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Assessment of the Antimicrobial Effect of Honey on *Listeria monocytogenes* Strains

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ABSTRACT
This study aimed to determine the antimicrobial effects of different honey types against *Listeria monocytogenes* strains. The antimicrobial activity of 40 honey samples, collected from different provinces of Türkiye and categorized as filtered floral honey, comb floral honey, acacia honey, and pine honey, was evaluated against 29 *L. monocytogenes* strains using the well diffusion method. The inhibition zone diameters formed by honey samples at 100% and 50% concentrations against *L. monocytogenes* strains ranged from 0.0 to 4.8 cm. The average inhibition zone diameter of the 100% honey samples was found to be 3.54 cm, while the average inhibition zone diameter of the 50% concentration was 3.30 cm. The 100% concentration of honey samples has higher antimicrobial activity, and when the honey samples are diluted, the antimicrobial activity decreases. Pine honey exhibited the highest antimicrobial activity in this study. Following pine honey, the antimicrobial effects decreased in the following order: filtered flower honey, comb flower honey, and acacia honey.

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Balın *Listeria monocytogenes* Suşları Üzerindeki Antimikrobiyal Etkisinin Değerlendirilmesi

ÖZET
Bu çalışma, farklı bal türlerinin *Listeria monocytogenes* suşlarına karşı antimikrobiyal etkilerini belirlemeyi amaçlamıştır. Türkiye'nin çeşitli illerinden toplanan ve süzme çiçek balı, petek çiçek balı, akasya balı ve çam balı olarak sınıflandırılan 40 bal örneğinin antimikrobiyal aktivitesi, 29 *L. monocytogenes* suşuna karşı kuyucuk difüzyon yöntemi kullanılarak değerlendirilmiştir. *L. monocytogenes* suşlarına karşı %100 ve %50 konsantrasyonlardaki bal örneklerinin oluşturduğu inhibisyon zon çapları 0,0 ile 4,8 cm arasında değişmiştir. %100 bal örneklerinin ortalama inhibisyon zon çapı 3,54 cm, %50 konsantrasyonda ise 3,30 cm olarak bulunmuştur. %100 konsantrasyondaki bal örneklerinin daha yüksek antimikrobiyal aktivite gösterdiği ve bal örnekleri seyreltilince bu etkinin azaldığı belirlenmiştir. Bu çalışmada en yüksek antimikrobiyal aktivite çam balında gözlemlenmiştir. Çam balını sırasıyla süzme çiçek balı, petek çiçek balı ve akasya balı takip etmiştir.

Mikrobiyoloji

Araştırma Makalesi

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Anahtar Kelimeler
Listeria monocytogenes
Antimikrobiyal aktivite
Kuyu difüzyon yöntemi
Bal

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INTRODUCTION
Each year, approximately 600 million people worldwide fall ill due to the consumption of contaminated food, with approximately 420,000 of these cases resulting in death. Similarly, around 125,000 children under the age of five die annually as a consequence of consuming contaminated food (Anonymous, 2024). Foodborne diseases caused by various pathogens pose a significant threat to public health and food safety in contemporary society. Pathogens such as *Salmonella* spp., *Staphylococcus aureus*, *Listeria monocytogenes*, *Escherichia coli*, *Clostridium botulinum*, *Campylobacter jejuni*, and *Vibrio parahaemolyticus* are frequently isolated from food sources and are known to

adversely affect human health (Istanbullugil et al., 2023). Among these, *L. monocytogenes* holds particular importance as it is responsible for listeriosis infections. Gastrointestinal symptoms such as headache, abdominal pain, fever, and vomiting are commonly observed in listeriosis cases. However, in individuals with compromised or suppressed immune systems, such as pregnant women, the elderly, infants, and patients with AIDS or cancer, *L. monocytogenes* can lead to severe complications, including meningitis, miscarriage, neonatal death, and septicemia, which may ultimately result in mortality (Grigore-Gurgu et al., 2024).

L. monocytogenes is commonly found in nature and, consequently, is frequently encountered in food and food processing environments. It can be isolated from soil, animal feed, water, feces of mammals and birds, raw foods, meat and meat products, poultry and their products, raw milk, and dairy products. This widespread presence enables it to cause contamination at various stages of food production, storage, and distribution (Zamuz et al., 2021). *L. monocytogenes* is characterized as a bacterium resistant to adverse environmental conditions. It can survive and proliferate even under conditions designed to control the microbial load of food, such as drying, cold storage, freezing, and increasing acidity. This pathogen is capable of growth within a temperature range of 0–45°C and thrives across a broad pH spectrum (4.4–9.4). Furthermore, it can survive and multiply in environments with high water activity (above 0.92) and in saline conditions (Orsi et al., 2011; Aktop et al., 2020; Taylor & Zhu, 2021).

Various methods are employed in food processing and preservation to control microbial growth, while also maintaining the nutritional properties and sensory quality of food. Commonly used techniques include thermal processing, reduction of water activity, the use of antimicrobial substances, application of antioxidants, cold storage, freezing, irradiation, and modified atmosphere packaging (Dweh et al., 2024). However, contemporary consumer preferences have shifted toward natural, healthy, and minimally processed foods. Consequently, the food industry has begun exploring alternative methods to prevent contamination by pathogenic microorganisms (Ariyamuthu et al., 2022). For centuries, honey has been valued not only as a food but also as a natural medicine and food preservative. Recent research has further validated its beneficial bioactive effects on human health (Tsadila et al., 2021).

Honey plays a significant role in human health due to its antimicrobial, antioxidant, and anti-inflammatory properties, attributed to its rich bioactive components. Extensive research has highlighted honey's broad-spectrum antimicrobial effects, including antibacterial, antifungal, antimycobacterial, and antiviral activities (Çınar, 2020; Ali et al., 2023). These properties have been confirmed through numerous in vitro studies and a limited number of clinical trials (Istanbullugil et al., 2023). Honey, containing over 200 components, has been used since ancient times in the treatment of various diseases and exhibits antimicrobial activity against many pathogenic microorganisms. Honey is primarily composed of carbohydrates. Additionally, it contains small quantities of proteins, amino acids, phytochemicals, and enzymes derived from plants and bees, such as glucose oxidase and catalase (Tsadila et al., 2021). Honey's antibacterial activity can be attributed to several factors, including the production of hydrogen peroxide, its high sugar concentration, low pH, low water activity, phenolic compounds, and flavonoids. (Bayrak, 2005; Brudzynski et al., 2012; Doğan, 2014). Poltorak et al. (2018) demonstrated that incorporating honey into sausage production reduces microbial load. Similarly, Çınar (2020) reported that multifloral honeys exhibit greater antimicrobial activity than monofloral honeys. Among monofloral honeys, lemon blossom honey was found to have the highest antimicrobial activity, followed by lavender and thyme honeys. Yalazi & Zorba (2020) investigated honeydew honeys from the Kazdağları region and found that they exhibited very low or low antimicrobial activity against *E. coli*, *S. aureus*, and *S.* Typhimurium. However, these honeys showed no antimicrobial effect against *C. albicans*, *S. cerevisiae* yeast strains, or *B. cereus* bacteria.

Different honey samples exhibit varying levels of antimicrobial activity against *L. monocytogenes* strains (Çam, 2006). Ertürk et al. (2009) found that "mad honey" obtained from *Rhododendron* (rosebay) demonstrated antimicrobial effects against *L. monocytogenes*. Similarly, Silici et al. (2010) reported that 50 honey samples at 50% and 75% concentrations showed moderate inhibition against *L. monocytogenes* strains. Polat (2011) observed that pine, davulga, and heath honeys produced in the Southern Marmara region exhibited antimicrobial activity against *L. monocytogenes* at concentrations of 40% or higher (100%, 80%, 60%, 40%, and 20%). Sousa et al. (2016) noted that 24 honey samples showed low antimicrobial activity against *L. monocytogenes* strains isolated from food products. According to Çınar (2020), multifloral honeys exhibited higher antimicrobial activity compared to monofloral honeys, such as lavender, lemon blossom, and thyme honeys. Among monofloral types, lemon blossom honey was identified as the most effective, demonstrating moderate antimicrobial activity against *L. monocytogenes*.

The aim of this study is to evaluate the antimicrobial effects of solutions prepared at different concentrations from honey samples, obtained directly from primary producers and available in the market, against *L. monocytogenes* strains that were previously isolated from ready-to-eat foods and identified using molecular methods.

MATERYAL and METOD

Honey Samples

In this study, 40 honey samples were categorized into four groups: filtered floral honey (FFH), comb floral honey (CFH), acacia honey (AH), and pine honey (PH). These samples were obtained from primary producers in the provinces of Ankara, Adana, Artvin, and Mersin in Türkiye (Table 1).

Table 1. Honey samples used in the study and their provinces of origin
Çizelge 1. Çalışmada kullanılan bal örnekleri ve menşei illeri

Honey code numbed	Honey type	Province of Origin	Honey code numbed	Honey type	Province of Origin	Honey code numbed	Honey type	Province of Origin
1	FFH	Ankara	15	FFH	Ankara	29	FFH	Adana
2	CFH	Ankara	16	AH	Ankara	30	FFH	Adana
3	FFH	Ankara	17	PH	Ankara	31	FFH	Adana
4	FFH	Ankara	18	FFH	Ankara	32	CFH	Adana
5	CFH	Ankara	19	FFH	Ankara	33	CFH	Adana
6	FFH	Ankara	20	FFH	Ankara	34	CFH	Adana
7	FFH	Ankara	21	FFH	Artvin	35	CFH	Mersin
8	FFH	Ankara	22	FFH	Artvin	36	CFH	Mersin
9	FFH	Ankara	23	FFH	Artvin	37	CFH	Mersin
10	AH	Ankara	24	FFH	Artvin	38	PH	Mersin
11	PH	Ankara	25	PH	Adana	39	PH	Mersin
12	FFH	Ankara	26	FFH	Adana	40	FFH	Mersin
13	FFH	Ankara	27	PH	Adana			
14	AH	Ankara	28	PH	Adana			

FFH: Filtered Floral Honey; CFH: Comb Floral Honey; AH: Acacia Honey; PH: Pine Honey

Listeria monocytogenes and Reference Strains

In the study, 29 *L. monocytogenes* strains, which were previously isolated from ready-to-eat foods and molecularly identified, were used as bacterial cultures. All *L. monocytogenes* strains and the *L. monocytogenes* ATCC 7644 reference strain were obtained from the culture collection of the Department of Food Engineering, Faculty of Engineering, Ankara University.

Preparation of Stock Cultures

The reference bacterium and *L. monocytogenes* strains were prepared as stock cultures in Brain Heart Infusion (BHI) broth and Tryptic Soy Broth (TSB) medium containing 20% sterile glycerol. The stock cultures were stored at -20°C. Throughout the study, the cultures were developed in TSB and/or BHI broth at 37°C for 18 hours before being used as working materials.

Preparation of Bacterial Cultures

In this study, a single colony of *L. monocytogenes* was first obtained by streaking on Tryptic Soy Agar (TSA) plates to isolate a pure culture. After 24 hours of incubation at 37°C, single colonies were selected using a sterile loop and transferred into 5 mL of TSB, then incubated for 24 hours at 37°C. After incubation, 100 µL of the culture was transferred to 10 mL of TSB, followed by another 24 hours of incubation at 37°C. After the final enrichment step, 100 µL of the culture was again transferred to 10 mL of TSB and incubated for 24 hours at 37°C. The microorganisms were then adjusted to a turbidity value of 0.5 McFarland (approximately 10^8 CFU/mL).

Comparison of Honey Samples and Pathogens Cultured Under *In Vitro* Conditions

The well diffusion method, modified from Bauer et al. (1966), was used to determine the antimicrobial efficacy of the selected honey samples against the *L. monocytogenes* strains. *L. monocytogenes* cultures containing the culture at 1×10^8 CFU/mL cell density were transferred from 10 mL to 90 mL of TSA when the optimal temperature for plating was reached (45°C). The medium was thoroughly mixed, and approximately 25 mL of the mixture was distributed into four Petri dishes. The Petri dishes were placed on a flat surface, and the agar was allowed to solidify. Wells of 6 mm in diameter were created on the agar surface using a cork borer. After each use, the cork borer was dipped in alcohol and sterilized by flaming. Once the agar solidified (Aytar et al. 2019). The 100% and

50% concentrations of honey samples were tested against *L. monocytogenes* strains. To prepare the 50% (v/v) concentrations of the honey samples, sterile distilled water was used. 100 µL of the 100% and 50% concentrations of honey were aseptically added to the wells created on the agar surface, and the Petri dishes were incubated at 37°C for 24 hours. After the incubation period, the inhibition zone diameters were measured using a ruler. The antimicrobial susceptibility of *L. monocytogenes* strains against honey samples was evaluated by measuring the inhibition zone diameter. Sterile distilled water was used as a negative control, and erythromycin (15 µg/disc) was used as a positive control. The honey samples were sterilized through 0.45 µm pore size sterile membrane filters (Sartorius, Germany).

Statistical Analysis

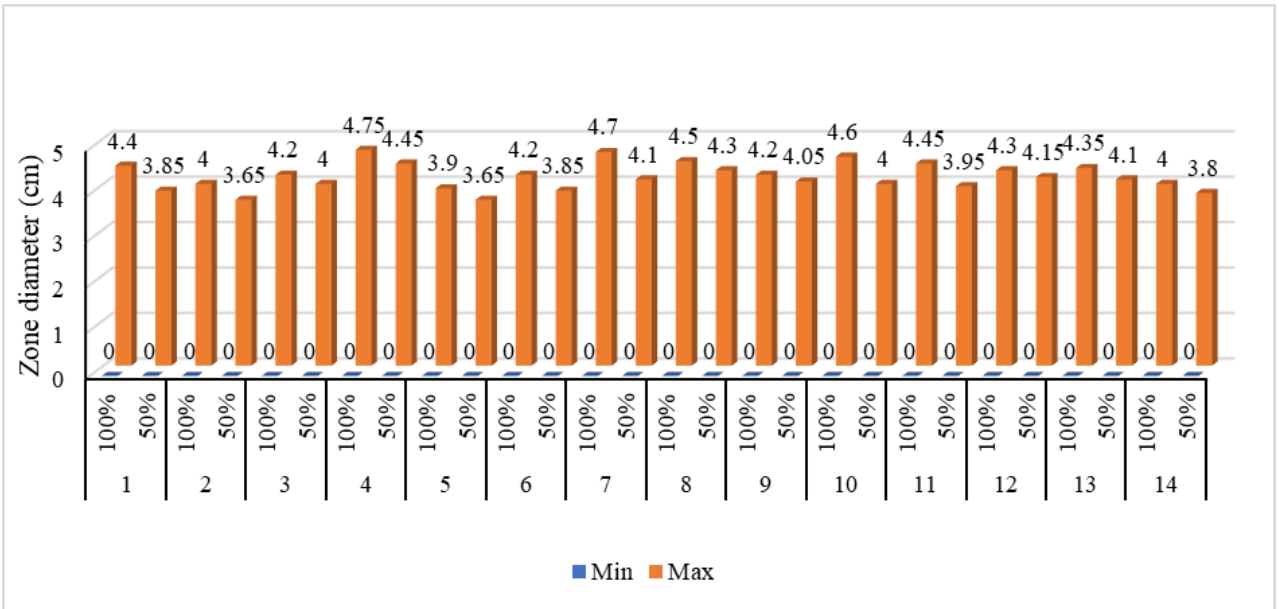
The average and standard deviation values of the measurements obtained from the analyses were determined. The differences in the average inhibition zone diameters were analyzed using a T-test. To evaluate the average inhibition zone diameters of honey samples at both 100% and 50% concentrations, based on the honey types classified into four groups, an analysis of variance (ANOVA) method was applied. The study was conducted according to the randomized plot design with two replications. Significant differences between the means were compared using Duncan's Multiple Comparison Test at a $p<0.05$ level. SPSS (Version 23) software was used for the analysis.

RESULTS and DISCUSSION

In the study, the antimicrobial activity values of different honey types against *L. monocytogenes* strains were evaluated by measuring the inhibition zone diameters. Accordingly, the maximum zone diameters formed by the different honey types against *L. monocytogenes* varied at different concentrations. All honey samples exhibited varying levels of antimicrobial activity against *L. monocytogenes* strains. For the 100% concentration, the zone diameters ranged from 4.25 to 4.8 cm, while for the 50% concentration, they ranged from 4.1 to 4.45 cm (Table 2, Figure 1, Figure 2).

Table 2. Minimum and maximum inhibition zone diameters of honey types against *L. monocytogenes* strains
Çizelge 2. Bal türlerinin L. monocytogenes suşlarına karşı minimum ve maksimum inhibisyon zon çapları

Honey type	Concentration			
	100%		50%	
	Min	Max	Min	Max
FFH	0	4.80	0	4.45
CFH	0	4.25	0	4.25
AH	0	4.6	0	4.1
PH	0	4.6	0	4.2



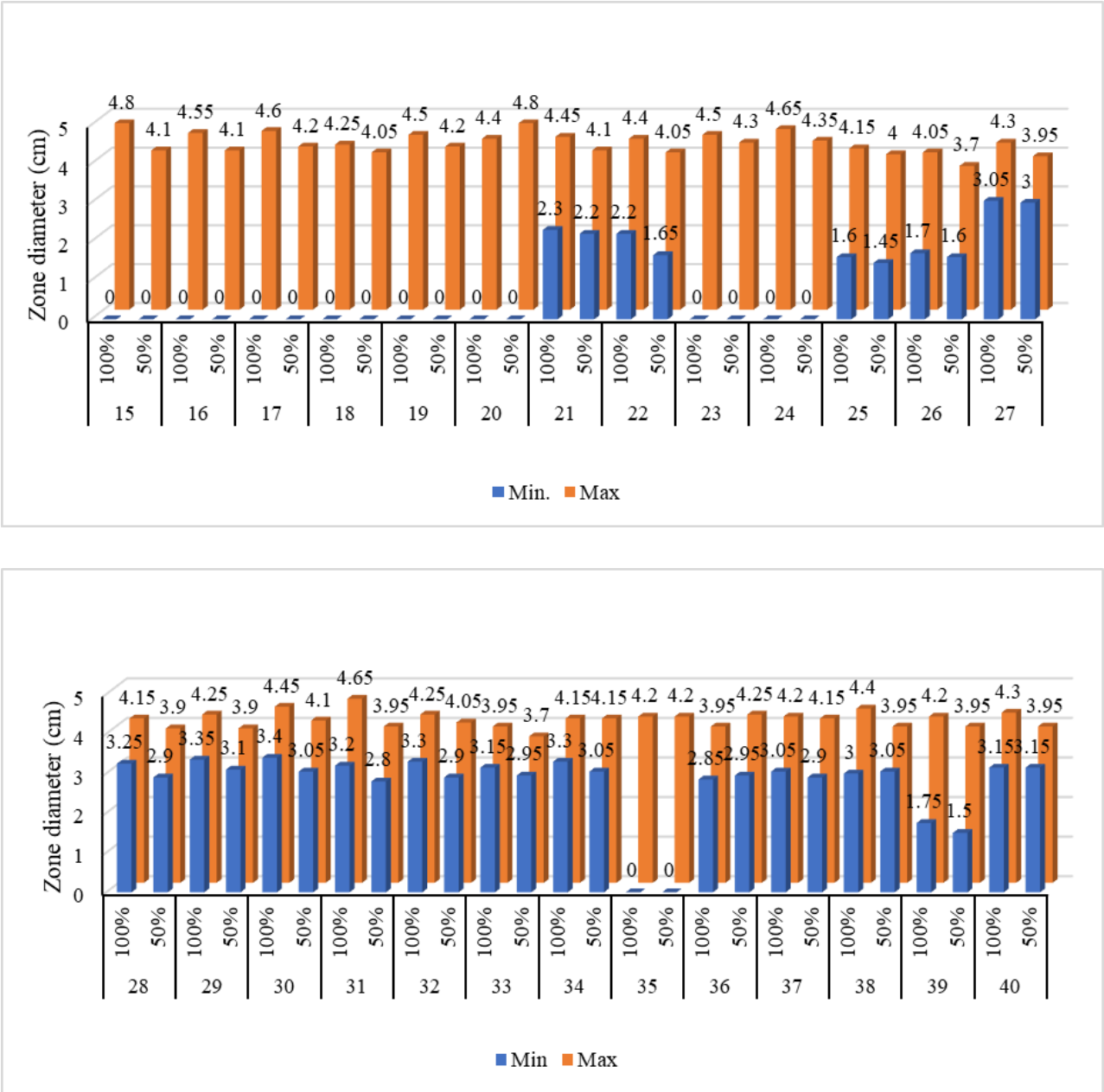


Figure 1. Minimum and maximum inhibition zone diameters (cm) of honey types against *L. monocytogenes*
Şekil 1. Bal türlerinin L. monocytogenes'e karşı minimum ve maksimum inhibisyon zon çapları (cm)

The highest antimicrobial effects were observed at 100% concentration, with inhibition zone diameters of 4.75 cm, 4.70 cm, and 4.8 cm in the filtered flower honey samples obtained from Ankara, numbered 4, 7, and 15, respectively (Figure 1). The average values of inhibition zone diameters and the changes according to concentration for honey samples at 100% and 50% concentrations against *L. monocytogenes* strains are shown in Figure 2. The highest antimicrobial effects were measured at 4.8 cm, 4.7 cm, and 4.65 cm inhibition zone diameters for the strains 142-1, 107-2, ATCC7644, and 151-1P. The difference between the antimicrobial activity measured by the average inhibition zone diameters of the honey samples at 100% concentration and the inhibition zone diameters at 50% concentration was statistically analyzed. The average inhibition zone diameter of the 100% honey samples was found to be 3.54 cm, while the average inhibition zone diameter of the 50% concentration was 3.30 cm (Table 3). The antimicrobial activity of honey samples, categorized by type (filtered flower honey, comb flower honey, acacia honey, and pine honey), against *L. monocytogenes* strains was also investigated. Statistically significant differences were observed in the average inhibition zone diameters formed by these honey samples against *L. monocytogenes* strains (Table 4).

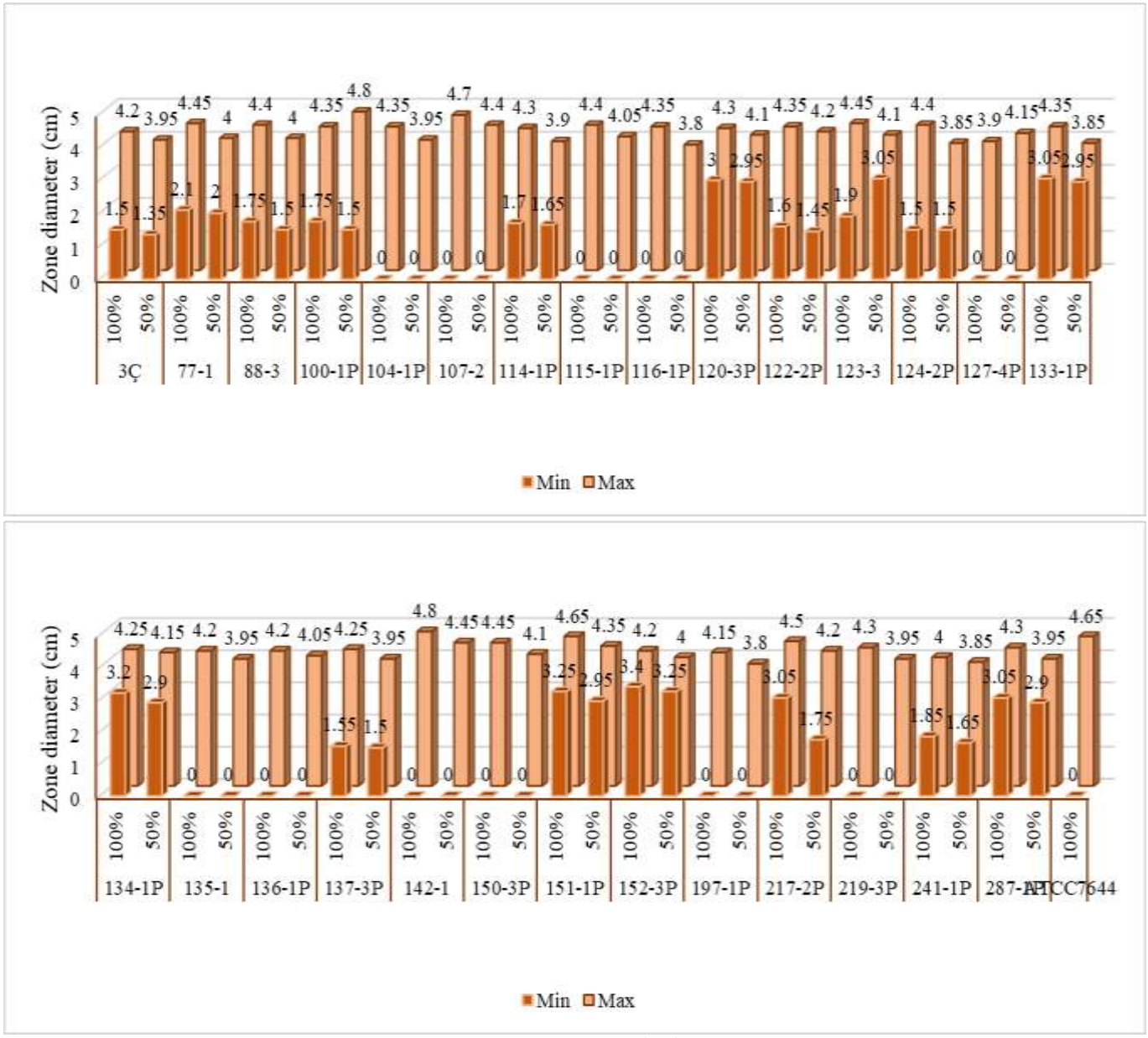


Figure 2. Minimum and maximum inhibition zone diameters (cm) observed in *L. monocytogenes* strains
Şekil 2. L. monocytogenes suşlarında gözlenen minimum ve maksimum inhibisyon zon çapları (cm)

When evaluating the average inhibition zone diameters formed by different honey types against *L. monocytogenes*, it was found that pine honey exhibited the highest antimicrobial activity in this study. Following pine honey, the antimicrobial effects decreased in the following order: filtered flower honey, comb flower honey, and acacia honey. However, based on the 95% confidence interval, the differences in the average zone diameters formed by filtered flower honey, comb flower honey, acacia honey, and pine honey against *L. monocytogenes* were found to be statistically insignificant (p>0.05) (Table 4). Therefore, it can be statistically concluded that the antimicrobial effects of the different honey types on *L. monocytogenes* strains did not differ significantly from one another.

In the T-Test analysis, it was determined that this difference in zone diameters was statistically significant at a 95% confidence level (p<0.05). Based on this result, it was concluded that the 100% concentration of honey samples has higher antimicrobial activity, and that when the honey samples are diluted, the antimicrobial activity decreases (Table 5).

In Table 6, the honey types were compared individually with each other, and the differences in the average inhibition zone diameters were found to be statistically insignificant based on the 95% confidence interval analysis (p>0.05). In this context, no superiority could be measured between the honey types based on the pairwise comparisons.

Table 3. Average inhibition zone diameters of 100% and 50% honey concentrations against *Listeria monocytogenes*
Çizelge 3. Listeria monocytogenes'e karşı %100 ve %50 bal konsantrasyonlarının ortalama inhibisyon zon çapları

T-Test				
	Average	Number of strains	Standard deviation	Standard error of the mean
Inhibition zone (for %100% honey concentration)	3.5423	29	0.26188	0.04863
Inhibition zone (for %50% honey concentration)	3.3032	29	0.25195	0.04679

Reliability of the average values of the obtained inhibition zone diameters							
	Average	Standard deviation	Standard error of the Mean (SEM)	Difference at 95% confidence interval Min	Max	Degrees of Freedom	Two-tailed significance level (*p*)
100% and 50% Honey Concentration Inhibition Zone	0.23909	0.06091	0.01131	0.21593	0.26226	28	.000

Table 4. Statistical evaluation of the antimicrobial activity of 100% honey samples against *L. monocytogenes* Strains
Çizelge 4. %100 bal örneklerinin L. monocytogenes suşlarına karşı antimikrobiyal aktivitesinin istatistiksel değerlendirmesi

Honey type	Concentration	Average	Standard deviation
FFH	100%	3.5675	.31388
CFH		3.4929	.26155
AH		3.5919	.27678
PH		3.3989	.69953

The reliability of the average inhibition zone diameters formed by 100% honey samples against *L. monocytogenes* strains

Within-Groups Effect Test				
Sources	Sum of Squares	Degrees of Freedom	Mean Square	*p*
Greenhouse-Geisser	0.656	1.725	0.38	0.143

Table 6. Comparison of the antimicrobial effect spectra of 100% honey samples with each other
Çizelge 6. %100 bal örneklerinin antimikrobiyal etki spektrumlarının birbiriyle karşılaştırılması

Pairwise Comparison						
Comparison of Samples with Each Other		Mean Diameter Differences	Standard Error	*p*	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	0.075	0.065	1	-0.111	0.261
	3	-0.024	0.063	1	-0.203	0.154
	4	0.169	0.096	0.544	-0.105	0.442
2	1	-0.075	0.065	1	-0.261	0.111
	3	-0.099	0.043	0.175	-0.221	0.023
	4	0.094	0.117	1	-0.239	0.427
3	1	0.024	0.063	1	-0.154	0.203
	2	0.099	0.043	0.175	-0.023	0.221
	4	0.193	0.103	0.423	-0.098	0.484
4	1	-0.169	0.096	0.544	-0.442	0.105
	2	-0.094	0.117	1	-0.427	0.239
	3	-0.193	0.103	0.423	-0.484	0.098

(1: Filtered Floral honey, 2: Comb Floral Honey, 3: Pine Honey, 4: Acacia Honey)

The average values of the inhibition zone diameters showing the antimicrobial activity of the 50% concentration honey samples against *L. monocytogenes* strains are presented in Table 7.

Table 5. Antimicrobial activity of honey kinds at 100% concentration against *L. monocytogenes* strains (zone diameter: cm)
Çizelge 5. %100 konsantrasyondaki farklı bal türlerinin L. monocytogenes suşlarına karşı antimikrobiyel aktivitesi (zon çapı: cm)

	1	2	3	4	5	6	7	8	9	10
3Ç	3.5 a *ABC*	3.6 abc *ABC*	1.5 ab *D*	3.9 ab *ABC*	3.55 ab *ABC*	3.65 b-e *ABC*	3.65 e-ı *ABC*	3.7 ab *ABC*	3.45 a *ABC*	3.55 ab *ABC*
77-1	3.75 a *NS*	4 a *NS*	3.45 a *NS*	4 ab *NS*	3.75 a *NS*	3.9 a-d *NS*	3.95 a-f *NS*	2.1 abc *NS*	2.3 ab *NS*	2.1 abc *NS*
88-3	1.75 ab *B*	3.75 ab *A*	3.65 a *A*	3.5 abc *A*	3.35 abc *A*	3.75 a-d *A*	3.95 a-f *A*	3.8 ab *A*	3.3 a *A*	3.65 ab *A*
100-1P	4 a *AB*	3.6 abc *AB*	3.4 a *AB*	4 ab *AB*	3.2 a-d *B*	3.55 b-e *AB*	3.7 d-ı *AB*	3.6 ab *AB*	4.1 a *AB*	3.65 ab *AB*
104-1P	3.45 a *İ-K*	3.45 abc *İ-K*	3.7 a *E-İ*	0 d *L*	3.25 a-d *K*	3.5 b-e *I-K*	4 a-f *BCD*	3.6 ab *G-J*	3.95 a *B-E*	3.9 ab *B-F*
107-2	3.85 a *ABC*	3.95 a *ABC*	3.8 a *ABC*	2.2 c *BCD*	3.7 a *ABC*	0 f *D*	0 j *D*	2.15 abc *BCD*	0 b *D*	1.95 bc *CD*
114-1P	1.7 ab *B*	1.8 cd *B*	3.95 a *A*	4.15 ab *A*	3.45 ab *A*	4 ab *A*	4.1 a-d *A*	3.75 ab *A*	3.65 a *A*	3.75 ab *A*
115-1P	3.65 a *A*	3.7 abc *A*	3.85 a *A*	4.4 ab *A*	3.9 a *A*	4.2 a *A*	4.05 a-e *A*	4.2 a *A*	3.95 a *A*	4.2 a *A*
116-1P	3.35 a *G-İ*	3.3 abc *H-İ*	3.4 a *F-İ*	3.6 ab *C-İ*	3.35 abc *G-İ*	3.8 a-d *B-G*	4.35 a *A*	4.1 ab *AB*	3.75 a *B-H*	3.95 ab *A-D*
120-3P	3.8 a *B-G*	3.85 ab *A-G*	3.7 a *C-G*	4.3 ab *A*	3.6 ab *E-H*	3.95 abc *A-G*	3.85 c-h *A-G*	3.85 ab *A-G*	4 a *A-F*	4.15 a *ABC*
122-2P	3.65 a *A*	3.95 a *A*	3.35 a *A*	4.3 ab *A*	3.8 a *A*	3.6 bcde *A*	3.65 e-ı *A*	3.55 ab *A*	3.85 a *A*	3.55 ab *A*
123-3	3.5 a *A*	3.5 abc *A*	3.55 a *A*	3.75 ab *A*	3.45 ab *A*	3.65 b-e *A*	3.85 c-h *A*	3.8 ab *A*	1.9 ab *B*	3.85 ab *A*
124-2P	3.45 a *AB*	3.45 abc *AB*	1.75 ab *C*	3.15 bc *AB*	1.5 d *C*	3.65 b-e *AB*	3.45 hıı *AB*	3.5 ab *AB*	3.3 a *AB*	3.25 abc *AB*
127-4P	0 b *E*	0 e *E*	3.4 a *BCD*	0 d *E*	3.35 abc *CD*	3.4 cde *BCD*	3.4 ıı *BCD*	3.6 ab *A-D*	3.3 a *CD*	3.6 ab *A-D*
133-1P	3.45 a *G-İ*	3.45 abc *G-İ*	3.05 a *İ*	4.35 ab *A*	3.15 a-d *İİ*	3.6 b-e *E-I*	3.95 a-f *A-F*	3.85 ab *B-G*	3.8 a *C-G*	3.6 ab *E-I*
134-1P	3.55 a *D-İ*	3.45 abc *F-İ*	3.35 a *Hİİ*	4.15 ab *ABC*	3.4 ab *G-İ*	4.05 ab *A-E*	3.9 b-g *A-H*	4.25 a *A*	3.6 a *C-İ*	3.8 ab *A-I*
135-1	3.4 a *A*	3.3 abc *A*	3.4 a *A*	4.1 ab *A*	3.45 ab *A*	4 ab *A*	3.7 d-ı *A*	2.05 abc *A*	3.95 a *A*	3.35 abc *A*
136-1P	0 b *G*	0 e *G*	3.35 a *DEF*	4.1 ab *ABC*	3.25 a-d *F*	3.35 de *DEF*	3.5 g-i *A-F*	3.3 ab *EF*	3.9 a *A-F*	3.4 abc *C-F*
137-3P	3.5 a *AB*	3.5 abc *AB*	1.6 ab *C*	4 ab *AB*	1.55 cd *C*	3.55 b-e *AB*	3.5 g-i *AB*	3.55 ab *AB*	3.65 a *AB*	3.4 abc *AB*
142-1	1.85 ab *BCD*	1.95 bcd *A-D*	1.75 ab *CD*	4.75 a *AB*	1.8 bcd *CD*	0 f *D*	0 j *D*	0 c *D*	2.15 ab *A-D*	0 d *D*
150-3P	3.8 a *AB*	3.8 ab *AB*	3.6 a *AB*	0 d *D*	3.7 a *AB*	4 ab *A*	4.1 a-d *A*	3.7 ab *AB*	3.85 a *AB*	3.9 ab *AB*
151-1P	3.65 a *E-G*	3.7 abc *E-G*	3.55 a *E-G*	4 ab *B-F*	3.55 ab *E-G*	3.6 b-e *E-G*	3.6 f-ı *E-G*	3.65 ab *E-G*	3.9 a *B-G*	3.5 ab *FGH*
152-3P	3.5 a *FG*	3.65 abc *C-G*	3.55 a *EFG*	4.05 ab *ABC*	3.5 ab *FG*	3.65 b-e *C-G*	3.85 c-h *A-F*	3.6 ab *D-G*	3.95 a *A-E*	3.8 ab *A-G*
197-1P	3.15 a *A-E*	1.35 de *EF*	0 b *F*	3.5 abc *AB*	3.75 a *A*	3.15 e *A-E*	3.15 i *A-E*	1.55 bc *C-F*	3.65 a *A*	1.45 cd *DEF*
217-2P	3.65 a *E-I*	3.8 ab *C-H*	3.25 a *İİ*	4.05 ab *A-F*	3.55 ab *F-I*	3.85 a-d *C-G*	4.15 abc *A-E*	3.85 ab *C-G*	4.2 a *A-D*	3.9 ab *C-G*
219-3P	3.55 a *FGH*	3.65 abc *E-H*	3.55 a *FGH*	3.8 ab *C-G*	3.45 ab *GH*	3.85 a-d *C-F*	4.3 ab *A*	4.05 ab *A-D*	0 b *I*	4.05 ab *A-D*
241-1P	1.85 ab *B*	3.55 abc *A*	3.1 a *A*	3.45 abc *A*	3.3 abc *A*	3.4 cde *A*	3.4 ıı *A*	3.4 ab *A*	3.55 a *A*	3.45 abc *A*
287-1P	3.8 a *B-G*	3.9 a *B-F*	3.25 a *İJ*	4.05 ab *A-D*	3.05 a-d *İ*	3.8 a-d *B-G*	4.05 a-e *A-D*	4.1 ab *ABC*	3.75 a *C-G*	4 ab *A-E*
ATCC	3.75 a *ABC*	3.6 abc *A-D*	1.75 ab *DE*	4.4 ab *A*	3.2 a-d *A-D*	0 f *E*	0 j *E*	0 c *E*	2 ab *CD*	0 d *E*

Two-way ANOVA; ns: not significant. Means with different lowercase letters in the columns indicate significant differences among strains for each honey type; Means with different uppercase letters in the rows indicate substantial differences among kinds of honey in each strain. The numbers are averages of all replicates.

Table 5. Antimicrobial activity of honey kinds at 100% concentration against *L. monocytogenes* strains (zone diameter: cm) (Continue)
Çizelge 5. %100 konsantrasyondaki farklı bal türlerinin L. monocytogenes suşlarına karşı antimikrobiyel aktivitesi (zon çapı: cm)

	11	12	13	14	15	16	17	18	19	20
3Ç	3.6 a *ABC*	3.65 a *ABC*	3.55 def *ABC*	3.1 cde *C*	4.05 a *AB*	3.7 b-g *ABC*	3.8 d *ABC*	3.6 a *ABC*	3.6 ab *ABC*	3.9 abc *ABC*
77-1	4.45 a *NS*	4.05 a *NS*	3.95 bc *NS*	3.7 bc *NS*	4.3 a *NS*	3.9 b-e *NS*	4.1 bcd *NS*	2.25 ab *NS*	4.05 a *NS*	3.85 abc *NS*
88-3	1.85 b *B*	3.8 a *A*	3.35 efg *A*	3.65 bcd *A*	3.55 ab *A*	3.45 efg *A*	3.25 e *A*	3.25 a *A*	3.45 ab *A*	3.55 abc *A*
100-1P	3.2 a *B*	4 a *AB*	3.8 bcd *AB*	3.45 b-e *AB*	3.8 ab *AB*	3.8 b-g *AB*	4.15 bcd *AB*	3.85 a *AB*	3.9 a *AB*	3.75 abc *AB*
104-1P	3.9 a *B-F*	3.9 a *B-F*	3.8 bcd *C-H*	3.8 ab *C-H*	0 c *L*	0 h *L*	0 f *L*	4 a *BCD*	3.95 a *B-E*	4.1 abc *B*
107-2	4.25 a *ABC*	4.5 a *AB*	4.35 a *ABC*	4.4 a *ABC*	2.4 b *ABC*	4.2 ab *ABC*	4.6 a *AB*	0 b *D*	4.7 a *A*	4.5 a *AB*
114-1P	4 a *A*	4 a *A*	3.85 bcd *A*	3.95 ab *A*	3.95 ab *A*	3.8 b-g *A*	3.95 cd *A*	3.75 a *A*	3.75 a *A*	3.8 abc *A*
115-1P	4 a *A*	3.9 a *A*	4.1 ab *A*	3.75 b *A*	4.1 a *A*	3.95 a-e *A*	3.95 cd *A*	4.25 a *A*	3.9 a *A*	3.9 abc *A*
116-1P	4 a *ABC*	3.95 a *A-D*	3.85 bcd *B-F*	3.85 ab *B-F*	3.65 ab *B-İ*	3.5 d-g *D-İ*	3.95 cd *A-D*	3.9 a *A-E*	3.9 a *A-E*	3.9 abc *A-E*
120-3P	4.2 a *AB*	3.9 a *A-G*	3.85 bcd *A-G*	3.55 bcd *F-I*	4.1 a *A-D*	3.85 b-f *A-G*	3.8 d *B-G*	4 a *A-F*	3.95 a *A-G*	3.8 abc *B-G*
122-2P	4.1 a *A*	3.95 a *A*	3.75 bcd *A*	3.5 bcd *A*	3.95 ab *A*	4.15 abc *A*	4.35 abc *A*	4.2 a *A*	3.75 a *A*	3.8 abc *A*
123-3	4.1 a *A*	4 a *A*	3.9 bcd *A*	3.95 ab *A*	3.9 ab *A*	3.75 b-g *A*	4.15 bcd *A*	3.7 a *A*	1.9 bc *B*	4.35 ab *A*
124-2P	3.35 a *AB*	3.35 a *AB*	3.2 g *AB*	2.9 e *B*	3.35 ab *AB*	3.25 fg *AB*	3.25 e *AB*	3.6 a *AB*	3.2 abc *AB*	3.25 bc *AB*
127-4P	3.4 a *BCD*	3.45 a *BCD*	3.3 efg *CD*	3.45 b-e *BCD*	0 c *E*	0 h *E*	0 f *E*	3.4 a *BCD*	3.3 abc *CD*	3.35 abc *CD*
133-1P	4.3 a *AB*	4 a *A-E*	3.9 bcd *A-G*	3.65 bcd *E-H*	4 ab *A-E*	4.15 abc *A-D*	3.9 d *A-G*	3.7 a *D-H*	3.75 a *C-G*	4 abc *A-E*
134-1P	4.25 a *A*	3.75 a *A-İ*	3.75 bcd *A-İ*	3.7 bc *A-İ*	4.1 a *A-D*	4.15 abc *ABC*	3.9 d *A-H*	3.8 a *A-I*	3.95 a *A-G*	3.75 abc *A-İ*
135-1	4.2 a *A*	4.15 a *A*	3.9 bcd *A*	3.5 bcd *A*	4.2 a *A*	3.95 a-e *A*	3.95 cd *A*	4.2 a *A*	4.1 a *A*	3.9 abc *A*
136-1P	3.7 a *A-F*	3.5 a *A-F*	3.6 cde *A-F*	3.5 bcd *A-F*	3.75 ab *A-F*	3.55 c-g *A-F*	3.3 e *EF*	3.9 a *A-F*	4.2 a *A*	3.8 abc *A-F*
137-3P	3.8 a *AB*	3.6 a *AB*	3.55 def *AB*	3.7 bc *AB*	3.95 ab *AB*	3.95 a-e *AB*	4.2 a-d *A*	3.8 a *AB*	3.8 a *AB*	4.25 ab *A*
142-1	0 c *D*	2 b *A-D*	0 h *D*	0 f *D*	4.8 a *A*	4.55 a *ABC*	4.6 a *ABC*	2.2 ab *A-D*	4.5 a *ABC*	4.4 ab *ABC*
150-3P	4.1 a *A*	3.7 a *AB*	3.9 bcd *AB*	3.9 ab *AB*	0 c *D*	0 h *D*	0 f *D*	3.9 a *AB*	3.8 a *AB*	3.85 abc *AB*
151-1P	3.8 a *C-H*	3.5 a *FGH*	3.6 cde *E-G*	3.7 bc *E-G*	3.65 ab *E-G*	4.1 a-d *A-F*	4.45 ab *AB*	4 a *B-F*	3.95 a *B-G*	4.35 ab *A-D*
152-3P	3.95 a *A-E*	4.05 a *ABC*	3.8 bcd *A-G*	3.7 bc *B-G*	4.05 a *ABC*	3.6 b-g *D-G*	4.2 a-d *A*	3.65 a *C-G*	3.6 ab *D-G*	4.05 abc *ABC*
197-1P	0 c *F*	0 c *F*	0 h *F*	0 f *F*	3.4 ab *ABC*	3.2 g *A-E*	3.35 e *A-D*	3.55 a *AB*	1.7 c *B-F*	1.7 d *B-F*
217-2P	4.05 a *A-F*	4 a *A-F*	3.8 bcd *C-H*	3.95 ab *B-G*	4.45 a *AB*	3.8 b-g *C-H*	4.05 bcd *A-F*	3.95 a *B-G*	3.95 a *B-G*	3.9 abc *C-G*
219-3P	3.9 a *B-F*	3.85 a *C-F*	3.9 bcd *B-F*	4 ab *A-E*	3.9 ab *B-F*	4.05 a-e *A-D*	3.9 d *B-F*	0 b *I*	0 d *I*	0 e *I*
241-1P	3.45 a *A*	3.35 a *A*	3.25 fg *A*	3.05 de *A*	3.25 ab *A*	3.25 fg *A*	3.25 e *A*	3.55 a *A*	3.5 ab *A*	3.9 abc *A*
287-1P	3.95 a *A-F*	3.95 a *A-F*	3.9 bcd *B-F*	3.8 ab *B-G*	4.3 a *A*	3.9 b-e *B-F*	4.05 bcd *A-D*	3.95 a *A-F*	4.1 a *ABC*	3.9 abc *B-F*
ATCC	4.25 a *AB*	4.3 a *A*	4.35 c *A*	3.9 ab *ABC*	4.2 a *AB*	4.15 abc *AB*	4.1 bcd *AB*	2.3 ab *BCD*	3.45 ab *A-D*	2.95 c *A-D*

Two-way ANOVA; ns: not significant. Means with different lowercase letters in the columns indicate significant differences among strains for each honey type; Means with different uppercase letters in the rows indicate substantial differences among kinds of honey in each strain. The numbers are averages of all replicates.

Table 5. Antimicrobial activity of honey kinds at 100% concentration against *L. monocytogenes* strains (zone diameter: cm) (Continue)
Çizelge 5. %100 konsantrasyondaki farklı bal türlerinin L. monocytogenes suşlarına karşı antimikrobiyel aktivitesi (zon çapı: cm)

	21	22	23	24	25	26	27	28	29	30
3Ç	3.95 a *ABC*	4.2 a *A*	3.8 c-f *ABC*	3.85 bc *ABC*	3.5 a *ABC*	3.65 a *ABC*	3.7 e-ı *ABC*	3.95 a-d *ABC*	3.35 k *ABC*	4 bc *ABC*
77-1	4.15 *NS*	4 a *NS*	4.05 a-e *NS*	3.9 bc *NS*	3.65 a *NS*	3.65 a *NS*	3.75 d-h *NS*	3.75 d-g *NS*	3.95 b-g *NS*	4 bc *NS*
88-3	3.7 ab *A*	4.4 a *A*	4.4 ab *A*	4.1 ab *A*	3.7 a *A*	4.05 a *A*	3.7 e-ı *A*	3.9 b-e *A*	3.8 e-ı *A*	3.85 abc *A*
100-1P	4.3 a *A*	4.05 a *AB*	4.05 a-e *AB*	4.35 ab *A*	3.9 a *AB*	3.35 a *AB*	3.75 d-h *AB*	3.8 c-f *AB*	3.7 g-j *AB*	3.6 de *AB*
104-1P	3.9 a *B-F*	3.9 a *B-F*	4 a-e *BCD*	3.85 bc *B-G*	3.55 a *H-J*	3.95 a *B-E*	4.05 abc *BC*	3.75 d-g *D-I*	3.95 b-g *B-E*	3.55 de *H-J*
107-2	4.6 a *AB*	4.2 a *ABC*	4.3 abc *ABC*	4.3 ab *ABC*	4 a *ABC*	3.85 a *ABC*	4.25 ab *ABC*	3.95 a-d *ABC*	4.1 a-d *ABC*	3.6 de *ABC*
114-1P	4.3 a *A*	3.95 a *A*	4 a-e *A*	4.05 bc *A*	3.4 a *A*	3.8 a *A*	3.3 i *A*	3.3 i *A*	4.2 ab *A*	3.75 cd *A*
115-1P	4.15 a *A*	3.6 ab *A*	0 h *D*	0 f *D*	1.9 b *BC*	1.7 b *C*	3.85 c-f *A*	3.75 d-g *A*	3.95 b-g *A*	3.85 abc *A*
116-1P	3.75 ab *B-H*	3.85 a *B-F*	3.95 a-f *A-D*	3.9 bc *A-E*	3.8 a *B-G*	3.7 a *B-I*	3.65 f-ı *B-İ*	3.45 hıı *E-İ*	3.85 d-ı *B-F*	3.85 abc *B-F*
120-3P	3.95 a *A-G*	4.3 a *A*	3.95 a-f *A-G*	3.9 bc *A-G*	3 ab *İ*	3.85 a *A-G*	3.5 hıı *GI*	4.05 ab *A-E*	3.7 g-j *C-G*	3.7 cde *C-G*
122-2P	3.8 ab *A*	3.95 a *A*	3.65 def *A*	4.25 ab *A*	1.6 b *B*	1.7 b *B*	4.05 abc *A*	4 abc *A*	3.65 h-j *A*	3.4 e *A*
123-3	4.45 a *A*	4 a *A*	4.25 abc *A*	4.3 ab *A*	3.55 a *A*	3.55 a *A*	4 bcd *A*	3.75 d-g *A*	3.6 ı-k *A*	3.85 abc *A*
124-2P	3.45 ab *AB*	3.25 ab *AB*	3.65 def *AB*	3.5 cde *AB*	3.35 a *AB*	3.4 a *AB*	3.5 hıı *AB*	3.45 hıı *AB*	3.85 d-ı *AB*	3.9 abc *AB*
127-4P	3.4 ab *BCD*	3.3 ab *CD*	3.4 fg *BCD*	3.3 de *CD*	3.55 a *A-D*	3.6 a *A-D*	3.55 g-i *A-D*	3.35 ıı *CD*	3.5 ijk *A-D*	3.55 de *A-D*
133-1P	3.9 a *A-G*	3.85 a *A-G*	3.95 a-f *A-F*	4 bc *A-E*	3.5 a *F-İ*	3.6 a *E-I*	3.85 c-f *A-G*	3.45 hıı *G-İ*	4.15 abc *A-D*	3.8 cd *C-G*
134-1P	3.8 ab *A-I*	4 a *A-F*	3.95 a-f *A-G*	3.9 bc *A-H*	3.45 a *F-İ*	3.45 a *F-İ*	3.8 c-g *A-I*	3.65 fgh *B-İ*	3.5 ijk *E-İ*	3.75 cd *A-İ*
135-1	2.3 b *A*	2.2 b *A*	0 h *B*	0 f *B*	3.5 a *A*	3.75 a *A*	3.95 cde *A*	4 abc *A*	3.5 ijk *A*	3.6 de *A*
136-1P	4 a *A-E*	4.05 a *A-D*	4.2 a-d *A*	4.15 ab *AB*	3.85 a	3.35 a *DEF*	3.55 g-i *A-F*	3.25 i *F*	3.9 c-h *A-F*	4.15 ab *AB*
137-3P	4.05 a *AB*	4.1 a *AB*	3.8 c-f *AB*	4.05 bc *AB*	3.6 a *AB*	3.6 a *AB*	3.95 cde *AB*	4.15 a *A*	4.15 abc *A*	3.75 cd *AB*
142-1	4.45 a *ABC*	4.25 a *ABC*	4.4 ab *ABC*	4.1 ab *ABC*	3.55 a *ABC*	3.8 a *ABC*	3.45 ıı *ABC*	3.7 efg *ABC*	3.9 c-h *ABC*	4.15 ab *ABC*
150-3P	3.75 ab *AB*	3.75 a *AB*	3.95 a-f *AB*	4.05 bc *A*	3.75 a *AB*	3.75 a *AB*	3.95 cde *AB*	3.8 c-f *AB*	3.85 d-ı *AB*	4.45 a *A*
151-1P	4.1 a *A-F*	4.15 a *A-E*	4.4 ab *ABC*	4.65 a *A*	3.5 a *FGH*	3.65 a *E-G*	3.9 c-f *B-G*	3.55 ghı *E-G*	3.75 f-i *D-H*	3.9 abc *B-G*
152-3P	4.1 a *AB*	3.75 a *B-G*	4 a-e *A-D*	4.2 ab *A*	3.75 a *B-G*	3.55 a *EFG*	3.75 d-h *B-G*	3.95 a-d *A-E*	4.05 a-e *ABC*	3.7 cde *B-G*
197-1P	3.55 ab *AB*	3.3 ab *A-D*	3.1 g *A-E*	3.25 e *A-D*	3.95 a *A*	3.8 a *A*	3.7 e-ı *A*	4.05 ab *A*	3.95 b-g *A*	3.6 de *AB*
217-2P	4 a *A-F*	3.9 a *C-G*	4.5 a *A*	4.25 ab *ABC*	3.8 a *C-H*	3.6 a *F-I*	3.05 j *İ*	3.45 hıı *G-İ*	3.45 jk *G-İ*	3.95 bc *B-G*
219-3P	4.05 a *A-D*	4.25 a *AB*	4.05 a-e *A-D*	4 bc *A-E*	3.8 a *C-G*	3.55 a *FGH*	3.85 c-f *C-F*	3.95 a-d *A-E*	3.8 e-ı *C-G*	3.9 abc *B-F*
241-1P	3.5 ab *A*	3.4 ab *A*	3.55 efg *A*	3.8 bcd *A*	3.6 a *A*	3.65 a *A*	3.5 hıı *A*	3.3 i *A*	3.6 ı-k *A*	3.7 cde *A*
287-1P	3.85 a *B-G*	3.5 ab *G-İ*	3.85 b-f *B-G*	3.8 bcd *B-G*	3.7 a *D-H*	3.75 a *C-G*	4.05 abc *A-D*	3.85 b-f *B-G*	4 a-f *A-E*	4.15 ab *AB*
ATCC	4.15 a *AB*	4.3 a *A*	3.65 def *A-D*	4.1 ab *AB*	4.15 a *AB*	3.75 a *ABC*	4.3 a *A*	3.75 d-g *ABC*	4.25 a *AB*	4 bc *AB*

Two-way ANOVA; ns: not significant. Means with different lowercase letters in the columns indicate significant differences among strains for each honey type; Means with different uppercase letters in the rows indicate substantial differences among kinds of honey in each strain. The numbers are averages of all replicates.

Table 5. Antimicrobial activity of honey kinds at 100% concentration against *L. monocytogenes* strains (zone diameter: cm) (Continue)
Çizelge 5. %100 konsantrasyondaki farklı bal türlerinin L. monocytogenes suşlarına karşı antimikrobiyel aktivitesi (zon çapı: cm)

	31	32	33	34	35	36	37	38	39	40
3Ç	3.6 b-e *ABC*	3.55 ghı *ABC*	3.65 a-f *ABC*	4.15 a *AB*	3.25 ab *BC*	3.35 efg *ABC*	4.2 a A	3.9 bcd *ABC*	3.7 a *ABC*	3.3 de *ABC*
77-1	4.05 bc *NS*	3.95 a-e *NS*	3.85 abc *NS*	3.55 b-e *NS*	3.1 ab *NS*	3.6 a-f *NS*	4.1 ab *NS*	3.35 f-ı *NS*	3.35 abc *NS*	3.4 de *NS*
88-3	4.15 b *A*	3.45 hı *A*	3.6 b-g *A*	3.5 c-e *A*	3.5 ab *A*	3.25 fgh *A*	3.85 a-f *A*	3.8 b-e *A*	3.55 ab *A*	3.5 cde *A*
100-1P	3.6 b-e *AB*	3.3 ı *AB*	3.9 ab *AB*	3.85 a-e *AB*	3.5 ab *AB*	3.1 gh *B*	3.55 d-ı *AB*	3.8 b-e *AB*	1.75 c *C*	3.6 b-e *AB*
104-1P	3.5 cde *I-K*	3.65 e-h *F-J*	3.85 abc *B-G*	3.5 c-e *I-K*	3.55 ab *H-J*	3.45 c-g *İ-K*	3.8 a-g *C-H*	3.6 d-g *G-J*	3.4 abc *J-K*	4.35 a *A*
107-2	3.85 bcd *ABC*	4.05 abc *ABC*	3.4 e-ı *ABC*	3.9 a-d *ABC*	3 ab *ABC*	3.5 b-g *ABC*	3.5 e-i *ABC*	3.75 b-e *ABC*	3.05 abc *ABC*	3.85 a-e *ABC*
114-1P	3.55 cde *A*	4 a-d *A*	3.15 ı *A*	3.85 a-e *A*	3.45 ab *A*	3.85 abc *A*	3.6 c-h *A*	3.7 c-f *A*	3.35 abc *A*	3.5 cde *A*
115-1P	3.9 bcd *A*	4.2 ab *A*	3.65 a-f *A*	3.85 a-e *A*	3.5 ab *A*	3.8 a-d *A*	3.1 ıi *AB*	3.2 hı *A*	3.35 abc *A*	3.75 a-e *A*
116-1P	3.95 bc *A-D*	3.5 ghı *D-İ*	3.95 a *A-D*	3.8 a-e *B-G*	0 c *J*	3.95 a *A-D*	3.25 hıi *I-İ*	3.8 b-e *B-G*	3.2 abc *İ*	3.45 cde *E-İ*
120-3P	3.75 b-e *B-G*	3.95 a-e *A-G*	3.8 a-d *B-G*	3.9 a-d *A-G*	3.65 ab *D-H*	3.55 a-f *F-I*	3.6 c-h *E-H*	3.6 d-g *E-H*	3.25 abc *Hİ*	3.15 e *Iİ*
122-2P	3.75 b-e *A*	3.6 f-ı *A*	3.7 a-e *A*	3.35 d-e *A*	3.9 a *A*	3.95 a *A*	3.45 f-i *A*	3.05 ı *A*	3.7 a *A*	3.2 de *A*
123-3	3.8 bcd *A*	3.55 ghı *A*	3.5 d-h *A*	3.8 a-e *A*	3.6 ab *A*	3.75 a-e *A*	3.4 f-i *A*	3.75 b-e *A*	3.45 abc *A*	3.45 cde *A*
124-2P	3.6 b-e *AB*	3.9 b-f *AB*	3.8 a-d *AB*	3.9 a-d *AB*	3.75 ab *AB*	3.35 efg *AB*	3.05 i *AB*	4.4 a *A*	3.9 a *AB*	3.35 de *AB*
127-4P	3.7 b-e *ABC*	3.55 ghı *A-D*	3.2 hı *D*	3.75 a-e *ABC*	3.35 ab *CD*	3.2 fgh *D*	3.8 a-g *AB*	3.35 f-ı *CD*	3.35 abc *CD*	3.9 a-d *A*
133-1P	3.7 b-e *D-H*	3.75 c-h *C-G*	3.45 e-ı *G-İ*	3.8 a-e *C-G*	3.85 ab *A-G*	3.25 fgh *HIİ*	4.2 a *ABC*	4 bc *A-E*	3.6 ab *E-I*	3.7 a-e *D-H*
134-1P	3.2 e *İ*	3.3 ı *Iİ*	3.85 abc *A-I*	4.05 abc *A-E*	4.2 a *AB*	3.7 a-e *A-İ*	3.8 a-g *A-I*	4 bc *A-F*	3.8 a *A-I*	3.6 b-e *C-İ*
135-1	3.2 e *A*	3.45 hı *A*	3.5 d-h *A*	3.9 a-d *A*	3.8 ab *A*	3.4 d-g *A*	3.95 a-e *A*	3.85 b-e *A*	3.6 ab *A*	3.7 a-e *A*
136-1P	3.7 b-e *A-F*	3.8 c-g *A-F*	3.55 c-g *A-F*	3.85 a-e *A-F*	3.45 ab *B-F*	3.9 ab *A-F*	3.6 c-h *A-F*	3.6 d-g *A-F*	3.6 ab *A-F*	3.85 a-e *A-F*
137-3P	3.65 b-e *AB*	4.05 abc *AB*	3.2 hı *AB*	4.1 ab *AB*	2.3 b *BC*	3.35 efg *AB*	3.65 b-h *AB*	3.55 d-h *AB*	3.85 a *AB*	3.85 a-e *AB*
142-1	3.55 cde *ABC*	3.7 d-h *ABC*	3.5 d-h *ABC*	3.6 a-e *ABC*	3.3 ab *ABC*	3.85 abc *ABC*	3.65 b-h *ABC*	3.6 d-g *ABC*	3.75 a *ABC*	4.3 ab *ABC*
150-3P	3.75 b-e *AB*	4.25 a *A*	3.85 abc *AB*	3.7 a-e *AB*	4 a *A*	2.85 h *B*	3.4 f-i *AB*	3.75 b-e *AB*	1.85 bc *C*	4.15 abc *A*
151-1P	3.55 cde *E-G*	3.75 c-h *D-H*	3.65 a-f *E-G*	3.65 a-e *E-G*	3.95 a *B-G*	3.35 efg *G-H*	3.6 c-h *E-G*	3.85 b-e *B-H*	3.25 abc *H*	3.85 a-e *B-H*
152-3P	3.75 b-e *B-G*	3.9 b-f *A-F*	3.7 a-e *B-G*	3.8 a-e *A-G*	3.4 ab *G*	3.75 a-e *B-G*	4.05 abc *ABC*	3.5 eh *FG*	4.2 a *A*	3.55 cde *EFG*
197-1P	3.6 b-e *AB*	3.6 f-ı *AB*	3.3 ghı *A-D*	4.15 a *A*	3.3 ab *A-D*	3.4 d-g *ABC*	3.35 g-i *A-D*	3.2 hı *A-E*	3.65 a *A*	4.15 abc *A*
217-2P	3.75 b-e *C-H*	3.9 b-f *C-G*	3.8 a-d *C-H*	3.7 a-e *D-I*	3.3 ab *HIİ*	3.25 fgh *Iİ*	3.45 f-i *G-İ*	3.7 c-f *D-I*	3.7 a *D-I*	3.7 a-e *D-I*
219-3P	3.7 b-e *D-H*	3.95 a-e *A-E*	3.65 a-f *E-H*	3.4 d-e *H*	3.45 ab *GH*	3.55 a-f *FGH*	3.65 b-h *E-H*	4.1 ab *ABC*	3.75 a *C-H*	3.7 a-e *D-H*
241-1P	3.5 cde *A*	3.3 ı *A*	3.8 a-d *A*	3.55 b-e *A*	3.05 ab *A*	3.1 gh *A*	4 a-d *A*	3 ı *A*	3.8 a *A*	3.85 a-e *A*
287-1P	3.35 de *H-J*	3.65 e-h *E-I*	3.35 f-ı *H-J*	3.3 e *IİJ*	3.25 ab *İJ*	3.25 fgh *İJ*	3.25 hıi *İJ*	3.6 d-g *F-İ*	3.65 a *E-I*	3.85 a-e *B-G*
ATCC	4.65 a *A*	3.95 a-e *ABC*	3.65 a-f *A-D*	3.3 e *A-D*	3.85 ab *ABC*	3.55 a-f *A-D*	4.15 a *AB*	3.3 ghı *A-D*	3.65 a *A-D*	3.7 a-e *ABC*

Two-way ANOVA; ns: not significant. Means with different lowercase letters in the columns indicate significant differences among strains for each honey type; Means with different uppercase letters in the rows indicate substantial differences among kinds of honey in each strain. The numbers are averages of all replicates.

Table 7. Statistical Evaluation of the Antimicrobial Activity of 50% Honey Samples Against *L. monocytogenes* strains

Çizelge 7. %50 bal örneklerinin L. monocytogenes suşlarına karşı antimikrobiyal aktivitesinin istatistiksel değerlendirmesi

Honey Type	Concentration	Average	Standard deviation
FFH	50%	3.3141	0.30478
CFH		3.3157	0.24943
AH		3.3382	0.25343
PH		3.108	0.71056

The reliability of the average inhibition zone diameters formed by 50% honey samples against *L. monocytogenes* strains

Within-Groups Effect Test Sources	Sum of Squares	Degrees of Freedom	Mean Square	*p*
Greenhouse-Geisser	1.012	1.674	0.605	0.063

When examining the differences in the average inhibition zone diameters formed by the 50% concentrations of the honey types, it was found that the highest antimicrobial effect was exhibited by pine honey, followed by comb floral honey, filtered floral honey, and acacia honey in descending order. Table 6 also presents the reliability of the average inhibition zone diameters formed by the 50% concentration honey samples against *L. monocytogenes* strains. The statistical analysis at the 95% confidence interval revealed that the differences in the inhibition zone diameters between the comb floral honey, filtered floral honey, acacia honey, and pine honeys were not statistically significant (p>0.05). Therefore, it was statistically observed that there were no significant differences in the antimicrobial effects of the honey types on the *L. monocytogenes* strains. In Table 8, the 50% concentrations of the honey types were compared with each other individually, and it was concluded that the differences in the average inhibition zone diameters were not statistically significant (p>0.05). As a result, it was statistically observed that the antimicrobial effects of the honey types on the test strains did not differ from each other.

Table 8. Comparison of the antimicrobial effect spectra of 50% honey samples with each other

Çizelge 8. %50 bal örneklerinin antimikrobiyal etki spektrumlarının birbiriyle karşılaştırılması

Comparison of Samples with Each Other		Pairwise Comparison: Mean Diameter Differences	Standard Error	*p*	95% Confidence Interval: Lower Bound	Upper Bound
1	2	-0.002	0.062	1	-0.178	0.175
	3	-0.024	0.062	1	-0.199	0.151
	4	0.206	0.103	0.33	-0.086	0.498
2	1	0.002	0,062	1	-0.175	0.178
	3	-0.022	0.039	1	-0.134	0.089
	4	0.208	0.117	0.514	-0.123	0.538
3	1	0.024	0.062	1	-0.151	0.199
	2	0.022	0.039	1	-0.089	0.134
	4	0.23	0.109	0.261	-0.079	0.539
4	1	-0.206	0.103	0.33	-0.498	0.086
	2	-0.208	0.117	0.514	-0.538	0.123
	3	-0.23	0.109	0.261	-0.539	0.079

(1: Filtered Floral honey, 2: Comb Floral Honey, 3: Pine Honey, 4: Acacia Honey)

The findings of our study align with several previous studies examining the antimicrobial activity of honey samples against *L. monocytogenes* strains. Silici et al. (2010) investigated the antimicrobial effects of honey samples at concentrations of 10%, 25%, 50%, and 75%, reporting no inhibition at the 10% and 25% concentrations, but varying degrees of inhibition at the 50% and 75% concentrations. Similarly, Polat (2011) observed the antimicrobial activity of honey at concentrations of 100%, 80%, 60%, and 40%, but no antimicrobial effect at the 20% concentration. Consequently, antimicrobial activity increased progressively with higher concentrations. Moussa et al. (2012) measured the antimicrobial effects of honey samples diluted to 100%, 70%, 50%, and 30%, and emphasized that undiluted samples exhibited the highest antimicrobial activity. Borum (2016) similarly found that undiluted honey samples showed the strongest antibacterial and antifungal effects at concentrations of 100%, 50%, and 25%. Nayaka et al. (2020), in line with our study, reported the highest antimicrobial activity in undiluted honey samples when tested at concentrations of 100%, 80%, 60%, 40%, and 20%, further confirming the trend observed in our study.

Table 9 presents the variance analysis results of honey samples at 100% and 50% concentrations. Statistically, the antimicrobial activity of honey samples at 100% concentration is found to be more significant.
Table 10 presents the effect size of honey samples at 100% concentration.

Table 9. Variance analysis of the antimicrobial activity of honey samples at 100% and 50% concentrations.
Çizelge 9. %100 ve %50 konsantrasyondaki bal örneklerinin antimikrobiyel aktivitesinin varyans analizi

Variance analysis of 100% concentrations

Source	Sum of Squares	df	Mean Square	F	Sig.
Strains	153.916	28	5.497	17.251	.000
100 %	101.592	39	2.605	8.175	.000
Strains*100%	1429.006	1092	1.309	4.107	.000
Error	369.625	1160	.319		
Total	2054.139	2319			

Variance analysis table of 50% concentrations

Source	Sum of Squares	df	Mean Square	F	Sig.
Strains	721.510	28	25.768	1.385	.088
50%	630.350	39	16.163	.869	.700
Strains*50%	21179.161	1092	19.395	1.043	.241
Error	21576.770	1160	18.601		
Total	44107.791	2319			

Tablo 10. Effect size of 100% concentrations
Çizelge 10. %100 konsantrasyonun etki büyüklüğü

	Eta	Eta Squared
Zon diameter * 100%	.222	.049
Zon diameter* Strains	.274	.075

The results from these studies, as well as from our own, demonstrate that higher concentrations of honey generally exhibit stronger antimicrobial effects against *L. monocytogenes*, supporting the hypothesis that dilution reduces the antimicrobial potency of honey. Additionally, Fratianni et al. (2021) conducted an evaluation of the effects of various monofloral honeys of Italian origin on *L. monocytogenes*. The findings revealed that *L. monocytogenes* was generally susceptible to the inhibitory effects of all tested honeys. Notably, the sensitivity of the bacteria reached 90% in the presence of ivy honey, while blackberry honey and snowberry honey demonstrated inhibitory effects exceeding 90%. Oğur & Dayan (2022) investigated the antimicrobial activity of natural honey against *L. monocytogenes* in the Bitlis region. The agar well diffusion method was employed to evaluate the antimicrobial effects of honey at concentrations of 10%, 25%, 50%, and 100%. The results demonstrated significant antimicrobial activity, with a 50% honey concentration producing an inhibition zone of 34.00 ± 1.10 mm against *L. monocytogenes*. The largest inhibition zones were observed at the 100% concentration. In contrast to our study, Çakır & Dervişoğlu (2022) explored the antimicrobial effects of honey collected from various regions of Bingöl province using the disk diffusion method. Honey samples were tested at three concentrations (500, 250, and 125 mg/mL) for their antibacterial activity against *L. monocytogenes*. The results indicated that none of the honey samples, regardless of concentration, exhibited antibacterial activity against *L. monocytogenes*.

The antimicrobial properties of honey have been extensively studied against various pathogenic bacteria. The results obtained in our study also support similar studies conducted on other pathogens. Mahendran and Kumarasamy (2015) evaluated the antibacterial activity of twelve honey samples from different origins against Gram-positive bacteria, including *S. aureus* and *Streptococcus pyogenes*, as well as Gram-negative bacteria such as *E. coli*, *Pseudomonas aeruginosa*, and *Proteus mirabilis*. Their results showed that among the twelve honey samples, summer honey (S1) and winter honey (W1) exhibited the highest antibacterial activity, particularly against *S. aureus*. Süerdem & Akyalçın (2017) examined the antimicrobial activity of six different honey samples against various Gram-positive (*Enterobacter faecalis* ATCC 29212, *S. aureus* ATCC 29213, *S. aureus* ATCC 6538P, *S. aureus* ATCC 25923, *Bacillus cereus*) and Gram-negative (*E. coli* ATCC 25922, *S.* Typhimurium ATCC 51812) bacteria. Their results demonstrated that all tested honey samples exhibited antimicrobial activity against the studied pathogens, except for *E. faecalis* and *E. coli* ATCC 25922, which were found to be resistant. The inhibition zones ranged between 10 mm and 40 mm in diameter, indicating variable antibacterial activity among the honey samples. Similarly, Guruvu et al. (2021) investigated the antimicrobial effects of commercial honey and Bharat honey against three different pathogens, namely *P. aeruginosa* ATCC 27853, *E. coli* ATCC 35218, and *S. aureus* ATCC 25923, using seven different dilutions. Their findings indicated that undiluted honey samples exhibited higher antimicrobial effects against these pathogens compared to the diluted samples. Additionally, Özkırım et al. (2021) investigated the antimicrobial activity of oak honey against *E. coli* ATCC 35218, *S. aureus* ATCC 29213,

and *P. aeruginosa* ATCC 27853. Their findings revealed that *S. aureus* was the most susceptible strain, followed by *P. aeruginosa* and *E. coli*, respectively.

CONCLUSION

The growing interest in natural products as potential treatments for antibiotic-resistant bacteria and the diseases they cause has increasingly captured the attention of researchers. The results of the study showed that it was statistically significant that the 100% concentrations exhibited higher antimicrobial activity compared to the 50% concentrations (p<0.05). The highest average inhibition zone diameter in undiluted samples was observed in pine honey, followed by flower honey, comb honey, and acacia honey in decreasing order. The study emphasizes the need for comprehensive, broad-spectrum research and clinical trials to validate the findings.

Contribution Rate Statement Summary of Researchers

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

Conflict of Interest

The authors express no conflict of interest associated with this work.

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