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DETERMINATION OF PHENOLIC CONTENTS AND ANTIOXIDANT ACTIVITIES OF INFUSIONS PREPARED FROM LEMONGRASS (*Melissa officinalis*)

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Lemongrass (*Melissa officinalis*) contains high amount of phenolic acids, specifically rosmarinic acid. In this study, dried *Melissa officinalis* teas were prepared at different water temperatures (65, 80, 95 °C) and infusion times (60, 120, 240 s) to determine the total amounts of phenolic compounds, antioxidant activities, and the physical properties of the prepared infusions. From the result the highest total phenolics content (TPC) in ground samples was recorded in infusions prepared at 95 °C at 240 s, but no statistically significant difference ($p > 0.05$) was found between the TPC of infusions prepared at lower temperatures in the same period. It was determined that the effect of time was not significant ($p > 0.05$) during each heat application in both ground and non-ground samples except for the ground lemongrass tea samples at 80 °C. Rosmarinic acid content in the ground samples increased significantly ($p < 0.05$) due to the increase in water temperature and achieved the highest value of 19.04±0.21 mg/g when a temperature of 95 °C was applied. As the water temperature of each treatment increased, the pH values of the ground infusions decreased significantly ($p < 0.001$), with the lowest pH value of 5.51±0.01 at 95°C water temperature and 240 s infusion time samples. The effect of water temperature and infusion time on the soluble solid content of the samples was not significant ($p > 0.05$) (except non-ground sample at 120 s infusion time). The results will help future research on factors such as water temperature and infusion time, as well as grinding, to ensure that bioactive components are transferred to antioxidant-rich infusions.

1. Introduction

Lemongrass (*Melissa officinalis* L.) is a perennial medicinal herb from the Lamiaceae family, native to the Mediterranean. It is grown in Europe, North America, and Asia. In traditional medicine, lemongrass is widely used as a tea infusion in the treatment of gastrointestinal complaints, headaches, and fever (Shakeri, Sahebkar and Javadi, 2016). Like other Lamiaceae member plants, lemongrass contains high amount of phenolic compounds, especially rosmarinic acid, which was the predominant hydroxycinnamic acid group (Shanaida et al., 2018). These phenolic compounds contribute to the medicinal properties of lemongrass and are associated with the plant's high antioxidant capacity (Mabrouki, Duarte and Akretche, 2018). It exhibits therapeutic properties such as sedative, carminative, and anti-spasmodic effects, which is also used in the treatment of headache, rheumatism, indigestion, and hypersensitivity (Barros et al., 2013). Melissa officinalis is most consumed in the form of infusion and decoction.

During these processes, hydrophilic compounds, including flavonoids and phenolic acids, diffuse into the water and becomes lemongrass tea (Sentkowska, Biesaga and Pyrzynska, 2015). It has been reported that lemongrass teas have a significant antioxidant effect, and this is related to the amount of phenolic substances (Jiménez-Zamora, Delgado-Andrade and Rufián-Henares, 2016).

In recent years, it has been observed that the demand for medicinal and aromatic plants is increasing and preferred for human consumption to improve health status. There is a wide variety of herbal teas or tea blends that can be used for this purpose. Different techniques can be used in their preparation (such as infusion, decoction). It is known that factors such as the temperature of the water used, the particle size of the material used in tea making, the brewing time will affect the type and amount of the components that pass into the water (Castiglioni et al., 2015). Therefore, there will be differences in the bioactive properties of the tea obtained.

In this study, teas prepared at different temperatures and infusion times from dried Melissa officinalis was used. This study aimed to determine the total amounts of phenolic compounds, antioxidant activities, and the physical properties of the prepared infusions. Due to the many different applications of water temperature and infusion time used in preparing infusions such as lemongrass that people consider to be healthy, this study is important to determine the optimum water temperature and infusion time.

2. Materials and methods

2.1. Materials

Lemongrass used in the study was obtained from Afyonkarahisar Medicinal and Aromatic Plants Center which is the Department of the Turkish Ministry of Agriculture and Forest, grown and dried drog was used. Folin-Ciocalteu reagent, 1,1-dipheny l-2-picrylhydrazyl (DPPH), formic acid, gallic acid, chlorogenic acid, rosmarinic acid, transcinnamic acid, sodium carbonate, and methanol were purchased from Sigma-Aldrich (St. Louis, MO, USA).

2.2. Preparation of Infusions

The packaged drogs (80 g) obtained from the center were first divided into two groups. Lemongrass samples in the first group were completely ground using a household grinder (Scm-2934, Sinbo). The other group was brewed without grinding. In the preparation of teas, modified methods of Golukcu et al. (2014) and Palamutoglu et al. (2018)'s have been used. Nine groups of infusions were prepared by 2 g of lemongrass samples in 200 ml distilled water for three different infusion times (60, 120, 240 s) at three different infusion temperatures (65, 80, 95 °C). At the end of the specified periods, the samples taken from the water bath and then were cooled to room temperature, and the liquid part collected by filtering through the filter paper were analyzed.

2.3. Soluble solid content

Soluble solid content of the infusions was determined using a hand-held refractometer (N2E/Atago, Tokyo, Japan).

2.4. pH

The pH of the infusion samples was determined using a pH meter (SevenGo/Metller-Toledo, OH, USA). The pH meter was calibrated before used.

2.5. Color

The color of the infusion was determined by measuring the CIE L *, a *, b * values using a colorimeter (Ci6X, X-Rite). The color analyzer was calibrated with white and black plates before used.

2.6. Determination of Total Phenolic Content

Determination of total phenolic content in methanolic extracts (1:10, v:v) obtained from lemongrass infusions was determined according to Kaur and Kapoor, (2002). Methanolic extract (0.5 ml), distilled water (7 ml), and Folin-Ciocalteu reagent (0.5 ml) were transferred to the test tube and mixed using a vortex for 3

minutes. Then, 20% sodium carbonate (2 ml) was added and mixed again. After the test tubes were kept in a water bath at 25 °C for 1 hour, the absorbances of the solutions were determined at 765 nm using a UV/Vis spectrophotometer (Optizen Pop/ Mecasys, Daejeon, Korea). Results are expressed as mg gallic acid equivalence (GAE)/100 ml tea determined by calibration curve (r2> 0.99) obtained from gallic acid (10, 20, 25, 50, 75, and 100 µg/ml).

2.7. Antioxidant Activity

The method of Choi et al. (2016) using DPPH radical was used in the determination of antioxidant activity. DPPH solution (0.4 ml; 96 mg/L, methanolic) was added to the methanolic extracts of teas (1.6 ml) and kept in the dark for 30 minutes. Then, the antioxidant activities (AA) were determined according to the formula below by reading the absorbances at 517 nm.

$$AA\ (\%) = [(Acontrol - Asample) / Acontrol] \times 100 \quad (1)$$

Acontrol: Absorbance of the solution using methanol instead of sample
Asample: Absorbance of the solution containing the sample

2.8. Determination of phenolic compounds

Phenolic compounds were determined by using High-Pressure Liquid Chromatography (HPLC) with a photodiode array detector (DAD). The modified method of Albishi et al. (2013) was used. HPLC (Ultimate 3000/ Thermo Fisher, Waltham, MA, USA) equipped with a quadruple gradient pump, degasser, autosampler, and DAD detector, 20 µl of the sample is automatically passed through the Hypersil ™ ODS-2 C18 column (250×4.6 mm, 5µm) at 30 °C and phenolic compounds determined at 300 nm. Elution solutions are A: 1% formic acid and B: 100% methanol. The samples were eluted according to the following flow pattern: up to 10 minutes 5% B, 10-15 minutes 50% B, 15-20 minutes 70% B, 20 minutes 80%, and 25 minutes 100% B. Flow rate 1.5 ml/min was applied. Standard curves (r2> 0.99) were prepared by defining the retention times of phenolic compounds (chlorogenic acid, rosmarinic acid, and trans-cinnamic acid).

2.9. Statistical Analysis

The analyzes were carried out in duplicate. The results were evaluated using Statistical Package for the Social Sciences (SPSS) software version SPSS 24. The effects of temperature and time on the ground and non-ground lemongrass infusions were separately determined using ANOVA. Differences between means were determined using Duncan Multiple Comparison Test.

3.Results and discussions

3.1. Soluble solid content

The soluble solid content and pH values of the infusions in which Melissa officinalis was used with and without grinding are given in Table 1. There was no statistically significant effect on soluble solid content values of teas prepared using ground lemongrass, neither the application of temperature nor the duration. It was observed that the time was not effective for each heat treatment in the unground samples. It has been determined that the non-ground infusions have more soluble substances in the samples at 95 °C in 120 s infussion time compared to the others, and the difference between 65 and 80 °C applications is not significant. In the infusions prepared with ground lemongrass, the highest brix value (3.15 ± 0.07 °Brix) was found in samples prepared at 65 °C for 120 s, and in the non-milled samples (2.55 ± 0.07 °Brix) prepared at 95 °C for 240 s. Palamutoglu et al. (2018) stated that the soluble solid content of elderflower infusions increased significantly depending on the increase in infusion time and water temperature. Dincer et al. (2008) reported that they obtained the highest soluble solid content values at 75 and 80 °C at the temperatures they used for instant mountain tea production.

3.2. pH

From Table 1, it was found that the pH values of the ground infusions decreased

significantly ($p<0.001$) as the water temperature of each treatment increased. Likewise, it was determined that the 240 s infussion time was very important in the samples prepared with ground lemongrass ($p<0.001$), while it was important in the other two infussion times ($p<0.01$). When the effect of time on the pH of the ground lemongrass infusions was examined, the result showed that there was a very significant difference in the 65 °C group ($p<0.01$) and significant differences ($p<0.05$) in the other groups. It has been determined that the time does not affect the 65 and 95 °C applications in the unground samples, however, there is a significant difference in the samples prepared at 80 °C. The highest and lowest pH values of teas prepared with the ground and non-ground lemongrass were determined as 6.02 ± 0.01 (65 °C, 60 s) 5.20 ± 0.01 (95 °C, 120 s), respectively. Palamutoglu et al. (2018) reported that the pH values of the samples decreased significantly due to the increase in temperature and time in the preparation of elderflower infusions.

Table 1. Soluble solid content and pH values of lemongrass infusions

			Time (s)			Sig.[1]
		Temperature (°C)	60	120	240	
Ground	Soluble solid content (°Brix)	65	2.90±0.14	3.15±0.07	3.00±0.00	ns
		80	2.95±0.07	3.05±0.07	3.00±0.00	ns
		95	3.00±0.00	3.00±0.14	3.10±0.00	ns
		Sig.[2]	ns	ns	ns	
	pH	65	6.02±0.01^{aA}	5.98±0.01^{bA}	5.88±0.01^{cA}	**
		80	5.66±0.02^{bB}	5.72±0.00^{aB}	5.63±0.02^{bB}	*
		95	5.58±0.01^{aC}	5.53±0.01^{bC}	5.51±0.01^{bC}	*
		Sig.[2]	***	***	***	
Non-Ground	Soluble solid content (°Brix)	65	2.25±0.07	2.20±0.00^{B}	2.35±0.07	ns
		80	2.15±0.07	2.15±0.07^{B}	2.35±0.07	ns
		95	2.35±0.07	2.45±0.07^{A}	2.55±0.07	ns
		Sig.[2]	ns	*	ns	
	pH	65	5.75±0.01^{A}	5.69±0.06^{A}	5.82±0.01^{A}	ns
		80	5.64±0.01^{aB}	5.59±0.00^{bA}	5.64±0.01^{aB}	*
		95	5.29±0.04^{C}	5.20±0.01^{B}	5.26±0.01^{C}	ns
		Sig.[2]	**	**	***	

Sig.[1]: Statistical significance of the effect of time, Sig.[2]: Statistical significance of the effect of temperature
[a-c]: The difference between the averages given in different letters in the same row is statistically significant.
[A-C]: The difference between the averages given with different letters in the same column is statistically significant.
ns: not significant, *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

3.3. Color

The effects of different water temperature and time applications on the color values of lemongrass infusions are given in Table 2.

Table 2 shows that infusion time at 65 °C had a significant ($p<0.05$) effect on L*, but infusion times at higher infusion temperatures had no such effect. For non-ground samples, the effect of time on samples infused at 80 °C was statistically significant ($p<0.05$), and it was more significant ($p<0.01$) at the other two infusion temperatures. The temperature of the infusion had no effect on the treatment of ground samples for 240 s, whereas samples infused for

60 and 120 s were significantly ($p<0.05$ and $p<0.001$ respectively) affected by temperature. In non-ground samples, the effect of infusion temperatures on L* value at different infusion times was found to be significantly different.

Table 2. Color values of lemongrass infusions

			Time (s)			Sig.[1]
		Temperature (°C)	60	120	240	
Ground	*L**	65	20.09±0.55^{bB}	18.63±0.04^{bC}	23.12±1.01^{a}	*
		80	25.05±0.37^{A}	23.77±0.51^{B}	25.01±0.75	ns
		95	24.92±1.11^{A}	25.64±0.18^{A}	23.53±0.00	ns
		Sig.[1]	*	***	ns	
	*a**	65	5.41±0.15^{b}	5.14±0.21^{b}	8.40±0.28^{aA}	**
		80	4.92±0.41	5.41±0.47	6.53±0.61^{B}	ns
		95	3.95±0.93	3.82±0.91	2.97±0.18^{C}	ns
		Sig.[1]	ns	ns	**	
	*b**	65	12.22±0.25^{b}	9.43±0.95^{cB}	15.19±0.34^{aA}	**
		80	16.52±0.05^{a}	14.56±0.51^{bA}	15.23±0.28^{bA}	*
		95	13.93±1.94	14.71±0.91^{A}	11.33±0.20^{B}	ns
		Sig.[1]	ns	*	**	
Non-Ground	*L**	65	35.54±0.53^{aA}	32.11±0.42^{bA}	31.70±0.26^{bA}	**
		80	32.24±0.18^{aB}	28.99±0.14^{bC}	28.87±0.82^{bB}	*
		95	27.94±0.07^{bC}	30.27±0.37^{aB}	26.07±0.23^{cC}	**
		Sig.[1]	***	**	**	
	*a**	65	-0.16±0.06^{AB}	-0.09±0.09	-0.08±0.06^{B}	ns
		80	-0.34±0.16^{B}	-0.23±0.03	-0.22±0.12^{B}	ns
		95	0.14±0.00^{A}	0.31±0.35	0.97±0.19^{A}	ns
		Sig.[1]	*	ns	**	
	*b**	65	7.84±0.37^{A}	8.05±0.20^{B}	9.75±1.21^{AB}	ns
		80	4.83±0.42^{bB}	4.77±0.21^{bC}	6.66±0.40^{aB}	*
		95	7.77±0.18^{bA}	12.35±0.96^{aA}	11.67±1.22^{aA}	*
		Sig.[1]	**	**	*	

Sig.[1]: Statistical significance of the effect of time, Sig.[2]: Statistical significance of the effect of temperature
$^{a-c}$: The difference between the averages given in different letters in the same row is statistically significant.
$^{A-C}$: The difference between the averages given with different letters in the same column is statistically significant.
ns: not significant, *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

3.4. Total Phenolic Content

Total phenolic content of ground lemongrass teas are given in Figure 1 and antioxidant activity values are given in Figure 2. The highest total amount of phenolic matter in ground samples was determined in teas prepared at 95 °C at 240 s, but no statistically significant difference was found between the phenolic content of teas prepared at lower temperatures in the same period. It was determined that it was significantly lower in samples prepared in the same period but at lower temperatures. Shanaida et al. (2018) determined the total amount of phenolic substance as 29.37-68.35 mg gallic acid equivalent /g dry sample in their infusion studies with 3 species from the Lamiaceae family. Except for the samples infused at 80 and 95 °C, the results of the total phenolic content analysis reported in Shanaida et al. (2018) research were similar in our research. It's possible that the variation is related to the herbal material used, as well as the infusion treatment method (such as time, temperature, grinding degree).

Mabrouki et al. (2018) found the highest amount of phenolic matter in ethanol extract in their studies on the effects of samples extracted using different solvents(ethanol, acetone,

hexane) from lemongrass on the total amount of phenolic matter and antioxidant capacity.

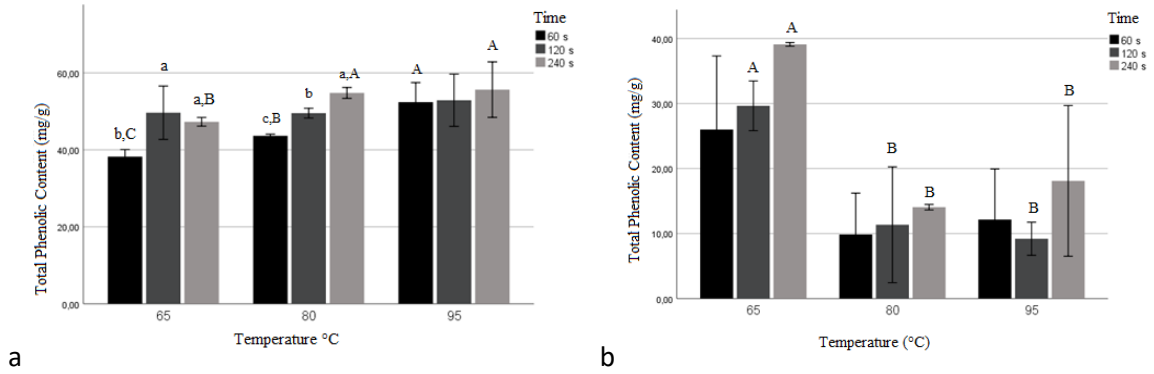

Figure 1. Total phenolic amount of *M. officinalis* infusions a. ground and b. non-ground
[a-c]: The difference between the averages given in different letters at the effect of time is statistically significant.
[A-C]: The difference between the averages given with different letters at the effect of temperature is statistically significant.

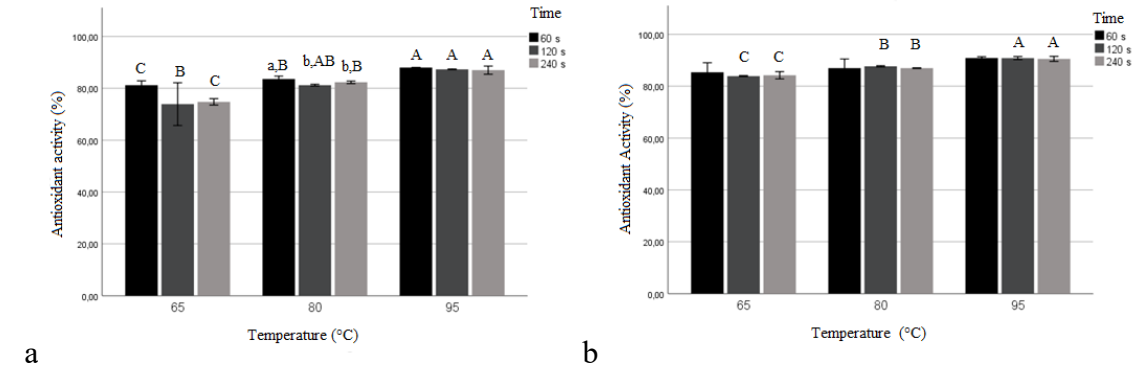

Figure 2. Antioxidant activities of unmilled *M. officinalis* infusions a. ground and b. non-ground
[a-c]: The difference between the averages given in different letters at the effect of time is statistically significant.[A-C]: The difference between the averages given with different letters at the effect of temperature is statistically significant.

When compared to ethanolic extracts, Papoti et al. (2019) found that aqueous lemongrass extracts showed the highest total phenolic content value and antioxidant activity. In addition, Papoti et al. (2019) found that lemongrass infusions had more phenolic compounds than chamomile and olive leaf infusions, and that 2% of infusions could be preferred in terms of sensory characteristics and nutritional qualities.

3.5. Antioxidant Activity

From Figure 2, it was determined that the differences between the mean levels of the antioxidant activities of the ground and non-ground lemongrass teas increased due to the increase in the temperature during each infusion time were statistically significant, except for the group prepared from unground lemongrass for 60 s. Except for the ground lemongrass tea samples at 80 ° C, it was determined that the effect of time was not significant during each water temperature in both ground and non-ground samples.

Barros et al. (2013) reported based on the literature that the antioxidant activity of lemongrass is mainly due to rosmarinic acid. However, they stated that the synergistic interaction between other antioxidant active compounds in the samples should not be neglected.

Table 3. Chlorogenic, rosmarinic and transcinnamic acid values of lemongrass infusions

			Time (s)			Sig.[1]
		Temperature (°C)	60	120	240	
Ground	Chlorogenic acid (mg/g)	65	7.31±0.73^{B}	12.15±3.49	10.75±0.47^{B}	ns
		80	12.58±0.90^{A}	14.06±0.67	13.02±1.07^{B}	ns
		95	13.78±0.03^{A}	16.46±1.48	16.98±0.94^{A}	ns
		Sig.[1]	**	ns	*	
	Rosmarinic acid (mg/g)	65	6.80±0.44^{C}	8.77±1.80^{B}	8.73±0.48^{B}	ns
		80	11.44±0.68^{bB}	11.73±0.84^{bB}	14.58±0.55^{aA}	*
		95	16.61±0.62^{bA}	19.04±0.21^{aA}	16.36±0.74^{bA}	*
		Sig.[1]	**	**	**	
	Trans-cinnamic acid (mg/g)	65	0.08±0.00^{B}	0.10±0.03	0.12±0.00^{A}	ns
		80	0.14±0.02^{aA}	0.01±0.01^{b}	0.18±0.01^{aA}	**
		95	0.05±0.00^{B}	0.09±0.11	0.04±0.03^{B}	ns
		Sig.[1]	**	ns	*	
Non-Ground	Chlorogenic acid (mg/g)	65	3.31±1.05^{B}	3.87±0.76^{B}	4.28±0.25^{B}	ns
		80	2.30±0.17^{bB}	2.53±0.02^{bB}	4.20±0.10^{aB}	**
		95	6.74±0.75^{bA}	9.17±1.12^{abA}	10.62±0.56^{aA}	*
		Sig.[1]	*	**	**	
	Rosmarinic acid (mg/g)	65	3.24±0,52	3.56±0.85	3.98±0.27	ns
		80	2.08±0.06^{b}	2.21±0.09^{b}	3.95±0.05^{a}	***
		95	ND	ND	ND	
		Sig.[1]	ns	ns	ns	
	Trans-cinnamic acid	65	0.02±0.01^{A}	0.02±0.01	0.04±0.00	ns
		80	0.001±0.00^{Bb}	0.001±0.00^{b}	0.03±0.00^{a}	***
		95	0.03±0.00^{A}	0.02±0.03	0.02±0.03	ns
		Sig.[1]	*	ns	ns	

Sig.[1]: Statistical significance of the effect of time, Sig.2: Statistical significance of the effect of temperature
a-c: The difference between the averages given in different letters in the same row is statistically significant.A-C: The difference between the averages given with different letters in the same column is statistically significant.
ns: not significant, *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$, ND: not detected.

Akowuah and Zhari (2010) determined the antioxidant activities of the main polyphenols and extracts from the leaves (dried, ground) of the Lamiaceae family. According to their study the levels of these polyphenolic compounds at the extraction temperature of 40 °C were statistically significantly higher than those obtained at 60 °C and above extraction temperatures. So the antioxidant activities of the extracts had significantly higher radical scavenging activity (DPPH) at low temperatures. Researchers have reported that polyphenolic compounds are not stable compounds, but degradation reactions occur at high temperatures. They reported that when the temperature is 60 °C and above, polyphenol oxidase can be activated and rosmarinic acid and sinensetin may be degraded (Akowuah and Zhari, 2010).

Rosmarinic acid was not detected at 95 °C infusions of nonground samples in our study, which is similar to the findings of others. From this perspective, it is possible to conclude that the cells in the ground samples have physically disintegrated, the polyphenol oxidase enzyme has been considered unusable by the diffusion, and rosmarinic acid has not been broken down.

Mabrouki et al. (2018) stated that DPPH radical scavenging activity increased due to the increase in the concentration of extracts.

From Figure 2, the samples infused at 95 °C in both groups had the highest antioxidant activity. Although rosmarinic acid has a significant effect on the antioxidant activities of infusions, other components can also be considered effective, according to Mabrouki et al. (2018) and Barros et al. (2013).

3.6. Phenolic compounds

From Table 3, it was observed that the amounts of chlorogenic, rosmarinic, and trans-cinnamic acid in lemongrass teas prepared by grinding were higher than the teas prepared without grinding, as in the results of total phenolic content.

The highest amount of chlorogenic acid was determined in teas prepared from ground lemongrass in samples prepared at 95 °C for 240 s. However, the effect of time on this temperature value was found to be statistically insignificant. A statistically significant increase was observed in teas infused for 60 and 240 s with the increase in temperature. Likewise, they reported that antioxidant activities had significantly higher radical scavenging activity (DPPH) at low temperatures. Researchers have reported that polyphenolic compounds are not stable compounds, but degradation reactions occur at high temperatures. They reported that when the temperature is 60 °C and above, polyphenol oxidase can be activated and rosmarinic acid and senisteine may be degraded.

Barros et al., (2013) reported based on the literature that the antioxidant activity of lemongrass is mainly due to rosmarinic acid. However, they stated that the synergistic interaction between other antioxidant active compounds in the samples should not be neglected.

It was determined that the differences between the mean levels of the antioxidant activities of the ground and non-ground lemongrass teas increased due to the increase in the temperature during each holding period were statistically significant, except for the group prepared from unground lemongrass for 60 s. Except for the ground lemongrass tea samples at 80 ° C, it was determined that the effect of time was not significant during each heat application in both ground and non-ground samples. Mabrouki, Duarte and Akretche, (2018) stated that DPPH radical scavenging activity increased due to the increase in the concentration of extracts.

When Table 3 was examined, it was observed that the amounts of lemongrass teas prepared by grinding the chlorogenic, rosmarinic, and trans-cinnamic acid contents were higher than the teas prepared without milling, as in the results of total phenolic content.

The highest amount of chlorogenic acid was determined in teas prepared from ground lemongrass in samples prepared at 95 ° C for 240 h. However, the effect of time on this temperature value was found to be statistically insignificant. A statistically significant increase

was observed in teas infused for 60 and 240 s with the increase in temperature. It was determined that the chlorogenic amount decreases when the temperature rises from 65 ° C to 80 ° C in the unground samples and increases when it is increased to 95 ° C. The amount of chlorogenic acid increased due to the increase in time in teas brewed at 80 and 95 ° C. The difference between the averages was found to be insignificant in the samples applied at 65 ° C.

When the rosmarinic acid content was examined, the effects of the time and temperature applications were statistically seen at different degrees of significance, while rosmarinic acid was not detected in any of the samples when a temperature of 95 ° C was applied to the non-ground samples.

Shanaida et al., (2018) reported that the most common phenolic compound in samples of the Lamiaceae family is rosmarinic acid and its amount is at the level of 3.64-5.28 mg / g dry weight.

According to the results of our study, the amount of rosmarinic acid in the ground samples increased significantly due to the increase in temperature at each time application. When 95 °C temperature is applied, it is seen that the highest value is obtained for 120 s. It should be considered that deterioration may occur due to the high temperature due to the extension of the time. In addition, the effect of the polyphenol oxidase enzyme may have lost its effect due to direct exposure to heat due to the cell structure that is broken down due to grinding. Therefore, an increase was observed in the amount of total phenolic substance and rosmarinic acid due to the increase in temperature. The total phenolic substance and rosmarinic acid amounts of the teas obtained from the ground lemongrass vary. The total phenolic amount decreases when the temperature rises from 65 °C to 80 °C. No significant difference was found between teas brewed at 95 °C and 80 °C. These differences in teas prepared from unground lemon herbs may be primarily due to the inhomogeneity of the samples. Because of the negative changes in the permeability of the cell wall due to the increase in temperature in these samples and the low solvent contact surface, the extraction of phenolic compounds decreases. At the same time, it is thought that with the slow conduction of temperature, the temperature in the plant tissue may stay longer in the optimum temperature range for the polyphenol oxidase enzyme and decompose rosmarinic acid.

Table 4. Correlations between some parameters of ground lemongrass infusions

	Brix	pH	TPM	DPPH	Chlorogenic acid	Rosmarinik acid	Trans-cinnamic acid
Temperature	0.076	-0.943**	0.635**	0.893**	0.791**	0.942**	-0.293
Brix		-0.046	0.501*	-0.147	0.424	0.094	-0.355
pH			-0.687**	-0.800**	-0.812**	-0.924**	0.097
TPM				0.303	0.824**	0.753**	-0.147
AA					0.471*	0.764**	-0.275
Chlorogenic acid						0.835**	-0.249
Rosmarinic acid							-0.108

*: $p<0.05$, **: $p<0.01$

Therefore, the time we used is thought to be very low compared to the infusion times in our study. For this reason, it is thought that the total amount of phenolic substance that can be extracted may have been low. Likewise, Sentkowska, Biesaga and Pyrzynska (2015) reported that the phenolic content and antioxidant capacities of teas prepared with the decoction method were higher than those obtained by the infusion method in their study comparing lemongrass infusions and decoctions. In their study, they applied the infusion and decoction times as 10, 15, and 20 minutes. However, they reported that phenolic compounds such as rutin, quercetin and myricetin were in higher amounts in the infused samples.

Table 5. Correlations between some parameters of non-ground lemongrass infusuions

	Brix	pH	TPM	DPPH	Chlorogenic acid	Rosmarinik acid	Trans-cinnamic acid
Temperature	0.546*	-0.945**	-0.738**	0.955**	0.724**	-0.514	-0.043
Brix		-0.608**	-0.050	0.487*	0.866**	0.797**	0.321
pH			0.612**	-0.930**	-0.828**	0.653*	-0.030
TPM				-0.664**	-0.181	0.623*	0.436
AA					0.698**	-0.604*	-0.035
Chlorogenic acid						0.961**	0.308
Rosmarinic acid							0.961**

*: $p<0.05$, **: $p<0.01$

4. Conclusions

In this research, the effects of temperature and time conditions on lemongrass infusions were determined. Although the effect of the grinding degree was not the subject of this study, the results give an idea that the composition of the infused components of the grinding degree may change. Results showed that ground lemongrass was infused at different temperatures for a different infusion time, more rosmarinic acid passed into the water. The amount of rosmarinic acid passed into the water was lower in non-ground samples and could not be detected at the infusions of the highest temperature treated samples. According to the antioxidant activity data, the effects of varied infusion times on the antioxidant activity of samples infused at different temperatures were not significant in general. Therefore, in the future, studies on the effect of grinding degree on infusion can be conducted taking this situation into consideration. The results showed that the amount of rosmarinic acid decrease due to the increase in the infusion temperature in the ground samples. For this reason, studies can be conducted to determine the effect of optimum grinding degree, infusion temperature, and infusion time for the optimum activities of bioactive components that are infused.

5.References

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