KSÜ Tarım ve Doğa Derg 24 (4): 725-732, 2021
KSU J. Agric Nat 24 (4): 725-732, 2021
DOI:10.18016/ksutarimdoga.vi.810689

The Effect of Sample Amount and Decoction Time on The Phytochemicals and Antioxidant Activities of Decoction Lemon Balm and Sage

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ABSTRACT

In this study, decoctions (herbal tea) of sage (*Salvia officinalis* L.) and lemon balm (*Melissa officinalis* L), two of the important medicinal plants, were analysed for antioxidant activity, antioxidants, and minerals (K, Na, Mg, Ca, Fe, Ba, Ag and Ga) were determined in each sage and lemon balm dry leaves as well as decoctions by inductively coupled plasma-mass spectrometry (ICP-MS). The antioxidant activities of decoctions were evaluated by scavenging activities against 1,1-diphenyl-2-picryl-hydrazyl (DPPH) and hydrogen peroxide (H_2O_2) radicals, and varied from 19.4 to 109.1 mg trolox equivalent (TE) cup^{-1} for DPPH and from 35.0 to 168.0 mg ascorbic acid equivalent (AAE) cup^{-1} for H_2O_2. The highest antioxidant activity and antioxidants such as total phenolic, flavonoid and flavanol contents were found in the decoction of lemon balm. The analysed minerals were most efficiently observed in sage decoctions. The study also showed that the best sample amount in terms of the minerals was 3 g for both species, but decoction time was statistically insignificant for sage and 10 min more effective for lemon balm. As a result, it was tried to determine the most appropriate sample amount and decoction time for the decoctions of both species according to the analysed parameters.

Research Article

Article History
Received : 15.10.2020
Accepted : 03.12.2020

Keywords
Decoction
Melissa officinalis
Mineral
Salvia officinalis
Phenolics

Tıbbi Adaçayı ve Oğul Otu Dekoksiyonlarının Fitokimyasalları ve Antioksidan Aktiviteleri Üzerine Örnek Miktarı ve Dekoksiyon Süresinin Etkisi

ÖZET

Bu çalışmada, önemli tıbbi bitkilerden olan tıbbi adaçayı (*Salvia officinalis* L.) ve oğul otu (*Melissa officinalis* L.) dekoksiyonlarının antioksidan aktivitesi ve antioksidantları analiz edilmiştir. Ayrıca bu türlerin yaprak ve dekoksiyonlarındaki mineral içerikleri (K, Na, Mg, Ca, Fe, Ba, Ag and Ga) indüktif eşleşmiş plazma kütle spektrometresi (ICP-MS) tarafından tespit edilmiştir. Dekoksiyonların antioksidan aktivitesi 1,1-difenil-2-pikril-hidrazil (DPPH) ve hidrojen peroksit (H_2O_2) radikalleri ile belirlenmiş, DPPH radikalli için 19.4 - 109.1 mg trolox eşdeğeri (TE) / fincan^{-1} ve H_2O_2 radikali için 35.0 - 168.0 mg askorbik asit eşdeğeri (AAE) / fincan^{-1} arasında değişmiştir. En yüksek antioksidan aktivite ve toplam fenolik, flavonoid ve flavanol gibi antioksidantlar oğul otu dekoksiyonlarından elde edilmiştir. Analiz edilen mineraller en verimli tıbbi adaçayı dekoksiyonlarında gözlenmiştir. Ayrıca mineraller açısından en iyi örnek miktarının her iki tür için 3 g olduğu, ancak dekoksiyon süresinin tıbbi adaçayı için istatistiksel olarak önemsiz ve oğul otu için 10 dk uygulamanın daha etkili olduğu saptanmıştır. Sonuç olarak, analiz edilen parametrelere göre her iki türün dekoksiyonları için en uygun örnek miktarı ve kaynatma süresi belirlemeye çalışılmıştır.

Araştırma Makalesi

Makale Tarihçesi
Geliş Tarihi : 15.10.2020
Kabul Tarihi : 03.12.2020

Anahtar Kelimeler
Dekoksiyon
Melissa officinalis
Mineral
Salvia officinalis
Fenolikler

To Cite : Yaman C 2021. The Effect of Sample Amount and Decoction Time on The Phytochemicals and Antioxidant Activities of Decoction Lemon Balm and Sage. KSU J. Agric Nat 24 (4): 725-732. DOI: 10.18016/ksutarimdoga.vi.810689.

INTRODUCTION

Natural botanical resources have long been used as therapeutical, disease preventive or refreshment, in many forms of traditional medicine, usually in the form of herbal teas which known also as tisanes (Büyükbalci and El, 2008; Poswal et al., 2019). Herbal teas are infusions or decoctions made from flowers, leaves, roots, seeds or twigs of herbs, spices, or other plants in hot water, usually devoid of caffeine. Since the infusions or decoctions are rich in antioxidants, their consumption is becoming more and more preferred among health-conscious people (Ivanova et al., 2005). They are usually consumed individually or as a mixture of herbs (Guimarães et al., 2011).

Sage (*Salvia officinalis* L.) and lemon balm (*Melissa officinalis* L.), well-known medicinal herbs of Lamiaceae commonly used as herbal tea since very early times, are aromatic plants and are still in wide use today. Although well-established traditional uses of sage and lemon balm include the treatment of various cancers, respiratory and cardiovascular problems, diabetes, and as a memory enhancer, sleeping aid, cardiac tonic, and antidepressant (Walch et al., 2011; Shakeri et al., 2016). Especially, the decoction of lemon balm is consumed due to these ethnopharmacological benefits and other uses in many countries such as Brazil, Greece, Kosova and Turkey (Walch et al., 2011).

The therapeutic properties of sage and lemon balm are generally related to their phytochemical content such as phenolics, flavonoids, triterpenes and volatile compounds as the main active constituents. Most of the polyphenolic compounds consist of rosmarinic acid, quercetin, rutin, caffeic acid, chlorogenic acid and gallic acid in both sage and lemon balm (Ghorbani and Esmaeilizadeh, 2017; Shakeri et al., 2019). These compounds are related to impressive many health benefits, such as antidepressant, improved brain health and support memory, reduce blood sugar levels and cholesterol (Fonteles et al., 2016; Alagawany et al., 2017; Ghorbani and Esmaeilizadeh, 2017; Asadi et al., 2018; Khedher et al., 2018). These are especially due to the high antioxidant and inflammatory activities of these compounds (Nunes et al., 2017; Shinjyo and Green, 2017). Antioxidant compounds help fortify your body's defenses, reducing the harmful effects of free radicals that are related to many diseases (Khansari et al., 2009).

Also, sage and lemon balm herb parts are rich sources of minerals like potassium, sodium, magnesium, calcium and iron. The minerals have many effects on human health. Potassium is an important mineral of cell and body fluids, which helps control heart rate and blood pressure (Nowak et al., 2019). Magnesium acts as a cofactor for many enzymes (Al Alawi et al., 2018).

There are many studies on the leaves of these species and their herbal teas (Arceusz et al., 2013; Herrera et al., 2018). There are no comprehensive reports about the variations in antioxidant activities, antioxidants and minerals of decoctions made from sage and lemon balm prepared with different sample amount and decoction time. Therefore, the aim of this study is to investigate the effect of different sample amounts and decoction time on the antioxidant activities, antioxidants and mineral compositions in decoctions of sage and lemon balm.

MATERIAL and METHOD

Plant material

Cultivated and exported populations of the lemon balm (*Melissa officinalis* L) and sage (*Salvia officinalis* L.) species grown in Yalova province of Turkey were used to prepare herbal teas. The fresh leaves of the plants containing thirty individuals of each species were harvested at the end of flowering in 2018, mixed and used to prepare herbal tea.

Preparation of Decoctions

The fresh leaves of both species were dried and powdered. As indicated in Fig. 1, the decoctions for both species were prepared by adding two different amounts (2g and 3g) in 100 ml of distilled water and heated (heating plate, Mipro MHP Series) until boiling. The mixtures of each amount were left to stand at boiling temperature for two different decoction times (5 min and 10 min) in order to determine the optimum decoction time, and at room temperature until cooled (Guimarães et al., 2011). Each experiment was conducted for 4 replicates. Each decoction obtained was filtered through Whatman filter papers and kept at -20 °C until the analyses. The samples were diluted 1/1 before mineral analysis.

Analysis of Antioxidant Capacity

The antioxidant capacity was evaluated by DPPH (1,1-diphenyl-2-picryl-hydrazyl) and H_2O_2 (hydrogen peroxide) radical scavenging activities, according to procedures previously described by the authors (Yaman et al., 2019 and Ruch et al., 1989).

DPPH and H_2O_2 radical scavenging activities of decoctions were calculated from the graphs of trolox and ascorbic acid standards, respectively. The results were expressed as equivalents of trolox (TE) cup^{-1} (150 ml) and equivalents of ascorbic acid (AAE) cup^{-1} of decoction.

Evaluation of Antioxidants

Total phenolics, flavonoids (Yaman et al., 2019) and flavanol (Quettier-Deleu et al., 2000) in the decoctions of lemon balm and sage were measured following spectrophotometer assays described by the authors.

Total phenolics and flavonoids were calculated using gallic acid and quercetin to obtain the standard curves. The results were expressed as mg gallic acid equivalents (GAE) cup^{-1} (150 ml) and mg quercetin equivalent (QE) cup^{-1} of decoction sample, respectively, for phenolics and flavonoids. The flavanol content was calculated on the basis of the calibration curve of authentic catechin and the results were expressed as µg catechin equivalent (CE) cup^{-1} of decoction sample.

Analysis of Mineral Content

Method for digestion of the samples as reported by Turksoy et al. (2019) was used to solubilize leave of the sage and lemon balm with a few modifications. 200 mg of samples were weighed and added to microwave Teflon tubes. After adding 5 ml suprapure HNO_3, 2 ml H_2O_2 and 3 ml ultrapure water to the samples, the caps were closed and digested with Microwave Digestion System (Milestone Stat D). The tubes cooled to the room temperature. On the other hand, their herbal tea samples were analyzed directly (without digestion). The digested samples were diluted to 1/1 with distilled water. Appropriately diluted samples were measured by an ICAPQc ICP-MS (Thermo Scientific, USA). The internal standard (Hafnium, Hf) for the minerals was used, and all analyses were performed at least three times. Calibration curves of all tested minerals were found at least R^2>0.9918 for all minerals. Determination of the minerals in sage and lemon balm as well as their herbal teas and were analyzed using ICP-MS with the following operating conditions: RF power, 1550 W; RF matching, 1.80 V; carrier gas, 0.97 l min^{-1}; spray chamber temperature, 2.7 °C.

Statistical Analysis

The results were expressed as mean values and standard deviations (±SD). The experiments of total bioactive contents and antioxidant activities were conducted by using one-way analysis of variance (ANOVA). Differences between the means were compared by Duncan's multiple range tests using SPSS (IBM SPSS 20.0 statistical software) computer program. The Pearson correlation analysis ($p < 0.05$) was used to evaluate the correlation between antioxidant activities and total phenolic contents, as well as minerals of the two species.

RESULTS and DISCUSSION

Antioxidant Capacity

The antioxidant capacities of decoctions prepared from sage and lemon balm with different sample amounts and decoction time were evaluated by two different assays: DPPH and H_2O_2 radical scavenging activities (Figure 1).

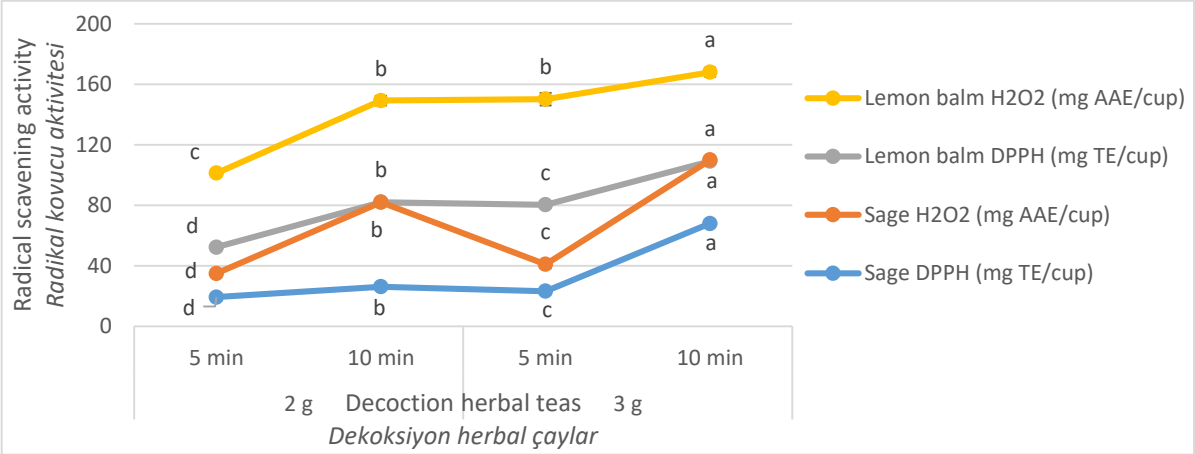

Figure 1. Antioxidant capacities of decoctions obtained from sage and lemon balm prepared with different sample amount and decoction times

Şekil 1. Farklı örnek miktarı ve dekoksiyon süresi ile hazırlanan tıbbi adaçayı ve oğul otu dekoksiyonlarının antioksidan kapasiteleri

Antioxidant activities of the decoctions were ranged from 19.4 to 109.1 mg TE cup^{-1} for DPPH, and 35.0 to 168.0 mg AAE cup^{-1} for H_2O_2. Among the decoctions of both species, the highest DPPH and H_2O_2 radical scavenging activities were observed in the decoctions prepared with 3 g sample amount and 10 min decoction time. In addition, the decoction of lemon balm for both radicals exhibited a very stronger antioxidant activity than the sage decoction. Many researchers reported the similar results on the antioxidant activity of their teas or extracts of both species (Atanassova et al., 2011; Albayrak et al., 2013; Toydemir et al., 2015).

Sage and lemon balm teas have very strong antioxidant activity because of rich phenolic components (especially, rosmarinic acid) (Lima et al., 2005; Petkova et. al., 2017). Lemon balm contains higher rosmarinic acid than sage (Nicolai et al., 2016). However, previous studies have noticed that some samples with higher rosmarinic acid exhibit no higher antioxidant activity than the samples with lower

content (Nicolai et al., 2016; Petkova et al. 2017). This can be attributed to the presence of other compounds or their synergistic effects that have an important effect on antioxidant activity.

Interestingly, the differences in antioxidant activity between 5 and 10 min decoction times in 2 or 3 g sample amounts of sage were higher than that of 2 and 3 g sample amounts in 5 min or 10 min decoction times. The decoction time was more effective than the sample amount on the antioxidant activity of sage. On the contrary, increasing the amount of sample used for lemon balm was found to be more important on its antioxidant power.

Antioxidants

Infusion and decoction of medicinal plants are important sources of polyphenolics in the human diet and for the treatment of diseases as these compounds are among the most widely occurring phytochemicals in plants (Balasundram et al., 2006). Antioxidant compounds such as phenolics, flavonoids and flavonol in decoctions obtained from sage and lemon balm prepared with different sample amounts and decoction times are given in Table 1.

Table 1. Antioxidants of decoctions obtained from sage and lemon balm prepared with different sample amount and decoction times

Çizelge 1. Farklı örnek miktarı ve dekoksiyon süresi ile hazırlanan tıbbi adaçayı ve oğul otu dekoksiyonlarının antioksidantları

	Treatments *(Uygulamalar)*			
The sample amount *(Örnek miktarı)*	2 g		3 g	
The decoction time (*Dekoksiyon süresi)*	5 min (*5 dk)*	10 min *(10 dk)*	5 min *(5dk)*	10 min *(10 dk)*
Sage	Abbreviated name of decoction herbal teas			
Tıbbi adaçayı	*Dekoksiyon herbal çayların kısaltılmış ismi*			
	S1	S2	S3	S4
Total Phenolics (mg GAE cup^{-1a})	81.7±0.05d	106.1±0.26b	92.9±0.25c	191.7±0.18a
Toplam fenolikler (mg GAE/ fincan^{-1})				
Total Flavonoids (mg QE cup^{-1})	18.1±0.20d	25.6±0.07b	22.3±0.34c	55.1±0.95a
Toplam flavanoidler (mg QE/ fincan^{-1})				
Total Flavanol (µg CE cup^{-1})	0.56±0.03b	0.62±0.03b	0.99±0.06a	1.11±0.06a
Toplam flavanol (µg CE/ fincan^{-1})				
Lemon balm	Abbreviated name of decoction herbal teas			
Oğul otu	*Dekoksiyon herbal çayların kısaltılmış ismi*			
	LB1	LB2	LB3	LB4
Total Phenolics (mg GAE cup^{-1a})	201.8±0.28d	228.6±0.08c	232.1±0.25b	234.6±0.17a
Toplam fenolikler (mg GAE/ fincan^{-1})				
Total Flavonoids (mg QE cup^{-1})	58.9±0.20d	77.3±0.27c	86.6±0.46b	98.2±2.11a
Toplam flavanoidler (mg QE/ fincan^{-1})				
Total Flavanol (µg CE cup^{-1})	1.18±0.06b	1.18±0.04b	1.38±0.02b	1.91±0.13a
Toplam flavanol (µg CE/ fincan^{-1})				

Statistically, each line was evaluated separately and indicated in small letters (P<0.01)
[a]cup(*fincan*)=150 ml

Clearly, all the decoctions investigated exhibited a generally high total phenolic (81.7 - 234.6 mg GAE cup^{-1}), flavonoid (18.1 - 98.2 mg QE cup^{-1}) and flavonol contents (0.56 - 1.91 µg CE cup^{-1}). All decoctions of lemon balm had higher antioxidants than all decoctions of sage. Similarly, Atanassova et al. (2011) reported that methanolic extract of lemon balm had a higher total phenolic and flavonoids than that of sage. The highest antioxidants for both species were recorded in decoctions prepared with 3 g sample amount and 10 min decoction times.

On the other hand, the lowest antioxidants were recorded in decoction prepared with 2 g sample amount and 5 min decoction times. Similar to the antioxidant activity of decoction samples, the decoction time for sage and the sample amount for lemon balm was remarkably effective on antioxidants.

Polyphenol compounds react with active oxygen radicals such as superoxide anion, hydroxyl and lipid peroxyl radicals (Afanasiev et al., 1989; Hussain et al., 1987), therefore, have a broad spectrum of biological activities including radical scavenging properties. The antioxidant capacity measured by DPPH and H2O2

radicals was a highly positive correlation with the polyphenols (except total flavanol) for the decoctions of sage and lemon balm (r^2>0.891)(Table 2). Total flavanol displayed a high correlation, but lower than other antioxidants (0.690< r^2<0.851). Previous studies on sage and lemon balm reported a strong correlation between phenolic content and antioxidant activity (Boneza and Niemeyer, 2018; Albayrak et al., 2013).

Mineral content in leaves and decoctions of sage and lemon balm

The knowledge of minerals in plants or traditionally used plant teas is essential for knowing their nutritional importance, considering the vital role of minerals in the human health. The composition of macrominerals (K, Mg, Ca, Na) and microminerals (Fe, Ba, Ga, Ag) in leaves and their decoctions of sage and lemon balm are detailed in Table 3.

Table 2. Correlation between antioxidant activity and antioxidants of sage and lemon balm decoctions

Çizelge 2. Tıbbi adaçayı ve oğul otu dekoksiyonlarının antioksidantları ve antioksidan aktiviteleri arasındaki korelasyon

Antioxidants *Antioksidantlar*	Sage *Tıbbi adaçayı*		Lemon balm *Oğul otu*	
	DPPH	H_2O_2	DPPH	H_2O_2
T. phenolic *T. fenolik*	0.997	0.999	0.891	0.980
T. flavonoid *T. flavonoid*	0.998	0.998	0.960	0.959
T. flavanol *T. flavanol*	0.719	0.700	0.851	0.691

Table 3. The concentrations of major (ppm) and minor (ppb) minerals in leaves and their decoctions of sage and lemon balm

Çizelge 3. Tıbbi adaçayı ve oğul otu'nun yaprakları ve onların dekoksiyonlarındaki major (ppm) ve minor (ppb) minerallerin konsantrasyonları

Minerals *(Mineraller)*		K	Ca	Mg	Na	Fe	Ba	Ga	Ag
		ppm (mg kg^{-1})						ppb (µg kg^{-1})	
Leaves *Yapraklar*	Sage *Tıbbi adaçayı*	34171.2**	10731.3**	2935.9**	430.0**	428.7	9.8**	4.69	3.00
	Lemon balm *Oğul otu*	18718.4	8456.3	2166.5	60.8	435.4	2.4	4.61	2.86
	p	<0.01	<0.01	<0.01	<0.01	0.602	<0.01	0.703	0.085
		ppm (mg l^{-1})						ppb (µg l^{-1})	
Decoctions (Average) *Dekoksiyonlar (Ortalama)*	Sage *Tıbbi adaçayı*	469.80	69.28	306.89**	77.25**	4.36	0.95**	1.61	0.20
	Lemon balm *Oğul otu*	429.09	60.60	167.67	56.67	4.41	0.32	1.37	0.20
	p	0.248	0.194	<0.01	<0.01	0.921	<0.01	0.081	0.929

p<0.01. **; *p*<0.05.*

As can be seen from Table 3, K is the major element detected in sage and lemon balm leaves as reported in Pytlakowska et al. (2012) and in their decoction with 469.80 and 429.09 mg l^{-1}, respectively. Özcan et al. (2008) noted that lemon balm had higher K content in its decoction than that of many medicinal plants such as *Sideritis* spp., *Salvia fruticosa*, and *Rosmarinus officinalis*.

In spite of the high Ca content of leaves of both plants, Ca content reported to decoction was very low (69.28 mg l^{-1} for sage and 60.60 mg l^{-1} for lemon balm). The Ca content in decoction sage and lemon balm is more higherthan that in infusion and decoction of *Fragaria vesca*'s wild roots (3.65 and 3.24 mg 100 ml^{-1}, respectively) (Dias et al., 2015) and in infusions and decoctions from stems and flowers of *Crithmum maritimum* L. (2.93-4.13 mg 200 ml^{-1}), but it is lower than the decoction of *C. maritimum* leaves (19.9 mg 200 ml^{-1}) (Pereira et al., 2017).

In terms of macromineral content, Mg in leaves of both plants after K and Ca minerals were detected with noticeable amounts, followed by Na and Fe. However, the contents of Ag and Ga were detected as trace and toxic elements in the decoction of both plants. Interestingly, the Mg contents in the decoction of sage and lemon balm (306.89 and 167.67 mg l^{-1}, respectively) are higher than that in the herbal teas from stems, leaves, flowers of *Crithmum maritimum* L. (1.69-55.5 mg 200 ml^{-1}) (Pereira et al., 2017) and in decoctions of *Fragaria vesca* L. (2.32-7.30 mg/100ml). Özcan et al (2008) reported that herbal tea of lemon balm (20.11 mg 100 ml^{-1}) had higher Mg content than *Salvia fruticosa*, *Rosa canina*, *Camelia sinensis* (black tea), *Coriandrum sativum*, *Matricaria chamomilla*, *Sideritis* spp., *Artemisia dracunculus*, *Foeniculum vulgare*, *Pimpinella anisum*, and lower than

Rosmarinus officinalis, *Ocimum basilicum*, *Thymbra spicata*, *Casia angustifolia*, *Urtica dioica*. Ca in leaves of both plants was the mineral with the highest content after K whereas it was less than the Mg content in the decoction.

The analyzed minerals had a higher concentration in sage leaves than in lemon leaves except for Fe. Chizzola (2012) reported that Fe consent in leaves of lemon balm was higher than that of sage. On the contrary, the decoction of sage had a lower concentration of analysed minerals than the decoction of lemon balm. Sage was found to accumulate the minerals better than lemon balm, also the concentrations of the minerals in the decoction of sage were higher than lemon balm except for Fe.

Although the concentrations of minerals in sage leaves are higher, no statistical difference was found between the concentrations of K and Ca minerals in decoction samples of both species. This indicated that there was a greater transition amount of those minerals from lemon balm leaves to decoction samples than sage.

Recommended dietary intakes of minerals were 4500–4700 mg day^{-1} for K, 1200–1500 mg day^{-1} for Na, 1000-1300 mg day^{-1} for Ca, 240–420 mg day^{-1} for Mg, 8–18 mg day^{-1} for Fe (Ross et al., 2011). In general, people take in less mineral than the recommended daily amount. For example, the average dietary Ca intake in most societies is between 500 and 800 mg day^{-1} (Wimalawansa et al., 2018). Thus the herbal teas are likely to be a significant source of dietary minerals.

When effects of the sample amount and decoction time on minerals in decoctions are examined (Table 4), it could be inferred that the application of a sample amount of 3 g significantly affects the mineral concentration in decoction of sage and lemon balm than 2 g application. Although, the decoction time had no statistically significant effect on mineral content in sage decoctions, the 10 min decoction time exhibited a higher effect on the concentration of minerals in the decoction of lemon balm than the 5 min duration.

Table 4. The effect of sample amount and infusion time on concentrations of minerals in decoctions of sage and lemon balm

Çizelge 4. Tıbbi adaçayı ve oğul otu dekoksiyonları içindeki minerallerin konsantrasyonları üzerine örnek miktarı ve dekoksiyon süresinin etkileri

Minerals (*Mineraller)*		Sage (*Tıbbi adaçayı)*							
		K	Ca	Mg	Na	Fe	Ba	Ga	Ag
		ppm (mg l^{-1})						ppb (µg l^{-1})	
Sample amount *Örnek miktarı*	Infusion time *Dekoksiyon süresi*								
2 g		419.19	58.61	264.08	75.27	3.61	0.82	1.41	0.33
3 g		520.42	79.96**	349.69**	79.23	5.11**	1.08**	1.8*	0.07*
p		0.13	<0.01	<0.01	0.568	<0.01	<0.01	0.023	0.039
	5 min (*5 dk)*	461.35	64.37	290.24	80.01	4.19	0.89	1.53	0.16
	10 min (*10 dk)*	478.26	74.2	323.53	74.49	4.53	1.01	1.69	0.25
	p	0.722	0.302	0.363	0.423	0.589	0.320	0.405	0.507

Minerals (*Mineraller)*		Lemon balm (*Oğul out*)							
		K	Ca	Mg	Na	Fe	Ba	Ga	Ag
		ppm (mg l^{-1})						ppb (µg l^{-1})	
Sample amount *Örnek miktarı*	Infusion time *Dekoksiyon süresi*								
2 g		365.44	51.51	144.22	51.75	3.65	0.28	1.16	0.20
3 g		492.75**	69.70*	191.11*	61.59*	5.16*	0.37*	1.57*	0.19
p		<0.01	0.041	0.045	0.049	0.011	0.012	0.020	0.761
	5 min (*5 dk)*	370.19	49.11	136.69	49.86	3.65	0.28	1.15	0.21
	10 min(*10 dk)*	488.00*	72.09**	198.65**	63.48**	5.16*	0.37*	1.58*	0.18
	p	0.015	<0.01	<0.01	<0.01	0.011	0.017	0.012	0.468

$p<0.01$. **; $p<0.05$.*

CONCLUSION

The sample amount and decoction durations had different effects on antioxidant activity, antioxidants and minerals of decoctions of sage and lemon balm plants. The decoctions of lemon balm had higher antioxidant activity and antioxidants than that of sage, however, were lower in terms of mineral content. Especially, the decoctions of sage contained high amounts of Mg. The most efficient antioxidant activity and phytochemicals for decoctions of both species were observed in their decoctions prepared with 3 g sample amount and 10 min decoction time. As the sample amount increased, the mineral content analysed in decoctions of both plants increased. The 10 min decoction of lemon balm was enough for the most efficient minerals, and 5 min decoction of sage was statistically found to be enough to prepare a mineral-rich tea. In this study, antioxidants and antioxidant activities and important minerals of decoctions of sage and lemon balm that are beneficial for human health were investigated. In future studies, analysing whether different chemical formations in decoctions of plants that occur during the boiling of plant decoction samples used for human consumption may be harmful to human health, will shed light on human health.

Author's Contributions

All contributions in authorship, design of the article, conducting and interpretation of the research belong to the author.

Statement of Conflict of Interest

Authors have declared no conflict of interest.

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