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Evaluation of total phenolic content and antioxidant activity of different solvent extracts of Egyptian purslane leaves

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ABSTRACT

Egyptian purslane (*Portulaca oleracea* L.) is a green plant which has been known since times of the ancient Egyptians rarely found now in Egypt. The objective of this work was carried out to evaluate the total phenolic content and antioxidant activity of different solvent extracts of Egyptian purslane leaves using different assays. Purslane leaves extracted by four different solvents: ethanol, methanol, cold water and hot water. The total phenolic and total flavonoid contents were determined in all extracts. The antioxidant activity was determined using total antioxidant capacity, reducing power, DPPH radical scavenging, nitric oxide scavenging, hydroxyl radical scavenging and Fe^{+2} chelating activities. The results revealed that the highest amount of phenolic content was found in methanol extract (326.80±31.22 mg/g purslane leaves) while the lowest amount was found in hot water extract (228.27±58.06 mg/g purslane leaves). The purslane extracts exhibited antioxidant activity in all assays. The methanol extract possessed the highest antioxidant activity among purslane extracts could be associated with its content of phenolic compounds. The result was concluded that the purslane and purslane extracts are an excellent source of natural antioxidant, which has biological impacts on human health and could be used for food and nutraceutical applications.

Keywords: *Portulaca oleracea* - purslane - antioxidant - Phenolic content

Introduction

Antioxidants, the majority of which are phenolic compounds, are capable of reducing oxidative stress by scavenging free radical species. Thus, they are known to be responsible for the antioxidant activity of plants. Antioxidants achieve the neutralizing or scavenging of free radicals by hydrogen donation before their attack to cells and other biological components. Thus, they are vital for well-being and protecting optimal health (Percival, 1998). Plants comprise a great diversity of compounds including flavonoids (flavones, anthocyanins, *etc*.) and several classes of non-flavonoids (phenolic acids, lignin, stilbenes, terpenoids, *etc*.) as phenolic components. These compounds vary in structure such as the number of phenolic hydroxyl groups and their position, leading to variation in their antioxidative capacity (Erkan, 2012).

Common purslane (*Portulaca oleracea* L.) is a member of Portulacaceae family, which consists of more than 120 species of succulent herbs and shrubs (Hyam and Pankhurst, 1995). Purslane is also consumed as vegetable, especially in the Mediterranean region and commonly called "Reglah" in Egypt. It is a summer annual green plant with edible succulent stems and leaves. It is widespread, fast-growing and self-compatible and produces large numbers of seeds that have long viability. Many varieties of purslane grow in a wide range of climates and regions. It is known to have higher nutritional value than major cultivated vegetables, with considerable amount of β-carotene, ascorbic acid and α-linolenic acid (Liu *et al*., 2000). Several studies reported that the presence of flavonoids as main bioactive purslane constituents (Xu *et al*., 2006, Zhu *et al*., 2010 and Erkan, 2012). *P. oleracea* has been shown to display radical scavenging activity (Lim and Quah, 2007, Oliveira *et al*., 2009 and Siriamornpun and Suttajit, 2010). Erkan (2012) investigated the antioxidant activities and phenolic compounds content of fractions obtained from the crude extract of *Portulaca oleracea* by reversed-

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phase separation. The results indicated that the fraction 3 displayed higher absorption than the other fractions. The total amount of quantified phenolics in this fraction was found to be quite high compared to that of crude extract. IC_{50} value of crude extract was found to be 511.8 µg/ml whereas fraction 3 exhibited an IC_{50} value of 154.1 µg/ml. TEAC of fraction 3 was found to be almost four times higher than that of the crude extract and showed the highest lipid peroxidation inhibiting capacity. Uddin *et al*. (2014) evaluated the changes in mineral content and antioxidant attributes of *Portulaca oleracea* over different growth stages. The results indicated that DPPH scavenging (IC_{50}) capacity ranged from 1.30±0.04 to 1.71±0.04 mg/ml, while the ascorbic acid equivalent antioxidant activity values were 229.5±7.9 to 319.3±8.7 mg AA/100 g, total phenol content varied from 174.5±8.5 to 348.5±7.9 mg GAE/100 g, ascorbic acid content 60.5±2.1 to 86.5±3.9 mg/100 g and ferric-reducing antioxidant power 1.8±0.1 to 4.3±0.1 mg GAE/g. Sicari *et al*. (2018) investigated that two different extracts (MeOH/H_2O and EtOH) from fresh and dried leaves of *P. oleracea* for their chemical profile and bioactivity. They carried out a qualitative analysis of phenolic compounds present in the leaves of purslane examined by using LC-DAD by comparison with standard and literature data. Phenolic acids (caffeic acid, *p*-coumaric acid and ferulic acid) and flavonoids (apigenin, kaempferol, luteolin, quercetin, isorhamnetin, kaempferol-3-*O*-glucoside and rutin) were identified in all samples. The results revealed that fresh hydroalcoholic purslane extract exhibited a promising radical scavenging activity.

There are alack investigation Egyptian purslane leaves. So that urges us to study the bioactive components in Egyptian purslane leaves.

The purpose of this investigation was to evaluate the total phenolic content and antioxidant activity of different solvent extracts of Egyptian purslane leaves through various assays.

Materials and Methods

Materials

The fresh leaves of purslane were collected from the Zagazig farms, El-Sharkia, Egypt. Plant samples were dried in an oven at 45-50°C for 12 h, then ground to a fine powder and stored in plastic vials.

Chemicals

Sodium nitroprusside, potassium ferricyanide, 2-deoxyribose, thiobarbitturic acid, 1, 10-phenanthrolin, L-ascorbic acid were purchased from S.D. Fine Chemical, India. Tris hydrochloride and N-(1-naphthyl) ethylenediamine dihydrochloride were purchased from Oxford Lab Chemical, India. Ferrous Sulphate was obtained from Alpha Chemika, India. 1, 1-diphenyl-2-picrylhydrazyl (DPPH) was obtained from Sigma-Aldrich Chemical Co., USA. All other chemicals were of analytical reagent grade.

Methods

Preparation of different extracts of Purslane leaves

Four different extracts were prepared from purslane leaves using the procedure described by Uddin *et al*. (2012) with some modifications as follows: Five grams of dried purslane leaves were grinded with 100 ml of different solvents (ethanol 80%, methanol 80%, cold water and boiling water). After 24 h at 5°C, the mixtures were centrifuged at 3000 rpm for 15 min. The supernatants were filtered through Whatman No.1 filter paper. The total soluble solid (%) in all extracts were determined by dry weights.

Determination of total phenolic content

The total phenolic content of different extracts of purslane leaves was determined using Folin – Ciocalteau method as described by Turkoglu *et al*. (2007) as follows: Briefly, 1 ml of extract in a volumetric flask was diluted with distilled water to 46 ml. 1 ml of Folin-Ciocalteu reagent was added and the contents of the flask were mixed thoroughly. After 3 min, 3 ml of Na_2CO_3 (2%) was added, then mixture was allowed to stand for 2 h. with intermittent shaking. The absorbance of each mixture

was measured at 760 nm. The concentration of total phenolic content was measured by plotting the calibration curve of a Gallic acid standard.

Determination of total flavonoid content

The total flavonoid content of different extracts of purslane leaves was determined according to the method described by Turkoglu *et al*. (2007) as follows: 1 ml of extract was diluted with 4.3 ml of 80 % aqueous ethanol containing 0.1 ml of 10 % aluminum nitrate and 0.1 ml of 1 M aqueous potassium acetate. After 40 min at room temperature, the absorbance was determined spectrophotometrically at 415 nm. The total flavonoid content was measured by plotting the calibration curve of a quercetin standard.

Determination of antioxidant activities

Determination of total antioxidant capacity

Total antioxidant capacity of extracts was assayed by the phosphomolybdenum method as described by Kumaran and Karunakaran (2007).

Determination of reducing power

The reducing power of extracts was determined by the method of Mathew and Abraham (2006).

Determination of DPPH radical scavenging activity

The antioxidant activity of extracts, based on the scavenging activity of the stable DPPH free radical was determined by the method described by Lee *et al*. (2004).

Determination of nitric oxide scavenging activity

The scavenging activity of nitric oxide by extracts was determined by the method described by Kumaran and Karunakaran (2007).

Determination of hydroxyl radical scavenging activity

The scavenging activity of hydroxyl radical by extracts was assayed using deoxyribose method as described by Nagia *et al*. (2005).

Determination of Fe^{+2} chelating activity

The ability of the extracts to chelate ferrous (Fe^{+2}) ion was determined as described by Oboh *et al*. (2007).

Statistical analysis

Analysis of variance (ANOVA) was conducted using Costat program software computer. Significant between differences were determined according to LSD values of Duncan's multiple rang test (Duncan, 1955).

Results and Discussion

Total phenolic and flavonoid contents

Phenolic compounds are a large group of secondary plant metabolites which play a major role in the protection of oxidation processes. Phenolic compounds have antioxidant properties and can act as free radical scavengers, hydrogen donators and singlet oxygen quenchers (Croft, 1999). The total phenolic and flavonoid contents of four different extracts of purslane leaves are shown in Table 1. The results revealed that the highest total phenolic content was found in methanol extract (326.80±31.22 mg/g purslane leaves), whereas the lowest content was found in hot water extract (228.27±58.06 mg/g purslane leaves). On the other hand, the amount of flavonoid content for different extracts of purslane leaves was in the following order: cold water extract (60.70±2.1 mg/g purslane leaves) > hot water (57.35±1.8 mg/g purslane leaves) >methanol extract (44.33±3.4 mg/g purslane leaves) >ethanol

extract (34.66±4.0 mg/g purslane leaves). The phenolic content of purslane varies with variety geographical origin, season and time of harvest. The selection of extraction method and solvent also effect on the amount of phenolic compounds. The results are supported by Lim and Quah (2007) who found that the total phenolic content of purslane varieties ranged from 127 to 478 mg/g of fresh weight. Oliveira *et al*. (2009) who found that the total phenolic content of purslane stems and leaves was very different between samples in the range from 78.3 to 633.9 mg/ kg dry weight.

Table 1: Total phenolic, flavonoid and solid contents of different extracts of purslane leaves

Extract	Total phenolic (mg/ g purslane leaves)	Total flavonoid (mg/ g purslane leaves)	Total solid (%)
Ethanol extract	239.30^{c}± 34.76	34.66^{b}±4.00	26.00
Methanol extract	326.80^{a} ± 31.22	44.33^{b}±3.40	26.41
Cold water extract	263.52^{b}± 12.75	60.70^{a}±2.10	61.02
Hot water extract	228.27^{d}± 58.06	57.35^{ab}±1.80	50.00
$LSD_{0.05}$	80.44	24.51	-

-Values are means of three replicates ±SD. Numbers in the same column followed by the same letter are not significantly different at $p < 0.05$.

Total antioxidant capacity

Results in Table (2) showed that the total antioxidant capacity of different extracts of purslane leaves compared to ascorbic acid. The result revealed that there were significant differences in the total antioxidant capacity of different extracts between the all concentrations, which used in this experiment. The results showed that all the extracts exhibited potent antioxidant activity. Among the extracts cold water extract and methanol extract exhibited higher potency of antioxidant activity (1.117±0.002 and 0.911±0.006) at maximum concentration (4545.45 ppm) in comparison with ethanol extract and hot water extract (0.848±0.011 and 0.771±0.001).

Table 2: Total antioxidant capacity of different extract of purslane leaves

	Total antioxidant capacity (O.D. 695 nm)				
Concentration (ppm)	**Ethanol extract**	**Methanol extract**	**Treatment Cold water extract**	**Hot water extract**	**Ascorbic acid (standard)**
1515.15	0.748^{c}±0.018	0.505^{c}±0.037	0.695^{c}±0.006	0.402^{c}±0.001	1.167^{c}±0.003
3030.30	0.777^{b}±0.010	0.720^{b}±0.078	0.738^{b}±0.005	0.533^{b}±0.002	1.615^{b}±0.002
4545.45	0.848^{a}±0.011	0.911^{a}±0.006	1.117^{a}±0.002	0.771^{a}±.0.001	1.724^{a}±0.004
$LSD_{0.05}$	0.013	0.116	0.00118	0.0044	0.0065

-Values are means of three replicates ±SD. Numbers in the same column followed by the same letter are not significantly different at $p < 0.05$.

Reducing power

The reducing power of different extract of purslane leaves are shown in Table 3. The reducing power of each extract increased with increasing the concentration. At 9090.90 ppm, the reducing power values of different extracts: methanol extract, ethanol extract, cold water extract and hot water extract were 1.763±0.015, 1.665±0.235, 1.434±0.069 and 1.751±0.036 respectively. The result showed that the reducing power of methanol extract and hot water extract was higher than ethanol extract and cold water extract. The reducing power of different extracts of purslane leaves related to

their contents of phenolic compounds. The highest value of reducing power in purslane extracts was observed in methanol extract.

Table 3: Total reduction capability of different extracts of purslane leaves

	Total reduction capability (O.D.700 nm)				
Concentration (ppm)	**Ethanol extract**	**Methanol extract**	**Treatment Cold water extract**	**Hot water extract**	**Ascorbic Acid (standard)**
1818.18	0.770^{c}±0.68	0.703^{c}±0.057	0.560^{c}±0.034	0.976^{c}±1.620	0.293^{c}±0.002
5454.54	1.0816^{b}±0.24	1.316^{b}±0.700	0.702^{b}±0.066	1.257^{b}±0.004	0.698^{b}±0.0035
9090.90	1.665^{a}±0.235	1.763^{a}±0.015	1.434^{a}±0.069	1.751^{a}±0.036	1.520^{a}±0.0025
$LSD_{0.05}$	0.265	0.118	0.154	0.192	0.0027

-Values are means of three replicates ±SD. Numbers in the same column followed by the same letter are not significantly different at $p < 0.05$.

DPPH scavenging activity

DPPH is a stable, free radical and accepts an electron or hydrogen radical to become a stable, diamagnetic molecule produces purple solution in methanol and becomes pale when it reacts with antioxidant molecules and the DPPH radical which results in the scavenging of the radical by hydrogen donation (Elmastasa *et al*., 2007). A lower absorbance at 517 nm indicated a higher radical-scavenging activity of the extract. The results of the DPPH radical-scavenging activity of different extracts of purslane leaves were demonstrated as the percentage increased with increasing concentration, as shown in Table 4. The scavenging effect of each purslane extract at higher concentration (25000 ppm) and ascorbic acid standard solution with the DPPH radical was in the following order: ascorbic acid (82.73±0.29%) > methanol extract (78.25±0.23%) > hot water extract (75.89±0.38%) > cold water extract (70.60±0.17%) > ethanol extract (65.92±0.57%).

Table 4: Scavenging activity of different extracts of purslane leaves against DPPH radical

	Scavenging activity %				
Concentration (ppm)	**Ethanol extract**	**Methanol extract**	**Treatment Cold water extract**	**Hot water extract**	**Ascorbic Acid (standard)**
5000	33.04^{c}±0.57	28.98^{c}±0.23	42.53^{c}±0.17	25.37^{c}±0.58	17.38^{c}±0.78
12500	44.26^{b}±0.11	54.43^{b}±0.23	55.58^{b}±0.17	43.62^{b}±0.17	45.36^{b}±0.61
25000	65.92^{a} ±0.57	78.25^{a}±0.23	70.60^{a}±0.17	75.89^{a}±0.38	82.73^{a}±0.29
$LSD_{0.05}$	0.572	1.261	0.471	0.608	1.442

-Values are means of three replicates ±SD. Numbers in the same column followed by the same letter are not significantly different at $p < 0.05$.

Nitric oxide scavenging activity

In addition to reactive oxygen species, nitric oxide is also implicated in inflammation, cancer and other pathological conditions (Moncada *et al*., 1991). The percentages of nitric acid scavenging activity of all crude extracts obtained by using hot and cold water, ethanol and methanol are shown in Table (5). In general, the ethanol and methanol extracts were found to be more active than the aqueous extracts (cold and hot water). The highest nitric oxide scavenging activity was shown by ethanol and methanol extracts of purslane leaves 75.69±0.13% and 50.33±0.17% respectively at concentration 7500 ppm. While, the lowest values were 43.76±0.75% and 38.60±0.25%, respectively

for cold and hot water extracts of purslane leaves. The extracts also showed a moderate nitric oxide scavenging activity at concentration 5000 ppm in a dose dependent manner (Table 5). The purslane extracts may have the ability to counteract the effect of NO formation and in turn may be of considerable interest in preventing the adverse effects of excessive NO generation in the human body. Further, the scavenging activity may also help to arrest the chain of reactions initiated by excess generation of NO that are detrimental to human health. The extracts showed a moderate nitric oxide-scavenging activity. The scavenging activity (%) was increased with increasing the concentration of the extract.

Table 5: Nitric oxide scavenging activity of different extract of purslane leaves

	Scavenging activity (%)				
Concentration (ppm)	**Ethanol extract**	**Methanol extract**	**Cold water extract**	**Hot water extract**	**Ascorbic Acid (standard)**
2500	19.71^{c}±0.28	14.046^{c}±0.26	43.76^{c}±0.75	38.60^{b}±0.25	22.25^{c}±0.15
5000	54.52^{b}±3.88	41.56^{b}±0.11	44.51^{b}±0.43	39.88^{b}±0.35	23.95^{b}±0.10
7500	75.69^{a}±0.13	50.33^{a}±0.17	49.91^{a}±0.19	49.04^{a}±1.54	44.91^{a}±0.38
$LSD_{0.05}$	0.118	0.265	0.154	0.192	0.421

-Values are means of three replicates ±SD. Numbers in the same column followed by the same letter are not significantly different at $p < 0.05$.

Hydroxyl radical scavenging activity

Data presented in Table (6) showed that the hydroxyl radical activity of purslane extracts (ethanol, methanol, cold water and hot water). The results revealed that the highest hydroxyl radical scavenging activity in all purslane extracts was at concentration 980.39 ppm comparison with other concentrations (470.58 and 1450.98 ppm). From the obtained result, it could be arranged these extracts at concentration 980.39 ppm in the following order: methanol extract (57.95±0.19%) > ethanol extract (50.92±1.62%) > hot water extract (45.92±0.57%) > cold water extract (37.32±0.82%).

Table 6: Hydroxyl radical scavenging activity of different extracts of purslane leaves

	Scavenging activity %				
Concentration (ppm)	**Ethanol extract**	**Methanol extract**	**Treatment Cold water extract**	**Hot water extract**	**Ascorbic Acid (standard)**
470.58	45.06^{b}±2.78	49.16^{b}±0.17	28.26^{b}±0.81	32.60^{b}±0.25	9.02^{c}±1.08
980.39	50.92^{a}±1.62	57.95^{a}±0.19	37.32^{a}±0.82	45.92^{a}±0.57	20.83^{b}±1.34
1450.98	41.51^{c}±0.72	41.51^{c}±0.72	26.26c±0.46	30.71^{c}±0.35	25.99^{a}±0.79
$LSD_{0.05}$	4.93	2.774	0.891	1.51	1.257

-Values are means of three replicates ±SD. Numbers in the same column followed by the same letter are not significantly different at $p < 0.05$.

Metal chelating activity

Transition metals such as the ferrous ion (Fe^{+2}) are good promoters of free radical reactions because of their single electron transfer during their change in oxidation state, with Fe^{+2} being the most powerful pro-oxidant among various species of metal ions (Jadhav *et al*., 1996). In addition,

transition metals assist the catalytic decomposition of hydroperoxide which appears to be the major source of free radicals. Chelating agents act as secondary antioxidants because they stabilize transition metals in living systems, and are important in retarding the radical degradation and inhibiting the generation of radicals (Gordon, 1990). The results presented in Table (7) showed that the chelating activity of purslane extracts on ferrous ion was determined as a percentage that increased with increasing the concentration. The results showed that the highest chelating activity was cold water extract (69.08±0.64%) followed by methanol extract (68.64±0.68%) then ethanol extract (66.15±0.17%) then hot water extract (64.17±0.20%) at maximum concentration 1401.34 ppm. There were significant differences in the chelating activity among the purslane extracts.

Table 7: Metal chelating activity of different extracts of purslane leaves

	Fe chelation (%)				
Concentration (ppm)	**Ethanol extract**	**Methanol extract**	**Cold water extract**	**Hot water extract**	**Ascorbic Acid (standard)**
560.53	30.34^{c}±0.69	53.95^{c}±0.69	44.77^{c}±0.28	46.86^{c}±0.44	32.59^{c}±0.85
840.80	47.41^{b}±0.89	63.51^{b}±0.66	66.71^{b}±0.25	58.68^{b}±3.60	62.48^{b}±0.52
1401.34	66.15^{a}±0.17	68.63^{a}±0.68	69.08^{a}±0.64	64.17^{a}±0.20	73.37^{a}±0.85
LSD $_{0.05}$	1.11	1.78	2.14	5.10	0.93

-Values are means of three replicates ±SD. Numbers in the same column followed by the same letter are not significantly different at $p < 0.05$.

In general, different extracts of purslane leaves exhibited different levels of antioxidant activity in all the models studied. The results from various free radical-scavenging systems revealed that the purslane extracts had significant antioxidant and free radical scavenging activities. The free radical-scavenging property of purslane extracts could be attributed mainly to phenolic compound as well as ascorbic acid, α–tocophenol and pigments (Oliveira *et al*., 2009; Uddin et al., 2012 and Erkan, 2012). The methanol extract possessed the highest antioxidant activity between purslane extracts, which associated with its content of phenolic compounds. Lim and Quah (2007) showed that methanol gave the highest extraction efficiency in *P. oleracea* and mainly this was due to the ability of the solvent to inhibit action of polyphenol oxidase that caused the oxidation of phenolic. Youssef *et al.* (2014) reported the radical scavenging potential of purslane leaves fresh and under different drying procedures (hot-air drying, microwave drying and freeze-drying). Sicari *et al.* (2018) indicator the fresh hydroalcoholic purslane extract exhibited a promising radical scavenging activity.

Conclusion

Finally, purslane and purslane extracts could be used as a rich source of natural antioxidant, bioactive component and can used as food supplement in nutraceutical purposes.

References

Croft, K.C., 1999. Antioxidant effects of plant phenolic compounds. CAB International Publishing Inc, Oxford, UK, 109- 121.

Duncan, D. B. (1955). Multiple range and multiple F tests. Biometrics, 11:1-41.

Elmastasa, M., O. Isildaka, I. Turkekulb and N. Temura, 2007. Determination of antioxidant activity and antioxidant compounds in wild edible mushrooms. Journal of Food Composition and Analysis, 20: 337-345.

Erkan, N., 2012. Antioxidant activity and phenolic compounds of fractions from *Portulaca oleracea* L. Food Chemistry, 133: 775–781.

Gordon, M.H., 1990. The mechanism of antioxidant action in vitro. In: Hudson, B.J.F. (Ed.), Food Antioxidants. Elsevier Publishing Inc, London, UK, 1-15.

Hyam, R. and P. Pankhurst, 1995. Plants and Their Names: A Concise Dictionary. Oxford: Oxford University Press, 545.

Jadhav, S.J., S.S. Nimbalkar, A.D. Kulkarni and D.L. Madhavi, 1996. Lipid oxidation in biological and food systems. Marcel Dekker Publishing Inc., New York, NY, USA, 5-63.

Kumaran, A. and R.J. Karunakaran, 2007. In vitro antioxidant activities of methanol extracts of five phyllanthus species from India. LWT-Food Science and Technology, 40(2):344-352.

Lee, J.Y., W.I. Hwang and S.T. Lim, 2004. Antioxidant and anticancer activities of organic extracts from *Platycodon grandiflorum* A. De Candolle roots. Journal of Ethnopharmacology, 93:409–415.

Lim, Y.Y. and E.P.L. Quah, 2007. Antioxidant properties of different cultivars of *Portulaca oleracea*, Food Chemistry, 103(3):734–740.

Liu, L., P. Howe, Y.F. Zhou, Z.Q. Xu, C. Hocart and R. Zhang, 2000. Fatty acids and β-carotene in Australian purslane (*Portulaca oleracea*) varieties. Journal of Chromatography A, 893: 207–213.

Mathew, S. and T.E. Abraham, 2006. Studies on the antioxidant activities of cinnamon (*Cinnamomum verum*) bark extracts, through various *in vitro* models. Food Chemistry, 94: 520–528.

Moncada, A., R.M.J. Palmer and E.A. Higgs, 1991. Nitric oxide: physiology, pathophysiology and pharmacology. Pharmacological Reviews, 43: 109–142

Nagia, T., R. Inour, N. Suzuki, T. Myoda and T. Nagashima, 2005. Antioxidative ability in α-linoleic acid oxidation system and scavenging abilities against active oxygen species of hydrolysates from pollen *Cistus ladaniferus*. International Journal of Molecular medicine, 15: 259-263.

Oboh, G., R.L. Puntel and J.B.T. Rocha, 2007. Hot pepper (*Capsicum annuum*, Tepin and *Capsicum Chinese*, Habanero) prevents Fe^{2+}-induced lipid peroxidation in brain *in vitro*. Food Chemistry, 102 (1):178-185.

Oliveira, I., P. Valentao, R. Lopes, P. B. Andrade, A. Bento and J.A. Pereira, 2009. Phytochemical characterization and radical scavenging activity of *Portulaca oleraceae* L. leaves and stems. Microchemical Journal, 92(2): 129–134.

Percival, M., 1998. Antioxidants. Clinical Nutrition Insight, 31: 1–4.

Turkoglu, A., M.E. Duru, N. Mercan, I. Kivrak and K. Gezer, 2007. Antioxidant and antimicrobial activities of *Laetiporus sulphureus* (Bull.) Murrill. Food Chemistry, 101, 267-273.

Sicari, V., M.R. Loizzo, R. Tundis, A. Mincione and T.M. Pellicano, 2018. *Portulaca oleraceal*. Purslane extracts display antioxidant and hypoglycemic effects. Journal of Applied Botany and Food Quality, 91:39-46.

Siriamornpun, S. and M. Suttajit, 2010. Microchemical components and antioxidant activity of different morphological parts of Thai wild purslane (*Portulaca oleracea*). Weed Science, 58:182–188.

Uddin, K. M., A.S. Juraimi, M.R. Ismail, and E.M. Ali, 2012. Evaluation of antioxidant properties and mineral composition of purslane (*Portulaca oleracea* L.) at different growth stages. International Journal of Molecular sciences, 13: 10257-10267.

Uddin, K. M.; Abdul, J.; Saber, H. M.; Altaf, U. M.; Eaqub, A. M. and Rahman, M.M., (2014). Purslane weed (*Portulaca oleracea*): a prospective plant source of nutrition, omega-3 fatty acid, and antioxidant attributes. Scientific World Journal, 2:1-6.

Xu, X., L. Yu and G. Chen, 2006. Determination of flavonoids in *Portulaca oleracea* L. by capillary electrophoresis with electrochemical detection. Journal of Pharmaceutical and Biomedical Analysis, 41: 493-499.

Zhu, H., Y. Wang, Y. Liu and T. Tang, 2010. Analysis of flavonoids in *Portulaca oleracea* L. by UV–Vis spectrophotometry with comparative study on different extraction technologies. Food Analytical Methods, 3(2):90-97.

Youssef, M.K. and M.S. Mokhtar, 2014. Effect of drying methods on the antioxidant capacity, color and phytochemicals of *Portulaca oleracea* L. Leaves. Journal Nutrition and Food Science, 4(6): 2-6.