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Research Article

The antibacterial and antioxidant activity of the tea bag and the bulk of herbal tea: Which one is more?

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ABSTRACT

This study aimed to compare the antibacterial (using the disc diffusion method) and antioxidant (using the FRAP method) properties of tea bag herbal tea and bulk herbal tea of linden and thyme against Streptococcus mutans, *Escherichia coli, Enterococcus faecalis, Staphylococcus aureus*, and *Staphylococcus epidermidis*. It has been observed that the antibacterial activity of bulk herbal tea of linden is higher than that of tea bags of herbal tea, and even the tea bags of herbal tea have no antibacterial effect on the test microorganisms except *S. aureus*. However, when tea bags of herbal tea and bulk herbal tea of linden were analysed in terms of antioxidant properties, it was determined that the antioxidant activity of tea bags of herbal tea was higher than that of bulk herbal tea. Analyses of thyme extract showed that the antibacterial activity of bulk herbal tea was relatively higher than that of tea bags of herbal tea. Considering the antibacterial activity of the bulk and tea bag form of thyme herbal tea of the same brand, the bulk herbal tea showed higher antibacterial activity than the tea bag of herbal tea, and even the tea bag of herbal tea had no antibacterial effect on the test microorganisms except *S. aureus* and *S. epidermidis*.

Keywords: Thyme, Linden, Herbal tea, Antimicrobial activity, Antioxidant activity

Introduction

Plants have been used by humans for centuries for various purposes, including nutrition, health protection, and the treatment of different diseases. Today, medicinal and aromatic plants, which are widely used in sectors such as food, health, cosmetics, and perfumery, have garnered attention in recent years due to their high commercial value in global markets. In recent years, there has been a two-fold increase in the demand for medicinal plants in the international market. According to World Health Organisation estimates, the current annual demand of $14 billion is projected to reach $5 trillion by 2050 (Can & Duraklı Velioğlu, 2018).

According to research conducted by the World Health Organisation (WHO) on 91 countries, the total amount of medicinal plants used for therapeutic purposes is around 20,000. It is recorded that around 500 of these were produced. Additionally, very few plants used for various purposes are registered in pharmacopoeias (Codex). However, the number of plants used for medicinal purposes among the public is very high (Nalbantbaşı & Gölcü, 2009).

Türkiye has a remarkable and rich flora in terms of plant diversity. The main reasons for this richness are its location at the intersection of three phytogeographic regions, being a bridge between Southern Europe and South-West Asia, and the fact that Anatolia is the centre of origin and differentiation of many genera and sections. As a result of the ecological and phytogeographic differentiation in Anatolia, species endemism is high (Benli & Yiğit, 2005).

The increasing use of antimicrobial drugs has caused multiple-drug resistance to increase day by day. Biologically active compounds from natural sources, such as plants, are of interest to scientists. Many medicinal plants around the world are used in daily life for the treatment of diseases. Turkish native plants are widely utilised in various sectors, including the food industry and traditional medicine (Albayrak et al., 2012). According to the Turkish Pharmacopoeia-2017 (European Pharmacopoeia Adaptation II-2017), there are 296 drugs derived from 209 medicinal plants (Onbaşlı & Dal, 2020).

Herbal products have been widely used all over the world for thousands of years. With the growing interest in complementary and alternative treatments, the consumption of herbal teas is also on the rise. Herbal teas are among the most widely consumed beverages worldwide, and their properties and health effects have been extensively researched. Their chemical composition comprises a diverse range of components, including amino acids, vitamins, and minerals (Yıldız et al., 2022). Herbal tea mixtures made from different plants may have been used in the treatment of diseases before written history, according to historians. Every civilisation in history has discovered the opportunity offered by the vegetation specific to their environment in different ways and utilised it by passing it down from generation to generation with minor changes. Herbal teas are prepared by drying the fragrant (aromatic) parts of plants, such as roots, root stems, branch shoots, leaves, flowers, barks, fruits, or seeds, and then making them suitable for drinking by infusing them in boiling water. There have been shown that herbal teas have positive effects on health due to the bioactive compounds with antioxidant properties they contain (Kasapoğlu, 2015).

Türkiye is a leading country in the field of tea production and consumption worldwide. In a study conducted to evaluate tea consumption habits in Türkiye, it was revealed that some participants who stated they consume herbal tea buy herbal teas from spice shops. At the same time, the majority purchase ready-made tea bags from markets. The reasons for consuming herbal tea bags, as stated by the participants, included being practical to brew, offering a large variety of options, being perceived as healthy, enjoying the taste and aroma, and being beneficial for various health conditions. It was reported that those who consumed a tea bag of herbal tea preferred linden at the highest rate, followed by sage and rosehip, respectively (Ulusoy & Şeker, 2013).

The Thymus genus comprises approximately 350 species of perennial, aromatic herbs and shrubs, primarily found in the Mediterranean region, Asia, Southern Europe, and North Africa. Several thyme ecotypes differ in their morphological characteristics and the composition of their essential oils. However, all of them are characterised by a moderate odour and sometimes a very pronounced balsamic and spicy taste. Essential oils, which are obtained from the species of thymus, are in increasing demand for perfumery, cosmetic and medicinal uses. Furthermore, the essential oils of thyme are among the top 10 essential oils used as a food preservative worldwide (Ballester-Costa et al., 2013).

The thyme plant likes to grow on the banks of grassy fields, on forest edges and above anthills in meadows. Because it needs sun and heat, it thrives in rocky and mountainous areas where soil temperatures are high. It has a characteristic odour. Thyme is primarily used as a spice. It enriches the taste of fatty and heavy dishes and facilitates digestion (Benli & Yiğit, 2005).

Thyme was used to treat coughing, upper respiratory congestion, gastritis, bronchitis, spasms, sprains, stomach cramps, dysmenorrhea, dyspepsia, and urinary tract infections (Balkan et al., 2016). Thyme is thought to be antiseptic, antimicrobial, astringent, anthelmintic, carminative, disinfectant, and tonic. Thyme is incredibly beneficial in treating various intestinal infections and infestations, including hookworms, ascarids, and infections caused by both Gram-positive and Gram-negative bacteria, as well as fungi, yeasts, and *Candida albicans*. It can also improve liver function and act as an appetite stimulant. It will be used in the treatment of cartilage, bronchial, and urinary infections in the future. Thyme used as a mouthwash is beneficial in treating laryngitis and inflammation. Its active ingredient, thymol, which is the main component of the volatile oil of thyme, is effective against Enterobacteria and cocci bacteria (Prasanth Reddy et al., 2014).

The alcoholic extracts of Tilia flowers exhibit antimicrobial activity, particularly against certain types of bacteria that can cause infections in the oral cavity. Additionally, since the infusion of its flowers and bracts is expectorant and antiseptic, they are also used to treat upper respiratory tract disorders. In recent years, some countries have made the use of natural products for various purposes mandatory. In Türkiye, plants known to be beneficial to health are used in the treatment of various diseases (Bayrak Özbucak et al., 2013).

This study aimed to compare the antibacterial properties of tea bag herbal tea made from linden and thyme, and bulk herbal tea made from linden and thyme, on the bacteria *Streptococcus mutans, Escherichia coli, Enterococcus faecalis, Staphylococcus aureus*, and *Staphylococcus epidermidis*, as well as their antioxidant properties using the FRAP (Ferric Reducing Antioxidant Power) method.

Materials and Methods

Materials

The herbal tea bag used in the present study, containing linden and thyme, was obtained from a spice shop in Türkiye. Also, a bulk herbal tea of linden and thyme was purchased from a spice shop in Türkiye. Test microorganisms used in experimental procedures were *Streptococcus mutans* (CNCTC 8/77), *Enterococcus faecalis* (ATCC 29212), *Escherichia coli* (ATCC 8739), *Staphylococcus aureus* (ATCC 29213), and *Staphylococcus epidermidis* (ATCC 12228). The İstanbul Medipol University School of Pharmacy Microbiology Research Laboratory supplied them.

Preparation of Extracts

The herbal tea bags containing linden and thyme, as well as the bulk herbal tea, were ground using a mill. The powders of plant materials were kept in absolute ethanol (ISOLAB UN 1170, for analysis) for 3 days in a dark place at a rate of 1:10 (w/v). The solvent in the obtained extracts was removed by using a rotary evaporator (BUCHI Rotavapor R3 and BUCHI Heating Bath B-100) under vacuum at 45°C for 15 minutes (Tunç et al., 2013).

Preparation of 24h Bacterial Cultures

Test microorganisms (*Streptococcus mutans*, *Escherichia coli, Enterococcus faecalis, Staphylococcus aureus, Staphylococcus epidermidis)* were inoculated into Tryptic Soy Broth (Merck) and were incubated at 37°C for 24 hours. The bacterial suspension was prepared from a 24h culture of test microorganisms (Tunç et al., 2013).

Determination of Antibacterial Activity

The disc diffusion method was applied to determine the antibacterial activity of each extract against *Streptococcus mutans, Escherichia coli, Enterococcus faecalis, Staphylococcus aureus*, and *Staphylococcus epidermidis*. The extract concentrations were obtained as 380 mg/mL by adding ethanol to each extract. Sterile discs (Bioanalyse, 6 mm in diameter) were impregnated with 20 µL of each extract and then allowed to dry. Ethanol-impregnated discs were used as a negative control. Amoxicillin impregnated discs (25 µg) were used as a positive control in this study (Semerci et al., 2020).

Bacterial suspensions were prepared from 24h bacterial cultures, and the bacterial density was adjusted to 0.5 McFarland by using a densitometer (Biosan). The bacterial suspension, which was adjusted to 0.5 McFarland, was inoculated onto 5% Sheep Blood Mueller Hinton Agar (Becton Dickinson GmbH, Germany) for *Streptococcus mutans* and Mueller Hinton Agar (Neogen, United Kingdom) for other test microorganisms by using sterile swabs. Next, the impregnated discs were slightly pressed onto the agar. After that, incubation was performed at 37°C for 24 hours. In addition to these, the incubation process was performed under 5-10% CO_2 conditions at 37°C for 24 hours for Streptococcus mutans. Finally, the diameters of the inhibition zone (IZs) were measured by using an electronic digital calliper after the incubation period (Semerci et al., 2020). The determination of antibacterial activity of extracts was performed three times under aseptic conditions.

Antioxidant Activity with FRAP Methodology

150 mL of 300 mM Acetate buffer adjusted to pH=3.6. It was mixed with 15 mL of a 10 mM 2,4,6-tris (2-pyridyl)-s-triazine (TPTZ) solution in 40 mM HCl. Then, 15 mL of 20 mM $FeCl_3 \cdot 6H_2O$ solution was added. Thus, the FRAP reagent was prepared. Sample blanks were composed of 0.5 mg/mL solutions of tea bag herbal teas of thyme and linden, and bulk herbal teas of thyme and linden, in three replicates, along with Trolox standards at six different concentrations. Fifty microliters of each were pipetted. Solvents of 50 µL samples were pipetted as a reagent blank. Every 20 seconds, 1.5 mL of FRAP reagent was pipetted and vortexed. After waiting for 20 minutes at room temperature, absorbances were read at 595 nm on the spectrophotometer and compared with the calibration graph of Standard Trolox (Benzie & Strain, 1999).

HPLC Analysis

LC-HPLC Agilent 1100 modular compact system (USA) with autosampler unit, UV-DAD, and a thermostable column cabinet with three trays utilised for gradient analysis, including a reagent programmable channel injection. The experimental determinations were conducted using an encapsulated Purospher Star C18 column with a guard column (5 µm, 4.6 × 250 mm) (Germany, Merck). The injection volume of all samples was 50 µL. Analysis time was 30 min. Data investigations (retention time, peak area, and detection limits) were performed using the ChemStation of the Agilent Program. The mobile phase consisted of quaternary solvents in harmony: solvent A was methanol, solvent B was a mixture of formic acid/ acetonitrile /aqua (3.5 / 48.25 / 48.25, v/v/v), solvent C was a mixture of 1.5 % formic acid: aqua (v/v), and solvent D was HPLC-grade acetonitrile. The Manager pump mobile phase flow rate was set at 0.5 mL/min. Detection signals were set at a maximum of 280 nm for UV phenolic peaks. The column oven was set at room temperature, 33-35°C. The reaction coil, made of polytetrafluoroethylene tubing (0.22 mm inner diameter), was adjusted to a length of 1.5 m. All tea extracts were filtered through a 0.20 micron filter prior to HPLC injection (Sinan et al., 2021).

For this study, validation parameters about LOD and LOQ were determined according to the International Conference on Harmonisation guidelines, respectively, 3 times and 10 times the average standard deviation of noise (Armbruster & Pry, 2008).

Results and Discussion

Antibacterial analyses have two main parts. Firstly, the antibacterial activity of linden extracts, which included a bulk herbal tea of linden-brand 1, a tea bag herbal tea of linden-brand 1, and a tea bag herbal tea of linden-brand two, was determined by the disc diffusion method against *Streptococcus mutans, Escherichia coli, Enterococcus faecalis, Staphylococcus aureus*, and *Staphylococcus epidermidis*. The inhibition zones of linden extracts tested for antibacterial activity are given in Table 1.

Secondly, it was determined that the antibacterial activity of thyme extracts, which were bulk herbal tea of thyme-brand 1, tea bag herbal tea of thyme-brand 1 and brand 2, by the disc diffusion method against *Streptococcus mutans, Escherichia coli, Enterococcus faecalis*, *Staphylococcus aureus*, and *Staphylococcus epidermidis.* Table 2 indicates the inhibition zones of thyme extracts tested for antibacterial activity.

Bulk herbal tea of the linden brand 1 had the lowest Trolox equivalent antioxidant capacity. The tea bags of herbal tea from the Linden brand 2 and Linden brand 1 had approximately equal Trolox equivalent antioxidant capacities. Tea bag herbal tea of thyme brand 2 had the highest FRAP activity (Figure 1).

In a study, sensor analysis and DPPH and FRAP antioxidant analyses were performed on linden tea, revealing that infusions prepared at a 10-minute boiling temperature yielded more effective results (Ilyasoğlu & Arpa Zemzemoğlu, 2021). In the antioxidant study conducted after 3 months of storage in thyme tea at different temperatures, up to 50% of the total antioxidant capacity was lost. For example, the FRAP activity of thyme tea decreased from 3.14 mmol Trolox equivalent to 2.31 mmol Trolox with three months of storage (Jiménez-Zamora et al., 2016). Therefore, FRAP activity varied across different brands of tea bag herbal tea or bulk herbal thyme tea (Figure 1). Additionally, HPLC analysis was performed to determine whether the antioxidant changes were caused by the tea bag or not. Epigallocatechin gallate and Epicatechin contents were found significantly higher than other phenolics in HPLC-UV analysis of all tea bags of herbal tea extracts (Figure 2, Table 3 and Table 4). The linearity of the methodology was tested in the range of 48-66 ppm for the detection of four phenolic acids (Table 3 and Table 4). All statistical Agilent-Chem-station detection limit data and concentrations were reported with significant standard deviations ($p < 0.05$). In another HPLC study, a similar content of quercetin 3-O-rutinoside was found in Linden tea (Elhussein et al., 2018). As a result, the herbal tea bag containing thyme and linden was rich in four main

phenolic acids. However, it was observed that the tea bag contained a high amount of epigallocatechin gallate, a phenolic acid. It can be assumed that there was contamination, or this component was used as an adhesive in the assembly of the tea bags.

Table 1. Linden extracts tested for antimicrobial activity using the disc diffusion method

Test Microorganisms	Inhibition Zone Diameter (mm)				
	Bulk herbal tea of linden-Brand 1	Tea bag herbal tea of linden-Brand 1	Tea bag herbal tea of linden-Brand 2	Ethanol (Negative Control)	Amoxicillin (25µg) (Positive Control)
S. aureus ATCC 29213	12.35±0.21	8.22±0.52	8.84±0.45	0	19.23±0.05
E. faecalis ATCC 29212	7.13±0.11	0	0	0	18.90±0.28
E. coli ATCC 8739	7.81±0.38	0	0	0	17.26±0.26
S. mutans CNCTC 8/77	0	0	0	0	38.90 ± 0.40
S. epidermidis ATCC 12228	10.80±1.98	0	0	0	28.53±0.50

±SD: Average Standard Deviation

Table 2. Thyme extracts tested for antimicrobial activity using the disc diffusion method

Test Microorganisms	Inhibition Zone Diameter (mm)				
	Bulk herbal tea of thyme-Brand 1	Tea bag herbal tea of thyme-Brand 1	Tea bag herbal tea of thyme-Brand 2	Ethanol (Negative Control)	Amoxicillin (25µg) (Positive Control)
S. aureus ATCC 29213	16.70±0.87	11.79±0.45	16.46±0.69	0	19.23±0.05
E. faecalis ATCC 29212	7.37±0.15	0	6.43±0.38	0	18.90±0.28
E. coli ATCC 8739	7.83±0.08	0	6.32±0.28	0	17.26±0.26
S. mutans CNCTC 8/77	0	0	0	0	38.90 ± 0.40
S. epidermidis ATCC 12228	23.10±0.63	21.61±0.35	22.16±0.41	0	28.53±0.50

±SD: Average Standard Deviation

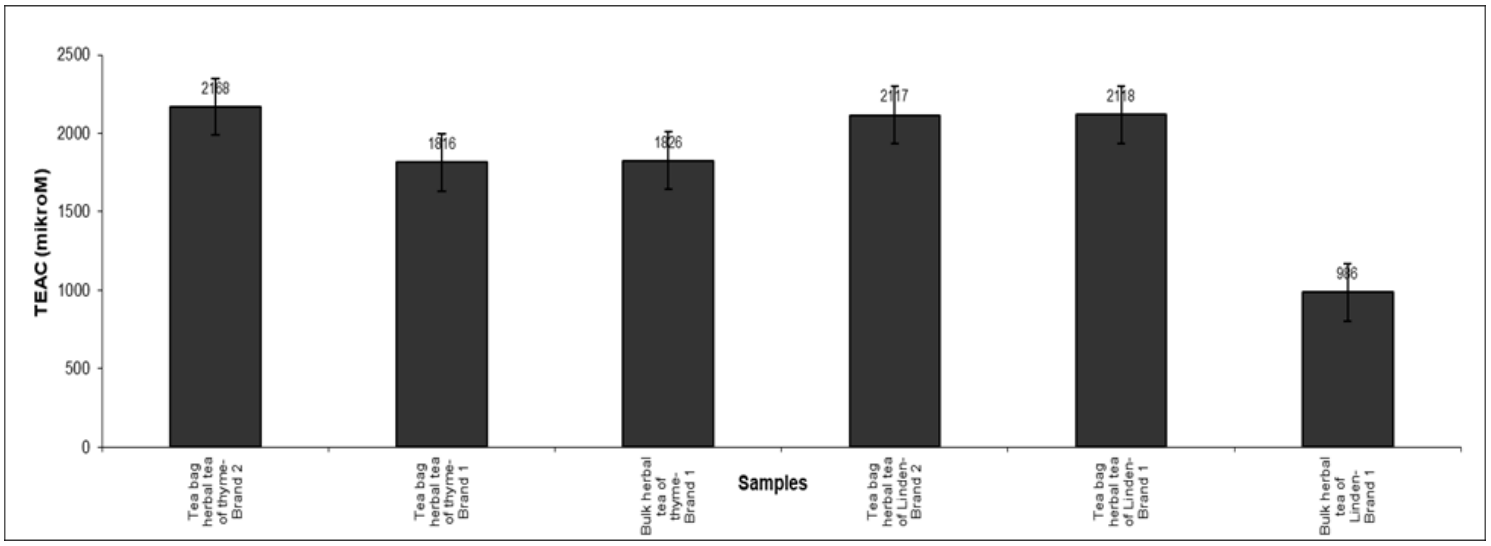

Figure 1. Trolox equivalents showing FRAP activities of herbal teas

Numerous studies have examined the *in vitro* antioxidant activity and polyphenol content of various medicinal plants. In contemporary medicine, plant-derived phytochemicals are utilised to maintain the balance between antioxidant and prooxidant status, thereby preventing and treating various diseases. Therefore, regular consumption of foods and beverages containing antioxidants is a good habit for health prophylaxis. For example, in Bulgaria, medicinal plants are widely incorporated into the daily diet of the population in the form of teas, infusions, and extracts (Kiselova et al., 2006). Synthetic substances are believed to be the reason why many diseases that were once less common or unknown in the past threaten human life. For this reason, there is a great interest in natural products today. Today, 500 different plants are used to produce herbal medicine in Germany, and 200 of them are used very frequently. In countries such as Romania, Hungary, and Bulgaria, the use of herbs in treatment is a state policy (Bağcı et al., 2006).

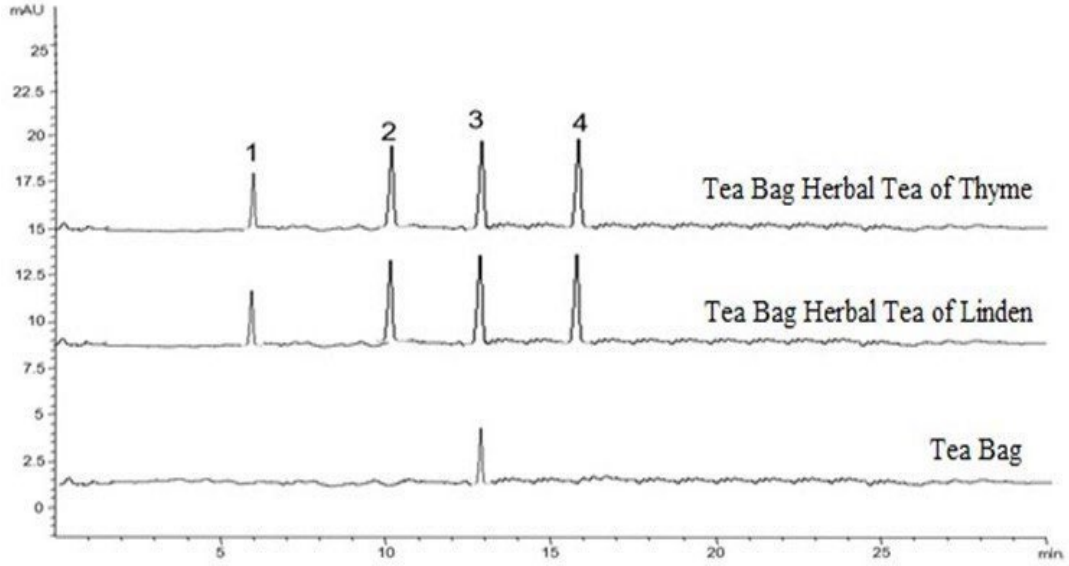

Figure 2. Chromatogram profile of defined peaks at 280 nm for a tea bag of herbal tea extracts and a tea bag, (1) Quercetin 3-O-rutinoside, (2) Isorhamnetin-3-O-rutinoside, (3) Epigallocatechin gallate, (4) Epicatechin

Table 3. The highest detection and amount limits of the peaks defined at 280 nm for bulk and tea bag herbal tea of linden extracts

Peak Numbers	Component Name	Retention Time (RT) (min.)	Concentrations (for 280 nm) (ppm)	Limit of Detection (LOD, ppm, 280 nm)	Limit of Quantitation (LOQ, ppm, 280 nm)
1	Quercetin 3-O-rutinoside	5.7	43.5±0.02	49.1±0.03	147.3±0.01
2	Isorhamnetin-3- O rutinoside	9.8	55.1±0.04	59.1±0.03	177.3±0.03
3	Epigallocatechin gallate	12.7	78.2±0.04	67.1±0.03	201.3±0.04
4	Epicatechin	15.8	82.5±0.03	65.1±0.03	195.3±0.03

±SD: Average Standard Deviation, 95 % confidence interval, critical ratio: $p<0.05$, ppm: parts per million

Table 4. The highest detection and amount limits of the peaks defined at 280 nm for the bulk and tea bag herbal tea of thyme extracts

Peak Numbers	Component Name	Retention Time (RT) (min.)	Concentrations (for 280 nm) (ppm)	Limit of Detection (LOD, ppm, 280 nm)	Limit of Quantitation (LOQ, ppm, 280 nm)
1	Quercetin 3-O-rutinoside	5.7	53.5±0.02	59.1±0.03	177.3±0.01
2	Isorhamnetin-3-O-rutinoside	9.8	75.1±0.04	69.1±0.03	207.3±0.03
3	Epigallocatechin gallate	12.7	88.2±0.04	77.1±0.03	231.3±0.04
4	Epicatechin	15.8	92.5±0.03	85.1±0.03	255.3±0.03

±SD: Average Standard Deviation, 95 % confidence interval, critical ratio: $p<0.05$, ppm: parts per million

In a study reported by Albayrak et al. (2012), among the methanol extracts of linden, laurel, fennel, senna, anise, nettle, parsley, and dill, the highest antioxidant activity and the highest amount of phenolic compounds were observed in the methanol extract of linden. There was a correlation between the phenolic content and antioxidant activity of each plant, and they suggested that the linden MeOH extract may have the highest antioxidant activity due to its higher polyphenolic content. They concluded that the MeOH extract of linden has the highest phenolic content and antioxidant, antiradical and antibacterial activities. It was reported that the extracts, infusions, decoctions and hydrosols obtained from the linden had no effect against *E. coli* and *Y. enterocolitica*. Surprisingly, the MeOH extract and decoction of linden have an antimicrobial activity against *K. pneumoniae* and *S. aureus*. Additionally, the decoctions of linden have an inhibitory effect against *B. cereus*, *K. pneumoniae* and *S. aureus* (Albayrak et al., 2012).

When we compare the bulk herbal tea of linden with the tea bag herbal tea of the same brand (Brand 1), it is noticeable that the antimicrobial activity of the bulk herbal tea of linden is significantly higher than that of the tea bag herbal tea. Mainly, the tea bag herbal tea of linden exhibits no antibacterial activity against *Escherichia coli*, *Enterococcus faecalis*, and *Staphylococcus epidermidis*; in contrast, the bulk herbal tea of linden displays antibacterial activity against these bacteria. When it was focused on *S. aureus*, it was observed that the inhibition zone of bulk herbal tea of linden against *S. aureus* was greater than that of tea bag herbal tea of linden. Interestingly, the bulk herbal tea of the linden brand 1 and the tea bags of the herbal tea brands 1 and 2 exhibit no antimicrobial activity against *S. mutans*. It was not observed that there was a difference in antimicrobial activity between the tea bags of the linden brand 1 and brand 2.

In a study on the antimicrobial activity of essential oils obtained from six different plants, including two thyme species, the essential oils of all plants were isolated and tested against bacteria. While antimicrobial activity was observed on *Staphylococcus aureus*, *Escherichia coli,* and *Candida albicans*, it was ineffective on *Pseudomonas aeruginosa* (Lisin et al., 1999).

The volatile oils of black pepper [*Piper nigrum* L. (Piperaceae)], clove [*Syzygium aromaticum* (L.) Merr. & Perry (Myrtaceae)], geranium [*Pelargonium graveolens* L'Herit (Geraniaceae)], nutmeg [*Myristica fragrans* Houtt. (Myristicaceae), oregano [*Origanum vulgare* ssp. *hirtum* (Link) Letsw. (Lamiaceae)] Moreover, thyme [*Thymus vulgaris* L. (Lamiaceae)] was tested for its antimicrobial activity against 25 different bacterial strains, and it was observed to be effective to varying degrees against these animal and plant pathogenic bacteria (Dorman & Deans, 2000).

In a study testing the essential oils of the thyme plant on 9 Gram-negative bacteria and 6 Gram-positive bacteria, it was found that they exhibited bacteriostatic activity against all test microorganisms. Essential oils obtained from the flowers of the plant were found to be the most effective (Marino et al., 1999).

Balkan et al. (2016) reported that thyme oil has a more potent antimicrobial activity than rose, ozone, and centaury oils. The striking difference was the antimicrobial effect of thyme oil against *Citrobacter freundii* and *Streptococcus* spp. Whose zones were 24 and 21 mm, respectively (Balkan et al., 2016). When comparing the bulk herbal tea of thyme to the tea bag herbal tea of the same brand (Brand 1), the tea bag herbal tea of thyme exhibits no antimicrobial activity against *E. faecalis* and *E. coli*. In contrast, the bulk herbal tea of thyme has an antimicrobial activity against them. Upon examination, it was found that the inhibition zones of bulk herbal tea were greater than those of a tea bag of herbal tea, for both

S. aureus and *S. epidermidis*. Interestingly, the bulk herbal tea of thyme brand 1 and the tea bag herbal tea brand 1 and 2 exhibit no antimicrobial activity against *S. mutans*. It was observed that the differences between the tea bags of herbal tea from brand 1 and brand 2 were in terms of antimicrobial activity. The tea bag herbal tea from brand 2 exhibits more antimicrobial activity than the tea bag herbal tea from brand 1. However, the inhibition zones of the tea bag herbal tea from brands 1 and 2 were similar against *S. epidermidis.*

The effect of consumed herbal teas, which may be derived from the seeds, flowers, leaves, stems, roots or all of these parts of the plant from which they are prepared, may vary depending on the species, region of growth, harvest time, drying method and storage conditions (Can & Duraklı Velioğlu, 2018).

Conclusion

This study is the first to investigate the differences between tea bag herbal teas of linden and thyme and bulk herbal teas of linden and thyme in terms of antibacterial and antioxidant properties.

When the linden extract was evaluated, it was observed that the antibacterial activity of the bulk herbal tea was higher than that of the tea bag herbal tea, and even the tea bag herbal tea had no antibacterial effect on the test microorganisms, except for *S. aureus*. When the thyme extract was analysed, it was observed that the antibacterial activity of the bulk herbal tea was relatively higher than that of the tea bag of herbal tea. When the bulk herbal tea and the tea bag of herbal tea of the same brand were evaluated, it was observed that the antibacterial activity of the bulk herbal tea was higher than that of the tea bag of herbal tea. Even the tea bag of herbal tea had no antibacterial effect on test microorganisms except *S. aureus* and *S. epidermidis*. On the other hand, the opposite is the case when the tea bag of herbal teas and the bulk herbal teas were analysed in terms of antioxidant properties. The antioxidant activity of the tea bag herbal tea of linden was determined to be higher than that of the bulk herbal tea of it.

In light of the data obtained from this study, it may be recommended to prefer bulk herbal teas if the aim is to benefit from antibacterial properties while consuming herbal teas. In further studies, the antibacterial and antioxidant properties of other tea bag of herbal teas, and bulk herbal teas, can be compared. Additionally, *in vivo* effects can also be investigated, and different herbal tea combinations can be examined.

Compliance with Ethical Standards

Conflict of interest: The author(s) declare that they have no actual, potential, or perceived conflicts of interest related to this article.

Ethics committee approval: Ethics committee approval is not required for this study.

Data availability: The data will be made available upon request by the author(s).

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