Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 13(4), 2818-2828, 2023
Journal of the Institute of Science and Technology, 13(4), 2818-2828, 2023

ISSN: 2146-0574, eISSN: 2536-4618

Chemistry **DOI: 10.21597/jist.1259358**

Research Article

Received: 03.03.2023 **Accepted: 06.07.2023**

To Cite: Camadan, Y., Akyıldırım Beğen, H., Ceylan, Ş., Saral Sarıyer, A. & Eminağaoğlu, Ö. (2023). Investigating In Vitro Antioxidant and Antimicrobial Activity of Different *Sorbus* Species in Artvin Province of Türkiyey. *Journal of the Institute of Science and Technology*, 13(4), 2818-2828.

Investigating *In Vitro* Antioxidant and Antimicrobial Activity of Different *Sorbus* Species in Artvin Province of Türkiye

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Highlights:

- Different *Sorbus* species were collected and identification
- TPC, TFC, FRAP, CUPRAC and DPPH analysis was performed Highlights
- Methanolic extracts showed antioxidant and antimicrobial activities

Keywords:

- Antimicrobial
- Antioxidant
- Methanolic extraction
- *Sorbus*

ABSTRACT:

In the present study, three *Sorbus* species in the Rosaceae family naturally growing in Artvin province of Turkey were collected. To determine the antioxidant activity, total phenolic and flavonoids capacity of the extracts, their scavenging capacity for (2,2-diphenyl-1-picrylhydrazyl (DPPH) radical, reducing capacity for Fe^{3+} (FRAP) and copper (II) ions (CUPRAC) were analyzed. Besides, disc diffusion method was used to determine antibacterial activity. It was found that all *Sorbus* fruit, flower, leaf and pedicle methanolic extracts showed different levels of antioxidant activity. Results of the the total polyphenol, total flavonoid, FRAP, CUPRAC and DPPH analysis, the highest activity was measured in *S. persica* pedicle, *S. umbellate* var. *cretica* leaf, *S. persica* leaf, *S. umbellata* var. *cretica* leaf and *S. persica* leaf extracts as 25.7 ± 16.49 mg GAE/g, 7.469 ± 0.4926 mg of quercetin/g, 6.248 ± 0.2374 µmol $FeSO4.7H_2O$/g and, 164.4 ± 4.209 mmol TEAC and 46.33 µg/mL, respectively. It was revealed that methanolic extracts of *Sorbus* plant showing antibacterial activity had very high minimum inhibitory concentration (MIC) values compared to ampicillin. Thus, considering the findings of the present study, it could be stated that these species merit further studies as natural antioxidant and antibacterial source*S*.

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INTRODUCTION

Humans live in the presence of various environmental stress factors such as microbes, allergens and polycyclic aromatic hydrocarbons, which can increase the production of reactive oxygen species (ROS) in the body. ROS can be defined as metabolites which carry intermediate oxygen with or without unmatched electrons that oxidize certain compounds and can convert them into free radicals, causing a chain reaction that produces numerous new radicals (Bouayed et al., 2010). Due to the increasing interest on the use of plants in different fields, it is important to discover new plant species and to examine their chemical compositions and biological propertie*S.* If not properly regulated by the endogenous defense system, ROS can react with important biomolecules, causing cellular damage, accelerated aging and the development of chronic diseases such as atherosclerosis, coronary diseases, cancer and neurodegenerative brain disorders (Olszewska et al., 2012).

The use of plants as food and medicinal drugs since ancient times is attributed to the biological activity of secondary metabolites with antioxidant activity such as phenolic compounds, vitamins C and E, and carotenoid*S.* Phenolic compounds form a class of secondary metabolites characterized by an aromatic ring and one or more hydroxyl groups (Ndhlala et al., 2010). Polyphenols were reported to exhibit a wide range of biological effects including antibacterial, antiviral, anti-inflammatory, antiallergic and vasodilatory properties (Cook et al., 1996). Besides the antioxidant effects, in animal and *in vivo* studies, plant polyphenols were shown to remove (scavenge) free radicals, regulate nitric oxide, reduce leukocyte immobilization, induce apoptosis and inhibit cell proliferation (Arts et al., 2005).

Due to the adverse effects of synthetic antioxidants used in foods on human health, interest in fruits and vegetables, which are natural antioxidant sources, has increased. (Aladedunye and Matthäus, 2014). Fruits, leaves and bark of different *Sorbus* L. species are used in the treatment of bronchitis and gastritis, as diuretics, anti-inflammatory, vasorelaxant, anti-diabetic and vitamin source (Raudonis et al., 2014; Bobinaitė et al., 2020). *Sorbus* is a plant genus in the Maloideae subfamily of the Rosaceae family. The genus consists of 100-200 tree and shrub species, and 12 *Sorbus* species and 17 taxa naturally grow in Turkey (Kavak et al., 2019). *Sorbus* is primarily found in small groups in the mixed angiosperm forests in Northern and Northwestern Anatolia. It is a small to medium-sized deciduous tree that typically grows to a height of 8-20 m and can live for more than 100 year*S.* It is very tolerant to a wide variety of soil condition*S.* The bark is smooth, silvery gray on young trees, turns into scaly pale gray-brown, and sometimes cracks in old trees (Korkut et al., 2009). *Sorbus* berries are used in various processed foods in Northern Europe such as jams, jellies and beverages as they have high nutritional value and potential to improve health (Berna et al., 2011). Flavonoids and phenolicacids found in its berries are important antioxidants that improve food quality by slowing lipid oxidation. In addition, as antioxidants that inhibit lipid oxidation, plant phenolics prevent food spoilage during storage and processing (Kylli et al., 2010). Because they can act as radical scavengers, reductive substances, chain-breaking antioxidants and inhibit lipid oxidation, *Sorbus* extracts can be used as cost-effective natural antioxidants, which are alternatives to synthetic antioxidants (Zymone et al., 2018).

Infection-related deaths are increasing worldwide. The fact that nearly half of the deaths in tropical countries are caused by infection is important for a better understanding of the extent of the situation. Only *E. coli* and Salmonella strains cause around 300,000 infection-related child deaths in Africa every year (Akbar et al., 2011). The first experiments on plant antimicrobial activity and chemical composition were conducted later in the 19th century. Extracts of many plant species were discovered to inhibit microbial growth. As a result of increased microbial resistance to antibiotics, there has also been an increased interest in natural antimicrobial compounds (Liepiņa et al., 2013). Plant-derived compounds with therapeutic value are secondary plant metabolites, which are often used traditionally for medicinal purpose*S*. Due to chemical composition differences associated with the countries in which they are grown, antimicrobial activity of the same plant species could also vary. Phytochemicals with antimicrobial properties in medicinal plants are flavonoids, alkaloids, phenolics, polyphenols, coumarins and terpenes (Savoia et al., 2012). Despite the increased bacterial resistance to antibiotics, a decrease in the discovery of new antimicrobial drugs led researchers to alternative therapie*S*. For the rapid development of new and effective treatment methods to fight antibiotic-resistant pathogens, the importance of natural plant products and plant extracts has increased (Cheesman et al., 2017).

Due to the growing interest towards and the need for natural antioxidants and antimicrobial compounds, we characterized morphologically *Sorbus umbellata* var. *cretica* (Lindl.) C. K. Schneid., *Sorbus persica* Hedl. and *Sorbus subfusca* Bois*S*. species of the Rosaceae family naturally grown in Artvin Province of Turkey and known as "oltu üvezi", "eyvaz" and "highland üvezi", respectively, and determined the amount of total phenols, flavonoids and antioxidant and antibacterial activities of extracts from the fruits, leaves and flowers of these specie*S*.

MATERIALS AND METHODS

Chemicals Used In The Study

Of the chemicals used in the study, methanol, ethanol, neocuproine, NaOH, Trolox (6-hydroxy-2,5,7,8-tetramethyl chroman-2-carboxylic acid), sodium acetate, ferric chloride, glacial acetic acid, HCl, KCl, sodium carbonate, H_2SO_4 and carbon tetrachloride were purchased from Sigma-Aldrich Chemie GmbH (Steinheim, Germany) and Merck (Darmstadt, Germany), while 2,2-diphenyl-1-picrylhydrazyl (DPPH), Folin-Ciocalteu's phenol reagent and 2,4,6-tri(2-pyridyl)-S-triazine (TPTZ) were purchased from Fluka Chemie GmbH (Buchs, Switzerland).

Land survey

Three different types of *Sorbus* were identified to be used in antioxidant and antimicrobial studie*S*. For the collection of these specimens, land surveys were carried out in predetermined localitie*S*. *Sorbus umbellate var*. cretica (Lindl.) C.K. Schneid. was collected from Ardanuç District while *Sorbus persica* Hedl. was collected from Ardanuç town and *Sorbus subfusca* Boiss was from Borçka highland. Shoot specimens with leaves, flowers, fruits and seeds were collected using appropriate techniques in certain period*S*. The flower, fruit and leaf forms of plants are given in Figure I. Detailed photos of the land were taken for habitat information. Clear, detailed photos of the plants were taken in case some parts of the plant could crumple, fold on top of each other and the morphological parts used in identification key could disappear in the herbarium making proces*S*. For each plant taxon collected, label information such as aspect, altitude, locality, collection date and GPS coordinates were recorded using a camera that could provide GPS information (Canon Powershot SX70 HS Digital). The leaves and fruits were collected when they were ripened, and were kept in a cool place.

Figure1. Flower, Fruit and Leaf Forms In *S. persica*, *S. subfusca* and *S. umbellata* var. cretica Species

Morphological examination

Collected plant specimens were dried between press boards (29 x 41 cm) to be turned into herbarium material and prepared for the identification. Species identifications were performed based on previous publications (Davis et al., 1965) using a stereomicroscope (Nikon SMZ1000). Stereomicroscope was employed to determine size (length-width), shape, color and maturity of fruit*S.* The photos were taken with a digital camera compatible with Trinocular Stereo Zoom light microscope. Morphological evaluations were carried out on herbarium material*S.* Important taxonomic characters crucial for the identification of taxa examined were determined, and leaf, seed, pedicel and fruit measurements were made. The information of the identified samples was recorded in Artvin Çoruh University Herbarium (ARTH). The plants were stuck on white cardboards, labels with all the recording information were printed from the herbarium system, and placed to the lower right corner of the cardboard.

Preparation of samples

After the *Sorbus* samples were dried for 1-2 months, the fruit, stem and flower parts were separated and grounded using a blender. The extraction of powdered samples was carried out through mixing each sample with methanol in a shaker for 24 hour*S.* The extracts were filtered through a regular filter paper and stored in a refrigerator at +4 °C for the assay*S.*

Antioxidant assays

DPPH, FRAP, CUPRAC, total polyphenol and flavonoid capacity were determined in the sample extract*S.*

Total polyphenol assay

In this method, the total soluble phenolic content in the sample reacts with Folin-Ciocalteu's reagent and creates a colored structure that absorbs at 760 nm. The standard curve was prepared with gallic acid (Slinkar et al., 1977).

Total flavonoid assay

The total amount of flavonoids is determined based on the method developed by Chang et al. (2002). In this method, aluminum chloride forms stable complexes with any of C-4 keto group or C-3 or C-5 hydroxyl groups of flavones and flavanols, and unstable complexes with ortho-dyhydroxy groups in A and B rings of flavonoid*S.* As standard, quercetin in the range of 0.03125-1.0 mg/mL was used, and a standard curve was prepared using the absorbance values corresponding to these concentration*S.*

Fe^{3+} reduction / FRAP method

In low pH, ferric tripyridyl triazine complex (Fe^{3+}-TPTZ) is reduced to ferrous complex (Fe^{2+}-TPTZ) due to the action of antioxidant*S.* The resulting complex is measured at 593 nm (Benzie et al., 1999; Huang et al., 2006). FRAP value of methanolic extracts was calculated as mg quercetin/g sample.

CUPRAC (Copper (II) Ion) reducing antioxidant capacity method

The basis of the method is to calculate the antioxidant capacity using the reduction capability of the copper (II)-neocuproine complex formed by Cu^{2+} ions in the environment to Cu(I)- neocuproine which has maximum absorption at 450 nm (Apak et al., 2004). Trolox (0.03125-1 mM) was used as standard in the analysi*S.* The test results obtained are expressed as Trolox equivalent antioxidant capacity (TEAC).

DPPH free radical scavenging activity assay

In the present study, the method developed by Yu et al. (2002) was modified, and commercially purchased DPPH radical (2,2-diphenyl-1-picrylhydrazyl) was used. A methanolic solution of DPPH radical (4 mg/100 mL) was prepared. Different concentrations of obtained extracts were prepared, mixed with equal volumes (0.750 mL) of DPPH solution and incubated at room temperature. Absorbance readings were made at 517 nm at which DPPH has maximum absorbance. The concentrations corresponding to the absorbance readings were plotted, and IC_{50} values were calculated as mg/mL.

Determination of minimum ınhibition concentrations (MIC) of plant methanolic extracts

Liquid microdilution method was used to determine the minimum inhibition concentrations of plant fruit and leaf methanolic extracts against standard strain*S.* The concentrations of plant methanol extracts used in the study are given in Table 1. Gram positive standard strains were *Bacillus subtilis* ATCC 6633, *S. aureus* ATCC 25923 and *S. pyogenes* ATCC 19615. Gram negative standard strains were *E. coli* ATCC 25922, *P. aeruginosa* ATCC 43288 and *Proteus vulgaris* ATCC 13315. Experiments performed in triplicate using 96-well plate*S.* Fifty µL Mueller Hinton Broth (MHB) was added to each well except for well 12. Hundred µL MHB was added to well 12 and evaluated as a sterility control. Additionally, well 11 was prepared as a growth control (50 uL MHB + 50 µL bacteria).

Table 1. Concentrations of Plant Methanol Extracts Used in the Study

Plant methanol extracts	Concentrations (mg/mL)	Evaluated concentration range (mg/mL)
S. umbellata var. *cretica* l.	100.0	0.09800-50.00
S. umbellata var. *cretica* fr.	447.0	0.4400-223.5
S. subfusca l.	100.0	0.09800-50.00
S. subfusca fr.	446.0	0.4300-223.0
S. persica l.	79.00	0.07700-39.50
S. persica fr.	472.0	0.4600-236.0

*Abbreviations: *S. umbellata* var. *cretica* l., leaf of *S. umbellata* var. *cretica*; *S. umbellata* var. *cretica* fr., fruit of *S. umbellata* var. *cretica*; *S. subfusca* l., leaf of *S. subfusca*; *S. subfusca* fr, fruit of *S. subfusca*; *S. persica* l., leaf of *S. Persic*; *S. persica* fr., fruit of *S. persica*

Serial dilutions (1/2) were made up to well 10. All strains were grown in MHB medium at 37 °C. After the cultures were adjusted according to the 0.5 McFarland standard, 50 µL of inoculum (5 x 105 CFU mL-1) was applied to all wells except for well 12. Ampicillin (0.98-500 µg/mL) was used as positive control. Plates were incubated at 37 °C. The minimum concentration without growth was considered as the MIC value (Chuah et al., 2014).

RESULTS AND DISCUSSION

Within the scope of the study. *Sorbus* plant species naturally growing in Artvin province of Turkey were collected, and total phenolic content in methanolic extracts using Folin-Ciocalteu's method, total flavonoid content as quercetin equivalent, ferric reducing antioxidant power (FRAP), CUPRAC and Trolox equivalents of antioxidant capacity (TEAC) and antioxidant activity (spectrophotometrically using DPPH free radical scavenging methods) were determined.

Results of the total polyphenol assay showed that the highest antioxidant activity was 25.7 ± 16.49 mg GAE/g sample in *S. persica* pedicle extract while the lowest was 1.53 ± 0.183 mg GAE/g sample in *S. persica* fruit extract. Based on the results of total flavonoid analysis, *S. umbellate* var. *cretica* leaf extract had the highest level of total flavonoids (7.469 ± 0.4926 mg of quercetin/g) whereas the lowest level was measured in *S. persica* fruit extract (0.3940 ± 0.005671 quercetin/g). In terms of FRAP analysis, the highest activity values were measured in *S. persica* leaf extract (6.248 ± 0.2374 µmol $FeSO_4.7H_2O$/g sample) and *S. umbellate* var. *cretica* leaf (6.070 ± 0.3125 µmol $FeSO_4.7H_2O$/g sample). In CUPRAC analysis, the highest activity (164.4 ± 4.209 mmol TEAC/g sample) was observed in *S. umbellata* var. *cretica* leaf extract. Based on the result of the DPPH method, the highest activity was measured in *S. persica* leaf extract as 0.04633 µg/mL, followed by *S. umbellata* var. *cretica* leaf and *S. subfusca* leaf extract*S.* Total polyphenol, total flavonoid, CUPRAC and FRAP results of methanolic extracts are given in Table 2. DPPH results of methanolic extracts are given in Figure 2.

Table 2. Polyphenol and FlavonoidC, FRAP and CUPRAC Results of Plant Samples

Extracts	Total polyphenol amounts (mg GAE/g sample)	Total Flavonoid amount (mg quercetin/g sample)	FRAP test (µmol $FeSO_4.7H_2O$/g sample)	CUPRAC test (mmol TEAC/g sample)
Trolox	-	-	-	-
S. persica fr.	1.530±0.1830	0.3940±0.005671	0.09080±0.004786	21.66±5.859
S. persica fl.	5.470±0.5590	2.766±0.1274	1.362±0.03549	63.23±1.575
S.persica. l.	10.30±3.405	5.807±0.1498	6.248±0.2374	92.54±10.18
S.persica p.	25.70±16.49	1.187±0.02887	1.797±0.08872	72.64±10.82
S. umbellata var. *cretica* fr.	2.450±1.570	0.4213±0.003146	0.03309±0.001155	8.398±0.1761
S. umbellata var. *cretica* l.	13.00±1.267	7.469±0.4926	6.070±0.3125	164.4±4.209
S. subfusca fr	1.570±0.4000	0.6909±0.01287	0.07255±0.002919	15.98±1.435
S.subfusca l.	10.00±1.066	7.147±0.4023	5.322±0.1806	63.93±17.44

Abbreviations: *S. persica* f., fruit of *S. persica*; *S. persica* f., flower of *S. persica*; *S. persica* l., leaf of *S. persica* leaf; *S. persica* p., pedicle of *S. persica*, *S. umbellata* var. *cretica* fr., fruit of *S. umbellata* var. *cretica*; *S. umbellata* var. *cretica* l., leaf of *S. umbellata* var. *cretica*; *S. subfusca* fr., fruit of *S. subfusca*; *S. subfusca* l., leaf of *S. subfusca*.

None of the plant methanolic extracts showed antibacterial activity against *B. subtilis* ATCC 6633, *S. aureus* ATCC 25923 and *S. pyogenes* ATCC 19615 strains in the concentration ranges studied. The MIC values of *S. subfusca* fruit methanolic extract and *S. persica* leaf methanolic extract against *E. coli* ATCC 25922 were 111.5 and 39.5 mg/mL, respectively. *S. umbellate* var. *cretica* fruit methanolic extract was found to have a MIC value of 223.5 mg/mL against *P. aeruginosa* ATCC 43288 and *P. vulgaris* ATCC 13315. *S. subfusca* leaf extract inhibited the growth of *P. aeruginosa* ATCC 43288 with 50 mg/mL MIC value. The MIC value of the *S. subfusca* fruit methanolic extract against *P. vulgaris* ATCC 13315 was 111.5 mg/mL. MIC results of methanolic extracts are given in Table 3.

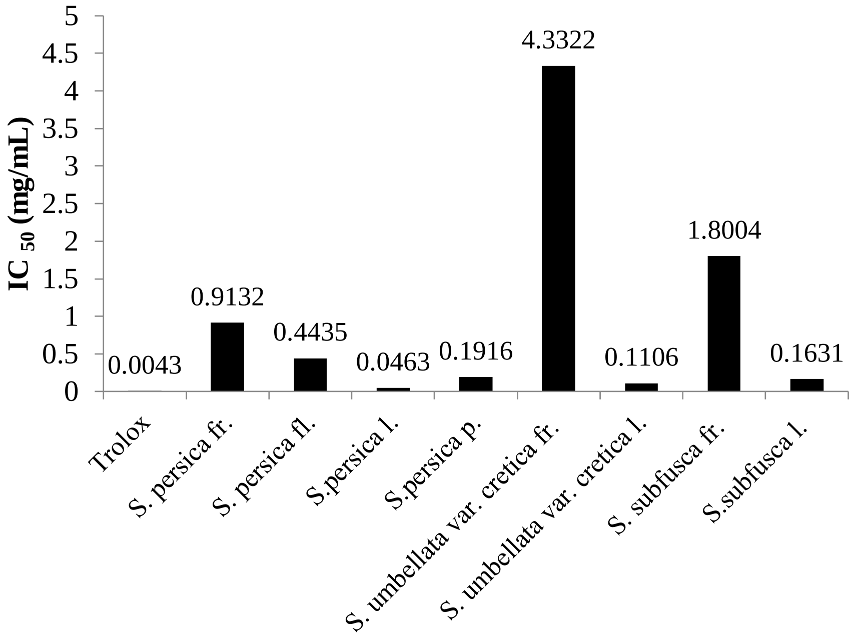

Figure 2. DPPH Results of Plant Samples

Abbreviations: *S. persica* fr., fruit of *S. persica*; *S. persica* fl., flower of *S. persica*; *S. persica* l., leaf of *S. persica* leaf; *S. persica* p., pedicle of *S. persica*, *S. umbellata* var. *cretica* fr., fruit of *S. umbellata* var. *cretica*; *S. umbellata* var. *cretica l.,* leaf of *S. umbellata* var. *cretica*; *S. subfusca* f., *fruit* of *S. subfusca*; *S. subfusca* l., leaf of *S. subfusca*.

Table 3. MIC Values of Plant Methanolic Extracts Against Standard Strains

MIC (mg/mL)							
Methanol extracts							
Standard strains	**1**	**2**	**3**	**4**	**5**	**6**	**Amp**
E. coli ATCC 25922	-	-	-	111.5	39.5	-	0.0078
P. aeruginosa ATCC 43288	-	223.5	50	-	-	-	0.0039
P. vulgaris ATCC 13315	-	223.5	-	111.5	-	-	0.0078
B. subtilis ATCC 6633	-	-	-	-	-	-	0.25
S. aureus ATCC 25923	-	-	-	-	-	-	0.0078
S. pyogenes ATCC 19615	-	-	-	-	-	-	0.0078

Abbreviations: 1: *S. umbellata* var. *cretica* leaf, 2: *S. umbellata* var. *cretica* fruit, 3: *S. subfusca* leaf, 4: *S. subfusca* fruit, 5: *S. persica* leaf, 6: *S. persica* fruit, Amp: Ampicillin

Antioxidant activities of various substances can be evaluated using the scavenging capacity of synthetic radical*S.* In the present study, we identified the free radical scavenging activities of plant extracts using one of the most widely used methods, i.e. DPPH free radical scavenging method. In addition, semi-maximum effective concentration IC_{50} was calculated to measure antioxidant activity. IC_{50} is defined as the efficient sample concentration required to reduce DPPH concentration by 50%. IC_{50} is similar to EC_{50} in biological measurements, and IC_{50} refers to the sample concentration required to reduce radical scavenging activity by 50 % (Çoban et al., 2021). The extract with the lowest IC_{50} values has the largest free radical scavenging activity. Based on the result of the DPPH method, the highest activity was measured in *S. persica* leaf extract as 0,04633 µg/mL and the result was found to be very close to the standard. Total polyphenol, total flavonoid, CUPRAC, FRAP results are given in Table 2 and DPPH results are given in Figure 2. A general evaluation of the results showed that leaf extracts of *S.* p*ersica* pedicle, *S.* p*ersica* leaf and *S. umbellata* var. *cretica* leaf extracts of *S. persica* had higher antioxidant levels and somewhat similar values in all assay*S.*

In a study dealing with methanolic extracts of flowers and leaves of different *Sorbus* species, DPPH IC_{50} values ranged from 15.23 ± 0.54 to 57.86 ± 1.63 g/mL while total polyphenol levels varied between 4.23 ± 0.15 and 11.67 ± 0.05 (GAE%) (Olszewska et al. 2010). Another study with *Sorbus* torminalis found that DPPH EC_{50} values ranged from 53.49 ± 0.65 to 210.6 ± 1.61 µg/mL, total amounts of polyphenols ranged between 2.14 ± 0.10 and 5.75 ± 0.09 (GAE %) (Olszewska et al., 2011). In their study, Hasbal et al. (2015) found that *Sorbus* torminalis methanolic extracts had total phenolic content of 3.83 ± 0.64 (mg/g), total flavonoid content of 1.73 ± 0.612 (mg/g), semi-maximum effective concentration of DPPH (EC_{50}) value of 32.31 ± 2.615 (mg/mL) and ferric reducing antioxidant power (FRAP) value of 0.45 ± 0.020 (mM). Thus, the findings of the present study were compatible with previous studies on *Sorbus* specie*S.*

As a result of their phenolic contents, various *Sorbus* species were reported to have hypoglycemic, diuretic, vasoprotective, anti-inflammatory and antidiarrheal properties (Tahirovic et al., 2019) and antioxidant activities (Hukkanen et al., 2006). Due to the linear relationship between phenolic compounds and antioxidant activity and due to the antioxidant activity and capacity of these compounds to neutralize reactive oxygen types, they are considered to be beneficial in sustaining human health and preventing diseases (Olszewska et al., 2010).

The rapid spread of bacteria with antibiotic resistance and the decreasing success rate against multiple antibiotic resistance in the treatment of infection indicate the importance of medicinal plants to develop antibiotics and use them as alternatives to drug*S.* In this context, the antibacterial activities of three *Sorbus* species, phytogeographically distributed in certain areas in Artvin province, whose antibacterial activities were not previously studied against standard strains, were evaluated in the present study. For this purpose, methanolic extracts were obtained from the leaves and fruits of *S. umbellata* var. *cretica*, *S. subfusca* and *S. persica*. Liquid microdilution method was used to determine the MIC values of methanolic extract*S.* None of the plant methanolic extracts showed antibacterial activity against *B. subtilis* ATCC 6633, *S. aureus* ATCC 25923, *S. pyogenes* ATCC 19615 strains in the concentration ranges studied. *S. subfusc*a fruit methanolic extract and *S. persica* leaf methanolic extract inhibited the growth of *E. coli* ATCC 25922 with 111.5 mg/mL and 39.5 mg/mL MIC values, respectively. *S. umbellata* var. *cretica* fruit methanolic extract inhibited the growth of *P. aeruginosa* ATCC 43288 and *P. vulgaris* ATCC 13315 strain*S. S. subfusca* leaf methanolic extract inhibited the growth of *P.* aeruginosa ATCC 43288 with a MIC value of 50 mg/mL. The MIC of *S. subfusca* fruit methanolic extract against *P. vulgaris* ATCC 13315 was 111.5 mg/mL. Ampicillin was used as a control in the antibacterial activity assay. Ampicillin appeared to have lower MIC values than plant methanolic extract*S.* This indicates that plant methanolic extracts have antibacterial activity at higher concentration*S.* There is no consensus over the acceptable level of inhibition when comparing natural products to antibiotic standard*S.* Some authors found that natural products are effective only when they have inhibition levels similar to antibiotic*S.* However, others considered the compounds to be effective at lower levels of inhibition than normal levels observed with commercial antimicrobials (Silva et al., 2011).

Based on these findings, it can be stated that the plant methanolic extracts evaluated in the present study have antibacterial effect*S.* Studies were conducted to evaluate the antibacterial activity of extracts of *Sorbus* specie*S.* In a study conducted by Liepina et al. (2013) with *S. orbussibirica*, it was determined that the plant extract had an antibacterial effect on *Bacillus* cereus and *Staphylococcus* aureus strains, but not against *Escherichia coli* strain*S.* Trumtay et al. (2017) evaluated *S. caucasica* and *S. aucuparia* and found that while *S. caucasica* leaf extract had an effect on *P. aeruginosa*, it did not affect *E. coli* or *Typhimurium* strain*S.* They also revealed that the fruit content of *S. aucuparia* did not affect the *S. typhimurium* strain, but was effective on *E. coli* and *P. aeruginosa*. The results obtained in the present study showed that *Sorbus* species have antibacterial activity against Gram-positive and Gram-negative strain*S.*

CONCLUSION

Antioxidants obtained from plants have been the subject of many studies in recent years due to their positive effects on human health and because they have stronger antioxidant properties compared to the synthetic antioxidants used in food*S.* It could be stated that *Sorbus* species collected from Artvin province in the present study have the capacity to be natural antioxidant*S. In vitro* efficacy of combinations of *Sorbus* extracts with commercial antibiotics could be investigated against antibiotic resistant strains in future studies, which may contribute to combating antibiotic resistance.

ACKNOWLEDGEMENTS

This work was supported by a grant from the Scientific Research Project of Artvin Çoruh University of Turkey Grant Number: BAP. 2017.F80.02.02.

Conflict of Interest

The article authors declare that there is no conflict of interest between them.

Author's Contributions

The authors declare that they have contributed equally to the article.

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