the phenolic compound level in the sample, but also the total reduction capacity of the sample (Ikawa et al., 2003). However, the determination of total phenolic compound with the Folin-Ciocalteu reagent is a standard method used in almost all antioxidant studies to determine the phenolic content in the sample.

The values recorded in the total phenolic substance content (TPC) analysis were recorded as gallic acid (GAE) equivalents. In this analysis, firstly, the gallic acid standard curve was drawn and calculations were made on the following equation;

$$y = 93.55x - 7.544 \quad (2)$$

Total flavonoid content

Flavonoids are aromatic pigment compounds found in fruits, vegetables, various beneficial biochemicals and some beverages with antioxidant effects. Flavonoids act as chemical messengers, physiological regulators or inhibitors of the cell cycle within the cell. Flavonoids have many other beneficial properties besides their high antioxidant effect (Akbasli, 2013).

In the analysis of total flavonoid substance content, the amount of flavonoid substance was recorded as catechin equivalent. Therefore, the catechin standard curve was drawn. The total amount of flavonoid substance was calculated using the following calibration equation;

$$Absorbance = 0.0023\ (catechin) + 0.0147 \quad (3)$$

Antimicrobial analysis

Various sensitivity tests are performed to determine the sensitivity of microorganisms to antimicrobials. In vitro tests used to determine antibacterial activity are as old as the use of the first antibiotic (Sumerkan, 1996). In this study, in addition to other analyzes, the antimicrobial effects of 6 samples were also investigated by well diffusion method. Six different sumac sample extracts, two gram-negative bacteria; *Salmonella typhimurium* (ATCC 1730), *Esterichia coli* (ATCC 25222) and four gram-positive bacteria; *Bacillus cereus* (ATCC 11778*), Bacillus subtilis* (AATC 6633*), Listeria monocytogenes* (ATCC 19118) and *Staphylococcus aureus* (ATCC 6538), ıt has been subjected to antibacterial tests against six different bacteria. Antibacterial activity of sumac extracts on test bacteria was investigated by agar-well diffusion method (NCCLS, 1999; Fazeli et al., 2007).

Statistical analysis

The statistics obtained as a result of the evaluations were recorded using the SPSS program and it was found that there were significant differences between the values ($p < 0.05$). Samples taken from 22 different regions were evaluated over 44 analyses in 2 repetitions. Comparisons of samples were made using one-way ANOVA test and Tukey test. Analyses were performed in duplicate; average results were noted.

Results and Discussion

Physicochemical analyses

Physical and chemical properties of agricultural products such as sumac have an important place in terms of transporting, processing, separating, qualitatively evaluating, and comparing multiple products among each other. The results of physicochemical analysis performed on sumac samples are given in Table 2.

In the pH of the samples, the highest pH value was observed in the sample taken from Hani with 3.29. This was followed by samples taken from Bismil with 3.23, Derik with 3.19, Eğil and Hazro with 3.18, Kulp and Mardin with 3.17. In the literature, Ozcan and Hacıseferogullari (2004) determined the pH of the sumacs they collected from Mersin as 3.7 ± 0.3. The obtained pH values in our study are among the values determined in previous studies in the literature. In the moisture analysis, the highest moisture was observed in the sample taken from Mardin Mazıdagi with 6.62 %. Moisture values varied between a maximum of 6.57 % and a minimum of 2.99 %. Kossah et al. (2009), observed that the moisture content of sumac samples taken from Turkey as 5:37 ± 0.14 %. The comparisons made with the literature; it was observed that the moisture values determined did not show much deviation. It is thought that the region where the collected sumac plants grow, and the climatic conditions are effective in different moisture values. The highest ash (%) content was observed in the samples obtained from Bismil district of Diyarbakır with 3.7%, and Savur district of Mardin with 3.25. The lowest value was observed in the first sample taken from the Kulp district of Diyarbakır with 2.02%. Al-Shabibi et al. (1982) stated that the ash content of the sumac samples varied 3.2 and 3.7%. Basoglu and Cemeroglu (1984) found 19.79% total ash in the sumac samples purchased from the market as spices.

The grain sizes of the sumac samples were measured with 4.7 mm as the highest in Kulp and at the lowest 1.9 mm in the sample taken from Hazro district. Mazaheri et al. (2017), found that the sizes of sumac fruits taken from Gonabad, Ferdows and Zohk regions of Iran, 3.84 mm, 3.58 mm and 3.6 mm respectively. Although different results have been reported in the literature, the recorded values are compatible with the literature.

Table 2. Physicochemical analysis values of the samples

Sample Code	pH	Moisture content (g/100 g)%	Ash %	Acidity %	Sample size (mm)
1	3.18±0.01^{ab}	3 ± 0.31^{hij}	2.6±0.14^{e}	1.65±0.1^{ij}	1,9±0.14^{g}
2	3.18±0.12^{ab}	5.56± 0.09^{abc}	2.7±0.06^{abcde}	1.5± 0.00^{jk}	3,75±0.3^{abcde}
3	3.29±0.06 ^{ab}	4.17± 0.07^{efg}	2.35±0.05^{cde}	1.3±0.03^{k}	3,6±0.8^{abcde}
4	3.23±0.19 ^{a}	6.57± 0.12^{a}	3.7±0.28^{a}	2.27±0.16^{bc}	3,25±0.3^{bcde}
5	3±0.12^{ab}	4.33± 0.26^{def}	3.2±0.00^{abc}	2.31±0.02^{bcde}	2,2±0.2^{fg}
6	3.12±0.15^{b}	3.86±0.39^{bcd}	2.26±0.07^{de}	2.09±0.0^{efgh}	3,9±0.14^{abcd}
7	3.08±0.02^{ab}	5.19±0.00^{bcd}	2.58±0.12^{bcde}	2.25±0.07^{bcde}	3±00^{cdefg}
8	3.09±0.00^{ab}	4.24±0.03^{efg}	2.97±0.02^{abcd}	1.7±0.21^{hi}	4,55±0.07^{a}
9	3.09±0.00^{ab}	4.95±0.02^{cde}	3.19±0.03^{abc}	2.07±0.00^{efgh}	2,25±0.3^{fg}
10	3.04±0.02^{b}	2.29±0.19^{j}	2.53±0.00^{bcde}	2.06±0.00^{efgh}	2,9±0.1^{defg}
11	3.11±0.02^{ab}	6.62±0.50^{a}	2.83±0.01^{abcde}	2.36±0.02^{bcd}	2,2±0.2^{fg}
12	3.13±0.00^{ab}	5.2±0.21^{bcd}	2.9±0.28^{abc}	2.55±0.07^{ab}	2,1±0.1^{fg}
13	3.14±0.00^{ab}	4.58±0.48^{efg}	2.02±0.73^{e}	1.9±0.07^{fgh}	4,1±0.1^{abc}
14	3.17±0.02^{ab}	4.8±0.48^{cde}	3.1±0.28^{ab}	2.11±0.02^{cdefgh}	4,7±0.4^{a}
15	3.19±0.02^{ab}	3.4±0^{ghi}	2.97±0.04^{abcd}	1.9±0.04^{gh}	2,4±0.1^{fg}
16	3.02±0.01^{b}	5.12±0.12^{bcd}	2.39±0.00^{cde}	2.79±0.02^{a}	3,9±0.1^{abcd}
17	3.14±0.02^{ab}	3.63±0.06^{ghi}	2.5±0.10^{bcde}	2.25±0.03^{cdef}	4,2±0.2^{ab}
18	3.2±0.02^{ab}	3.67±0.07^{ghi}	2.78±0.13^{abc}	1.56±0.00^{jk}	3,1±0.1^{bcde}
19	3±0.07^{b}	4.64±0.00^{def}	3±0.14^{abcde}	2.09±0.00^{defgh}	3±0.00^{cdefg}
20	3.08±0.01^{ab}	5.86±0.09^{ab}	2.86±0.02^{abcde}	2.17±0.01^{cdefg}	2,65±0.2^{efg}
21	3±0.13^{ab}	2.99±0.02^{ij}	2.7±0.14^{bcde}	1.98±0.01^{fgh}	3,25±0.3^{bcde}
22	3.15±0.05^{ab}	4±0.01^{ghi}	3.25±0.35^{abc}	2.048±0.00^{efgh}	3±0.00^{cdefg}

*Letters in the same column indicate no statistical difference (p >0.05). $^{a-j}$ Different superscript lowercase letters show differences between samples.

Antioxidative analysis

Antioxidant analysis values of the samples are given in table 3. In this study, the highest inhibition value was seen in the 1st sample taken from Çermik with 75.7%. The lowest inhibition percentages were observed in the 3rd sample taken from Savur with 39.6%, followed by the samples taken from Midyat with 45.7% and 48.2% and Çüngüş with 48%. When looking at the studies on the phenolic substance and antioxidant properties of sumac, Torun (2019) investigated the antioxidant activities of the samples collected from Aydın, Gaziantep, Silifke and Van, and noted the inhibition (%) values according to the region as; Aydın with 57.01%, Gaziantep with 52.82%, Silifke with 78.76% and Van with 45.08%. When looking at the range in general, the percent inhibition values were recorded after our trials are consistent with the literature.

When the total phenolic substance contents of the samples are examined, the highest phenolic substance was observed in the 1st sample taken from Çermik district of Diyarbakır with the highest ratio of 82.2 (mg gallic acid g^{-1} sumac). The lowest amount was observed in samples taken from Hazro with 26.3 (mg gallic acid g^{-1} sumac) and Çermik 2 and 31.4 (mg gallic acid g^{-1} sumac) and when evaluated statistically, significant differences were observed between each other (p <0.05). Unver (2006) determinedgallic acid amount in the sumac samples collected from Çanakkale and Siirt provinces, as 67.56 (mg gallic acid g^{-1} sumac) in Çanakkale sample and 19.01 (mg gallic acid g^{-1} sumac) in Siirt sample. In a study conducted with sumac samples taken from Syria and China, the total amount of phenolic matter was determined by extraction under different experimental conditions such as ethanol concentration, extraction time, particle size, ratio of solvent to sumac amount. The total amount of

phenolic substance was determined as 159.32 mg gallic acid g^{-1} for Syrian sumac and 150.68 (mg gallic acidg^{-1}) for Chinese sumac (Kossah et al., 2010). In another study, Yegin (2017) investigated the antioxidant capacities of sumac taken from Hatay, Gaziantep and Mersin and recorded the total phenolic substance amount as 17.37 mg gallic acid g^{-1}, 18.22 mg gallic acid g^{-1} and 13.03 mg gallic acid g^{-1}, respectively.

While the highest flavonoid substance was found with 7.55 (mg catechin g^{-1} sumac) samples taken from Diyarbakır Çermik 1 and Siçva village of Mardin Savur; with 7.4 (mg catechin g^{-1} sumac), it was observed at least in samples taken from Hazro, Eğil, Hani, Bismil and Mazıdagi districts. In the literature, Torun (2019), in her master's thesis on the phenolic substance content and antioxidant activity properties of the sumac plant, in the aqueous extracts prepared from the sumac samples collected from Aydın, Gaziantep, Silifke and Van provinces. The amount of flavonoid substance was 5.58, 1.59, 2.80 and 3.01 in the samples taken from Silifke, Aydın, Van and Gaziantep provinces respectively.

Table 3. Antioxidant analysis values of the samples.

Sample code	Total Flavonoid Content (mg catechin g^{-1} sumac)	Total Phenolic Content (mg gallic acid g^{-1}sumac)	Antioxidant Activity (Inhibition%)
1	7.4±0.01^{c}	31.4±0.03^{mn}	50±0.07^{ij}
2	7.4±0.00^{c}	55.4±0.07^{dc}	60.5±0.84^{ef}
3	7.4±0.01^{c}	38.7±0.09^{l}	62.5±1.41^{e}
4	7.4±0.00^{c}	54.6±0.14^{de}	72.3±0.70^{b}
5	7.42±0.03^{bc}	48.1±0.06^{g}	57.9±0.07^{fg}
6	7.45±0.00^{bc}	32.4±0.02^{m}	48.8±0.28^{jk}
7	7.55±0.01^{a}	82.2±0.06^{a}	75.7±2.40^{a}
8	7.5±0.00^{bc}	26.3±0.00^{o}	55.3±0.28^{gh}
9	7.45±0.00^{bc}	46.5±0.09^{i}	66.2± 0.21^{de}
10	7.45± 0.03^{bc}	39±0.02^{l}	48±0.63^{jk}
11	7.4± 0.00^{c}	52±0.07^{f}	61.8±0.35^{e}
12	7.45± 0.00^{bc}	55.6±0.00^{dc}	52.9±0.63^{hi}
13	7.4± 0.03^{c}	44.5±0.06^{j}	50±0.00^{ij}
14	7.45± 0.00^{bc}	67.3±0.00^{c}	52.8±0.21^{hi}
15	7.45±0.01^{bc}	53.4±0.02^{e}	56.5±0.70^{g}
16	7.45± 0.01^{bc}	54.5±1.5^{de}	53.3±0.14^{h}
17	7.5± 0.00^{ab}	30.5±0.07^{n}	45.7±0.45^{k}
18	7.5±0.01^{ab}	41.6±0.06^{j}	48.2±1.13^{jk}
19	7.55± 0.01^{a}	40.4±0.16^{kl}	68.8±0.00^{cd}
20	7.5±0.01^{ab}	53.4±0.00^{e}	63.7±0.28^{de}
21	7.45± 0.00^{bc}	74.3±0.35^{b}	69.6±0.35^{bc}
22	7.45± 0.00^{bc}	39.2±0.00^{l}	39.6±0.84^{l}

*Letters in the same column indicate no statistical difference ($p > 0.05$). $^{a-j}$ Different superscript lowercase letters show differences between samples.

Antimicrobial analysis

The effect of samples and cephalexin and tetraxylin antibiotics on bacterias is shown in Table 4. When looking at the previous studies, a research was conducted on the effects of ethanol extracts of 15 different plants on some gram-positive and gram-negative bacteria; It has been observed that sumac is more effective than pomegranate and thuja. It has been observed that tannins, which are the common components of the materials, are effective as antibacterial (Nimri et al., 1999). The effects of methanol extracts of *R.coriaria* against gram-positive and gram-negative bacteria and *Candida albicans* were tested, and it was reported that they were highly effective against pathogenic bacteria and low against C. *albicans* (Iauk et al., 1998). In this study, *E. Coli*, among the two gram negative bacteria we used, mostly showed greater resistance compared to gram positive bacteria and *S. aureus* by affecting the lower inhibition area. Among gram-negative and gram-positive bacteria, *L. monocytogenes* showed the greatest area of inhibition, showing less resistance. When

looking at the effect of different sample on bacteria; It has been observed that the sample taken from Bismil has an antibacterial effect on more inhibition areas in direct proportion to its antioxidant effect. Sumac sample taken from Bismil, which shows a strong antimicrobial effect by affecting the highest zone area among the 6 samples that were analyzed for antibacterial, was likewise antoxidative, with a percentage inhibition value of 72.3% DPPH and 54.6 (mg gallic acid g^{-1} sumac) It has been observed that it has an effect directly proportional to the total phenolic content and antioxidative values. It has been noted that the sample taken from Hazro has the least inhibition area on bacteria and has the least effect. When the effect of antibiotics on bacteria is compared to sumac samples, it has been observed that sumac is quite effective.

Table 4. Inhibition areas (mm) of sumac extracts (100µl / mL) for 6 different microorganisms.

	Area of inhibition (mm)					
	E. coli	*S. typhimurium*	*S.aureus*	*B.Subtilis*	*B.cereus*	*L. monocytogenes*
Sumac Extracts						
Midyat 1	11.5±0.01	13.5±0.00	19.2±0.00	16.4±0.00	14.0±0.01	28.2±0.00
Kulp 1	17.3±0.00	16.7±0.01	24.5±0.01	20.2±0.00	20.5±0.01	33.5±0.01
Hazro	12.1±0.01	14.6±0.01	19.0±0.00	14.5±0.01	14.5±0.01	22.5±0.01
Mazidagi 2	22.5±0.02	21.4±0.00	28.2±0.02	23.4±0.01	18.0±0.00	30.2±0.00
Bismil	22.1±0.00	22.2±0.00	29.1±0.01	24.6±0.00	20.2±0.00	29.0±0.01
Çermik 3	16.5±0.01	17.0±0.01	23.4±0.00	17.8±0.00	19.5±0.01	32.2±0.00
Antibiotics						
Cephalexin	10.5±0.00	12.5±0.00	18.8±0.01	23.0±0.01	18.5±0.00	20.2±0.00
Tetracycline	33.6±0.00	32.1±0.00	29.5±0.01	16.5±0.00	28.0±0.01	31.0±0.01

Conclusions

Sumac plant is a plant that grows wild spontaneously in nature. It has characteristic color, smell and taste. In this study on sumac, which has a great importance in terms of health, it was determined that sumac samples collected from the regions have a great importance in terms of antioxidants and have a very rich antioxidative potential with directly proportional to its antimicrobial potential. As a result of the analysis, it was determined that the most antioxidant-rich sumac sample was in the 1st sample collected from Diyarbakır Çermik. The highest levels of total phenolic substance, flavonoid and DPPH percentage inhibition were observed in this sample. Although the grain size and epicarp color were smaller and less noticeable compared to other sumac samples, it was found to be quite rich in antioxidants.

On the other hand, in antimicrobial analysis, it was observed that all samples formed an effective inhibition zone area, especially the sample taken from Bismil was found to have a strong antimicrobial effect in direct proportion to the antioxidative analysis. At the end, it has been observed that sumac plants taken from Mardin and Diyarbakır have a strong antioxidant and antimicrobial effect when compared with the studies conducted in different regions similar to this subject. Changes in the structure of foods and scarcity of products close to nature have led to an increase in diseases in recent years. With the developing and renewed technology, ready-made foods are preferred more than traditional foods, which brings along many health problems that we cannot prevent. Therefore, sumac can be used as a natural source of antimicrobials and antioxidants to protect foodstuffs against a number of food-related microorganisms.

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Author contributions: Both authors conceived and designed formal analysis, writing the data, performed the analysis, wrote and submitted the manuscript.

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