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Research Article

Influence of drying method and infusion time on purple basil leaves tea

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Abstract: In this study, purple basil leaves were dried in 3 different methods (oven, microwave, and shade drying) and then infused 5 different times in hot water at 90 °C. Analyses of total phenolic content, antioxidant activity, total monomeric anthocyanin content, and color parameters were performed on tea samples. When the analysis results were evaluated, the best results were determined in the tea samples prepared from the leaves dried in the oven and in the shade, at brewing times of 10 and 15 minutes. 45 minutes was the best infusion time for the tea sample prepared from microwave dried leaves. When the three different drying methods were compared, the shade drying method gave better results than the other drying methods. According to the highest values obtained from the analysis results, the effect of the functional compounds in the purple basil leaves on the tea was calculated. It was determined that the highest percentage of phenolic compounds in tea was found in the samples prepared by the shade drying method.

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1. INTRODUCTION

Herbal teas are popular beverages preferred in the daily diet in recent years because they are sugar-free, calorie-free and offer different tastes. For a healthy adult person, daily average consumption of tea and herbal teas is recommended up to 2 liters (Schulzki *et al*., 2017). Hundreds of pure or blended herbal teas sold in health food stores contain active phytochemicals with various biological properties. These phytochemicals help prevent or treat many diseases such as allergic reactions, insomnia, headaches, anxiety, intestinal disorders, depression, and high blood pressure. In addition, studies have reported that herbal teas have anticarcinogenic, antioxidant (Jin *et al*., 2016; Schulzki *et al*., 2017), and antimicrobial (Chan *et al*., 2010; Oh *et al*., 2013) activities. Herbal preparations consumed in the form of tea are usually infused from the leaves, flowers, seeds, fruits, stems, and roots of the plant (Oh *et al*., 2013; Jin *et al*., 2016; Schulzki *et al*., 2017). Basil (*Ocimum basilicum* L.), one of the important industrial, pharmaceutical and aromatic plant species of the Lamiaceae family, has an important place in various food applications, essential oil production, ornamental, pharmaceutical, and cosmetic industries (Ekren *et al*., 2012; Fratianni *et al*., 2017). Components of sweet basil include various phenolic acids (such as cinnamic, sinapic, caffeic, rosmarinic, caffeic, and ferulic acid) and flavonoids (such as apigenin and catechin). These compounds act as free

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radical scavengers and metal chelators by showing strong antioxidant effects against free radicals known to be harmful to humans (Flanigan and Niemeyer, 2014; McCance *et al*., 2016; Fratianni *et al*., 2017). Basil leaves and basil tea are beneficial in medical treatments for digestion, cough, headache, worms, diarrhea, and stomachache (Ekren *et al*., 2012; Ahmad *et al*., 2016).

Purple basil varieties have rich anthocyanin content. Anthocyanins belong to one of the largest classes of secondary metabolites known as flavonoids and dissolve in water to form red-blue color pigments (Ahmad *et al*., 2016). Anthocyanins offer numerous benefits in relation to antioxidant properties and radical-scavenging abilities for human health, as well as having different functions for plants (Flanigan and Niemeyer, 2014; McCance *et al*., 2016). The shelf life of fresh purple basil is short due to the high water content (Fratianni *et al*., 2017). Therefore, it is more appropriate to use fresh purple basil leaves as tea in the food industry by drying them. The aim of this study is to determine the effects of various infusion times of purple basil (*O. basilicum* L.) leaf tea, dried by different methods, on total phenolic, total monomeric anthocyanin, antioxidant activity, and color parameters.

2. MATERIAL and METHODS

2.1. Drying of Purple Basil Leaves and Brewing

Purple basil plant was supplied from the local market in Balikesir, Turkey. The purple basil sprigs were washed under running water and leaves were separated from their stems by hand. The leaves were spread on a qualitative filter paper (Whatman) to remove the wash water. The leaves were dried by oven, microwave, and shade drying methods. Microwave drying was carried out in a microwave oven (Arçelik, MD 564) at 90 W for 2 min. For oven drying, the leaves were spread on a tray and dried in an oven drier (Nuve, Turkey) set at 80 ^{o}C. For shade drying, the leaves were spread on qualitative filter paper and kept away from direct sunlight and dried at room temperature. Drying in all methods was completed when the products reached a dry matter of 95±1%. The boiled distilled water was cooled to 90°C. It was then added to the dried purple basil leaves (1.0 g) and infused for 5, 10, 15, 30 and 45 minutes. Prepared teas were stored at -20 °C until analysis. At the end of each infusion time, leaves were removed from the infusions by using a sieve and immediately cooled to room temperature.

2.2. Extraction Procedure for Antioxidants and Polyphenolic Compounds

A 0.1 g of ground dried purple basil weighed into a tube and 15 mL of acidified methanol was added. The mixture was shaken at 35°C for 60 minutes in a shaking water bath, centrifuged at 7000 rpm for 10 minutes and the supernatant was collected in a jar and the residue was re-extracted with fresh methanol and according to the same procedure and the supernatants were combined. Total phenolic compounds, monomeric anthocyanin, and antioxidant activity were analyzed in the prepared extracts.

2.3. Determination of Total Phenolic Compounds

Total phenolic substance amounts were determined according to the method developed by Singleton and Rossi (1965). The solution mixture prepared for this method consists of 0.5 mL of methanol extract, 2.5 mL of Folin-Ciocaleu solution (0.2 N), and 2.0 mL of Na_2CO_3 (75 g/L). After the samples were treated with the solution mixture, absorbance was read at 765 nm after 120 min in the spectro-photometer (U-1800, Hitachi, Japan). The results obtained were given as gallic acid (GAE)/kg dry weight (DW).

2.4. Determination of Antioxidant Activity

Antioxidant capacities of extract and tea samples Brand-Williams *et al*. (1995) developed by the DPPH (2,2-Diphenyl-1-picrylhydrazil) method. In this method, 0.1 mL of the test materials

were taken and 3.9 mL of methanolic DPPH ($6x10^{-5}$ M) solution was added to it to complete the total volume to 4 mL. Afterward, the obtained mixtures were incubated at 25 °C for 30 min in the dark, and their absorbance was determined at 515 nm in a spectrophotometer. The data obtained are given in mmol Trolox Equivalent/kg.

2.5. Total Monomeric Anthocyanin Content

TMAC was determined according to the pH differential analysis reported by Lee *et al*. (2008). According to the method, 1 mL sample taken from the extracts was diluted separately in 4 mL KCl (pH 1.0, 0.025 M) and $C_2H_3NaO_2$ buffers (pH 4.5, 0.4 M). Approximately 30 minutes after dilution, absorbance was obtained at two different wavelengths (515 and 700 nm), and absorbance differences were used to calculate the anthocyanin content.

2.6. Color Parameters

L* (lightness), a* (position between red and green), b* (position between yellow and blue), C* (chroma), and h (hue) color values of tea samples were measured by using a Minolta colorimeter (CM-5, Minolta, Japan).

2.7. Statistical Analysis

Study results were expressed as mean ± standard deviation. Two-way analysis of variance (ANOVA) at a 95% confidence level was used to determine a statistically significant difference between drying methods and infusion times. Statistical analyzes were calculated using the MINITAB (Minitab Inc. USA) software program.

3. RESULTS and DISCUSSION

3.1. Changes in Total Phenolic Content (TPC)

The TPC of dried purple basil samples is shown in Table 1. Oven, shade, and microwave dried basil contained 22.38, 45.16 and 34.81 mg/g DW phenolic compounds, respectively. Flanigan and Niemeyer (2014) found mean TPC levels in purple basil cultivars in the range of 13.1 mg GAE/g DW for Johnny's Purple Ruffles to 26.9 mg GAE/g DW for Purple Delight basil. Another study reported the mean TPC levels of three different varieties of purple basil harvested at different maturity stages in the range of 3.30-20.08 mg/g DW (McCance *et al*., 2016).

The TPC results we obtained in the current study are slightly higher than the concentrations obtained by Flanigan and Niemeyer (2014) and McCance *et al*. (2016). Total phenolic compounds, monomeric anthocyanin contents, and antioxidant activities of tea samples are shown in Table 2. Among all purple basil teas, total phenolic content varied between 158.89 and 325.20 mg/L. The lowest TPC value was determined in the oven dried samples and the highest value was in the shade dried samples. When the brewing times are compared; the total phenolic content was found as 174.65 mg/L in 5 minutes infusion time in samples prepared by oven drying method. The TPC of the tea prepared with microwave dried samples in 45 minutes of brewing time was 308.35 mg/L. The highest TPC was calculated as 325.20 mg/L in the samples prepared with shade dried basil infused for 15 minutes. While there was a difference between the phenolic substance content of the purple basil samples dried by different methods, the purple basil teas brewed for different periods did not make a statistically ($p>0.05$) significant difference in terms of phenolic substance.

Table 1. TPC, TMAC and antioxidant activities of dried purple basil leaves

	Dried Sample		
	Oven	Microwave	Shade
TPC*	22.38±0.65	34.81±0.07	45.16±1.03
TMAC**	1.74±0.04	4.45±0.17	10.91±0.12
AA***	11.28±0.10	10.86±7.84	14.35±4.23

*mg GAE/g DW, **mg/ g DW, *** mmol TE/100 g DW

The highest transition rates were calculated as 78.05, 88.60 and 72.02% for oven dried basil infused for 5 min, microwave dried basil infused for 45 min, and shade dried basil infused for 15 min, respectively. As general, the highest phenolic transfer was seen in the tea sample prepared by the microwave drying method.

It is possible to find many studies in which different herbs are prepared and analyzed in tea form. However, in the literature studies, there is no study on purple basil leaf tea and different infusion times. Hajiaghaalipour *et al*. (2016) stated that the TPC of white, green, and black tea infusions was significantly affected by the steeping time and temperature. In all of the samples, the highest TPC for white tea was determined in long-term hot water infusion, in long-term cold water infusion for green tea, and in short-term hot water infusion for black tea. The lowest TPC was determined in a short-term cold water infusion. Atoui *et al*. (2005) observed that the amounts of total phenolics ranged from 88.1 to 1216 mg GAE/cup in Greek mountain tea and Chinese green tea, respectively. In another study, the values of total phenolic content varied widely in the leafy herbal tea extracts, ranged from 10.98 to 144.52 mg GAE/g herb tea (Oh *et al*., 2013). It was stated that *Centella asiatica* herbal teas should be prepared in 100 ºC water for 10 minutes to obtain the maximum TPC. The TPC values of unfermented, partially fermented (120 min) and fermented (24 h) *C. asiatica* herbal teas were 7.3, 6.8, and 5.3 mg GAE/ g, respectively (Ariffin *et al*., 2011). The highest TPC value was detected in *C. asiatica* tea infused at 100 °C for 5 minutes (45.99 mg/L GAE) and at 80 °C for 10 minutes (45.53 mg/L GAE) (Siah *et al*., 2011).

3.2. Changes in TMAC Color Parameters

As seen in Table 1, the total monomeric anthocyanin contents of purple basil samples were 1.74 mg/g DW for the oven drying method to 10.91 mg/g DW for the shade drying method. The result obtained in purple basil sample dried in microwave oven was found as 4.45 mg/g DW. The average anthocyanin concentrations of basil cultivars harvested at varying maturities are presented in a study done by McCance *et al*. (2016). Accoring to their results, anthocyanin concentrations ranged from 2.07 mg/g DW for Sweet Petra Dark Red to 9.72 mg/g DW for Purple Ruffles. These values are lower than the results of Flanigan and Niemeyer (2014), who observed anthocyanin contents of Rubin and Purple Ruffles (Richter's Herbs) cultivars as 7.55 and 16.6 mg/g DW, respectively.

Table 2 shows the monomeric anthocyanin contents of purple basil teas. TMAC varied from 4.86 to 27.99 mg/L. The lowest value was found in the sample prepared from oven dried leaves, whereas the highest value was in the sample prepared from shade dried sample. In the samples prepared by oven drying method, at the infusion time of 15 min. total monomeric anthocyanin content was found as 5.29 mg/L. TMAC value of tea prepared by microwave dried samples at the infusion time of 45 minutes was 19.69 mg/L. In the samples prepared by shade dried basil at the infusion time of 10 minutes, TMAC has been detected as 27.99 mg/L. According to our results, the TMAC of purple basil tea was affected by different drying methods. Monomeric anthocyanin in the oven drying method was found to range from 4.86 to 5.29, but this value is

higher in the shade drying method (19.65-27.99 mg/L). The effect of different brewing times on the TMAC was not found to be statistically ($p>0.05$) significant.

The highest anthocyanin transition rates were calculated as 30.40, 44.24 and 25.65% for oven dried basil infused for 15 min, microwave dried basil infused for 45 min, and shade dried basil infused for 10 min, respectively. As in the case of total phenolic compounds, the best drying method was microwave drying in terms of anthocyanins transfer.

Vinokur *et al*. (2006) obviously reported that the total anthocyanin content in rose teas was correlated with the petal color, and higher anthocyanin values obtained in the samples prepared from the red-flowered cultivars. Zijuan (*Camellia sinensis* var. *assamica*) with purple leaves and rich anthocyanin content is widely consumed in China. Anthocyanin levels in infusions made from various Zijuan tea products have been reported to be in the range of 115.4-198.2 µg/mL (Lv *et al*., 2015). In the study, the total monomeric anthocyanin content was determined in selected Kenyan tea cultivars processed into black and green tea products. Green tea (2.25-108.26 mg/L) had significantly higher total monomeric anthocyanins than black tea (0.82-45.48 mg/L) (Kerio *et al*., 2012).

3.3. Changes in Antioxidant Activity

Table 1 shows the DPPH assay for the free radical scavenging activity of methanolic extracts of the dried purple basil samples. The antioxidant activity results of purple basil samples were calculated as 11.28, 10.86, and 14.35 mmol Trolox equivalent/100 g DW for oven dried, microwave dried, and shade dried samples, respectively. Drying methods had a significant effect antioxidant activity of purple basil leaves. The decrease in antioxidant activity could arise from the decrement in phenolic content of the samples with the effect of the drying.

Flanigan and Niemeyer (2014) reported the antioxidant capacities of purple basil cultivars ranging from 24.6 mmol/100 g DW for Johnny's Purple Ruffles to 34.8 mmol/100 g DW for Purple Delight basil. The authors attributed the free radical scavenging activity of the teas to phenolic components (Bhebhe *et al*., 2015; Abdullah and Mazlan, 2020). Higher phenolic content and composition of major phenolic compounds are associated with higher antioxidant activity. According to our analysis results; the highest antioxidant activity value was found in shade dried sample and followed by microwave dried sample. Total phenolic content and antioxidant activity results were in parallel. Our results indicate that the total monomeric anthocyanin content also plays an important role in the measured antioxidant capacities of purple basil leaves tea.

Antioxidant activity values of tea samples are shown in Table 2. A wide range of variations exists in the antioxidant capacity of all purple basil teas. The antioxidant capacity ranged from 0.229 to 0.855 mmol Trolox equivalent/L.

Usually, the lowest DPPH value was found in the sample dried in oven, whereas the highest value was in the shade dried leaves. In the samples prepared by oven drying method, the highest value was found with 0.250 mmol Trolox equivalent/L at the infusion time of 15 min. The DPPH value of the tea prepared with microwave dried samples in 45 min. infusion time gave the highest result with 0.758 mmol TE/L. In the samples prepared with basil dried in the shade, the highest DPPH value was determined as 0.855 mmol TE/L at the infusion time of 10 minutes. While the effect of purple basil samples dried with different methods in antioxidant activity was statistically significant ($p<0.05$), differences in brewing times did not make a significant difference on antioxidant activity ($p>0.05$).

The effect of infusion time and temperature on Turkish black tea is examined by Kelebek (2016). Antioxidant capacity, depending on brewing (infusion) time and temperature, showed statistically significant results ($p<0.05$). It was determined that ABTS and DPPH levels reached the highest values numerically in teas with a 10-minute brewing time. The IC_{50} of the DPPH

radical scavenging assay of white, green, and black teas steeped at different temperatures and times was investigated. This value was found between 84.03-101.5 µg/mL in white teas, 79.4-98.33 µg/mL in green teas and 91.55-105.6 µg/mL in black teas (Hajiaghaalipour *et al*., 2016). It has been reported that at least 15 minutes of steeping period is required for green tea samples to exhibit the highest antioxidant activity (Abdullah and Mazlan, 2020). In another study, the antioxidant activities of teas with different infusion times were optimized according to the extraction procedure. No statistically significant difference was detected in the samples extracted with green tea in 5-30 min periods ($p>0.05$). In rose tea samples, the highest radical scavenging activity was determined during the 20 min brewing period.

These brewing times were used in the brewing methods of both green tea and rose leaf tea samples in later studies (Vinokur *et al*., 2006). Comparing tropical and temperate herbal teas with *C. sinensis* teas, Chan *et al*. (2010) found that lemon myrtle, guava, oregano, and black teas gave similar results. In a study comparing green tea with different herbal teas, it was reported that most of the herbal teas showed lower antioxidant activity than green tea (Jin *et al*., 2016).

The antioxidant capacity, measured by the DPPH method ranged from 0 to 273.43 mmol TE/ 100 g DW in herbal teas and between 140.13 and 221.21 mmol TE/ 100 g DW in green teas. According to results of Siah *et al*. (2011), the highest antioxidant activity was (52.8%) in *C. asiatica* tea infused for 5 minutes at 100 °C, and the lowest value was (32%) in tea infused at 60 °C for 3 minutes.

The total antioxidant capacity values of sweet basil (*O. basilicum*) herbal tea as dried obtained from the Turkish market, measured by CUPRAC and ABTS assays, were determined as 1.18 mmol TE/g and 0.77 mmol TE/g, respectively (Apak *et al*., 2006).

Table 2. TPC, TMAC and DPPH values of tea samples.

Drying method	Infusion time (min)	TPC*	TMAC*	DPPH**
Oven	5	174.65±13.04	5.23±0.43	0.293±0.017
	10	170.85±0.76	5.22±0.04	0.277±0.013
	15	171.83±2.61	5.29±0.04	0.250±0.017
	30	158.89±15.33	5.05±0.02	0.229±0.014
	45	163.78±2.39	4.86±0.10	0.270±0.003
Microwave	5	297.91±6.52	19.58±0.55	0.732±0.039
	10	277.80±15.76	17.36±0.22	0.702±0.042
	15	285.09±9.35	17.78±0.51	0.734±0.070
	30	306.50±0.77	19.24±0.39	0.748±0.017
	45	308.35±0.87	19.69±0.13	0.758±0.011
Shade	5	312.91±5.22	26.54±1.06	0.843±0.003
	10	307.15±28.80	27.99±3.07	0.855±0.040
	15	325.20±4.67	26.60±0.74	0.814±0.029
	30	324.87±14.13	19.65±2.20	0.774±0.061
	45	324.76±27.72	22.26±3.82	0.793±0.155

*(mg/L), ** mmol trolox equivalent/L

3.4. Changes in Color Parameters

L*, a*, b*, h, and C* values of purple basil teas dried by different methods are summarized in Table 3. Among all the purple basil leaves teas, a* value ranged from 7.11 to 15.72, with the lowest values coming from the oven drying method, whereas the highest value was from the shade drying method. While brewing time was not statistically ($p>0.05$) significant on the a* value of purple basil tea, drying method had significant effect on this color parameter. Among all the purple basil leaves teas, the L* value ranged from 62.84 to 77.67, the b* value ranged

from 17.42 to 32.02, the C* value ranged from 22.77 to 32.83, and the h value ranged from 49.85 to 77.70. According to these data, while the effect of different drying methods on the L* and h values of purple basil tea was statistically (p<0.05) significant, the brewing time did not have a significant effect on this color parameter. The effect of purple basil samples dried by different methods and purple basil tea brewed for different times on the b* and C* values were found to be statistically (p<0.05) significant.

Consumer preferences are influenced by the color properties of herbal teas. Color differences were observed between different experiments in relation to time and temperature (Kelebek, 2016). In a previous study (Jin *et al*., 2016), among all the herbal teas, lightness (L*) has been reported between 46.38-99.98. The a*, b*, C*, and h values of herbal teas have ranged between -7.68- 44.85, 0.35-24, 0.35-86.26, and 17.65-109.78, respectively. Kelebek (2016) found that the L*, a*, and b* values are significantly correlated with infusion time and temperature. The L* value is negatively correlated with infusion time and temperature and the tea infusions become darker with a long infusion time. Moreover, the values of a* and b* of the tea are positively correlated with infusion time and temperature. No proportional relationship was found between L*, b*, C*, and h values with the drying methods and infusion time (min). The a* values of the prepared tea samples were significantly affected by the drying methods and infusion times. Redness value (a*) is increased in proportion to the amount of anthocyanin contained in the prepared purple basil leaves tea. a* value results are one of the color parameters that are very important for this study. The purple basil tea prepared by the shade drying method gave the highest a* value results with respect to the other drying methods. The highest result was 15 minutes of infusion time (15.72). The lowest color values were obtained from samples prepared by the oven drying method. The results were found to be parallel to the total monomeric anthocyanin content.

Table 3. L*, a*, b*, C* and h color values of tea samples.

Drying methods	Infusion time (min)	L*	a*	b*	C*	h
Oven drying	5	75.94±1.13	7.11±2.00	32.02±2.32	32.83±2.69	77.70±2.55
	10	76.19±0.02	7.61±0.12	31.10±0.30	32.00±0.30	76.25±0.09
	15	77.67±0.43	7.78±0.17	31.41±0.41	32.36±0.44	76.09±0.13
	30	76.13±3.45	7.76±0.05	29.65±2.25	30.43±2.40	77.13±0.72
	45	75.72±0.08	7.56±0.06	31.49±0.16	32.39±0.14	76.50±0.16
Microwave drying	5	71.38±0.93	13.69±0.34	27.06±0.59	30.32±0.68	63.18±0.07
	10	73.63±0.67	11.87±0.21	24.83±0.07	27.52±0.03	64.44±0.45
	15	71.63±0.66	12.54±0.17	26.76±0.40	29.55±0.43	64.89±0.03
	30	68.80±0.14	13.88±0.24	28.58±0.28	31.77±0.36	64.10±0.16
	45	68.73±0.40	14.55±0.15	29.27±0.29	32.69±0.33	63.57±0.02
Shade drying	5	65.07±0.21	14.66±0.42	17.42±0.39	22.77±0.03	49.93±1.43
	10	63.46±0.52	15.52±1.29	18.54±0.31	24.21±0.59	50.15±2.80
	15	65.29±0.28	15.72±0.05	18.63±0.24	24.37±0.21	49.85±0.29
	30	62.84±0.61	15.21±0.27	24.35±0.78	28.72±0.53	57.99±1.27
	45	64.71±2.46	15.12±1.69	22.59±0.23	27.21±1.13	56.33±2.68

4. CONCLUSION

This study provides a foundation for the TPC and TMAC content, antioxidant activity and color parameters of a large group of purple basil leaves teas. The highest results in terms of TPC, TMAC, DPPH, and a* values were obtained with 5, 10, and 15 min infusion time in tea samples prepared with purple basil dried in an oven and shade. If the microwave drying method is preferred, an infusion time of 45 min is recommended. The results showed that purple basil leaf tea can be an economical dietary source as well as a healthy, natural antioxidant. These study

data may be of benefit to researchers and people adopting traditional complementary therapies. According to the results obtained in this study, the shade drying method values of purple basil leaves tea are generally better than oven and microwave drying methods. In order to shorten the drying time between these methods, drying in the microwave could be a good alternative to the shade drying method.

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Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research and publishing ethics. The scientific and legal responsibility for manuscripts published in IJSM belongs to the authors.

Authorship Contribution Statement

Ayca Gulhan: Investigation, Resources, Visualization, Software, Formal Analysis, and Writing-original draft. **Hacer Coklar:** Methodology, Supervision, and Validation. **Mehmet Akbulut:** Supervision, Writing-original draft.

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