

Assessment of antioxidant potential of *Moringa stenopetala* leaf extract

Tesfaye Tebeka¹ and Solomon Libsu*²

¹Department of Chemistry, Arba Minch University, Arba Minch, Ethiopia;

E-mail: tesffish41@gmail.com

²Department of Chemistry, Bahir Dar University, Bahir Dar, Ethiopia;

E-mail: solomonlibsu@yahoo.com

ABSTRACT

This study was conducted to assess the antioxidant potential of *Moringa stenopetala* leaf obtained from a private garden in Bahir Dar City and powdered *Moringa* leaf purchased from a supermarket in Bahir Dar City by using ferric reducing antioxidant power, 2,2-diphenyl-1-picrylhydrazyl radical scavenging capacity, peroxide value and conjugated diene hydroperoxide assays. The powdered *Moringa stenopetala* leaf extract was invariably found to have a higher antioxidant capacity than the purchased *Moringa* powder. In the conjugated diene hydroperoxide and peroxide value assays, sunflower oil was used as an oxidation substrate. Both peroxide value and conjugated diene concentration for sunflower oil containing extracts of *Moringa* leaf and purchased *Moringa* powder were found to be lower than the corresponding values observed for the control showing the effectiveness of the extracts in delaying oxidation of the oil. The total phenolic content, in terms of mg gallic acid equivalent per 100 g of dry weight of sample was found to be 92.8 ± 1.01 and 75.5 ± 2.28 for, respectively, powdered leaves of *M. stenopetala* and purchased powder of *Moringa* leaf. The antioxidant capacity of the powdered *Moringa stenopetala* leaf and purchased *Moringa* powder were found to be, respectively, 442.0 ± 10.58 and 291.3 ± 15.52 mg of ascorbic acid equivalent per 100 g of dry weight of plant sample in the FRAP assay. The corresponding values for the powdered *Moringa stenopetala* leaf and purchased *Moringa* powder in the DPPH assay were found to be, respectively, 144.0 ± 0.53 , 138.8 ± 1.05 mg of ascorbic acid equivalent per 100 g of dry weight of the sample. This difference in antioxidant capacity of these two samples can be attributed to differences in their total phenolic content. It is suggested that this antioxidant potential of the leaves of *Moringa stenopetala* may underlie the widespread use of the plant in traditional medicine.

Key words: *Moringa stenopetala*, Antioxidant potential, Ferric reducing antioxidant power (FRAP), 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical, Folin-Ciocalteu's phenol reagent (FCR), Peroxide value (PV).

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INTRODUCTION

The rapid rise of degenerative diseases is threatening economic and social development as well as claiming the lives of millions of people worldwide. It represents a major health challenge to mankind in the coming century. It is estimated that up to 80% of cardiovascular diseases, 90% of Type II diabetes, and one third of cancers can be avoided by changing life-style, including diet (Stampfer *et al.*, 2000; Hu, 2001; Key, 2002). Diet-related high cholesterol, high blood pressure, obesity, and insufficient consumption of fruits and vegetables have been cited

as significant interlinking risk factors that cause the majority of these diseases (WHO, 2003).

It is now widely believed that the main causes of these diseases are highly reactive chemical species known as free radicals. Notable among the free radicals are the reactive oxygen species (ROS) such as superoxide anion radical ($O_2^{\cdot-}$), hydroxyl radical (HO^{\cdot}) as well as the non-radical molecule hydrogen peroxide (H_2O_2), all of which occur in the body either as a result of normal metabolic processes or enter the body from external sources. Cell damage caused by free radical-induced chain reactions ap-

*Corresponding author

appears to be a major contributor to aging and degenerative diseases such as cataracts, immune system decline, brain dysfunction, cancer and many more (Halliwell, 1994; Halliwell, 1999; Temple, 2000; Lee *et al.* 2004; Sharma and Verma, 2013).

The buildup of ROS in the body is counteracted by various beneficial compounds known as antioxidants which stabilize or deactivate free radicals thereby safeguarding cells from oxidative damage (Tyagi *et al.*, 2010). The health-beneficiary effect of antioxidants is ascribed to their ability to break up the free radical-induced chain reactions by providing a hydrogen atom or an electron to the free radical and receiving the excess energy possessed by the activated molecule (Osawa and Namiki, 1981).

Several studies have shown that a number of plant products including polyphenolic substances (e.g. flavonoids and tannins) and various plant or herb extracts exert antioxidant actions (Osawa and Namiki, 1981; Yen *et al.*, 1996; Thea, 2012). The *Moringa* species like *M. stenopetala*, *M. peregrina*, *M. oleifera* and *M. concanensis* are currently of wide interest because of their outstanding potential as nutritious vegetables, antibiotics and water clarification agents (Booth and Wickens, 1988; Nikon *et al.*, 2003).

Moringa stenopetala, also known locally, amongst others, as Shiferaw or Aleko, belongs to the family *Moringaceae* which consists of a single genus, *Moringa*, which has about 14 different species (Edwards *et al.*, 2002). The plant is native to the Horn of Africa particularly in Southern Ethiopia, North Kenya and Eastern Somalia (Mohammed Adefa, 2013). Of the 14 different species of *Moringa* the antioxidant activity of *M. oleifera* is extensively studied (Nwosu and Okafor, 1995).

Reported health benefits of *M. stenopetala* include its use for the treatment of ailments such as hyper-

tension, asthma, diabetes, and stomach pain as well as antifertility and antileishmanial effect (Yalemtsehay Mekonnen and Amare Gessesse, 2002; Yalemtsehay Mekonnen, 1999) and water clarification (Zenebe Shiferaw, 2011). However, a search into the literature made using the software SciFinder did not reveal any study made on the anti-oxidant capacity of the leaves of *M. stenopetala* grown in Ethiopia. In light of the expanding use of *M. stenopetala* in folk medicine, it is felt desirable to look into the antioxidant capacity of its leaves using a variety of standard methods as well as to investigate the relationship between antioxidant capacity and total phenolic content, which are believed to safeguard the body against pathogens and free radicals.

MATERIALS AND METHODS

Gallic acid, Folin-Ciocalteu's phenol reagent (FCR), 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical are all Sigma Aldrich products. Hydrochloric acid, potassium iodide and ferric chloride were obtained from BDH, England. Glacial acetic acid (NICE, laboratory reagent), chloroform (WINLAB limited), vitamin E, *o*-phosphoric acid (Fisher Scientific Limited, UK) were used in this work. Sunflower oil used as an oxidation substrate was obtained from a local small-scale edible oil producer in Bahir Dar City, Ethiopia. All other chemicals and solvents were procured from Blulux Laboratories Pvt. Ltd., India. All the chemicals used were of analytical grade and distilled water was used throughout the experiments. Double Beam Perkin Elmer Lambda 35 UV-Visible and Single Beam UV-Visible (NV2003) spectrophotometer were used for absorbance measurements.

Sample collection and preparation

Leaves of *Moringa stenopetala* were collected from a garden in Bahir Dar City in February 2014 and further identified by comparison with a sample previously authenticated (Edwrd *et al.*, 2002). Soon after

collection, the leaves were wrapped up with aluminum foil, taken to the laboratory and washed with tap water and then with distilled water in order to remove dirt matter. The leaves were then air-dried for 10 days at room temperature away from the reach of sunlight. The dried samples were ground and 50 g of the resulting powder was placed in cellulose cone and defatted with petroleum ether (300 mL) for 7 h using a soxhlet extractor. The purpose of defatting is to remove fatty acids and lipids which will otherwise interfere with the intended antioxidant study. The residue was separated using suction filtration, dried and kept in air-tight container until use. In a parallel experiment, a 50 g portion of a green packed powder purchased from a supermarket in Bahir Dar City and claimed to be ground *Moringa stenopetala* leaves was defatted as described above. Residue was separated using suction filtration and dried at room temperature for one day.

The defatted powdered samples (20 g) were separately mixed with 200 mL of 80% aqueous methanol in Erlenmeyer flasks, completely wrapped with aluminum foil, and gently shaken (120 rpm) by an electrical shaker at room temperature for 24 hours and filtered. The filtrates were kept in dark place for further analysis.

Total phenolic content determination

The amounts of phenolic compounds in the aqueous methanol extract of powdered *Moringa stenopetala* (MS) and purchased *Moringa* (MP) powder were determined by Folin-Ciocalteu reagent assay. To 1 mL of the extract (800 mg/L), 2 mL of Folin-Ciocalteu reagent and 5 mL of distilled water were added. The mixture was kept at room temperature for 10 min, and then 20% sodium carbonate (w/v, 2 mL) was added and heated on a water bath at 40°C for 20 min and then cooled in an ice bath. Absorbance was read at 755 nm. The total phenolic content was calculated and expressed as gallic acid equivalent in

mg/g (GAE) per 100 g of dry weight of the plant matter (Dehshahri *et al.*, 2012).

Ferric reducing antioxidant power (FRAP) assay

The reducing power of the extracts was determined according to a literature procedure (Atawodi *et al.*, 2010; Jayanthi and Lalitha, 2011). Variable concentrations (200-1200 mg/L) of extracts (2.5 mL) were mixed with sodium phosphate buffer (2.5 mL, 0.2 M, pH 6.6) and potassium ferricyanide (2.5 mL, 1.0%). The mixtures were incubated at 50°C for 20 min. Then 10% trichloroacetic acid (2.5 mL) was added and centrifuged at 1000 rpm for 10 min. The upper layer of the solution (5.0 mL) was decanted and diluted with 5.0 mL of water. Ferric chloride (0.1 mL, 0.1%) was added and absorbance was read at 700 nm. The antioxidant capacities of the extracts in terms of AAE (mg AAE per 100 g of dry weight of sample) were determined. Ascorbic acid was used as a standard in the range of (25-400 mg/L).

DPPH radical scavenging assay

DPPH radical scavenging by *Moringa* extracts were estimated according to a previously reported method (Irshad *et al.*, 2012). 2 mL of DPPH solution in methanol (0.004%, 0.102 mM) was mixed with 2 mL of extracts with different concentrations (200-800 mg/L). For blank solution, the extracts were substituted by methanol and used for the correction of baseline at 515 nm. The tubes were allowed to stand at room temperature for 20 min. The anti-radical activity was based on measurement of the reducing ability of the plant extract toward DPPH radical. Ascorbic acid was used as a standard in the range of (25-100 mg/L) and the scavenging effect of the leaf extracts were determined with a linear curve of ascorbic acid standard.

Oil storage studies

The storage tests and the storage methods were carried out as described by Chang *et al.* (2013) on refined sunflower oil. The methanolic extracts of both

plant materials were separately added to pre-heated (50°C) 100 mL refined sunflower oil at concentrations of 1000 and 2000 mg/L. The oil samples were stirred with a magnetic stirrer for 30 min at 40°C for uniform dispersion. Vitamin E (1000 mg/L) was used as reference substance for comparative purposes and a control set without added extracts was prepared under the same set of analytical conditions. The oils were then stored in an oven at 65°C for 6 days (to accelerate the deterioration of the oil) and at room temperature for 18 days. Approximately 25 mL of the oils were withdrawn and pipetted in to Erlenmeyer flask at intervals of 0, 2, 4 and 6 days and 0, 6, 12 and 18 days after storage in oven and at room temperature, respectively, for monitoring peroxide value and conjugated dienes (at 232 nm) resulting from the oxidative changes.

Peroxide value determination

Peroxide value was evaluated according to studies reported elsewhere (White and Crowe, 2001). Thus, 5 g of oil with or without added antioxidant (*Moringa* leaves extracts and vitamin E) and 30 mL of the solvent (glacial acetic acid-chloroform, 3:2) were added into a 250 mL glass-stoppered Erlenmeyer flask. The solution was swirled until the sample is dissolved. Fresh 0.5 mL saturated KI (10%) solution was added and the mixture was shaken for 1 min. Thereafter, 30 mL of water was added and titrated with 0.01N Na₂S₂O₃ solution using 0.5 mL of 1% starch indicator until the yellow color was discharged. A blank was prepared alongside the oil samples.

Statistical Analysis

All the experiments were performed in triplicates and the data have been presented as Mean ±

Standard deviation. The significance of the data was assessed using one way ANOVA with significance level set as $p \leq 0.05$ by applying Tukey's post hoc test using SPSS 20 software package (IBM Corporation, 1989) and graphs as well as regression coefficients were displayed using Origin 7 and Excel 2007.

RESULTS AND DISCUSSION

Total phenolic contents

Appearance of a blue colored solution due to the reduction of phospho-molybdic and phospho-tungstic acids contained in the Folin-Ciocalteu reagent indicates the presence of phenolic compounds in the samples (Rusak *et al.*, 2008). Absorbance of the blue complex was measured at 755 nm. To estimate the total phenolic content, a calibration curve of gallic acid absorbance (at 755 nm) versus concentration was constructed ($y = 3.745x + 0.0188$; $R^2 = 0.99812$). Total phenolic content of the aqueous methanol extract of powdered leaves of *M. stenopetala* and the purchased *Moringa* powder, expressed as mg gallic acid equivalents (GAE) per 100 g dry weight (DW) of the *Moringa* material, were found to be 92.8 ± 1.01 and 75.5 ± 2.28 mg, respectively (Table 1). These results are within the range of the values (68.8-200 mg GAE/100 g DW) reported for the methanolic extract of different parts of *M. oleifera* in winter and summer seasons (Shih *et al.*, 2011). Reports in the literature reveal that the drying conditions such as the drying temperature and circumstances might induce changes in the composition of chemical constituents which, in turn, might affect the antioxidant activities of plant materials. Very high phenolic content from *Moringa oleifera* species in freeze-dried sample was reported (Siddhuraju and Becker, 2003). In contrast to this, a significant decrease of up to 33% in the to-

tal phenolic contents of tomatoes when dried at 42°C was reported by Kerkhofs and coworkers (2005). The amount of phenols in fruits and vegetables are also affected by genetic factor, environmental conditions, such as light, temperature and growing season and analytical methodology (Wasim *et al.*, 2013).

The antioxidant effects of the *Moringa* samples in-

As shown in Figure 1, an increase in absorbance of the reaction mixture is accompanied by an increase in the reducing capacity due to an increase in the formation of the complex. This observation suggests that some polyphenolic compounds in the sample extracts are electron donors. Similar increase in reducing power with increase in concentration was

Table 1: Total phenolic contents of MS and MP leaf extract (80% methanol extracts)

<i>Moringa</i> samples	TPC ^a mg GAE/100 g d w
<i>Moringa stenopetala</i>	92.8 ± 1.01 ^b
Purchased <i>Moringa</i> powder	75.5 ± 2.28 ^b

Values are means of triplicate determination of mean ± SD, there was no significant difference in the mean mg GAE/100g of the samples with same superscript at p<0.05. TPC^a is total phenolic content.

vestigated in the present study can be ascribed to their phenolic constituents whose antioxidant character is reported to emanate from their ability to donate hydrogen atoms and chelate metal ions (Costa *et al.*, 2012; Shahriar *et al.*, 2013).

Ferric Reducing Antioxidant Power

The ferric reducing antioxidant power assay measures the ability of antioxidants in the *Moringa* samples to reduce potassium ferricyanide, $K_3[Fe(CN)_6]$, to potassium ferrocyanide, $K_4[Fe(CN)_6]$. Addition of free Fe^{3+} to the reduced product leads to the formation of ferric ferrocyanide, $Fe_4[Fe(CN)_6]_3$, also known as Perl's Prussian blue complex which has a strong absorbance at 700 nm. In this regard, increase in Fe^{3+} to Fe^{2+} transformation in the presence of test sample implies that the sample contains electron-donating compounds and can thus cause reduction of the oxidized intermediates (Sayed *et al.*, 2011).

observed in a study conducted on methanolic extracts of pulp and seed of *Cassia fistula* (Irshad *et al.*, 2012). It has been reported that crude phenolic extracts of blueberry leaves displayed a considerable reducing power, primarily due to their effect as electron donors and thereby halting radical chain reactions by converting free radicals to more stable products (Naczka *et al.*, 2003). The ferric reducing capacity of MS extract was observed to be higher than MP (Table 2). The higher antioxidant activity of MS leaf extract might be attributed to its higher phenolic contents relative to the MP extract as described in the aforementioned FC assay.

Free radical scavenging activity (DPPH)

Scavenging of the stable 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical, which shows a strong absorption at 515 nm, is a widely used method to

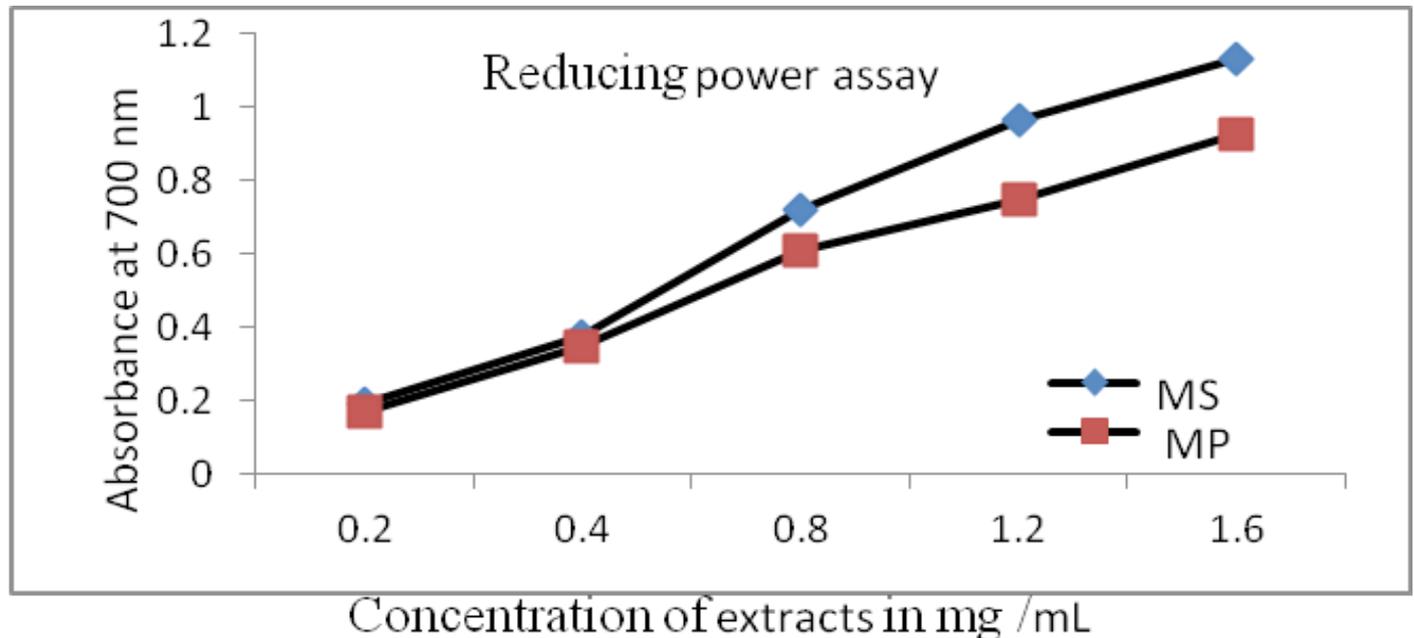


Figure 1: Absorbance versus concentration of extracts in reducing power assay.

(MS: *Moringa stenopetala*; MP: *Moringa* powder purchased).

Table 2: Antioxidant activities of *Moringa* leaf extract in reducing power assay

<i>Moringa</i> sample	AOA ^a in terms of mg AAE ^b /100 g dry weight
MS	442.0±10.58
MP	291.3±15.52

Values are mean ± SD for triplicate determinations AOA^a is antioxidant activity, AAE^b is ascorbic acid equivalent.

evaluate antioxidant activities in a relatively short time compared with other methods (Rajesh *et al.*, 2011). Substances capable of donating hydrogen atoms or electrons are able to convert DPPH (Purple) free radical into the non-radical reduced form, a reaction that can be monitored spectrophotometrically (Rajesh *et al.*, 2011). The free radical scavenging activity of the extracts in the present work was thus also evaluated by investigating their ability to quench the DPPH free radicals through donation of hydrogen atoms or electrons. The bleaching of DPPH color is indicative of the capacity of the test extract to scavenge free radicals.

The scavenging effects of extracts increased with their concentration and the percentage inhibitions values are presented in Table 3. The present study showed that scavenging of DPPH radicals by aqueous methanol extracts of powdered *Moringa* leaves occurred in a dose-dependent manner, an observation that has also been reported for leaf extracts of *M. oleifera* (Kumar *et al.*, 2012) and *M. peregrine* (Dehshahri *et al.*, 2012).

In the present study, the scavenging ability of the aqueous methanol extract of purchased *Moringa* powder (MP) was found to be lower than that of

powdered *M. stenopetala* (MS) leaves extract (Table 4). This is also in line with the higher total phenolic content of powdered *M. stenopetala* (MS) leaves extract relative to that of purchased *Moringa* powder (MP) extract. The difference in the proportion of phenolic compounds between the two plant samples can be traced to differences in their drying conditions as well as differences in the time lapse between collection of the plant leaves and antioxidant studies.

Correlation between total phenol content and antioxidant capacity

The extents of antioxidant capacity of the *Moringa* extracts were correlated with their total phenolic content. A linear correlation appeared between the antioxidant capacity and the total phenolic content of the extracts ($R^2 = 0.98628, 0.99033$ for FRAP and DPPH, respectively) suggesting that the antioxidant capacity may be due to the phenolic compounds as well as other constituents like flavonoids present in

Table 3: Antioxidant activity of MS leaf and MP extract with different concentrations against DPPH radical.

Concentration of extracts (mg/mL)	% inhibition of MS	% inhibition of MP
0.2	54.8±0.09 ^a	51.4±0.29 ^a
0.4	75.5±1.90 ^b	71.2±0.54 ^b
0.6	80.8±0.17 ^c	78.4±0.34 ^c
0.8	85.8±0.49 ^d	83.6±0.45 ^d

Values are mean ± SD of triplicate analysis. Different superscript letters within columns showed significant differences

at ($P < 0.05$), MS: *Moringa stenopetala* leaf, MP: *Moringa* leaf purchased.

Table 4: The antioxidant activity of *Moringa* leaf extract in mg of AAE/100g DW in DPPH.

<i>Moringa</i> sample	AOA in terms of mg AAE/100g dry weight
MS	144.0±0.53
MP	138.7±1.05

Values are mean ± SD of triplicate analysis.

the *Moringa* leaves extracts. Flavonoids like quercetin-3-O-rhamnoglucoside and quercetin 3-O-glucoside have been reported as constituents of *M. stenopetala* (Bennett *et al.*, 2003).

Stabilization of sunflower oil by extract of *Moringa* leaves

Peroxide value (PV)

Peroxide value (PV) is often used as a measure of oxidation status of oils, fats and fatty foods (Bushra

et al., 2007). Table 5 (a and b) depicts the relative increase in peroxide value of sunflower oil (SFO) containing extracts of powdered leaves of *M. stenopetala* (MS), purchased *Moringa* powder (MP) and vitamin E kept at 65°C and at room temperature for six and eighteen days, respectively. The highest PV was observed for the control sample (C-SFO) while lower peroxide values were observed for SFO containing extracts from *Moringa* and vitamin E at the end of the experimental period in both conditions, indicat-

ing a higher rate of oxidation for the control sample. A slow rise in the PV of the oil containing the plant extracts as compared to those of the control clearly indicates that the compounds in the plant extracts are able to deter oil oxidation. It may be noted from Table 5 (a and b) that *Moringa* leaf extract is able to prevent oxidative deterioration of sunflower oil to a comparable extent as the familiar antioxidant vitamin E, a finding in agreement with reported data for *M. oleifera* (Akhtar and Tsao, 2005; Atawodi *et al.*, 2010). In a related study, vitamin E was shown to be a poor protector against oil oxidation compared with ethanol extracts of grape waste whose phenolic constituents are reported to be responsible for the antioxidant behavior (Theodora-Ioanna *et al.*, 2007).

Conjugated dienes (CD)

Free radicals formed by abstraction of a hydrogen atom from a bis-allylic position of unsaturated fatty acids readily undergo allylic rearrangement to produce conjugated dienes (Chatha *et al.*, 2006, Valko, *et al.*, 2006). Molar absorptivities or molar extinction coefficients pertaining to absorption at 232 nm by conjugated dienes can be measured for their determination. As can be seen from Table 6, almost all of the stabilized SFO samples showed the formation of CD to a significantly lower level than the control, thus reflecting the antioxidant efficacy of the investigated *Moringa* leaf extracts.

Table 5: Relative increase in peroxide value (PV) of SFO stabilized with the extracts of MS, MP and vitamin E under room temperature and oven (65°C) storage.

a) Peroxide value of SFO stored at 65°C for six days						
ST	C-SFO	Vit ES-SFO	MSS-SFO	MS*S-SFO	MPS-SFO	MP*S-SFO
0	5.2±0.56 ^a	5.2±0.56 ^b	5.2±0.56 ^c	5.2±0.56 ^d	5.2±0.56 ^e	5.2±0.56 ^f
2	11.07±0.61 ^a	7.5±0.83 ^b	7.3±1.00 ^c	7.2±2.11 ^d	7.5±2.00 ^e	7.3±1.89 ^f
4	18.3±1.00 ^a	12.3±0.61 ^b	11.87±1.2 ^c	10.8±1.44 ^d	12±0.35 ^e	11.5±0.70 ^f
6	28.5±1.02 ^a	17.3±2.01 ^b	17±2.58 ^c	15.2±1.83 ^d	17.3±2.4 ^e	15.3±0.42 ^f
% inhibition		47.9	49.4	57.0	47.9	56.5
b) Peroxide value of SFO stored at room temperature for 18 days						
ST	C-SFO	Vit ES-SFO	MSS-SFO	MS*S-SFO	MPS-SFO	MP*S-SFO
0	5.2±0.56 ^a	5.2±0.56 ^b	5.2±0.56 ^c	5.2±0.56 ^D	5.2±0.56 ^E	5.2±0.56 ^f
6	6.6±0.20 ^a	6.27±1.90 ^b	6.2±0.53 ^c	6.1±0.94 ^d	6.3±0.61 ^e	6.1±1.30 ^f
12	8.3±0.85 ^a	7.5±2.20 ^b	7.1±1.70 ^c	7.0±1.40 ^d	7.3±0.42 ^e	7.1±0.28 ^f
18	9.9±0.60 ^a	8.8±0.40 ^b	8.4±0.80 ^c	8.3±0.80 ^D	8.5±0.61 ^E	8.3±0.57 ^f
% inhibition		22.9	31.4	34.3	28.67	32.9

Values in the same column that are followed by different letters (a-f) are significantly different $p < 0.05$ in table a, and in table b (a-f) are insignificant $p < 0.05$ but capital letters in each column are significant at $p < 0.05$ by Tukey's multiple range tests. ST is storage time, C-SFO is control sunflower oil, vit ES-SFO is vitamin E stabilized sunflower oil, MSS-SFO is *Moringa stenopetala* at 1000 mg/L stabilized SFO, MS*SSFO is *Moringa stenopetala* at 2000 mg/L stabilized SFO, MPS-SFO is *Moringa purchased* at 1000 mg/L stabilized SFO and MP*S-SFO is *Moringa purchased* at 2000 mg/L stabilized SFO.

a) Peroxide value of SFO stored at 65°C for six days.

b) Peroxide value of SFO stored at room temperature for 18 days.

Table 6: Relative increase in conjugated dienes of SFO stabilized with extracts of MS, MP and vitamin E.

a) Conjugated dienes ($1\% \epsilon_{1\text{cm}} (\lambda=232 \text{ nm})$) of SFO stored at 65°C for six days

St	C-SFO	Vit ES-SFO	MSS-SFO	MS*S-SFO	MPS-SFO	MP*S-SFO
0	0.6±0.07 ^a	0.6±0.07 ^b	0.5±0.06 ^c	0.5±0.04 ^d	0.55±0.04 ^e	0.549±0.40 ^f
2	1.9±0.03 ^a	1.5±0.08 ^b	1.4±0.02 ^c	1.2±0.006 ^d	1.44±0.06 ^e	1.28±0.05 ^f
4	3.4±0.00 ^a	2.5±0.09 ^b	2.3±0.05 ^c	1.98±0.02 ^d	2.35±0.04 ^e	2.01±0.005 ^f
6	6.4±0.06 ^a	3.9±0.05 ^b	3.5±0.02 ^c	3.17±0.15 ^d	3.6±0.009 ^e	3.32±0.002 ^f

b). Conjugated dienes ($1\% \epsilon_{1\text{cm}} (\lambda=232 \text{ nm})$) of SFO stored at room temperature for 18 days.

ST	C-SFO	Vit ES-SFO	MSS-SFO	MS*S-SFO	MPS-SFO	MP*S-SFO
0	0.6±0.066 ^a	0.6±0.07 ^b	0.6±0.07 ^c	0.6±0.07 ^d	0.6±0.07 ^e	0.6±0.07 ^f
6	1.6±0.01 ^a	1.3±0.01 ^b	1.2±0.16 ^c	1.0±0.008 ^d	1.2±0.008 ^e	1.0±0.02 ^f
12	2.9±0.133 ^a	2.19±0.011 ^b	1.97±0.021 ^c	1.88±0.004 ^d	2.00±0.01 ^e	1.9±0.01 ^f
18	4.3±0.30 ^a	3.4±0.001 ^b	3.3±0.04 ^c	3.2±0.007 ^d	3.3±0.01 ^e	3.3±0.02 ^f

Values in the same column that are followed by a different letters (a-f) are significantly different $p < 0.05$ by Tukey's multiple range tests.

a) Conjugated dienes ($1\% \epsilon_{1\text{cm}} (\lambda=232 \text{ nm})$) of SFO stored at 65°C for six days.

b) Conjugated dienes ($1\% \epsilon_{1\text{cm}} (\lambda=232 \text{ nm})$) of SFO stored at room temperature for 18 days.

CONCLUSION

The present study has shown that aqueous methanol (80%) extract of the powdered leaves of *M. stenopetala* is able to scavenge DPPH radicals, reduce $\text{K}_3[\text{Fe}(\text{CN})_6]$ to $\text{K}_4[\text{Fe}(\text{CN})_6]$ (reducing power ability) and inhibit oxidation of sunflower oil. Lower values of PV and CD contents for sunflower oil containing *M. stenopetala* leaf extract relative to the control indicated effectiveness of the extract in preventing oxidation of the oil. It has also been noted in the present study that the ability of *Moringa* leaf extracts to deter oxidative deterioration of sunflower oil is comparable to that of the familiar antioxidant vitamin E. This property of the extract might be due to the presence of polyphenolic compounds that can act as natural antioxidants. This prompts further study to look into the feasibility of using this plant

material as a natural antioxidant to protect, for instance, edible oils from oxidative deterioration. The antioxidant activity of aqueous methanol extract of *M. stenopetala* leaf documented in the current study may underlie the widespread use of the plant in folk medicine. However, further work is in order to establish the medicinal value traditionally associated with the leaves of this plant.

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