SAKARYA ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ DERGİSİ

Sakarya University Journal of Science
SAUJS

ISSN 1301-4048 e-ISSN 2147-835X Period Bimonthly Founded 1997 Publisher Sakarya University
http://www.saujs.sakarya.edu.tr/

Title: Survay Study of Antimicrobial Activities of Different Region Honeys in Turkey

Authors: Mehtap USTA

Recieved: 2023-04-15 00:00:00

Accepted: 2023-06-05 00:00:00

Article Type: Research Article

Volume: 27
Issue: 4
Month: August
Year: 2023
Pages: 920-929

How to cite
Mehtap USTA; (2023), Survay Study of Antimicrobial Activities of Different Region Honeys in Turkey. Sakarya University Journal of Science, 27(4), 920-929, DOI: 10.16984/saufenbilder.1284027
Access link
https://dergipark.org.tr/en/pub/saufenbilder/issue/79486/1284027

Sakarya University Journal of Science 27(4), 920-929, 2023

Survay Study of Antimicrobial Activities of Different Region Honeys in Turkey

Mehtap USTA *1

Abstract

Honey is a functional food with high nutritional properties and rich in bioactive components. The fact that the biological activity of honey differs according to botanical origin, geography and climatic characteristics necessitates a comprehensive consideration of monofloral and multifloral honeys produced in Turkey. The adoption of the understanding of replacing natural preservatives with synthetic products enables the search for alternative uses of honey. For this purpose, the antimicrobial activities of linden, rhododendron, chestnut and multifloral honeys were determined in this study and their antimicrobial activities were compared. Obtained zone diameters were statistically compared with the IBM SPSS version 22.0 statistical program. According to the results, it was determined that in general, multifloral honey has higher antimicrobial activity than monofloral honey, rhododendron honey from monofloral honeys shows strong inhibition against the tested microorganisms, and Yalova linden honey has the weakest antibacterial effect. It was determined that the antimicrobial activity in all honey varieties was generally bacteria > yeast > mold respectively.

Keywords: Antimicrobial activity, honey, microbiology, monofloral, multifloral

1. INTRODUCTION

Honey is a highly nutritious food produced by bees using pollen and plant secretions. Although it varies depending on the variety of plants obtained, it is known that there are over 200 compounds in honey. While sugars constitute 95% of the dry matter as the basic component, the rest is composed of proteins, free amino acids, phenolic compounds, vitamins, minerals and organic acids. It has been stated that the amount and variety of minor components also vary according to bee species, seasonal and environmental factors [1-5].

Scientific studies have reported that honey has antioxidant, antidiabetic, antimicrobial, anti-inflammatory, antiproliferative, anticancer and antimetastatic effects, which are important for human health, thanks to its many bioactive components [6-17]. It is stated that its antimicrobial activity is due to its biological properties, hydrogen peroxide, osmolarity, acidity, aromatic acids and phenolic compounds [18, 19].

In studies examining the antibacterial effect, it has been reported that honey has an inhibitory effect on approximately 60 species of Gram-negative and Gram-positive bacteria with aerobic/anaerobic properties [20].

* Corresponding author: mehtapyakupoglu@trabzon.edu.tr (M. USTA)
[1] Trabzon University, Tonya Vocational School
ORCID: https://orcid.org/0000-0001-7656-5655

Among the reported bacterial species, it was determined that it showed broad-spectrum activity on antibiotic-resistant strains, and honey had a bactericidal effect, especially on methicillin-resistant *Staphylococcus aureus* (MRSA). It has also been reported to be effective on clinical strains of biofilm-forming *Staphylococcus aureus* and *Pseudomonas aeruginosa* [21]. However, many *Candida* spp., *Trichosoporon* spp. and antifungal activity against mold species (*Fusarium oxysporum*, *Cladosporium herbarum*, *Botrytis cinerea*, *Aspergillus flavus*) [22-24].

Honeys are named according to the plant source from which they are obtained and its diversity, geography and production methods. Generally, it is divided into two as flower and secretion honey according to the way the nectar is obtained. Flower honeys are called monofloral and multifloral according to the floral sources they contain. Monofloral honeys are preferred by today's consumers because of their different tastes and the biological benefits they provide. Since minor components such as aromatic and phenolic compounds, to which antimicrobial activity and other biological benefits are attributed, vary according to the floral source, different monofloral honeys are available for various uses [25].

Turkey is extremely suitable for the production of different kinds of monofloral honeys due to its favorable ecology, rich vegetation and faunistic diversity. Among these, chestnut, linden, rhododendron, thyme, lavender and citrus honeys are among the honeys whose production has become increasingly widespread from past to present [26]. When the studies on this subject are examined, the determination of the inhibition zone and the Minimum Inhibition Concentration (MIC) is generally focused on determining the antimicrobial activities of multifloral and monofloral honeys.

In this study, it was aimed to determine the antimicrobial activities of monofloral honeys such as rhododendron, chestnut, linden and multifloral honey, which are known to be widely produced in Turkey, as well as the inhibition zone and MIC value, as well as the Minimum Bacterial/Fungicidal Honeys that have a killing effect on microorganisms. Concentrations (MBK/MFK) were also determined.

2. MATERIALS AND METHODS

2.1. Materials

In this study, 25 different flower honey and chestnut honey from 5 different regions were used. The flower and chestnut honeys used in the experiment were obtained from beekeepers in different regions of Turkey (Gümüşhane, Artvin, Ordu, Rize, Isparta, Bingöl, Bursa, Erzincan, Aydın, Ardahan, Kars, Yalova). It has been confirmed by beekeepers that flower honeys are linden, rhododendron and multifloral. Honey samples were stored in the dark and at room temperature until the beginning of the analysis.

2.2. Methods

2.2.1. Test microorganisms and Inoculums Preparation

The antimicrobial properties of honey were tested on the bacteria and yeast given in Table 1. Bacteria (Mueller Hinton Broth) and yeast (Sabouraud Dextrose Broth) was adjusted to 0.5 McFarland turbidity with appropriate medium after 24 hours of incubation at 37°C and 25°C, respectively.

2.2.2. Agar well diffusion method

100 µL of set inoculum; Mueller Hinton Agar (MHA) for bacteria and SDA medium for yeast were transferred to the surface and spread with a drigalski spatula. 50 µL of 70% (v/v) honey sample was added to the wells opened sterilely with a 5 mm diameter tip

(Magaldi et al. 2004, Valgas et al. 2007). Bacteria were incubated at 37°C for 24 hours and yeast at 25°C for 48 hours for 3 to 5 days. The inhibition zone diameters (mm) formed were measured. Sterile water was used as negative control. Kanamycin was used as a positive control.

Table 1 Test microorganisms used for the antimicrobial activity

Microorganism	**Bacteria/Fungus/Yeast**
Bacillus subtilis ATCC 6051-U	Bacteria
Enterobacter cloacae ATCC 2468	Bacteria
Enterococcus feacalis ATCC 51299	Bacteria
Escherichia coli ATCC 2471	Bacteria
Klepsiella pneumonia ATCC 700603	Bacteria
Proteus vulgaris ATCC 6896	Bacteria
Salmonella typhimurium ATCC 13311	Bacteria
Serretia marcescens ATCC 13880	Bacteria
Staphylococcus epidermis ATCC 14990	Bacteria
Candida albicans ATCC 10351	Yeast
Penicillium italicum ATCC 10454	Fungus

2.2.3. Liquid microdilution method

Each honey sample was adjusted to nine different doses in the range of 10-90% (v/v) with sterile water and 180 µL sample was transferred to the microplate. Inoculum prepared in 0.5 McFarland turbidity standard was diluted 1:20 and added to the microplate with 20 µL of inoculum [27, 28]. Bacteria were incubated for 18-24 hours at 37°C, yeast and fungus were incubated for 46-72 hours, and the microorganism density was measured at 600 nm with a microplate reader.

2.2.4. Statistical analysis

Zone diameters are given as mean ± standard deviation. The obtained zone diameters were statistically compared with the IBM SPSS version 22.0 statistical program. First of all, it was tested whether the data fit the normal distribution (Shapiro-Wilk Test), then the statistical difference in the data conforming to the normal distribution was determined by applying the one-way ANOVA analysis, which is a parametric test, and the Duncan multiple comparison test. The Kruskall Wallis H test was used for data that did not fit the normal distribution, and the Mann Whitney U test was used to determine the difference between the groups.

3. RESULTS AND DISCUSSION

Inhibition zones formed by honey samples on bacteria, yeast and fungus are given in Table 2. Accordingly, it was seen that all honey samples exhibited antibacterial and antifungal activity on the selected microorganisms, and the results of both methods used were consistent with each other. It was determined that the effects of honey varieties on different microorganisms were statistically different ($p<0.001$).

In this study, the antimicrobial effect of 11 different microorganisms against 25 different types of honey were tested. Microorganisms *Bacillus subtilis* ATCC 6051-U, *Enterobacter cloacae* ATCC 2468, *Enterococcus feacalis* ATCC 51299, *Escherichia coli* ATCC 2471, *Klepsiella pneumonia* ATCC 700603, *Proteus vulgaris* ATCC 6896, *Salmonella typhimurium* ATCC 133113880 *Staphylococcus epidermis*, ATCC 10351 and *Penicillium italicum* ATCC 10454. Honey samples, obtained from the regions where the beekeeping industry is developed, representing different regions of Turkey. These honey samples are multifloral, chestnut, rhododendron from Gümüşhane, multifloral and chestnut from Artvin, multifloral and rhododendron from Ordu, chestnut and linden from Rize, linden and multifloral from Isparta, multifloral and linden from Bingöl, Chestnut and linden from Bursa, multifloral and chestnut from Erzincan, linden and multifloral from Aydın, linden and multifloral from Ardahan, linden and chestnut from Kars and multifloral and linden from Yalova. In particular, the same type of honey was tried to be selected. It is aimed to see the differences of the same type of honey according to the region. Considering these results, the highest rate for Bacillus subtilis seems to be for G. Rhododendron. For Enterobacter cloacea, the highest rate was seen for G. Rhododendron again. Enterecoccus feacalis gave the highest rate for G. Multifloral. Escherichia coli gave the highest rate for G. Rhododendron. Klepsiella pneumonia gave the highest rate for O. Rhododendron. Pretous vulgaris gave the highest rate for G. Multifloral. Salmonella typhium gave the highest rate in R. Linden honey. Serretia marcescens gave the highest rate in O. Multifloral honey. Staphylococcus epidermis bacteria gave the highest rate in O. Multifloral honey. Candida albicans yeast gave the highest rate for O. Rhododendron honey. Penicillium italicum gave the highest rate for I. Linden honey. It was determined that antibacterial properties between honeys did not cause a significant difference between gram properties of bacteria ($p<0.001$).

The abbreviations of the honey names in the table are as follows: G. Multifloral: Gümüşhane Multifloral, G. Chestnut: Gümüşhane Chestnut, G. Rhododendron: Gümüşhane Rhododendron, Art. Multifloral: Artvin Multifloral, Art. Chestnut: Artvin Chestnut, O. Multifloral: Ordu Multifloral, O. Rhododendron: Ordu Rhododendron, R. Chestnut: Rize Chestnut, R. Linden: Rize Linden, I. Linden: Isparta Linden, I. Multifloral: Isparta Multifloral, B. Multifloral: Bingöl Multifloral, B. Linden: Bingol Linden, Bu. Chestnut: Bursa Chestnut, Bu. Linden: Bursa Linden, E. Multifloral: Erzincan Multifloral, E. Chestnut: Erzincan Chestnut, Ay. Linden: Aydin Linden, Ay. Multifloral: Aydın Multifloral, Ar. Linden: Ardahan Linden, Ar. Multifloral: Ardahan Multifloral, K. Linden: Kars Linden, K. Chestnut: Kars Linden, Y. Multifloral: Yalova Multifloral, Y. Linden: Yalova Linden.

Among the honeys used in this study, except for multifloral honey, the antimicrobial effect was found to be bacteria > yeast > mold, respectively ($p<0.001$). In this respect, it can be said that the antibacterial activity of monofloral honey is higher than its antifungal property. MIC, MBK and MFK values of honey are given in Table 3. It was observed that 10-60% (v/v) concentrations of honey samples were sufficient to inhibit all bacteria. These results emphasize that it is similar to the agar well diffusion method. According to the results of the liquid microdilution analysis, MIC values were listed as mold > yeast > bacteria, and molds were seen to be the most resistant group of microorganisms. This result supports the agar well diffusion method. As a result of both antimicrobial and MIC tests, it is seen that the most effective samples are those obtained from Gümüşhane.

Table 2 Inhibition zone diameter of honey samples on test microorganisms (mm)

	Bacillus subtilis ATCC6051U	*Enterobacter cloacae* ATCC2468v	*Enterococcus feacalis* ATCC51299	*Escherichia coli* ATCC2471	*Klepsiella pneumonia* ATCC700603	*Proteus vulgaris* ATCC6896	*Salmonella typhimurium* ATCC13311	*Serretia marcescens* ATCC13880	*Staphyloccus epidermis* ATCC14990	*Candida albicans* ATCC10351	*Penicillium italicum* ATCC10454
G. Multifloral	15.46±0.66^{ab}	17.26±0.61^{bc}	22.30±0.55^{e}	20.20±0.58^{d}	16.36±0.57^{b}	23.26±0.54^{ef}	18.23±0.60^{c}	17.10±0.40^{bc}	19.00±0.75	14.26±0.54^{ab}	15.03±0.17^{ab}
G. Chestnut	18.10±0.78^{c}	17.30±0.51^{bc}	19.10±0.56^{dc}	22.33±0.54^{e}	18.20±0.51^{c}	18.10±1.19^{c}	18.00±0.57^{c}	18.10±0.41^{c}	20.06±0.52	15.16±0.61^{ab}	17.00±0.57^{bc}
G. Rhododendron	22.03±0.53^{e}	24.90±0.49^{f}	23.20±0.60^{ef}	24.33±0.57^{f}	20.33±0.33^{d}	18.26±0.55^{c}	19.10±0.62^{dc}	17.33±0.75^{bc}	17.96±0.57^{bc}	16.30±0.47^{b}	14.26±0.40^{ab}
Art. Multifloral	14.06±0.67^{ab}	14.96±0.50^{ab}	17.00±0.69^{bc}	16.00±0.57^{d}	20.26±0.37^{d}	21.43±0.29^{de}	19.00±0.72^{dc}	19.20±0.55^{dc}	21.43±0.29de	13.90±0.45^{a}	13.43±0.29^{a}
Art. Chestnut.	20.53±0.24^{d}	21.83±0.44^{de}	22.90±0.45^{e}	19.03±0.17^{dc}	21.63±0.28^{de}	17.26±0.08^{bc}	16.96±0.24^{b}	19.36±0.31^{dc}	20.26±0.08^{d}	16.10±0.15^{b}	14.70±0.86^{ab}
O. Multifloral	17.33±0.12^{bc}	17.30±0.26^{bc}	16.80±0.11^{b}	16.86±0.28^{b}	20.93±0.27^{d}	19.23±0.08^{dc}	21.43±0.29^{de}	24.33±0.08^{f}	22.63±0.32^{e}	15.60±0.25^{ab}	15.46±0.32^{ab}
O. Rhododendron	21.70±0.35^{de}	22.80±0.36^{e}	20.80±0.36^{d}	23.60±0.40^{ef}	22.46±0.27^{e}	19.46±0.27^{dc}	19.30±0.05^{dc}	18.66±0.33^{c}	16.96±0.28^{b}	17.76±0.27^{bc}	15.73±0.54^{ab}
R. Chestnut	16.40±0.25^{b}	17.60±0.11^{bc}	20.53±0.29^{d}	18.33±0.33^{c}	18.60±0.11^{c}	22.63±0.24^{e}	21.86±0.33^{de}	19.80±0.30^{dc}	19.33±0.33^{dc}	15.06±0.67^{ab}	14.93±0.58^{ab}
R. Linden	14.50±0.25^{ab}	17.30±0.05^{bc}	17.83±0.08^{bc}	17.96±0.57^{bc}	19.26±0.37^{dc}	21.83±0.41^{de}	22.40±0.05^{e}	20.96±0.08^{d}	16.26±0.08^{b}	14.93±0.27^{ab}	16.20±0.20^{b}
I. Linden	17.06±0.18^{bc}	17.36±0.14^{bc}	17.00±0.11^{bc}	15.93±0.18^{ab}	19.46±0.12^{dc}	20.80±0.11^{d}	17.60±0.40^{bc}	18.33±0.33^{c}	17.83±0.08^{bc}	15.00±0.11^{ab}	17.20±0.36^{bc}
I. Multifloral	21.06±0.18^{de}	19.10±0.47^{dc}	16.56±0.23^{b}	17.63±0.20^{bc}	18.76±0.38^{c}	18.70±0.17^{c}	15.83±0.32^{ab}	16.03±0.27^{b}	14.30±0.25^{ab}	13.73±0.14^{a}	13.50±0.25^{a}
B. Multifloral	19.33±0.23^{dc}	17.90±0.11^{bc}	15.90±0.32^{ab}	16.43±0.28^{b}	16.40±0.34^{b}	14.33±0.37^{ab}	17.50±0.36^{bc}	16.33±0.37^{b}	18.36±0.38^{c}	14.53±0.44^{ab}	16.33±0.43^{b}
B. Linden	15.33±0.35^{ab}	14.40±0.34^{ab}	16.33±0.40^{b}	13.43±0.34^{a}	17.40±0.32^{bc}	17.33±0.37^{bc}	15.33±0.37^{ab}	15.40±0.32^{ab}	14.36±0.40^{ab}	13.36±0.41^{a}	11.20±0.46^{a}
Bu. Chestnut	15.36±0.34^{ab}	14.40±0.34^{ab}	15.36±0.40^{ab}	14.33±0.37^{ab}	14.43±0.44^{ab}	13.33±0.40^{a}	16.33±0.35^{b}	17.50±0.36^{bc}	16.33±0.44^{b}	11.50±0.32^{a}	12.37±0.34^{a}
Bu. Linden	17.53±0.40^{bc}	17.36±0.34^{bc}	19.60±0.61^{dc}	21.66±0.33^{de}	15.53±0.24^{ab}	14.50±0.36^{ab}	17.46±0.35^{bc}	16.60±0.20^{b}	17.33±0.35^{bc}	15.73±0.14^{ab}	14.13±0.24^{ab}
E. Multifloral	16.36±0.34^{b}	15.33±0.35^{ab}	15.33±0.37^{ab}	17.30±0.35^{bc}	17.46±0.40^{bc}	18.46±0.40^{c}	19.36±0.58^{dc}	22.00±0.15^{e}	17.36±0.37^{bc}	16.33±0.35^{b}	16.43±0.35^{b}
E. Chestnut	16.36±0.41^{b}	15.46±0.40^{ab}	17.56±0.43^{bc}	16.50±0.40^{b}	18.40±0.32^{c}	18.46±0.39^{c}	15.70±0.20^{ab}	16.70±0.17^{b}	17.53±0.32^{bc}	15.70±0.20^{ab}	16.53±0.41^{b}
Ay. Linden	18.23±0.46^{c}	19.86±0.43^{dc}	16.56±0.21^{b}	15.66±0.20^{ab}	17.40±0.34^{bc}	20.63±0.18^{d}	22.83±0.08^{e}	21.66±0.33^{de}	16.93±0.17^{c}	16.76±0.14^{b}	14.40±0.32^{ab}
Ay. Multifloral	17.26±0.31^{bc}	17.93±0.06^{bc}	15.53±0.44^{ab}	17.70±0.37^{bc}	16.56±0.53^{b}	16.23±0.28^{b}	16.03±0.14^{b}	18.83±0.08^{c}	20.00±0.17^{d}	15.80±0.11^{ab}	16.93±0.47^{b}
Ar. Linden	18.33±0.88^{c}	19.80±0.11^{dc}	16.46±0.47^{b}	17.53±0.37^{bc}	17.36±0.32^{bc}	16.23±0.31^{b}	16.00±0.20^{b}	16.76±0.26^{b}	18.33±0.35^{c}	14.23±0.39^{ab}	15.00±0.57^{ab}
Ar. Multifloral	14.46±0.35^{ab}	15.63±0.42^{ab}	15.56±0.38^{ab}	16.93±0.63^{b}	16.36±0.34^{b}	18.36±0.34^{c}	19.70±0.51^{dc}	17.40±0.37^{bc}	16.36±0.37^{b}	14.70±0.17^{ab}	14.43±0.31^{ab}
K. Linden	18.90±0.20^{c}	17.80±0.11^{bc}	19.00±0.11^{dc}	19.96±0.14^{dc}	13.40±0.34^{a}	15.46±0.35^{ab}	17.43±0.31^{bc}	18.93±0.21^{c}	14.50±0.36^{ab}	13.83±0.08^{a}	16.26±0.37^{b}
K. Chestnut	17.33±0.33^{bc}	18.96±0.14^{c}	16.36±0.34^{b}	17.30±0.65^{bc}	15.40±0.32^{ab}	14.83±0.41^{ab}	16.40±0.34^{b}	17.33±0.35^{bc}	18.40±0.34^{c}	15.46±0.40^{ab}	14.80±0.50^{ab}
Y. Multifloral	15.80±0.11^{ab}	15.50±0.36^{ab}	16.40±0.36^{b}	14.50±0.36^{ab}	17.53±0.41^{bc}	16.23±0.39^{b}	14.70±0.17^{ab}	18.33±0.35^{c}	16.50±0.25^{b}	11.46±0.43^{a}	13.80±0.11^{a}
Y. Linden	11.06±0.54^{a}	15.46±0.35^{ab}	14.36±0.34^{ab}	13.36±0.37^{a}	16.40±0.34^{b}	17.43±0.43^{bc}	14.33±0.35^{ab}	15.33±0.33^{ab}	16.66±0.33b^{b}	13.33±0.33^{a}	13.33±0.33^{a}

In this study, the antimicrobial effect of 11 different microorganisms against 25 different types of honey were tested. Microorganisms *Bacillus subtilis* ATCC 6051-U, *Enterobacter cloacae* ATCC 2468, *Enterococcus feacalis* ATCC 51299, *Escherichia coli* ATCC 2471, *Klepsiella pneumonia* ATCC 700603, *Proteus vulgaris* ATCC 6896, *Salmonella typhimurium* ATCC 133113880 *Staphylococcus epidermis*, ATCC 10351 and *Penicillium italicum* ATCC 10454. When the antimicrobial results are examined, it is observed that the effects of rhododendron, linden and multifloral honeys obtained from Gümüşhane are high. When all the results are examined, it is seen that the activity of honey from the Black Sea region is high. Of course, it can be said that this is related to the flora of this region.

The antimicrobial activity of honey depends on its acidity, pH, osmotic pressure, and enzymatic hydrogen peroxide production via glucose oxidase. As additional honey components, aromatic acids or phenolic compounds may contribute to the overall antimicrobial activity. The reason for the antibacterial activity observed in various honey samples was classified as four factors. These; inhibition due to high sugar concentration (low water activity), hydrogen peroxide formation, presence of proteinaceous antimicrobial components and unidentified components [29].

It is known that honey has a broad spectrum antimicrobial effect against bacteria and many yeast/mold species [30-33]. In a study examining the antimicrobial activity and mechanism of action of multifloral and monofloral honeys, all bacteria except *P. aeruginosa* ATCC 27853 were found in all honey samples. Antibacterial effects were observed at different concentrations on however, it has been determined that 100% (v/v) concentrations of some multifloral honeys and monofloral honeys provide inhibition on bacteria such as *L. monocytogenes* ATCC 15313, *B. cereus* ATCC 9634 and *Streptococcus mutans* ATCC 25175 [34]. It is thought that hydrogen peroxide and high sugar concentration in the structure of honey are the main factors in providing antimicrobial activity, while phenolic compounds and other component diversity cause honey to show activity in a wide spectrum [1, 35, 36].

In this study, antibacterial and antifungal activity of multifloral honey was found to be higher compared to other honey samples. It is predicted that the diversity of components in multifloral flower honey contributes to the antimicrobial activity and thus has an inhibitory effect on more microorganisms. In the study evaluating the antifungal activities of honeys with different floral sources (multifloral, eucalyptus, orange and rhododendron) on forty different yeast strains including *C.albicans*, *Candida krusei*, *Candida glabrata* and *Trichosoporon*, the MIC value on multifloral flower honey *C. albicans* was 35%. While it was 56 (v/v), MIC values in rhododendron, orange and eucalyptus honeys were reported as 40.00%, 62.22% and 44.44%, respectively [22]. These findings support that the multifloral flower honey in the study showed high antifungal activity compared to other honeys.

Mundo et al., in their microbiological analysis on 27 honey samples from different flora and geographical regions; 7 food spoilage microorganisms (*Alcaligenes faecalis*, *Aspergillus niger*, *Bacillus stearothermophilus*, *Geotrichum candidum*, *Lactobacillus acidophilus*, *Penicillium expansum*, *Pseudomonas fluorescens*) and 5 pathogens that cause food poisoning (*Bacillus cereus*, *Escherichia coli* O157:H7, *Listeria monocytogenes*, *Salmonella enterica*, *Ser. typhimurium*, and *Staphylococcus aureus*) They found that they showed inhibitory properties on staph. Inhibition effect was observed in the samples on aureus. None of the samples inhibited mold growth [29].

Table 3 MIC, MBC and MFC of honey samples (% v/v)

Microorganisms	*Bacillus subtilis* ATCC 6051U	*Enterobacter cloacae* ATCC2 468v	*Enterococcus feacalis* ATCC5 1299	*Escherichia coli* ATCC 2471	*Klepsiella pneumonia* ATCC70 0603	*Proteus vulgaris* ATCC 6896	*Salmonella typhimurium* ATCC1 3311	*Serretia marcescens* ATCC1 3880	*Staphyloccus epidermis* ATCC14 990	*Candida albicans* ATCC1 0351	*Penicillium italicum* ATCC1 0454
G. Multifloral	30	50	40	30	40	50	20	40	50	60	70
G. Chestnut	40	40	30	50	60	30	30	40	50	70	80
G. Rhododendron	50	30	50	60	50	40	40	50	60	60	70
Art. Multifloral	30	40	20	40	30	50	30	40	50	70	90
Art. Chestnut.	20	30	40	50	30	40	50	40	30	50	60
O. Multifloral	20	20	30	40	30	50	30	20	40	60	70
O. Rhododendron	50	40	50	50	60	40	30	20	40	50	60
R. Chestnut	30	20	40	20	30	40	50	40	30	60	70
R. Linden	30	40	20	40	40	30	20	50	60	70	80
I. Linden	40	20	30	50	30	20	50	40	30	60	50
I. Multifloral	20	60	30	40	30	50	20	30	40	50	60
B. Multifloral	30	40	20	40	30	50	40	30	60	70	60
B. Linden	20	10	40	30	50	40	30	20	50	50	60
Bu. Chestnut	20	30	40	30	20	50	40	30	60	60	70
Bu. Linden	20	40	30	30	40	50	60	40	30	50	60
E. Multifloral	20	50	40	30	20	40	30	50	60	50	70
E. Chestnut	50	20	40	40	30	30	20	40	40	60	70
Ay. Linden	30	20	40	40	20	50	40	40	50	60	60
Ay. Multifloral	30	50	20	40	20	40	50	40	50	60	80
Ar. Linden	40	10	30	20	30	40	30	50	30	60	70
Ar. Multifloral	20	40	30	30	40	30	50	50	60	70	80
K. Linden	30	20	40	20	30	40	40	50	50	70	60
K. Chestnut	20	30	50	30	40	10	40	30	50	60	50
Y. Multifloral	20	20	30	40	30	50	40	30	10	50	70
Y. Linden	20	20	30	30	20	40	50	30	60	50	40

4. CONCLUSION

In this study, the highest antimicrobial activity was observed against rhododendron honey obtained from Gümüşhane of *E. coli* with a ratio of 24.33±0.57. The lowest antimicrobial activity was the activity of linden honey obtained from Yalova against *Bacillus subtilis* with a ratio of 11.06±0.54. As it is known, rhododendron honeys are unique to the Black Sea Region and should be consumed in a controlled manner due to their toxic effects. Antibacterial activity is significantly related to the acidity of honey, but is not pH dependent. The antibacterial activity of honey varies depending on the plants from which it is produced rather than the genus of the bee [1].

According to the findings, as stated in the literature, the characteristics of honey, the environment in which it is grown, and the obtained plants are important. In terms of content and medicinal properties, the properties of honey differ according to the obtained plants.

Funding
The author (s) has no received any financial support for the research, authorship or publication of this study.

Authors' Contribution
The authors contributed equally to the study.

The Declaration of Conflict of Interest/ Common Interest
No conflict of interest or common interest has been declared by the authors.

The Declaration of Ethics Committee Approval
This study does not require ethics committee permission or any special permission.

The Declaration of Research and Publication Ethics
The authors of the paper declare that they comply with the scientific, ethical and quotation rules of SAUJS in all processes of the paper and that they do not make any falsification on the data collected. In addition, they declare that Sakarya University Journal of Science and its editorial board have no responsibility for any ethical violations that may be encountered, and that this study has not been evaluated in any academic publication environment other than Sakarya University Journal of Science.

REFERENCES

[1] S. Bogdanov, K. Ruoff, L. Persano Oddo. "Physico-chemical methods for the characterisation of unifloral honeys: A review," Apidologie, vol. 35, no. 1, pp. 4-17, 2004.

[2] E. Mahmoodi-Khaledi, J. Lozano-Sánchez, A. Bakhouche, M. Habibi-Rezaei, I. Sadeghian, A. Segura-Carretero. "Physicochemical properties and biological activities of honeys from different geographical and botanical origins in Iran," European Food Research and Technology, vol. 243, no. 6, pp. 1019-1030, 2017.

[3] S. Samarghandian, T. Farkhondeh, F. Samini. "Honey and Health: A Review of Recent Clinical Research," Pharmacognosy Research, Vol. 9, no. 2, pp. 121-127, 2017.

[4] F. J. Leyva-Jimenez, J. Lozano-Sanchez, I. BorrasLinares, M. L. Cadiz-Gurrea, E. MahmoodiKhaledi. "Potential antimicrobial activity of honey phenolic compounds against Gram positive and Gram negative bacteria," LWT- Food Science and Technology, vol. 101, pp. 236-245, 2018.

[5] E. I. Ramsay, S. Rao, L. Madathil, S. K. Hegde, M. P. Baliga-Rao, T. George, M. S. Baliga. "Honey in oral health and care: A mini review," Journal of Oral Biosciences, vol. 61, pp. 32- 36, 2019.

[6] N. Gheldof, X. H. Wang, N. J. Engeseth. "Buckwheat honey increases serum antioxidant capacity in humans," Journal of Agricultural Food Chemistry, vol. 51, no. 5, pp. 1500-1505, 2003.

[7] R. A. Pérez, M. T. Iglesias, E. Pueyo, M. Gonzalez, C. de Lorenzo. "Amino acid composition and antioxidant capacity of Spanish honeys," Journal of Agricultural Food Chemistry, Vol. 55, no. 2, pp.360-365, 2007.

[8] S. K. Jaganathan, M. Mandal. "Honey constituents and their apoptotic effect in colon cancer cells," Journal of ApiProduct ApiMedical Science, vol. 1, no. 2, pp. 29–36, 2009.

[9] A. N. Fauzi, M. N. Norazmi, N. S. Yaacob. "Tualang honey induces apoptosis and disrupts the mitochondrial membrane potential of human breast and cervical cancer cell lines," Food and Chemical Toxicology, Vol. 49, no. 4, pp. 871- 878, 2011.

[10] R. B. Pimentel, C. A. de Q., da Costa, P. M. Albuquerque, S. D. Junior. "Antimicrobial activity and rutin identification of honey produced by the stingless bee Melipona compressipes manaosensis and commercial honey," BMC Complementary and Alternative Medicine, vol. 13, no. 1, pp. 1-14, 2013.

[11] D. M. Borsato, A. S. Prudente, P. M. Döll-Boscardin, A. V. Borsato, C. F. P. Luz, B. H. L. N. S. Maia, O. G. Miguel. "Topical anti-Inflammatory activity of a monofloral honey of *Mimosa scabrella* provided by *Melipona marginata* during winter in Southern Brazil," Journal of Medicinal Food., vol. 17, no. 7, pp. 817–825, 2014.

[12] O. O. Erejuwa, S. A. Sulaiman, M. S. Wahab. "Effects of honey and its mechanisms of action on the development and progression of cancer," Molecules, vol. 19, no. 2, pp. 2497-522, 2014.

[13] P. M. Kustiawan, S. Puthong, E. T. Arung, C. Chanchao. "In vitro cytotoxicity of Indonesian stingless bee products against human cancer cell lines," Asian Pacific Journal of Tropical Biomedicine, vol. 4, no. 7, pp. 549–556, 2014.

[14] P. V. Rao, K. T. Krishnan, N. Salleh, S. H. Gan. "Biological and therapeutic effects of honey produced by honey bees and stingless bees: A comparative review," Brazilian Journal of Pharmacognosy, vol. 26, no. 5, pp. 657–664, 2016.

[15] M. S. A. Aziz, N. Giribabu, P. V. Rao, N. Salleh. "Pancreatoprotective effects of Geniotrigona thoracica stingless bee honey in streptozotocin-nicotinamide-induced male diabetic rats," Biomedicine & Pharmacotherapy, vol. 89, 135–145, 2017.

[16] P. Saranraj, S. Sivasakthi. "Comprehensive Review on Honey: Biochemical and Medicinal Properties," Journal of Academia and Industrial Research, vol. 6, pp. 165–181, 2018.

[17] V. C. Nolan, J. Harrison, J. A. G. Cox. "Dissecting the Antimicrobial Composition of Honey," Antibiotics, vol. 8, no. 4, pp. 251, 2019.

[18] P. C. Molan. "The antibacterial activity of honey: 1. The nature of the antibacterial activity," Bee World, vol. 73, no. 1, pp. 5-28, 1992.

[19] S. Anand, M. Deighton, G. Livanos, P. D. Morrison, E. C. K. Pang, N. Mantri. "Antimicrobial activity of Agastache Honey and characterization of its bioactive compounds in comparison with important commercial honeys," Frontiers in Microbiology, vol. 10, pp. 269- 285, 2019.

[20] V. Bansal, B. Medhi, P. Pandhi. "Honey–a remedy rediscovered and its therapeutic utility," Kathmandu University Medical Journal, vol. 3, no. 3, pp. 305–309, 2005.

[21] R. Wang, M. Starkey, R. Hazan, L. G. Rahme. "Honey's ability to counter bacterial infections arises from both bactericidal compounds and QS inhibition," Frontiers in Microbiology, vol. 3, pp. 144-150, 2012.

[22] A. N. Koc, S. Silici, B. D. Ercal, F. Kasap, H. T. Hörmet- Öz, H. Mavus-Buldu. "Antifungal activity of Turkish honey against *Candida* spp. and *Trichosporon* spp: an in vitro evaluation," Sabouraudia, vol. 47, no. 7, pp. 707-712, 2009.

[23] M. Candiracci, B. Citterio, E. Piatti. "Antifungal activity of the honey flavonoid extract against *Candida*

albicans," Food Chemistry, vol. 131, no. 2, pp. 493 – 499, 2012.

[24] H. Zafar, M. S. Israili. "Antimicrobial Properties of Honey," American Journal of Therapeutics, vol. 21, no. 4, pp. 304-323, 2014.

[25] J. M. Alvarez-Suarez, S. Tulipani, S. Diaz, Y. Estevez, S. Romandini, F. Giampieri, P. Damiani, S. Astolfi, S. Bompadre, M. Batting. "Antioxidant and antimicrobial capacity of several monofloral Cuban honeys and their correlation with colour, polyphenol content and others chemical compounds," Food and Chemical Toxicology, vol. 48, pp. 2490- 2499, 2010.

[26] Ö. Seçmen, Y. Gemici, G. Görk, L. Bekat, E. Leblebici. "Systematic of seeded plants," Bornova, İzmir: Ege Üniversitesi, Faculty of Science Publications, vol. 116. pp. 396, 2000.

[27] M. Balouiri, M. Sadiki, S. K. Ibnsouda. "Methods for *in vitro* evaluating antimicrobial activity: A review," Journal of Pharmaceutical Analysis, vol. 6, no. 2, pp. 71-79, 2016.

[28] I. Wiegand, K. Hilpert, R. E. Hancock. "Agar and broth dilution methods to determine the minimal inhibitory concentration (MIC) of antimicrobial substances," Nature Protocols., vol. 3, no. 2, pp. 163-175, 2008.

[29] M. M. Mundo, O. I. Padılla-Zakour, R. W. Worobo. "Growth inhibition of foodborne pathogens and food spoilage organisms by select raw honeys," International Journal of Food Microbiology, vol. 97, pp. 1–8, 2004.

[30] Ö. Ertürk, H. Şahin, S. Kolaylı, M. Ç. Ayvaz. "Antioxidant and antimicrobial activity of East Black Sea Region honeys," Turkish Journal of Biochemistry/Turk Biyokimya Dergisi, vol. 39, no. 1, pp. 99-106, 2014.

[31] J. Irish, D. A. Carter, T. Shokohi, S. E. Blair. Honey has an antifungal effect against *Candida* species," Medical Mycology, vol. 44, no. 3, pp. 289-291, 2006.

[32] M. D. Mandal, S. Mandal. Honey: its medicinal property and antibacterial activity," Asian Pacific Journal of Tropical Biomedicine, vol. 1, no. 2, pp. 154-160, 2011.

[33] P. J. Taormina, B. A. Niemira, L. R. Beuchat. "Inhibitory activity of honey against foodborne pathogens as influenced by the presence of hydrogen peroxide and level of antioxidant power," International Journal of Food Microbiology, vol. 69, no. 3, pp. 217-225, 2001.

[34] J. J. Gallardo-Chacón, M. Caselles, M. IzquierdoPulido, N. Rius. "Inhibitory activity of monofloral and multifloral honeys against bacterial pathogens," Journal of Apicultural Research, vol. 47, no. 2, pp. 131-136, 2008.

[35] K. L. Allen, P. C. Molan, G. M. Reid. "A survey of the antibacterial activity of some New Zealand honeys," Journal of Pharmacy and Pharmacology,vol. 43, no. 12, pp. 817-822, 1991.

[36] Jr. J. W. White, M. H. Subers, A. I. Schepartz. "The identification of inhibine, the antibacterial factor in honey, as hydrogen peroxide and its origin in a honey glucose-oxidase system," Biochimica et Biophysica Acta (BBA)- Specialized Section on Enzymological Subjects, vol. 73, no. 1, pp. 57-70, 1963.