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Research Article

Antioxidant Activities and Chemical Composition of Essential Oil of Rhizomes from *Zingiber officinale* R. (Ginger) and *Curcuma longa* L.(Turmeric)

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Abstract: This study aimed to determine the essential oil volatile components of ginger and turmeric rhizomes, as well as to determine the total antioxidant capacity of essential oil samples according to the CUPric Reducing Antioxidant Capacity (CUPRAC), ferric reducing antioxidant potential (FRAP) method and free radical scavenging activities of oil samples and standards such as BHA, BHT, and Trolox were determined using a DPPH method. Essential oil analysis of volatile components was also performed on a Shimadzu GCMS-QP2010 SE (Japan) model with Support Rx-5Sil MS capillary column (30 m x 0.25 mm, film thickness 0.25 µm). Antioxidant capacities of essential oils were evaluated according to the CUPRAC method in millimole Trolox/gram -oil equivalent. GC-MS analysis of ginger showed the presence of 5 major peaks identified as Curcumene (13.46%), Zingiberene (33.92%), α-Farnesene (8.07%), β-Bisabolene (6.39%), and β-Sesquiphellandrene (15.92 %), respectively. GC-MS analysis of Turmeric showed the presence of 3 major peaks identified as Ar-Turmerone (29.24%), α-Turmerone (22.8 %), and β-Turmerone (18.84%). CUPRAC values of calculated antioxidant capacities of essential oil samples were determined as 1.97 ± 0.102 mmolTR/g-oil for *Zingiber officinale* R. and 3.40 ± 0.071 mmol TR/g-oil for *Curcuma longa* L. The scavenging effect of turmeric, ginger and standards on the DPPH radical decreased in the order of Trolox>BHA>BHT>Turmeric>Ginger which were 95.25 ± 0.05%, 62.57 ± 0.34%, 61.6 ± 0.3%, 51.45 ± 0.59%, and 50.26 ± 0.09%, at the concentration of 150µg/mL, respectively. Additionally, it revealed that essential oils of turmeric and ginger exhibited effective ferric reducing power.

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1. INTRODUCTION

Essential oils are volatile, strong-smelling, and oily mixtures obtained from plants by hydrodistillation of water or water vapor, liquid at room temperature, but can sometimes freeze. They are called "essential oil" or "etheric oil", because they can evaporate even under room temperature and "essence" because they are fragrant. Essential oils obtained from spices have been used since ancient times for their perfume, medicinal and preservative properties, and

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adding aroma and flavor to food (Bilia *et al.,* 2014). Essential oils are generally complex mixtures of volatile organic compounds produced as secondary metabolites in plants. Essential oils consist of components belonging to the terpene and phenylpropanoid groups, such as monoterpenes and sesquiterpenes, where the main compounds usually determine the biological properties of the essential oil (de Cássia Da Silveira e Sá *et al.,* 2015). Terpenes are constructed from combinations of several 5-carbon-based (C5) units called isoprenes, forming structurally and functionally diverse classes (Bilia *et al.,* 2014). Sesquiterpenes, consisting of a combination of three isoprene units (C15), are a subclass of terpenes that have been described to exhibit a broad spectrum of biological and pharmaceutical activities (Moujir *et al*., 2020).

Antioxidant components can sweep free radicals and prolong shelf life by delaying the lipid peroxidation process, which causes food and pharmaceutical products to deteriorate (Halliwell, 1996). In general, antioxidants act by chain-breaking reactions, reducing the concentration of reactive oxygen species, scavenging initiating radicals, and chelating transition metal catalysts (Eroğlu *et al.,* 2015). An inquiry of normally happening antioxidant ingredients from plant sources may prompt the advancement of novel medicines, which may diminish the danger of long-term infections brought about by free radicals (Abuja & Albertini, 2001). Many methods based on free radical scavenging have been developed to determine antioxidant capacity in recent years. The CUPric Reducing Antioxidant Capacity (CUPRAC) method is a simple and versatile antioxidant capacity method for applying many different components, including nutritional components, synthetic antioxidants, and vitamins C and E (Özyürek *et al.,* 2011).

Turmeric (*Curcuma longa* L.) is a perennial plant that belongs to the Zingiberaceae family and is widely cultivated in Asian countries. *Curcuma longa* L. rhizomes are used in many fields such as textile, medicine, cosmetics, and food (Singh *et al.,* 2003). The rhizomes of this plant are the most useful and are used for culinary and traditional medicinal purposes (Bagchi, 2012). Turmeric rhizomes are widely used as a spice in Indian and Mediterranean cuisine. It is frequently used for many therapeutic purposes in alternative medicine. Turmeric is also used in medicines to treat cancer, dermatitis, AIDS, and high cholesterol (Ammon, & Wahl, 1991; Kuttan *et al.,* 1985). Curcumin is the most important bioactive component of turmeric, which is also used as a spice (Martín-Cordero *et al*., 2003). Investigations of turmeric have uncovered various pharmacological properties (Huei-Chen *et al.,* 1992; Wichitnithad *et al.*, 2009). However, Ginger, whose Latin name is *Zingiber officinale*, is a plant of the Zingiberaceae family, growing up to one meter in length, with long leaves and yellow-red flowers. The antioxidant, antiseptic and carminative properties of many different bioactive components of ginger have made its use popular (Mushtaq *et al*., 2019). Also, the essential oil from ginger has been found to have antibacterial, antiviral, and antifungal properties (Koch *et al*., 2008; Singh *et al*., 2005). Our previous study has already reported that the phytochemical profile of ethanolic extraction from both rhizomes is very rich (Erdoğan & Erbaş, 2021).

This study aimed to determine the essential oil volatile components of ginger and turmeric rhizomes and determine the total antioxidant capacity of essential oil samples according to the CUPRAC, FRAP, and DPPH methods.

2. MATERIAL and METHODS

2.1. Chemicals

Copper(II) chloride dihydrate ($CuCl_2 \cdot 2H_2O$), 1,1-diphenyl-2-picryl-hydrazyl (DPPH•), butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), Trolox, Neocuproine (Nc-$C_{14}H_{12}N_2$) were purchased from Sigma Chemical Co. (St. Louis, MO, USA). Absolute ethanol (EtOH) was purchased from ISOLAB Laborgeräte GmbH (Eschau, GERMANY**).** Potassium hexacyanoferrate(III) ($K_3[Fe(CN)_6]$), di-Sodium hydrogen phosphate dihydrate ($Na_2HPO_4 \cdot 2H_2O$), Sodium dihydrogen phosphate dihydrate ($NaH_2PO_4 \cdot 2H_2O$), Iron(III)

chloride hexahydrate ($FeCl_3 \cdot 6H_2O$), trichloroacetic acid (TCA), and Ammonium acetate (NH_4Ac) were purchased from Merck (Darmstadt, Germany).

2.1. Preparation of Solutions

All CUPRAC reagents were prepared by dissolving in a small amount of distilled water and then diluting with ethanol. The copper (II) chloride solution was prepared by weighing 0.085 g of $CuCl_2.2H_2O$ to be 1.0×10^{-2} M, dissolving it in a small amount of distilled water and diluting it to 50 mL with ethanol. Ammonium acetate buffer is prepared by weighing 7.71 g at 1 M (pH=7), dissolving it in a small amount of distilled water, and diluting it to 100 mL with ethanol. Neocuproin solution was prepared by weighing 0.78 g as 7.5×10^{-3} M and diluting to 50 mL with ethanol.

The FRAP reagents were prepared as follows: To prepare 0.2 M phosphate buffer at pH 6.6, 7.80 g of $NaH_2PO_4 \cdot 2H_2O$ was dissolved in water and diluted to 250 mL with H_2O such that its final concn. would be 0.2 M; 8.90 g of $Na_2HPO_4 \cdot 2H_2O$ was dissolved in water and diluted to 250 mL such that its final concn. would be 0.2 M. To prepare 0.2 M phosphate pH 6.6 buffer, 62.5 mL of $NaH_2PO_4 \cdot 2H_2O$ solution was mixed with 37.5 mL of $Na_2HP0_4 \cdot 2H_2O$ and diluted to a total of 200 mL with H_2O (Stoll & Blanchard, 2009). Potassium ferricyanide solution (1%, w/v) was prepared daily by dissolving 1 g $K_3Fe(CN)_6$ in 1 mL of 1 M HCl and some water and diluting to 100 mL with water. Ferric chloride solution (0.1%, w/v) was prepared daily by dissolving 0.1 g of $FeCl_3 \cdot 6H_2O$ in 1 mL of 1 M HCl and some water and diluting to 100 mL with water. Trichloroacetic acid (TCA) solution (10%, w/v) was prepared by dissolving 10 g of TCA in water and diluting it to 100 mL with H_2O (Berker *et al.,* 2007).

2.3. Plant Material

The turmeric and ginger were obtained from the Isparta University of Applied Sciences Faculty of Agriculture. Plant specimens were also identified by Prof. Hasan Baydar and deposited at the herbarium of Faculty of Agriculture, Isparta University of Applied Sciences, with voucher specimen numbers: TP32-2020 and GP32-2020, respectively.

2.4. Essential Oil Isolation

The isolation procedure of the essential oil is as follows; 100 g of both types of rhizome preparations were subjected to hydrodistillation, separately, in a Clevenger apparatus for 4 h. From 100 grams of turmeric and ginger powder samples, 3.15 and 1.65 mL of pure essential oil were obtained, respectively. The essential oils obtained were kept at +4 ºC until used in the analysis.

2.5. Essential Oil Components Analysis with GC-MS

Essential oil analysis of volatile components was performed on a Shimadzu GCMS-QP2010 SE (Japan) model with Support Rx-5Sil MS capillary column (30 m x 0.25 mm, film thickness 0.25 µm). GC analyses were performed under the following conditions (Erdoğan *et al*., 2020). The carrier gas (helium) flow rate was 1 ml/min. The split ratio was 1:10. After 1 min at 60 ºC, the temperature program reached 250 ºC with an increase of 4 ºC per min and was kept at 250 ºC for 15 min. The mass spectra were taken at 70 eV. 970 µL hexane was added over 30 µL of pure essential oil. 1 µL was injected from the capped vial. The identification of the separated compounds was made based on a comparison of the mass spectra obtained with NIST27 and NIST147 from the US National Institute of Technology and Standards (NIST) mass spectra libraries.

2.6. CUPRAC Assay of Total Antioxidant Capacity

Total antioxidant analysis of oil samples was done by modifying the CUPRAC method developed by Çelik *et al.* (2019). The method has been modified to be applied to oil samples.

Therefore, CUPRAC reagents were prepared fresh daily in ethanol medium. Briefly, to a test tube were added 1 mL each of ethanolic Cu(II), Nc, and NH_4Ac buffer solutions. Then a 0.5 mL oil sample diluted with acetone at a specific ratio (1:100, v/v) and 0.6 mL of EtOH were added. The tubes were closed, and after 30 min, the absorbance at 450 nm (A450) was recorded against a reagent blank. According to the equation below, the total antioxidant capacity of the oil samples was calculated as mmol/g Trolox equivalent. If the absorbance of the sample was greater than 2 when the CUPRAC method is applied, the extract should be diluted at an appropriate ratio, and the measured absorbance should be in the range of 0.2<A<1.5 in order to prevent deviations from the Lambert-Beer law. The assays were carried out in triplicate, and the results were expressed as (mean values ± standard deviations).

Reagent blank solution: 1 mL Cu(II) + 1 mL Nc + 1 mL NH_4Ac + 1.1 mL ethanol

Sample solution: 1 mL Cu(II) + 1 mL Nc + 1 mL NH_4Ac + X mL sample + (1.1-X) mL ethanol

$$TAC(mmolTR\ /\ g-oil) = \frac{A}{\varepsilon} x \frac{V_t}{V_{\ddot{o}}} x\ S.f x \frac{Ve}{m}$$

Where;
A: Sample absorbance measured at 450 nm
Ɛ: Molar absorption coefficient of TR compound in the CUPRAC method (16700 L $mol^{-1}.cm^{-1}$) (Çelik *et al.,* 2010)
Vt: Total volume of CUPRAC measuring solution (4.1 mL)
Vö: Sample volume (mL)
S.f.: Dilution factor (if no dilution will be made, this factor is taken as "1")
Ve: Volume of the prepared extract (mL)
m: The amount of sample taken in the extraction process (g)

2.7. Free Radical-Scavenging Activity on DPPH

The free-radical-scavenging capacity of oil samples was evaluated, using the DPPH• stable radical and following the methodology described by Blois (1958). The free radical scavenging capacity of pure essential oil samples was determined by considering the recommendations on using DPPH radicals in Molyneux's study (2003). Briefly, 0.1mM solution of DPPH• in ethanol was prepared, and 2 mL of this solution was added to 2 mL of oil sample solution at 150 ug/mL concentration in ethanol medium. After 30 min, the absorbance was measured at 517 nm against ethanol as a blank in a spectrophotometer (SHIMADZU UV-1280 UV-Vis Spectrophotometer).

The ability to sweep the DPPH• radical was counted up using the following equation: DPPH• scavenging effect (%) = $[(A_{Control} - A_{Sample} / A_{Control}) \times 100]$ where $A_{Control}$ was the absorbance of the control reaction (ethanol solution containing 0.1 mM DPPH•) and A_{Sample} was the absorbance in the presence of oil samples and standards (BHT, BHA, Trolox).

2.8. Ferriccyanide (Fe^{3+}) Reducing Antioxidant Power Assay

Procedure. The reducing capacity (RP) of the extracts was assessed as described by Oyaizu (1986). 2.5 mL of 0.2 M phosphate buffer (pH 6.6) and 2.5 mL of $K_3Fe(CN)_6$ solution (1%) were added to 1 mL of oil sample solution at different concentrations (500-1000 µg/mL) in ethanol); the mixture was incubated at 50 ˚C on a water bath for 20 min. The incubated mixture was let to cool to room temperature, and 2.5 mL of TCA (10%) was added. The solution was thoroughly mixed by vortexing for 30 s., an aliquot of 2.5 mL was withdrawn from the supernatant, and 2.5 mL water was followed by 0.5 mL of $FeCl_3 \cdot 6H_2O$ solution (0.1%) added so that the final volume was 5.5 mL. The colored solution was read at 700 nm against the blank regarding standard using UV Spectrophotometer (SHIMADZU UV-1280 UV-Vis Spectrophotometer). BHA and BHT were used as standard references.

3. RESULTS and DISCUSSION

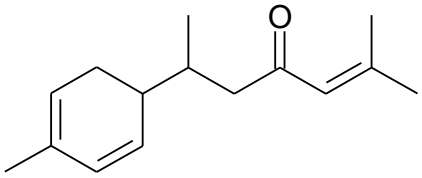
3.1. Essential Oil Efficiency

From 100 grams of turmeric and ginger powder samples, 3.15 and 1.65 mL of pure essential oil were obtained, respectively. In a study presented in the literature, essential oil isolation from turmeric was performed using a modified microwave distillation system and a rotary evaporator unit. This study determined that essential oils ranging from 1.895% to 4.973% were obtained from turmeric rhizomes (Sachin *et al.,* 2020). On the other hand, it has been reported that the essential oil obtained from ginger varies between 1% and 4% depending on the region and variety (El-Ghorab *et al.,* 2010). It was determined that the results obtained in our study were consistent with the data presented in the literature.

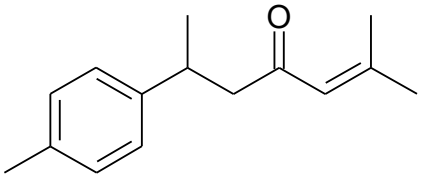
3.2. Chemical Composition of The Essential Oil of Dry Rhizomes from *Zingiber officinale* and *Curcuma longa*

Almost all (about 90%) of *Z. officinale* essential oil consists of sesquiterpenes components. Sesquiterpenes are molecules in the composition of essential oils and are responsible for the pharmacological activity of essential oils. The GC-MS analysis of *Z. officinale* rhizome (Table 1) showed the presence of 5 major peaks distinguished at 38.624, 39.663, 40.235, 40.341, and 41.31 min, which were identified as ar-Curcumene (13.46%), Zingiberene (33.92%), α-Farnesene (8.07%), β-Bisabolene (6.39%), and β-Sesquiphellandrene (15.92 %) respectively (Figure 1). It has been reported that these components have many different bioactivities such as antioxidant (Marliyana *et al*., 2019), antimicrobial (Pulido-Moran *et al.,* 2016), antiaging (Nelson *et al*., 2017), and anticancer (Naksuriya *et al.,* 2014). Simultaneously, 40 minor compounds were also identified, presented in Table 1. Other researchers also reported similar results concerning the content of major constituents (Pino *et al*., 2004; Sasidharan & Menon, 2010). On the other hand, Approximately 80% of the essential oil obtained from *C. longa* rhizomes consists of sesquiterpenes. GC-MS analysis of *C. longa* rhizome (Table 2) showed the presence of 3 major peaks distinguished at 49.548, 49.85, and 51.62 min, which were identified as Ar-Turmerone (29.24%), α-Turmerone (22.8 %), and β-Turmerone (18.84%), respectively. Simultaneously, 23 minor compounds were also identified as minor compounds were presented in Table 3. These findings were compatible with many studies in the literature (Gopalan *et al*., 2000; Zaeoung *et al*., 2005).

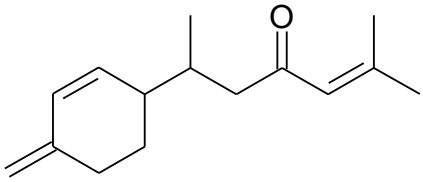
Figure 1. Major compononents of essential oil from *Zingiber officinale* R. and *Curcuma longa* L. Rhizome.



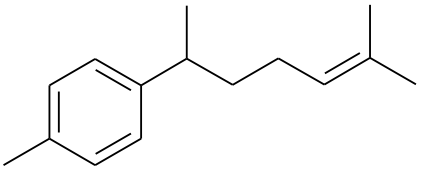
α-Turmerone



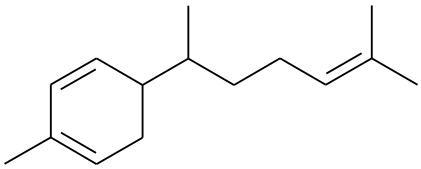
Ar-Turmerone



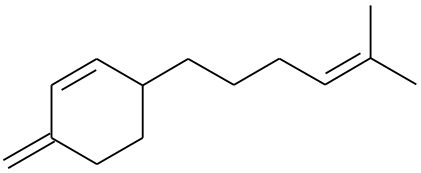
β-Turmerone



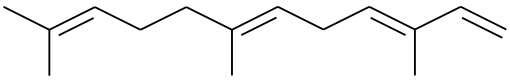
Ar-Curcumene



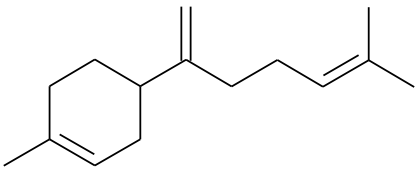
Zingiberene



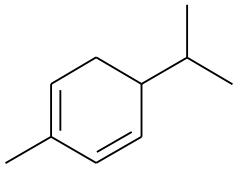
β-Sesquiphellandrene



α-Farnesene



β-Bisabolene



α-Phellandrene

Table 1. Chemical composition of *Zingiber officinale* (Ginger) essential oil.

Compound[a]	RI[b]	R.Time	% area
Camphene	950.3	7.258	0.33
β-Phellandrene	1030.0	9.485	0.83
Eucalyptol (1,8-cineole)	1031.8	10.694	0.5
Linalool	1099	14.263	0.32
β-Terpineol	1143.9	17.400	0.11
Borneol	1166.2	18.489	1.58
Terpinen-4-ol	1177.1	19.044	0.29
α-Terpineol	1189.7	19.986	0.89
Nerol	1228.9	23.698	0.11
Neral	1242.1	22.777	0.23
Linalyl acetate	1255.2	32.079	0.44
Geranial	1270.3	24.735	0.39
Isobornyl acetate	1285.9	25.767	0.22
2-Undecanone	1293.1	26.462	0.85
Citronellyl acetate	1352.4	30.219	0.18
Cyclosativene	1368.2	31.110	0.26
α-Ylangene	1369.9	38.308	1.11
α-Copaene	1376.2	31.672	0.61
β-Elemene	1390.4	32.622	0.38
7-epi-Sesquithujene	1393	33.574	0.27
α-Gurjunene	1408.6	36.264	0.11
β-Caryophyllene	1420.1	36.883	1.25
α-Bergamotene	1434.5	49.701	0.49
γ-Elemene	1436.4	35.178	0.17
α-Guaiene	1439.6	47.392	0.17
α-Patchoulene	1457.2	41.406	0.38
ε-Muurolene	1458.8	36.392	0.28
γ-Gurjunene	1472.2	47.010	0.43
ar-Curcumene	1482.2	38.624	13.46
Eudesma-4(14),11-diene	1486.1	38.790	0.47
Valencene	1491.7	41.821	0.17
α-Zingiberene	1495.3	39.663	33.92
β-Himachalene	1501.0	54.060	0.12
α-Farnesene	1504.1	40.235	8.07
β-Bisabolene	1508.4	40.341	6.39
γ-Cadinene	1513.1	38.025	0.67
Δ-Cadinene	1523.2	40.810	1.43
β-Sesquiphellandrene	1523.5	41.311	15.92
Elemol	1547.5	42.524	0.3
Germacrene B	1550.9	43.010	0.38
α-Cedrol	1600.1	50.710	1.18
γ-Eudesmol	1630.9	46.733	0.2
Murolan-3,9(11)-diene-10-peroxy	1730	42.063	0.43
Farnesol	1743.5	43.453	0.81
α-Springene	1940	51.119	0.77
Monoterpene hydrocarbons (%)			1.82
Oxygenated monoterpenes (%)			4.60
Sesquiterpene hydrocarbons (%)			86.91
Oxygenated sesquiterpenes (%)			2.92
Others (%)			1.62
Total (%)			97.87

[a]Compounds were listed in order of their elution from a Restek Rxi®-5Sil MS column using a series of the standards of C_7-C_{30} saturated n-alkanes. [b]Retention index from the literature (Adams, 2007; Babushok *et al.,* 2011)

Table 2. Chemical composition of *Curcuma longa* L.(Turmeric) essential oil.

Compound	RI	R.Time	% area
Bornylene	908	10.558	0.39
α-Pinene	936.1	6.686	0.17
β-Myrcene	989.2	8.742	0.16
α-Phellandrene	1004.1	9.499	4.2
Δ-3-Carene	1011.3	9.612	0.1
Eucalyptol	1031.8	10.698	1.76
O-Cymene	1041	10.325	2.47
γ-Terpinene	1059.7	12.004	0.17
Terpinolene	1086.9	13.455	0.29
β-Fenchyl Alcohol	1100.7	19.962	0.11
Phenethyl alcohol	1114.9	19.443	0.1
Camphor	1143.4	47.845	0.12
α-Longipinene	1352.1	45.072	0.61
2,2,4,4,7,7-Hexamethyl-2,3,3a,4,7,7a-hexahydro-1H-indene	1367	55.455	2.69
Sesquithujene <7-epi->	1393	39.383	2.6
β-Caryophyllene	1420.1	34.391	0.61
β-Farnesene <(E)-	1455.9	36.826	0.21
ar-Curcumene	1482.2	38.468	2.51
β-Bisabolene	1508.4	40.165	0.73
β-Sesquiphellandrene	1523.5	41.111	2.97
6,10-Dodecadien-1-yn-3-ol, 3,7,11-trimethyl-	1562	48.180	0.16
α-Cedrol	1600.1	42.956	0.86
α-Turmerone	1631	49.859	22.8
β-Turmerone	1647	51.622	18.84
Ar-Turmerone	1664	49.548	29.24
cis α-Santalol	1683	45.989	0.6
(Z)-valerenyl acetate	1804	47.693	0.96
Monoterpene hydrocarbons (%)			5.09
Oxygenated monoterpenes (%)			1.87
Sesquiterpene hydrocarbons (%)			11.2
Oxygenated sesquiterpenes (%)			72.11
Others (%)			5.81
Total (%)			96.2

[a]Compounds were listed in order of their elution from a Restek Rxi®-5Sil MS column using a series of the standards of C_7-C_{30} saturated n-alkanes. [b]Retention index from the literature (Adams, 2007; Babushok *et al.,* 2011)

3.3. Antioxidant Capacity of *Zingiber officinale* and *Curcuma longa* Essential Oil

The antioxidant capacity of essential oils is most likely due to the interaction between their main components. The antioxidant capacity of essential oil samples was evaluated according to the CUPRAC, FRAP, and DPPH methods. CUPRAC reagent has more stable and accessible advantages over other chromogenic reagents (e.g., ABTS, DPPH) (Apak *et al.,* 2008). CUPRAC values of calculated antioxidant capacities of essential oil samples were determined as 1.97± 0.102 mmolTR/g-oil for *Zingiber officinale* and 3.40 ± 0.071 mmol TR/g-oil for *Curcuma longa*. When the data were analyzed, the antioxidant capacity of turmeric essential oil was greater than ginger.

In the FRAP method, the reducing capacity of oil samples was accomplished using Fe^{3+} to Fe^{2+} reduction assay. In this analysis, the yellow color of the frap test solution changed to shades of green and Prussian blue depending on the concentration of the reducing agent. The presence of reducing agents acting as antioxidants in the samples causes the Fe^{3+}/ferricyanide complex to be reduced to the ferric form. Thus, Fe^{2+} can be tracked by measuring the formation of Prussian blue of Perl at 700 nm (Gülçin *et al.,* 2006). The absorbance values of oil samples and reference antioxidant substances at different concentrations at 700 nm were presented in Table 3. The higher the absorbance measured at 700 nm, the higher the reducing power. The data in Table 3 revealed that BHA had the highest FRAP value at 1000 ug/ml concentration, followed by BHT, Turmeric, and ginger, respectively. The Frap values of turmeric and ginger were almost close to each other. However, the absorbance value measured at 700 nm increased depending on the concentration.

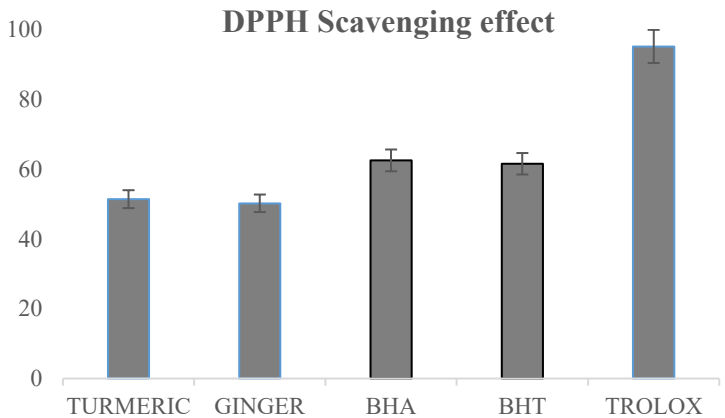
Table 3. Total reducing power of different concentrations (500–1000 µg/mL) of oil samples, BHA and BHT determined by Ferriccyanide method of the Fe^{3+}–Fe^{2+} transformation.

Sample	*FRAP value (at 700 nm)*	
	500 µg/mL	1000 µg/mL
BHA	2.834 ± 0.071*	3.029 ± 0.049
BHT	0.993 ± 0.0103	1.844 ± 0.058
TURMERIC	0.147 ± 0.013	0.351 ± 0.020
GINGER	0.131 ± 0.003	0.296 ± 0.007

* Data expressed as mean± S.D (n=3).

In this study, free radical scavenging activities of oil samples and standards such as BHA, BHT, and Trolox were determined using a DPPH method. DPPH is often used to evaluate different antioxidant substances' free radical scavenging effects (Erdoğan & Gökçe, 2021). When a DPPH solution is mixed with a substance that donates a hydrogen atom, this leads to the reduced form with loss of this violet color (Molyneux, 2003). Figure 2 displayed a significant decrease in the concentration of DPPH radical due to the scavenging ability of oil samples and standards. The scavenging effect of turmeric, ginger and standards on the DPPH radical decreased in the order of Trolox>BHA >BHT>Turmeric>Ginger which were 95.25 ± 0.05%, 62.57 ± 0.34%, 61.6 ± 0.3%, 51.45 ± 0.59%, and 50.26 ± 0.09%, at the concentration of 150µg/mL, respectively.

Figure 2. Scavenging effect of Turmeric, Ginger, BHA, BHT, and Trolox on the stable DPPH• at concentration 150 µg/mL. (DPPH•: 1,1-diphenyl-2-picryl-hydrazyl free radicals, BHA: butylated hydroxyanisole, BHT: butylated hydroxytoluene, Data expressed as mean± *S.D* (n=3).



4. CONCLUSION

GC-MS essential oil analysis results from ginger and turmeric revealed that the oils were rich in sesquiterpene content. Both essential oils exhibited a strong antioxidant capacity. These essays have significant applications for the food and pharmaceutical industry. Moreover, the components used in the pharmaceutical, food, and cosmetics industries have also been identified in the essential oils of *C. Longa and Z. officinale*. These data revealed that turmeric and ginger profiles were similar in essential oil components and antioxidant capacity. This study also presented the total antioxidant capacity of pure essential oils of turmeric and ginger for the first time according to the CUPRAC method.

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Declaration of Conflicting Interests and Ethics

The author declares 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 author.

Authorship contribution statement

Umit Erdogan: Writing-Original draft preparation, Formal Analysis, Conceptualization, Resources, Investigation, Supervision, Methodology, and Validation.

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