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Comparison of antioxidant activity of clove (*Eugenia caryophylata* Thunb) buds and lavender (*Lavandula stoechas* L.)

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Abstract

The antioxidant activity of water and ethanol extracts of clove (*Eugenia carophyllata*) buds and lavender (*Lavandula stoechas* L.) was studied. The antioxidant properties of both extracts of clove and lavender were evaluated using different antioxidant tests; reductive potential, free radical scavenging, superoxide anion radical scavenging and metal chelating activities. The both extracts of clove and lavender exhibited strong total antioxidant activity. At the concentrations of 20, 40, and 60 μg/ml, water extract of clove and lavender showed 93.3%, 95.5%, 97.9%, 86.9%, 92.3%, and 94.8% inhibition on lipid peroxidation of linoleic acid emulsion, respectively. At the same concentrations, ethanol extract of clove and lavender exhibited 94.9%, 95.5%, 98.2%, 92.5%, 93.8%, and 96.5%, respectively. Comparable, 60 μg/ml of standard antioxidant such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and α-tocopherol exhibited 96.5%, 99.2%, and 61.1% inhibition on peroxidation of linoleic acid emulsion, respectively. The both extracts of clove and lavender had effective reductive potential, free radical scavenging, superoxide anion radical scavenging, and metal chelating activities at all tested concentrations (20, 40, and 60 μg/ml). Those various antioxidant activities were compared to standard antioxidants such as BHA, BHT, and α-tocopherol. In addition, total phenolic compounds in the both extracts of clove and lavender were determined as gallic acid equivalent.

Keywords: Antioxidant activity; Clove; Lavender; *Eugenia caryophylata*; *Lavandula stoechas*

1. Introduction

Antioxidants are used to preserve food quality mainly by prevention of oxidative deterioration of constituent of lipids. The most commonly used antioxidants at the present time are butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate (PG), and *tert*-butylhydroquinone (TBHQ) (Sherwin, 1990). However, BHA and BHT have suspected of being responsible for liver damage and carcinogenesis (Grice, 1986; Wichi, 1988). Therefore, the development and utilization of more effective antioxidants of natural origin are desired (Gülçin, Büyükokuroğlu, Oktay, & Küfrevioğlu, 2002a; Jayaprakasha, Sing, & Sakariah, 2001; Loliger, 1991; Moure et al., 2001; Oktay, Gülçin, & Küfrevioğlu, 2003). Natural antioxidants can protect the human body from free radicals and retard the progress of many chronic diseases as well as lipid oxidative rancidity in foods (Gülçin, Oktay, Kireçci, & Küfrevioğlu, 2003a; Kinsella, Frankel, German, & Kanner, 1993; Lai, Chou, & Chao, 2001; Pryor, 1991; Gülçin, Büyükokuroğlu, Oktay, & Küfrevioğlu, 2003b).

Syzygium aromaticum, among clove species, are sources of antimicrobial agents against oral bacteria that are commonly associated with dental caries and periodontal disease (Cai & Wu, 1996). It was reported that *Syzygium aromaticum* have been successfully used for asthma and various allergic disorders by oral administration (Kim et al., 1998). In addition, the cloves are widely used traditional medicine for treatment many

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diseases such as disorder of digestive systems (Baytop, 1999), bacterial and fungal infections and toothaches (Zhang & Chen, 1997). Sesquiterpenes, found in clove, were investigated as potential anticarcinogenic agents (Zheng, Kenny, & Lam, 1992). The major aroma constituents of *Syzygium aromaticum* buds were eugenol and eugenyl acetate (Lee & Shibamoto, 2002). Eugenol was reported to have antifungal activity (Martini, Weidenborner, Adams, & Kunz, 1996) and inhibited malonaldehyde formation from cod liver oil and the formation of hexanal (Lee & Shibamoto, 2002).

Clove essential oils have been analysed by GC-MS and 18 components found in essential oils. These components have been tested for antioxidant properties in an egg yolk-based thiobarbituric acid reactive substances (TBARS) assay and also undiluted in a β-carotene agar diffusion assay. The essential oils and the components tested in the TBARS assay have demonstrated some degree of antioxidant activity (Dorman, Figueiredo, Barroso, & Deans, 2000). In addition, the effect of clove oil on the oxidative stability was studied (Nguyen, Takacsova, Dang, & Kristianova, 2000).

Lavender has been extensively studied phytochemically, with limited work on pharmacological aspects and is used by traditional healers for various diseases of the central nervous system, like epilepsy and migraine. It is called broom of the brain (Nadkarni, 1982). It is also used in folk medicine, as an antispasmodic in colic pain (Nadkarni, 1982; Usmanghani, Saeed, & Alam, 1997) and has analgesic, tranquillizer, antiseptic (Baytop, 1999), and antimicrobial (Asimgil, 1997) effects. Lavender also has positive effects on wound, urinal infections, cardiac diseases and eczema (Baytop, 1999). It has been used traditionally in epilepsy and as an antispasmodic and sedative remedy (Gilani et al., 2000). Lavender has been shown to reduce blood sugar levels (Gamez, Jimenez, Risco, & Zarzuelo, 1987).

The aerial parts of the plant contain oleanolic acid, ursolic acid, vergatic acid, β-sitosterol, α-amyrin, α-amyrin acetate, lupeol, erythrodiol, flavonoids, luteolin, acacetin, vitexin (Ulubelen & Olcay, 1989) and two longipinane derivatives; longipin-2-ene, 7β, 9α-diol-1one and longipin-2-ene, 7β, 9α-diol-1one-monoacetate (Ulubelen, Gören, & Olcay, 1988).

The antioxidant activity of essential oils and dried deodorised aqueous extracts of lavender have been assessed by the β-carotene bleaching test (Dapkevicius, Venskutonis, van Beek, & Linssen, 1998). In addition, Parejo et al. (2002) evaluated the antioxidant activity of spike lavender with radical scavenging activity, NBT/Hypoxanthine superoxide and OH/Luminol chemiluminescence methods. Morever, Economou, Oreopoulou, and Thomopoulos (1991) determined the antioxidant activity against oxidative deterioration of lard.

In the present study, the antioxidant activity of water and ethanol extracts from of clove buds and lavender was examined in the different antioxidant assays including total antioxidant activity, reductive potential, DPPH free radical scavenging, superoxide anion radical scavenging and metal chelating activity.

2. Materials and methods

2.1. Chemicals

Ferrous chloride, polyoxyethylenesorbitan monolaurate (Tween 20), α-tocopherol, 1,1-diphenyl-2-picryl-hydrazyl (DPPH·), 3-(2-Pyridyl)-5,6-bis(4-phenyl-sulfonic acid)-1,2,4-triazine (Ferrozine), nicotinamide adenine dinucleotide (NADH), phenazine methosulphate (PMS), nitroblue tetrazolium (NBT), trichloracetic acid (TCA), BHA and BHT were purchased from Sigma (Sigma–Aldrich GmbH, Sternheim, Germany). Ammonium thiocyanate was purchased from Merck. All other chemicals used were of analytical grade and were obtained from Sigma.

2.2. Plant material and extraction

Clove buds and lavender were obtained from a local market at Erzurum, Turkey. For water extraction, 20 g of clove buds or lavender ground into a fine powder in a mill and was mixed with 400 ml boiling water by magnetic stirrer during 15 min. Then the extract was filtered over Whatman No. 1 paper. The filtrates were frozen and lyophilized in lyophilizator at 5 μmHg pressures at −50 °C (Labconco, Freezone). For ethanol extraction, 25 g sample of clove buds or lavender ground into a fine powder in a mill and was mixed with 500 ml ethanol. The residue was re-extracted under same condition until extraction solvents became colorless. The obtained extracts were filtered over Whatman No. 1 paper and the filtrate was collected, then ethanol was removed using a rotary evaporator (RE 100 Bibby, Stone Staffordshire England, ST15 OSA) at 50 °C to obtain dry extract. The both extracts were placed in a plastic bottle and then stored at −20 °C until used.

2.3. Total antioxidant activity determination

The antioxidant activity of clove buds and lavender was determined according to the thiocyanate method of Mitsuda, Yuasumoto, and Iwami (1996). 10 mg lyophilized water extracts was dissolved in 10 ml water. 10 mg ethanol extracts of clove buds and lavender was dissolved in 10 ml ethanol. 20, 40, and 60 μg/ml of extracts or standards samples in 2.5 ml of potassium phosphate buffer (0.04 M, pH 7.0) were added to linoleic acid 2.5 ml of emulsion in potassium phosphate buffer (0.04 M, pH 7.0). 50 ml linoleic acid emulsion consists 175 μg Tween 20, 155 μL linoleic acid, and 0.04 M potassium phosphate

buffer (pH 7.0). 50 ml control contains 25 ml linoleic acid emulsion and 25 ml potassium phosphate buffer (0.04 M, pH 7.0). The mixed solution was incubated at 37 °C in a glass flask and in the dark. After the mixture was stirred for 3 min, the peroxide value was determined by reading the absorbance at 500 nm in a spectrophotometer (8500 II, Bio-Crom Gmb, Zurich, Switzerland), after reaction with $FeCl_2$ and thiocyanate at intervals during incubation. During the linoleic acid oxidation, peroxides formed and these compounds oxidize Fe^{2+} to Fe^{3+}. The latter Fe^{3+} ions form complex with SCN^- and this complex has maximum absorbance at 500 nm. Therefore, high absorbance indicates high linoleic acid oxidation. The solutions without added extracts or standards used as blank samples. All data are the average of duplicate analyses. The inhibition of lipid peroxidation in percentage was calculated by following equation:

$$\% \text{ Inhibition} = [(A_0 - A_1)/A_0] \times 100,$$

where A_0 was the absorbance of the control reaction and A_1 was the absorbance in the presence of the sample.

2.4. Reductive potential

The reductive potential of extracts was determined according to the method of Oyaizu (1986). The different concentrations of clove buds and lavender (20, 40, 60 μg/ml) in 1 ml of distilled water was mixed with phosphate buffer (2.5 ml, 0.2 M, pH 6.6) and potassium ferricyanide [$K_3Fe(CN)_6$] (2.5 ml, 1%). The mixture was incubated at 50 °C for 20 min. A portion (2.5 ml) of trichloroacetic acid (10%) was added to the mixture, which was then centrifugation for 10 min at 1000*g* (MSE Mistral 2000, UK). The upper layer of solution (2.5 ml) was mixed with distilled water (2.5 ml) and $FeCl_3$ (0.5 ml, 0.1%), and the absorbance was measured at 700 nm in a spectrophotometer. Higher absorbance of the reaction mixture indicated greater reductive potential.

2.5. Superoxide anion scavenging activity

Measurement of superoxide anion scavenging activity of extracts was based on the method described by Liu, Ooi, and Chang (1997) with slight modification (Oktay et al., 2003). Superoxide radicals are generated in PMS-NADH systems by oxidation of NADH and assayed by the reduction of NBT. In this experiments, the superoxide radicals were generated in 3 ml of Tris–HCl buffer (16 mM, pH 8.0) containing 1 ml of NBT (50 μM) solution, 1 ml of NADH (78 μM) solution and sample solution of clove buds and lavender extracts in water were mixed. The reaction started by adding 1 ml of PMS solution (10 μM) to the mixture. The reaction mixture was incubated at 25 °C for 5 min, and the absorbance at 560 nm in a spectrophotometer was measured against blank samples. L-Ascorbic acid was used as a control. Decreased absorbance of the reaction mixture indicated increased superoxide anion scavenging activity. The percentage inhibition of superoxide anion generation was calculated using the following formula:

$$\% \text{ Inhibition} = [(A_0 - A_1)/A_0] \times 100,$$

where A_0 was the absorbance of the control (L-Ascorbic acid) and A_1 was the absorbance of clove buds or lavender extracts and standards.

2.6. Free radical scavenging activity

The free radical scavenging activity of extracts were measured by 1,1-diphenyl-2-picryl-hydrazil (DPPH·) using the method of Shimada, Fujikawa, Yahara, and Nakamura (1992). Briefly, 0.1 mM solution of DPPH· in ethanol was prepared and 1 ml of this solution was added 3 ml extracts solution in water at different concentrations. The mixture was shaken vigorously and allowed to stand at room temperature for 30 min. Then the absorbance was measured at 517 nm in a spectrophotometer. Lower absorbance of the reaction mixture indicated higher free radical scavenging activity. The DPPH radical concentration was calculated using the following equation:

$$\text{DPPH}\cdot \text{ Scavenging Effect } (\%) = 100 - [(A_0 - A_1/A_0) \times 100],$$

where A_0 was the absorbance of the control reaction and A_1 was the absorbance in the presence of the sample.

2.7. Metal chelating activity

The chelating of ferrous ions by the extracts and standards was estimated by the method of Dinis, Madeira, and Almeida (1994). Extracts were added to a solution of 2 mM $FeCl_2$ (0.05 ml). The reaction was initiated by the addition of 5 mM ferrozine (0.2 ml) and the mixture was shaken vigorously and left standing at room temperature for 10 min. After the mixture had reached equilibrium, the absorbance of the solution was then measured spectrophotometrically at 562 nm in a spectrophotometer. All test and analyses were run in triplicate and averaged. The percentage of inhibition of ferrozine–Fe^{2+} complex formation was given below formula:

$$\% \text{ Inhibition} = [(A_0 - A_1)/A_0] \times 100,$$

where A_0 was the absorbance of the control and A_1 was the absorbance in the presence of the sample of CB extracts and standards. The control contains $FeCl_2$ and ferrozine, complex formation molecules.

2.8. Determination of total phenolic compounds

Total phenolic compounds in the clove buds and lavender extracts were determined with Folin–Ciocalteu

reagent according to the method of Slinkard and Singleton (1977) using gallic acid as a standard phenolic compound. 1 ml of extract solution (contains 1000 μg extracts) in a volumetric flask was diluted with distilled water (46 ml). 1 ml of Folin–Ciocalteu reagent was added and the content of the flask mixed thoroughly. After 3 min 3 ml of Na_2CO_3 (2%) was added then the mixture was allowed to stand for 2 h with intermittent shaking. The absorbance was measured at 760 nm in a spectrophotometer. The concentration of total phenolic compounds in the extracts determined as microgram of gallic acid equivalent by using an equation that was obtained from standard gallic acid graph

$$\text{Absorbance} = 0.0053 \times \text{Total Phenols} \times [\text{Gallic Acid Equivalent } (\mu g)] - 0.0059.$$

2.9. Statistical analysis

Experimental results were means ± SD of tree parallel measurements. Analysis of variance was performed by ANOVA procedures (SPSS 9.0 for Windows). Significant differences between means were determined by Duncan's Multiple Range tests. P values <0.05 were regarded as significant and p values <0.01 very significant.

3. Results and discussion

3.1. Total antioxidant activity determination in linoleic acid emulsion

There are a numerous antioxidant methods and modifications for evaluation of antioxidant activity. Of these, total antioxidant activity, reductive potential, DPPH assay, metal chelating, active oxygen species such as H_2O_2, $O_2^{\cdot-}$, and $OH^{\cdot}$ quenching assay are most commonly used for the determination of antioxidant activities of extracts (Amarowicz, Naczk, & Shahidi, 2000; Chang, Yen, Huang, & Duh, 2002; Mitsuda et al., 1996).

Table 1 shows the yields and antioxidant activity of water and ethanol extracts of clove buds and lavender. Total antioxidant activity of clove buds and lavender extracts was determined by the thiocyanate method. Clove buds and lavender extracts exhibited effective and powerful antioxidant activity at all concentrations. The effects of various concentrations of water extract of clove buds and lavender (from 20 to 60 μg/ml) on peroxidation of linoleic acid emulsion are shown in Fig. 1. The antioxidant activity of clove buds and lavender extracts increased with increasing concentration. The different concentrations of water and ethanol extracts of clove buds and lavender (20, 40 and 60 μg/ml) showed higher antioxidant activities than the 60 μg/ml concentration of α-tocopherol. The percentage inhibition of peroxidation in linoleic acid system by 20, 40, and 60 μg/ml concentrations of water extracts of clove and lavender was found to be 93.3%, 95.5%, 97.9%, 86.9%, 92.3%, and 94.8% respectively. At the same concentrations, the percentage inhibition of peroxidation on linoleic acid emulsion of ethanol extracts of clove and lavender was found to be 94.9%, 95.5%, 98.2%, 92.5%, 93.8%, and 96.5%, respectively and greater than the 60 μg/ml of α-tocopherol (61.1%). On the other hand, percentage inhibition of 60 μg/ml concentrations of BHA and BHT was found to be 96.6% and 99.1%.

3.2. Reductive potential

Fig. 2 shows the reductive capabilities of clove buds and lavender extracts compared to BHA, BHT and α-tocopherol. For the measurements of the reductive ability, Fe^{3+}–Fe^{2+} transformation in the presence of clove buds and lavender extracts samples was investigated (Oyaizu, 1986). The antioxidant activity of putative antioxidants have been attributed to various mechanisms, among which are prevention of chain initiation, binding of transition metal ion catalysts, decomposition of peroxides, prevention of continued hydrogen abstraction, reductive capacity and radical scavenging (Diplock, 1997). Like the antioxidant activity, the reductive potential of both extracts of clove buds and lavender increased with increasing concentration. All of concentration of clove buds and lavender extracts showed higher activities than control and these differences were statistically very significant ($p < 0.01$). Ethanol extract of both plant exhibited stronger reductive potential than water extract and these difference was found as significant statistically ($p < 0.01$). Reductive potential of water and ethanol extracts of clove buds, lavender and standard compounds followed the order:

Table 1
Yield, total phenolic content and inhibition of lipid peroxidation in percent of water and ethanol extracts of clove buds and lavender

	Yield (g extract/20 g plant)	Total phenolic compounds (μg)	Inhibition of lipid peroxidation (%)
Water extract of clove	3.228	179.8	97.9[a]
Ethanol extract of clove	3.200	264.9	98.2[a]
Water extract of lavender	2.165	153.92	94.8[a]
Ethanol extract of lavender	1.880	226.74	96.5[a]

[a] The antioxidant activity of extracts (60 μg/ml) was determined by the thiocyanate method.

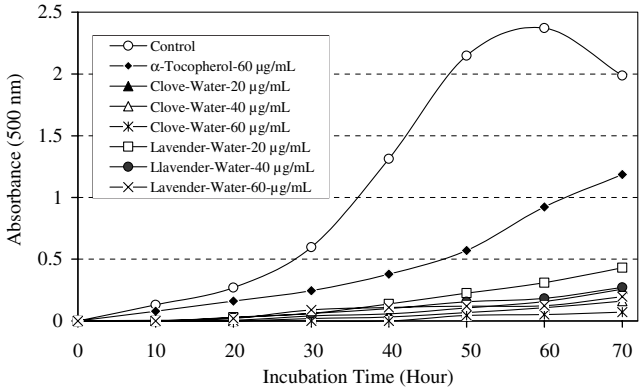

Fig. 1. Antioxidant activities of different concentrations of water extract of clove buds, lavender and α-tocopherol in the linoleic acid emulsion was determined by the thiocyanate method.

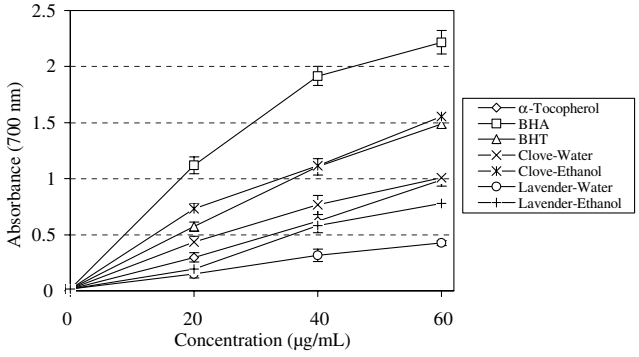

Fig. 2. Reductive potential of different concentrations of water and ethanol extracts of clove buds, lavender, BHA, BHT, and α-tocopherol using spectrophotometric detection of the Fe^{3+}–Fe^{2+} transformations (BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene).

BHA > ethanol extract of clove buds > BHT > water extract of clove buds > α-tocopherol > ethanol extract of lavender > water extract of lavender.

3.3. Superoxide anion scavenging activity

Superoxide anion derived from dissolved oxygen by PMS-NADH coupling reaction reduces NBT. The decrease of absorbance at 560 nm with antioxidants indicates the consumption of superoxide anion in the reaction mixture. Fig. 3 shows the percentage inhibition of superoxide radical generation by 60 μg/ml of water and ethanol extracts of clove buds and lavender and comparison with same concentration of BHA, BHT, and α-tocopherol. Both extracts of clove buds and lavender have strong superoxide radical scavenging activity and exhibited higher superoxide radical scavenging activity than BHT and α-tocopherol. The results were found statistically very significant ($p < 0.01$). However, water and ethanol extracts of clove buds and lavender and BHA have similar inhibition of superoxide radical generation, statistically. The percentage inhibition of superoxide generation by 60 μg/ml concentration of

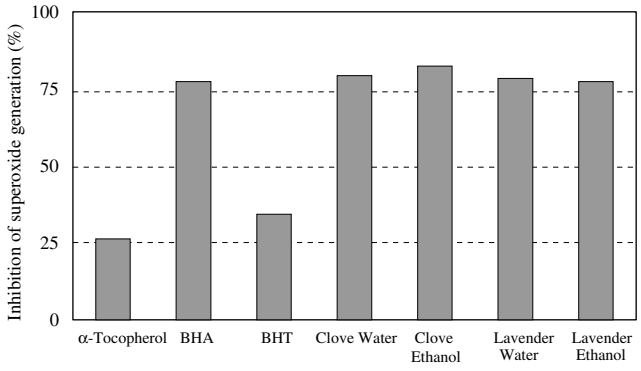

Fig. 3. Superoxide anion radical scavenging activity of 60 μg/ml concentration of water and ethanol extracts of clove buds, lavender, BHA, BHT, and α-tocopherol by the PMS-NADH-NBT method (BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene).

water and ethanol extracts of clove buds and lavender was found as 79%, 82%, 78%, and 77% and greater than that same doses of BHA, BHT, and α-tocopherol (77%, 34% and 26%), respectively. Superoxide radical scavenging activity of those samples followed the order: ethanol extract of clove buds > water extract of clove buds > water extract of lavender > ethanol extract of lavender = BHA > BHT > α-tocopherol.

3.4. Free radical scavenging activity

The model of scavenging the stable DPPH radical is a widely used method to evaluate antioxidant activities in a relatively short time compared with other methods. The effect of antioxidants on DPPH radical scavenging was thought to be due to their hydrogen donating ability. DPPH· is a stable free radical and accepts an electron or hydrogen radical to become a stable diamagnetic molecule (Soares, Dins, Cunha, & Almeida, 1997). The reduction capability of DPPH radicals was determined by the decrease in its absorbance at 517 nm induced by antioxidants. Fig. 4 illustrates a significant ($p < 0.01$) decrease the concentration of DPPH radical due to the scavenging ability of each concentration of both plants extracts and standards. Ethanol extract of both plants was showed stronger DPPH scavenging activity rather than water extract and this difference was found significant statistically ($p < 0.05$). The DPPH· scavenging effect of both plant extracts and standards on the DPPH radical decreased in the order of ethanol extract of clove buds > water extract of clove buds = BHA > BHT > ethanol extract of lavender > water extract of lavender > α-tocopherol and were 74%, 62%, 62%, 60%, 50%, 45% and 31% at the concentration of 60 μg/ml, respectively. These results indicated that both plant extracts have a noticeable effect on scavenging free radical. Free radical scavenging activity also increased with increasing concentration.

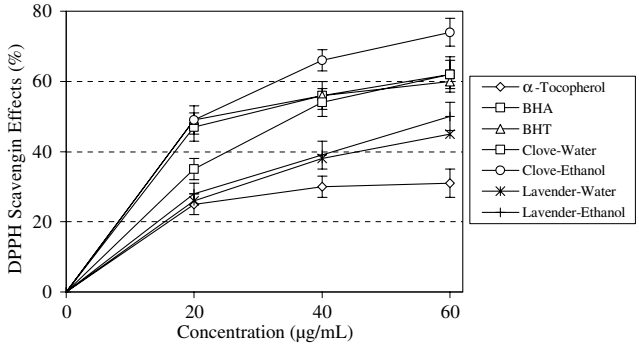

Fig. 4. Free radical scavenging activity of water and ethanol extracts of clove buds, lavender, BHA, BHT, and α-tocopherol by 1,1-diphenyl-2-picrylhydrazyl radicals (BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene).

3.5. Metal chelating activity

Ferrozine can quantitatively form complexes with Fe^{2+}. In the presence of chelating agents, the complex formation is disrupted with the result that the red colour of the complex is decreased. Measurement of colour reduction therefore allows estimation of the chelating activity of the coexisting chelator. In this assay the water and ethanol extracts of clove buds and lavender and standard antioxidant compounds interfered with the formation of ferrous and ferrozine complex, suggesting that they have chelating activity and capture ferrous ion before ferrozine.

Iron can stimulate lipid peroxidation by the Fenton reaction, and also accelerates peroxidation by decomposing lipid hydroperoxides into peroxyl and alkoxyl radicals that can themselves abstract hydrogen and perpetuate the chain reaction of lipid peroxidation (Halliwell, 1991).

As shown in Fig. 5, the formation of the Fe^{2+}–ferrozine complex is not complete in the presence of water and ethanol extracts of clove buds and lavender, indicating that both extracts of clove buds and lavender chelate the iron. The absorbance of Fe^{2+}–ferrozine complex was linearly decreased dose dependently (from 20 to 60 μg/ml). The difference between both extracts of clove buds and lavender and the control was statistically significant ($p < 0.01$). The percentage of metal chelating capacity of 60 μg/ml concentration of water and ethanol extracts of clove buds and lavender, α-tocopherol, BHA, and BHT were found as 84%, 88%, 84%, 92%, 56%, 59%, and 71%, respectively. However, there was statistically significant difference between 60 μg/ml of water or ethanol extracts of clove buds and lavender and same concentration of BHA, BHT and α-tocopherol ($p < 0.05$). The metal scavenging effect of both extracts of clove buds and lavender and standards decreased in the order of ethanol extract of lavender > ethanol extract of clove buds > water extract of clove buds > water extract of lavender > BHT > BHA > α-tocopherol.

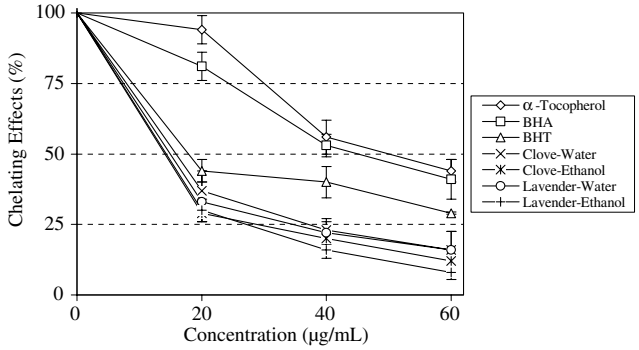

Fig. 5. Metal chelating effect of different concentrations of water and ethanol extracts of clove buds, lavender, BHA, BHT, and α-tocopherol on ferrous ions (BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene).

Metal chelating capacity was significant since it reduced the concentration of the catalyzing transition metal in lipid peroxidation (Duh, Tu, & Yen, 1999). It was reported that chelating agents, which form σ-bonds with a metal, are effective as secondary antioxidants because they reduce the redox potential thereby stabilizing the oxidized form of the metal ion (Gordon, 1990). The data obtained from Fig. 5 reveal that both plant extracts demonstrate a marked capacity for iron binding, suggesting that their action as peroxidation protector may be related to its iron binding capacity.

3.6. Determination of total phenolic compounds

Phenols are very important plant constituents because of their scavenging ability due to their hydroxyl groups (Hatano, Edamatsu, Mori, Fujita, & Yasuhara, 1989). As it can be seen in Table 1, 179.8, 264.9, 153.92, and 226.74 μg gallic acid equivalent of phenols was detected in 1 mg of water and ethanol extracts of clove buds and lavender. Ethanol extracts of both plant had grater total phenolic compound than water extracts. It was reported that phenolic compounds were associated with antioxidant activity and play an important role in stabilizing lipid peroxidation (Yen, Duh, & Tsai, 1993). According to recent reports, a highly positive relationship between total phenols and antioxidant activity was found in many plant species (Gülçin, Oktay, Küfrevioğlu, & Aslan, 2002b; Velioglu, Mazza, Gao, & Oomah, 1998; Vinson, Yong, Xuchui, & Zubik, 1998). It is suggested that polyphenolic compounds have inhibitory effects on mutagenesis and carcinogenesis in humans, when up to 1.0 g daily ingested from a diet rich in fruits and vegetables (Tanaka, Kuei, Nagashima, & Taguchi, 1998).

4. Conclusion

The various antioxidant mechanisms of both plant extracts may be attributed to strong hydrogen donating

ability, a metal chelating ability, and their effectiveness as good scavengers of hydrogen peroxide, superoxide, and free radicals. In addition, phenolic compounds appear to be responsible for the antioxidant activity of both extracts of clove buds and lavender. However, the components responsible for the antioxidative activity of both extracts of clove buds and lavender are currently unclear.

On the basis of the results of this study, it is clear that both plant extracts have powerful antioxidant activity against various antioxidant systems in vitro, moreover, clove buds and lavender can be used as easily accessible source of natural antioxidants and as a possible food supplement or in pharmaceutical applications.

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