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Research Article

Antimicrobial Activities of Propolis Samples Collected From Different Provinces of Turkey

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Abstract

The propolis, which is a natural product that is collected by honey bees from the plants, especially flowers and buds, by mixing it with wax and resin, is used in the hive for many purposes. Apart from the use by the bees in the hive, propolis is a versatile compound that is used in medicine, cosmetics, food industry and apitherapy and which contains a wide variety of chemical substances having antibacterial and antioxidant effects. It was determined that the antimicrobial effects of propolis samples were higher against the Gram-positive bacteria species included in the study when compared to the Gram-negative bacteria and yeasts. The majority of the samples were found to be highly sensitive (16 mm and larger), while some were found to be moderately sensitive (11-15 mm). Among all strains of bacteria; it was demonstrated that the propolis sample obtained from Cankiri (Yaprakli) region performed the highest activity against *Staphylococcus aureus* while the lowest activity was performed by the propolis sample obtained from Balıkesir region against *E. coli*. In addition, it was determined that the propolis sample obtained from Eskişehir region had no antifungal effect against *Candida parapsilosis* yeast strain. It was specified that the antimicrobial activity demonstrated by all microorganisms against the propolis samples was less effective when compared to the control compounds, except for *Candida krusei*.

Keywords: Antifungal activities, antimicrobial activities, apitherapy, honey, propolis

INTRODUCTION

Many factors such as healthy eating awareness, decrease in the effectiveness of drugs as well as the side effects caused by them and the economic losses have increased the consumer demand for natural foods in recent years. Bee products are also among these natural products and attract the attention of the medicine, drug and food industries in terms of their antibacterial, antioxidant, antifungal, anti-inflammatory, anti-tumour and antiseptic properties. Treatment with bee products (apitherapy) is applied all over the world and is accepted as a medical support by scientific authorities. Propolis, which is among these products, is a resinous, sticky substance that honey bees collect from the buds and leaves of trees and plants to ensure hygiene in their hives. This substance is mixed with pollen and enzymes secreted by the bees (Crane, 1997; Mărghitas, et al., 2013). Generally, propolis consists of 50% resin and vegetable balm, 30% wax, 10% essential and aromatic oils, 5% pollen and 5% organic residues including a variety of other ingredients. In addition, bees (Apis mellifera) use propolis as a sealant in their hives against heat, moisture and wind (Burdock, 1998). Bees create a means of defence against germs and mould thanks to Propolis. By covering the hive's entrance and closing the holes with this substance, they are able control the entrance and exit doors of the hive. Thanks to its antiseptic effect, it prevents the contamination by bacteria, viruses or parasites inside the hive while covering the uninvited guests who died inside (Salatino et al., 2005; Righi et al., 2010). This substance has been used for a long time because of its effectiveness against microorganisms and its pharmaceutical properties (Ghisalberti, 1978; Bankova et al., 2000). The antimicrobial property of propolis against different bacteria (Sforcin et al., 2000), yeasts (Sforcin et al., 2001), viruses (Gekker et al., 2005, Búfalo et al., 2009) and parasites (Freitas et al., 2006) has been widely recorded. In addition, the propolis is stated to have many beneficial biological activities such as antioxidant (Ahn et al., 2007, El-Guendouz et al., 2017), anti-inflammatory (De Groot et al., 2013, Franchin et al., 2013), antitumor (Banskota et al., 2000, Veiga et al., 2017) and hepatoprotective (Banskota et al., 2001) etc. The antioxidant, antibacterial and antifungal properties of propolis, along with the fact that many of its components are present in food and / or food additives and are generally recognized as safe and harmless (GRAS), contribute to its acceptance as a natural preservative in new food products (Ghisalberti, 1978; Bankova et al., 2000; Banskota et al., 2001). Park et al., (1998); reported that the growth of *Streptococcus*, an oral pathogen, was inhibited by propolis obtained from various regions of Brazil and dissolved in ethanol extract. Fernandes et al., (1995) revealed the antimicrobial activity of propolis against bacteria and yeast pathogens isolated from human infection. In addition, Grange & Davey (1990); Dobrowalski et al., (1991) and Siheri et al., (2017) found that propolis was more active against Gram-positive bacteria, but showed a more limited activity against Gram-negative bacteria. Another study indicates that propolis has strong antibacterial potential against Gram-positive pathogenic bacteria like *Staphylococcus aureus* and *Rhodococcus equi*, but has no effect on Gram-negative bacteria (Hadžić et al., 2019). Researchers have observed that the antimicrobial activity of propolis depended on its chemical composition that differ from region to region. In the studies, it has been determined that the

propolis samples of different origins have different biological activities. The propolis component changes depending on factors such as climate, source of secretion, environmental factors etc. (Chen and Wong, 1996). It is stated that the chemical components that cause the antimicrobial activity of propolis differ from region to region and from season to season (Hegazi et al., 2000; Sforcin et al., 2000). Similarly, some studies have revealed that propolis has an antibacterial activity that may vary depending on geographical regions and seasons (Ghisalberti, 1978; Kujumgiev et al., 1999). In a study, the antimicrobial activity of three propolis samples obtained from Germany, France and Austria against *Staphylococcus aureus*, *Escherichia coli* and *Candida albicans* has been investigated and it was determined that German propolis performed the highest antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli* and Austrian propolis performed the highest activity against *Candida albicans*. It was also specified that French propolis is less effective than German and Austrian propolis (Hegazi et al., 2000). Similarly, in another study evaluating the antimicrobial activity of propolis samples collected from different geographic and climatic regions, it was stated that the antimicrobial activity of propolis samples collected from humid tropical climates was higher (Seidel et al., 2008). The collection of propolis also changes according to the different breeds of honey bees. In the study conducted by Silici & Kutluca (2005) on propolis collection behaviour of different honey bee breeds and chemical properties of these propolis and in which the chemical composition and antibacterial activity of propolis samples collected by three different honey bee breeds living in the same region have been determined, the propolis sample collected by A. mellifera caucasica (Caucasian bee) was found to perform a higher antibacterial activity when compared to the samples collected by A. m. anatolica and A. m. carnica (Silici & Kutluca, 2005). In this study, the antimicrobial activity of propolis samples collected from different regions of Turkey against some pathogenic microorganisms have been investigated.

MATERIALS and METHODS

Propolis samples

Propolis samples collected from different regions of Turkey were investigated. Most of the crude propolis samples were collected from Cankiri center and its surroundings. Other examples were collected from the provinces of Adana, Antalya, Eskisehir, Kutahya, Balikesir. All samples were obtained from beekeepers in October and November 2018. Propolis samples were taken into sterile jars and brought to the laboratory. The samples were stored at 4 °C until antimicrobial activity studies were performed.

Sample preparation

Propolis samples were grounded and 4 mg of grounded propolis were dissolved in 2 mL of dimethyl sulfoxide (DMSO) by continuous mixing for 5 h. These were then incubated at 37 °C in water bath overnight. After centrifuging at 800 × g for 15 min, extracts were filtered (Barlak et al., 2015; Ilkimen et al., 2016).

Antimicrobial and antifungal activity

The antimicrobial activities of propolis samples were evaluated against *Staphylococcus aureus* ATCC 29213, *Enterococcus faecalis* ATCC 29212 (Gram positive), *Escherichia coli* ATCC 25922, (Gram negative) bacterial species and *Candida krusei* ATCC 6258 and *Candida parapisilosis* ATCC 22019 yeast species. To detect the antimicrobial activities of the samples was used by the

well-diffusion method. All microorganisms were obtained from the from the Faculty of Medicine of Osmangazi University, Turkey. Bacterial cultures for antimicrobial testing were prepared in brain heart infusion broth medium and yeast cultures for antimicrobial testing were prepared Sabouraud dextrose broth. The compounds were dissolved in DMSO at concentrations of 10 mg mL−1 using a Millipore membrane filter (0.45 µm, Millipore). Approximately 1 mL of 24 h broth cultures containing 106 cfu mL−1 were placed in sterile Petri dishes. Moltent Mueller Hinton Agar (15 mL) was allowed to cooled at 45 °C was then poured into the Petri dishes and allowed to solidify. Then wells of 6 mm diameter were punched carefully using a sterile cork borer and were filled with test solution. The plates were incubated for 24 h at 37 °C. The diameter of the zone of inhibition for all the test compounds was measured and the results were compared with the control compounds (Seferoğlu et al., 2008; Ilkimen et al., 2016).

RESULTS and DISCUSSION

In this research, antimicrobial and antifungal activities of 15 propolis samples collected from the different provinces of Turkey (Cankiri, Adana, Antalya, Eskisehir, Kutahya and Balikesir) were investigated. Propolis samples were found to be have antibacterial effects against all gram negative and gram positive bacteria included in the study. Vancomycin, Levofloxasin and Cefepime were used as standard antibacterial agents, whereas Fluconazole was used as an antifungal agent. The observed data on the antimicrobial effects of all samples and control drugs are given in (Table1 and Table 2).

Table 1. Antibacterial activity results of propolis samples

Propolis samples and antibiotics (10 mg mL^{-1})	***E. faecalis* (ATCC 29212)**	***E. coli* (ATCC 25922)**	***S. aureus* (ATCC 29213)**
Vancomycin	5.1	2.5	5.4
Levofloxasin	4.3	5.2	5.1
Cefepime	5.2	5.3	3.2
Cankiri (Kurşunlu)	2.4	1.7	2.7
Cankiri (Kurşunlu)	1.3	1.8	2.6
Cankiri (Yaprakli)	1.5	2.3	2.4
Cankiri (Yaprakli)	1.4	1.4	4.3
Cankiri Center	2.2	2.2	2.6
Cankiri Center	1.5	2.2	2.8
Cankiri Center	2.3	2.3	2.4
Cankiri Center	1.5	2.4	2.6
Cankiri Center	1.5	1.7	2.5
Cankiri Center	2.6	1.6	2.8
Adana	1.5	2.4	3.4
Antalya	2.5	2.3	2.7
Eskisehir	2.7	1.5	2.6
Kutahya	1.4	1.3	2.3
Balikesir	2.7	1.2	2.5

Table 2. Results of antifungal activity of propolis samples

Propolis samples and antifungal agent (10 mg mL^{-1})	***Candida krusei* (ATCC 6258)**	***Candida parapisilosis* (ATCC 22019)**
Flucanozole	-	2.5
Cankiri (Kurşunlu)	1.5	1.6
Cankiri (Kurşunlu)	2.7	1.5
Cankiri (Yaprakli)	2.3	1.5
Cankiri (Yaprakli)	2.2	2.5
Cankiri Center	2.4	2.5
Cankiri Center	2.6	2.5
Cankiri Center	1.5	2.3
Cankiri Center	2.5	2.5
Cankiri Center	2.3	1.5
Cankiri Center	1.5	1.5
Adana	2.5	2.4
Antalya	3.4	1.5
Eskisehir	3.2	-
Kutahya	2.3	2.3
Balikesir	2.6	1.5

In the study, propolis samples collected from different geographical regions of Turkey was determined to show antimicrobial activity against bacteria and yeast species. According to the results, no significant difference was found between the provinces in terms of antimicrobial effect. It was determined that a sample belonging to Cankiri region showed the highest activity against *S. aureus* bacteria and the propolis sample from Eskisehir region did not show antifungal effect against *C. parapisilosis* yeast species. The results obtained are consistent with the studies conducted both in Turkey and abroad. In studies investigating the effects of antimicrobial activity of propolis samples collected from different regions and provinces, it is stated that propolis extracts have antibacterial and antifungal effects against different bacterial and fungal species. Antimicrobial activity is one of the most important characteristics of the propolis. Therefore, the propolis samples of different geographical origins and chemical compositions are stated to have certain antibacterial and antifungal effects against different types of bacteria and fungi. The antimicrobial characteristics of propolis vary depending on its chemical composition and the vegetative flora of the area where it was collected and therefore differ from region to region and this situation also leads to changes in the antimicrobial activity of the propolis (Bankova et al., 2000; Hegazi et al., 2001). In this study, the antimicrobial and antifungal activities of 15 propolis samples collected from different geographical regions of Turkey including Cankiri, Adana, Antalya, Kütahya, Eskişehir and Balıkesir provinces have been investigated by well diffusion method. It was specified that the propolis samples have an antimicrobial effect against all bacteria and yeast species included within the study. *Vancomycin*, *Levofloxacin* and *Cefepime* were used as standard antibacterial agents and *Fluconazole* was used as the antifungal agent. The results have been interpreted as Highly sensitive (16 mm and larger), Moderately sensitive (11-15 mm), Low sensitive (5.5-10 mm) and Not sensitive (Inactive, <5.5 mm) in terms of the diameter of the inhibition zones (Ilkimen & Gulbandilar 2018). The observed data regarding the antimicrobial properties of all samples and control drugs are given in Table 1 and Table 2. It was determined

that the antimicrobial effects of propolis samples were higher against Gram-positive bacteria species included in the study when compared to the Gram-negative bacteria and yeasts. Except for one yeast strain, the majority of the samples were found to be highly sensitive (16 mm and larger), while some were found to be moderately sensitive (11-15 mm). Samples were found to be less effective against the bacteria when compared with the control compounds. Among all strains of bacteria; it was demonstrated that the propolis sample obtained from Cankiri (Yaprakli) region performed the highest activity against *Staphylococcus aureus* while the lowest activity was performed by the propolis sample obtained from Balıkesir region against *E. coli*. As for the yeasts, it was determined that *Candida krusei* strain was more effective than the control compound, the *Candida parapsilosis* strain showed a similar effect in four samples and the other samples were less effective than the control compound. In addition, it was determined that the propolis sample obtained from Eskişehir region had no effect against this yeast strain. There was no significant difference between the regions regarding the activity efficiency of the samples. The results of the research are consistent with the studies conducted in Turkey and abroad (Table 1). In a study conducted in our country, it was determined that the propolis extracts were stronger against the gram-positive bacteria *S. aureus* and *Beta hem. Streptococcus*, but on the other hand performed a weaker antibacterial activity against gram-negative bacteria *E. coli* and *P. aeruginosa* (Keskin et al., 2001). In a similar study, it was reported that ethanolic extract of propolis showed high antibacterial activity against Gram (+) bacteria *S. aureus*, but performed a weaker activity against Gram (-) bacteria *E. coli* and *P. aeruginosa* and the yeast strain *C. albicans* (Silici & Kutluca, 2005). Uzel et al. (2005) revealed the antibacterial activity of propolis against *Micrococcus luteus* and *Salmonella typhimurium* bacteria. In another study, it was determined that propolis showed strong antibacterial activity against 13 different bacterial plant pathogens (Basim et al., 2006). The antimicrobial activity of the propolis samples obtained from Adana region against the microorganisms within the scope of our study including *Staphylococcus aureus* (ATCC 29213), *Enterococcus faecalis* (ATTCC 29212) and *Escherichia coli* (ATCC 25922) bacteria and *Candida krusei* (ATCC 6258), *Candida parapsilosis* (Clinical isolate) yeast strains has been investigated. It has been specified that the propolis samples have higher antimicrobial effects against Gram-positive bacteria when compared to Gram-negative bacteria and yeasts (Duran et al., 2010). Similarly, in our study, it was determined that the propolis sample obtained from Adana region performed the highest activity against *Staphylococcus aureus* (ATCC 29213) bacteria, which is a Gram-positive bacterium. On the other hand, the other microorganisms such as Gram-negative bacteria and yeast strains have been found to perform similar activities. In another study conducted in our country, it was stated that the propolis had a wider antibacterial activity against gram-positive bacteria (Kartal et al., 2003). The antibacterial activities of 25 propolis samples collected from various geographical regions of Turkey against two food pathogens *Salmonella enteritidis* and *Listeria monocytogenes* bacteria have been investigated by Temiz et al (2011). Depending on the EEP concentration of propolis samples, antibacterial activity on gram-positive bacteria was found to be higher than

gram-negative bacteria (Temiz et al., 2011). Similarly, the antimicrobial characteristics of the propolis have also been investigated in various countries. It was determined that four different propolis samples collected from Brazil performed antibacterial activity (Bankova et al., 1995). On the other hand, Velikova et al., (2000) found out that the propolis samples collected from Bulgaria, Turkey, Greece and Algeria performed a high antibacterial activity while their antifungal effect was weak to moderate. In another study investigating the antifungal properties of propolis in Brazil, it is reported that *C. albicans* is more sensitive than *C.tropicalis* (Sforcin et al., 2001). In some of the studies conducted on the antimicrobial activity of propolis, it has been stated that the propolis is active against only Gram (+) bacteria and some fungi (Marcucci 1995; Nieva et al., 1999), while others stated that its activity against Gram (-) bacteria was weak (Sforcin et al. 2000; Grange & Davey 1990; Dobrowolski et al., 1991). It has been reported that Gram (+) bacteria are generally more sensitive to propolis compared to Gram (-) bacteria (Mirzoeva et al., 1997). In their recent study, Przybyłekand et al., (2019) stated that the propolis performs an antimicrobial activity against more than 600 types of bacteria that have been examined so far and that it has a higher activity against Gram-positive bacteria when compared to Gram-negative bacteria. In their study comparing the antimicrobial activity of propolis samples obtained from different parts of the world, the same researchers stated that the highest activity related to the Gram-positive (*Staphylococcus aureus*) and Gram-negative (*Escherichia coli*) bacteria species was observed in the propolis obtained from the Middle East while the lowest activity was observed in the propolis obtained from Germany, Ireland and Korea (Przybyłekand et al.,2019). The findings obtained from the studies conducted in our country and other countries are consistent with the findings that we have obtained as a result of our study. Our study has shown that the antimicrobial activities of the propolis samples collected from different regions of Turkey are quite high. It has been determined that the use of propolis in prevention of diseases and infections can be promising. Determining the antimicrobial activities of the propolis samples to be collected from other parts of Turkey with the new studies to be conducted will make a positive scientific contribution.

CONCLUSION

In this study, samples of propolis from different regions were screened for their antibacterial and antifungal activities by well-agar diffusion method by using three bacteria and two fungi. It was determined that a sample belonging to Cankiri region showed the highest activity against *S. aureus* bacteria and the propolis sample from Eskisehir region did not show antifungal effect against *C. parapisilosis* yeast species. The results obtained are consistent with the studies conducted both in Turkey and abroad.

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