EFFECT OF GINGER EXTRACT (*ZINGIBER OFFICINALE*) AS NATURAL ANTIOXIDANT ON SUNFLOWER OIL OXIDATION

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Abstract
Oil oxidation is significant for acceptability, nutritional quality, and toxicity of edible oils. Antioxidant supplementation for oil is basic and common strategy for improving its oxidative stability and prolonging induction time. *Ginger contains natural antioxidants such as phenolic and flavonoids compounds. Ginger extracts were extracted by different solvents (methanol, ethanol, acetone and water). Ethanolic ginger extract had the highest yield (10.52%), while, aqueous extract had the lowest yield (8.10%). Also, ethanolic extract had the highest contents of phenols and flavonoids compounds (75.17 and 19.55 mg/g, respectively) followed by methanolic extract (67.24 and 17.46 mg/g, respectively). Ginger had the ability to scavenge DPPH free radicals. With the increase of ginger extract concentration, there was an observed increase in scavenging ability. The ginger extract had lower DPPH scavenging activity than BHT (synthetic antioxidant). The ginger extract should be added below concentration 600 ppm to sunflower oil. Free fatty acid (FFA), peroxide value (PV), conjugated dienes (CD) and thiobarbituric acid (TBA) value were used to evaluate the effect of ginger extract as natural antioxidant on sunflower oil oxidation. The higher concentrations of ginger extract, the lower FFA, PV, CD, and TBA were. Therefore, ginger extract is recommended as a natural antioxidant to retard sunflower oil oxidation.*

Keywords: Antioxidant; Flavonoids; Ginger; Oxidation; Phenols; Sunflower oil.

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1. INTRODUCTION

Oil oxidation is affected by several factors such as oxygen, light, heat, fatty acids composition and antioxidants. Oxidative stability is an important parameter for oil quality and shelf life. During oxidation process, production of off flavor, toxic and polymer compounds occurs. Antioxidants are added to oil to improve oxidative stability by scavenging free radicals, control transition metals, and quenching singlet oxygen. Synthetic antioxidants have harmful effect on human health. There was a trend to replace synthetic antioxidants with natural antioxidants compounds (Choe and Min, 2006).

Ginger (Zingiber officinale) rhizomes which are consumed as a fresh, dried powder and slices. Its unique flavor manifests from combination of pungency (oleoresin) and aromatic essential oil (Tyler, 1993). Ginger is used as a traditional medicine in Asian and Arabic countries (Altman and Marcussen, 2001).

Ginger consumption is useful in many diseases such as hypertension, diabetes and Alzheimer diseases. In traditional medicine, it treats headache, cold, arthritis, rheumatic disorders and muscular discomfort. Also, ginger has anti-inflammatory, anticancer and antioxidant effects (Tohma et al., 2017).

Natural antioxidants such as phenolic and flavonoid compounds are able to protect from free radicals and retard the progress of many chronic diseases and lipid oxidative rancidity in foods (Elsorady and Abdl Aziz, 2011). Natural plant antioxidants are important because of two reasons. Firstly, the consumption of a food rich in antioxidants are necessary to prevent damages of oxidative cell, which related many diseases. Secondly antioxidants are used in food preservation to prevent oxidation of food, and increase their shelf life by delaying lipid peroxidation process. Although synthetic antioxidants are strong, but have toxic effects. Natural antioxidants could be safe for human use (Tohma et al., 2017). Therefore the

objectives of this investigation were to study the antioxidant activities of ginger extract and its influence on sunflower oil oxidation.

2. MATERIALS AND METHODS

2.1. Materials

Ginger was purchased from a local market. Sunflower oil (SO) was obtained from Arma Oils Co. 10th of Ramadan, Egypt. Chemicals and reagents were obtained from Sigma Chemical Co, (ST. Louis, US) and El-Gomhoria Co. for Pharmaceutical, Cairo, Egypt.

2.2. Methods

2.2.1. Proximate composition of Ginger

Moisture, fat, protein, fiber and ash content were determined using the method of A.O.A.C (2007) and total carbohydrates were determined by difference.

2.2.2. Preparation of ginger extracts

The ginger was washed, peeled and dried at 55ºC. The dried ginger was ground to a fine powder. The powder (10g) was added to 100ml of different solvents (80% methanol, 80% ethanol, 80% acetone and 100% water) overnight in a shaker at 22±2 ºC. The extract was filtered, and then evaporated in a rotary evaporator below 40ºC. The solid extract was weighed to calculate the yield using Equation (1):

$$\text{Extraction Yield\%} = \frac{\text{Weight of solid extract}}{\text{Weight taken for extraction}} \times 100 \quad (1)$$

2.2.3. Determination of total phenols and flavonoid contents

Total phenol content (mg GAE/g) of the ginger extract was determined by Folin-Ciocalteu reagent according to the method of Kim et al. (2003). The flavonoid content (mg quercetin/g) was determined according to the method of Kreft et al., (2006).

2.2.4. Antioxidant activities of ethanolic ginger extract using (DPPH) method

The scavenging ability of ginger extract (0 - 20.0 mg/ml) on 2, 2 diphenyl-1- picryl hydrazyl (DPPH) radicals was determined according to the method of Elsorady and Abdl Aziz (2011). The scavenging ability was calculated as follows: Scavenging ability (%) = [(Δ A517 of control – Δ A517 of sample) / Δ A517 of control]. BHT was used for comparison.

2.2.5. Sensitivity (threshold) test

This test was carried out according to Elsorady and Abdl Aziz (2011). Two sets of beakers (8 each) containing sunflower oil were mixed with different concentrations of ethanolic ginger extract (100, 200, 400, 600, 1000, 1200, 2000 and 3000 ppm). Panelists (8) were chosen from personnel within Food Technology Research Institute, and asked to sniff and taste each sample, characterized the flavor and rate the flavor intensity on a scale 0 (no flavor) to 5 (extremely strong flavor).

2.2.6. Application of ginger extract to sunflower oil

Sunflower oil (free synthetic antioxidant) was used as the substrate for oxidation studies. Different concentrations of ethanolic ginger extract (200,400 and 600 ppm) were added separately to the sunflower oil (100 g). Control samples of sunflower oil without added antioxidant were also prepared. In addition, synthetic antioxidants BHT was tested in sunflower oil for comparative purposes at their legal limit of 200ppm (Elsorady & Abdl Aziz, 2011). The oxidation rates of sunflower oil were followed at 60 ºC for 20 days.

2.2.7. Measurements of sunflower oil oxidation

Free fatty acid (FFA) (%, as oleic acid), peroxide value (PV) (meq. O2/Kg oil) and conjugated dienes (CD) were carried out according to A.O.A.C, (2007). TBA value (mg malonaldehyde/kg oil) was determined according to Elsorady and Abdl Aziz (2011).

2.2.9. Statistical analysis

One-way analysis of variance was carried out on all the data of each oil quality variable studied using a SPSS program (SPSS Statistic 16th version).

3. RESULTS AND DISCUSSION

3.1. Proximate Composition of Ginger

Proximate composition of ginger rhizome is indicated in Table 1. Moisture content was 72.24%. It is lower than observed by Peter and Kandiannan, (1999); EL- Ghorab et al., (2010); Maizura et al., (2011). This may be due to difference in varieties and climatic conditions. It has 0.24% (fat), 1.30% (protein), 1.42% (fiber) and 1.62% (ash). These findings agreed with EL- Ghorab et al., (2010).

3.2. Ginger Extracts

Table 2 shows the extraction yield (%) of ginger extract using different organic solvents, ie ethanol, methanol, acetone, and aqueous water. The maximum yield was extracted with ethanol (10.52%), followed by those extracted with methanol (9.74%), acetone (8.24%) and aqueous (8.10%). These results were in according with Qadir et al., (2017).

3.2.1. Total phenols and flavonoid contents

The anti-oxidative action of phenols and flavonoids are acting as scavengers of singlet oxygen, removing free radicals; activating antioxidant enzymes and inhibiting oxidases (Shetty and McCue, 2003). The total amount of phenolic and flavonoid content of ginger extracts by different solvents also are shown in Table 2. Total phenols and flavonoids contents of ginger extracts between 57.38 and 75.17 mg/mg and 15.30 and 19.55 mg/g, respectively. Also, the same trends were observed for total phenols and flavonoids contents for different solvent extraction. These findings agreed with Zia-ur-Rehman and Habib, (2003); Stoilova et al., (2007); Qadir et al., (2017). Therefore, the antioxidant activity of ethanolic extract of ginger was tested in sunflower oil at 60ºC for 20 days of storage. Free fatty acids, peroxide values and TBA were determined to assess sunflower oil oxidation.

Table 1. Proximate composition of ginger

Characteristics (%)	Ginger
Moisture	72.24±0.32
Crude fat	0.24±0.04
Crude protein	1.30±0.25
Crude fiber	1.42±0.21
Ash	1.62±0.02
Carbohydrates	23.18±0.85

Table 2. Extraction yield, total phenols and flavonoids contents of ginger extract obtained with different organic solvents [a]

Solvent	Extraction yield (%)	Total phenols content (mg/g)	Total Flavonoids content (mg/g)
Methanol	9.74±0.18^{b}	67.24±0.23^{c}	17.46±0.22^{c}
Ethanol	10.52±0.69^{c}	75.17±0.34^{d}	19.55±0.34^{d}
Acetone	8.24±0.21^{a}	62.13±0.26^{b}	16.50±0.21^{b}
Aqueous	8.10±0.15^{a}	57.38±0.25^{a}	15.30±0.26^{a}

[a] a-d different superscripts indicate significant differences ($p<0.05$)

3.2.2. Scavenging activity of ginger extract on DPPH

DPPH radical was used to determined antioxidant activity of natural compounds (Ozturk et al., 2007). Antioxidant activity of ginger extracts is related to phenols and flavonoids components such as shogol, gingerol, gingerdiol and cumcumin for their capability to be donors of hydrogen atoms or electrons and to scavenge the free radicals (Kikuzaki and Nakatani, 1993; Stoilova et al., 2007). The ginger extract showed a significant effect in inhibiting DPPH, reaching up to 85.58% at concentration 20 mg/ml compared with BHT 90.35% at the same concentration (Figure 1). DPPH scavenging activity of BHT was higher than ginger extract and its activity increased with higher concentrations. This finding is agreed with Ghasemzadeh et al., (2010) who reported that plant extracts were less DPPH scavenging activities than those of butylated hydroxyl toluene (BHT). On the other hand, this finding is not agreed with Stoilova et al., (2007) who found that ginger extract had higher DPPH scavenging activity than BHT.

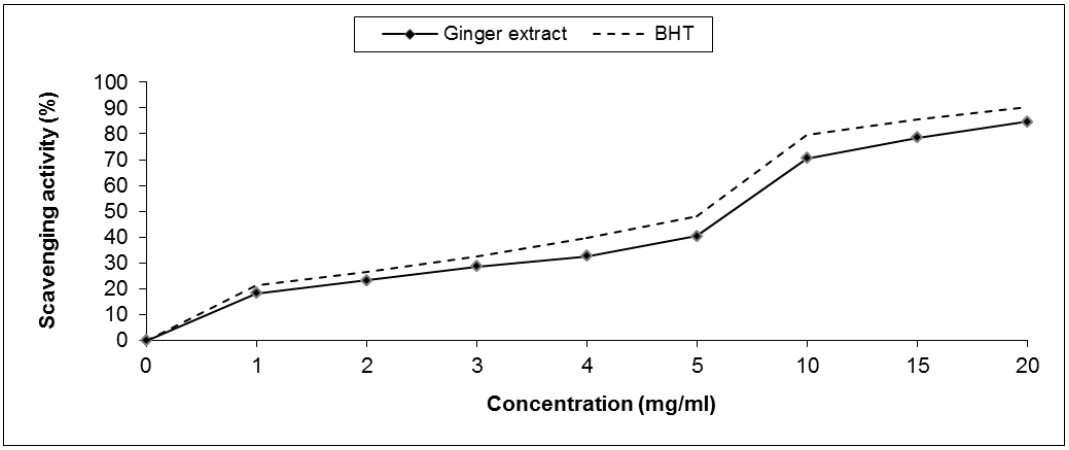

Figure 1. Scavenging activity of ginger extract on 2, 2 diphenyl-1- picryl hydrazyl radical (DPPH) compared to butylated hydroxytoulene (BHT)

3.3. Application of ginger extract to sunflower oil

The threshold values for ginger extract added to sunflower oil are shown in Table 3. These values were the same at the range of 100 to 400 ppm did not at all affect the flavor note of sunflower oil and consequently the addition ginger extract to sunflower oil is acceptable for human consumption. The addition of ginger extract to sunflower oil at 600, 1000, 1200, 2000, 3000 ppm possessed weak, medium, medium, strong and very strong flavor, respectively. The ginger extract should be added below concentration 600 ppm to sunflower oil.

In the initiation stage oil oxidation, free fatty acids is formed which are susceptible to oxygen attack in the presence of light, resulting in the formation of many organic compounds and free fatty acids which are responsible for the rancidity and off-flavors in food. Free fatty acids and peroxide value are the primary predictors of oil oxidation (Zia-ur-Rehman and Habib, 2003). Figure 2 shows the effect of storage period on the FFA content of sunflower oil (SO). A gradual increase in FFA content was observed during storage of sunflower oil at 60ºC for 20 days. Initially, the FFA content of sunflower oil was 0.02%. After 20 days of storage at 60ºC, FFA contents were 0.07, 0.12, 0.19, 0.26 and 0.39% (as oleic acid) for SO+200ppm BHT, SO+600ppm ginger extract, SO+400ppm ginger extract, SO+200ppm ginger extract, SO (control), respectively. The addition of ginger extract 600ppm and BHT caused a reduction in FFA content from 0.39% (control) to 0.12 and 0.07%, respectively after storage for 20 days at 60ºC. With the increase of ginger extract concentration in SO, there was an observed decrease in FFA.

Table 3. Mean threshold values for ginger extract added to sunflower oil

Concentration (ppm)	Ginger extract	Flavor score [b]
100	None	0.0
200	None	0.0
400	None	0.0
600	Weak [a]	1.0
1000	Medium	2.0
1200	Medium	2.4
2000	Strong	3.2
3000	Very strong	4.1

a Threshold value refer to the minimum concentration at which a stimulus is easily characterized.

b The intensity of flavor was described according to the following scale :0, None (flavor of control); 1, weak (flavor different from control); 2, medium; 3, strong; 4, very strong; 5, extremely strong.

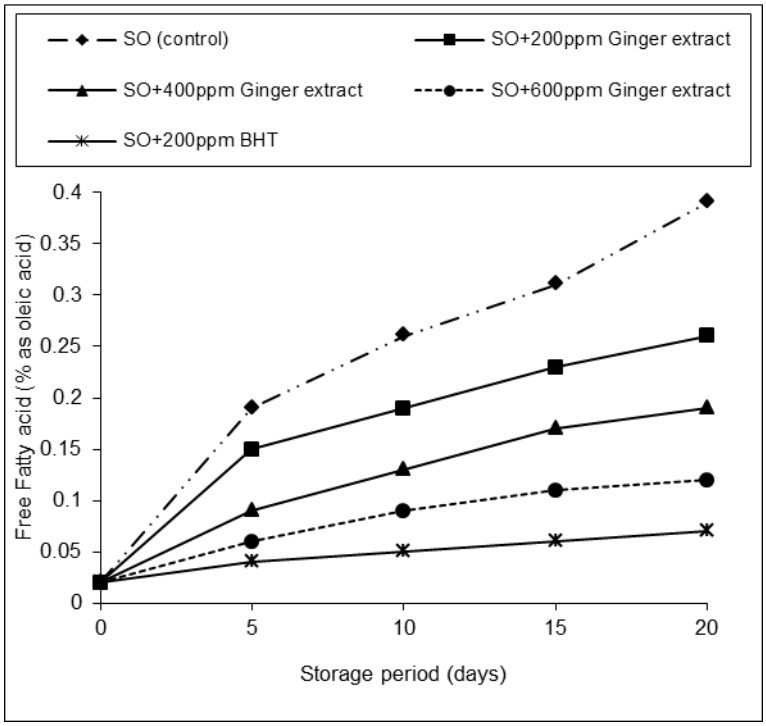

Figure 2. Free fatty acid of sunflower oil (SO) without and with added different concentrations of ginger extract during storage at 60 ºC for 20 days

Figure 3 shows effect of addition of ginger extract with different concentrations on PV of sunflower oil during 20 day at 60 ºC. Results revealed that the control had the highest PV (55.3 meqO2/kg oil) after heating at 60 ºC for 20 days. On the other hand, sunflower oil with 200 ppm BHT had the lowest PV (30.2 meqO2/kg oil). These results agreed with Jorge and Andreo, (2013). Data also showed that the higher the concentrations of ginger extract, the lower the PV were. It is apparent from these results that addition of ginger extract and BHT retarded the development of rancidity in sunflower oil, but BHT gave better protection than ginger extract.

Besides an increase in free fatty acid content and peroxide value, a marked increase in TBA was observed during storage of sunflower oil at 60ºC for 20 days (Figure 4). The TBA test measures a secondary product of lipid oxidation, malonaldehyde. Sunflower oil (control) had the highest TBA values, while sunflower oil with BHT (200 ppm) and sunflower oil with ginger extract (600 ppm) gave the lowest TBA values.

Peroxide values may not indicate the actual extension of oil deterioration (Yaghmur et al., 2001). Conjugated diene (CD) at 232 nm are considered important parameter for the investigation of primary oxidative deterioration of the oils (Elsorady and Abdl Aziz, 2011). Figure 5 indicated that the CD was increased during storage for 20 days at 60 ºC. The highest increase in CD was observed for control as compared to those other concentrations of ginger extract. Results, revealed, again, the same trend as for FFA, PV and TBA.

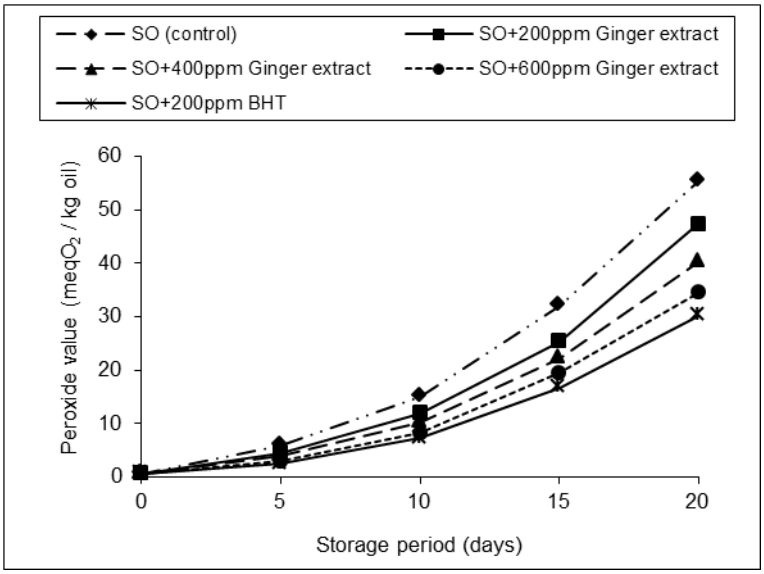

Figure 3. Peroxide value of sunflower oil (SO) without and with added different concentrations of ginger extract during storage at 60 ºC for 20 days

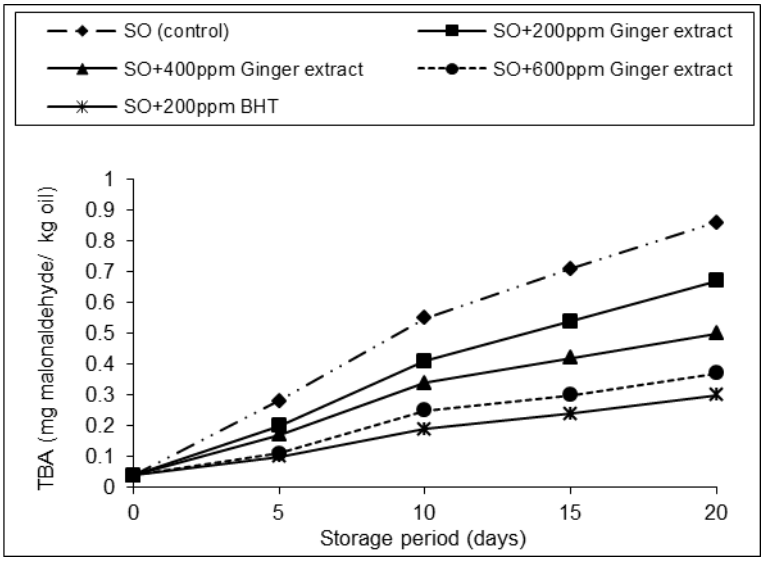

Figure 4. TBA values of sunflower oil (SO) without and with added different concentrations of ginger extract during storage at 60 ºC for 20 days

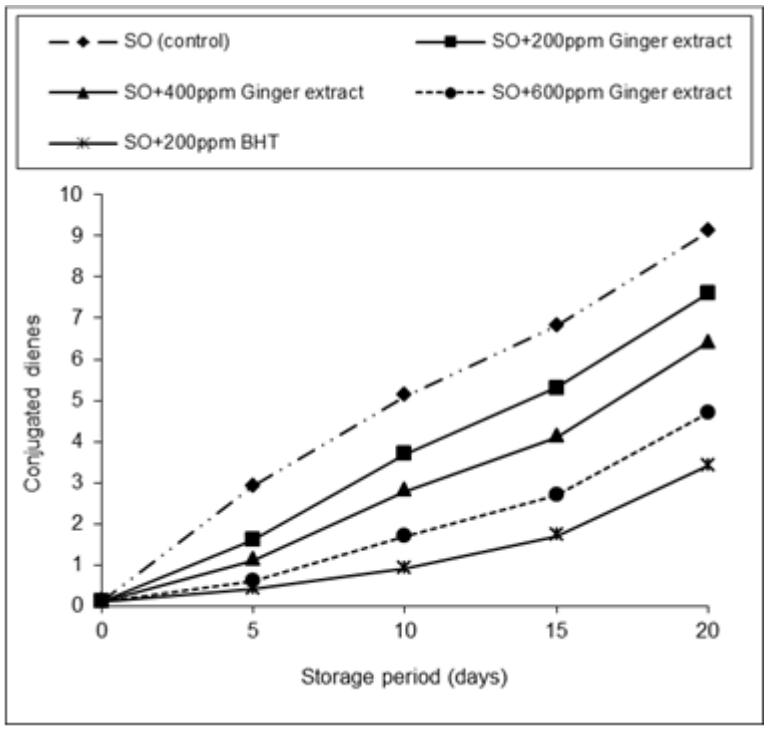

Figure 5. Conjugated dienes of sunflower oil (SO) without and with added different concentrations of ginger extract during storage at 60 ºC for 20 days

4. CONCLUSIONS

Finally, it could be concluded, ethanolic ginger extract had the highest total phenols and flavonoids contents as compared with other solvents extracts. Also, the extract had the ability to scavenge DPPH and could be used as natural antioxidant in protecting sunflower oil against lipid oxidation.

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