Polyphenol and Flavonoid Contents and Antioxidant Activity in Freshly Consumed Rocket (Eruca sativa)

Rihan saadi abdul-jabbar

Department of Chemistry, Faculty of Science, University of Zakho, Zakho, Kurdistan Region, Iraq.
Tel.: 07504574233
E-mail: rihan.saadi@uoz.edu.krd

Abstract. Rocket (Eruca sativa) salad is commercially important it is taken as freshly cut ready to make salads necessary as nutritional characteristics. In the present study, alcoholic, flavonoid and anthocyanin extracts of E. sativa leaves cultivated in Kurdistan Region of Iraq was determined by in several methods including β-Carotene-linoleic acid assay, reducing power assay, H_2O_2 scavenger, and total antioxidant capacity. The antioxidant activity of fresh rocket leaves was determined as well. Temperature, pH and storage time that effecting on their activity as antioxidant was also studied. The results illustrate that alcoholic extract yield was 29.13%, about 25.2% of alcoholic are flavonoid compound, while anthocyanin yield 18.8% (g/g raw material). Total phenolic contents in E. sativa, have been quantified using beer law. Total flavonoid contents were also measured. The study shows that E. sativa is a good source of phytochemicals (total phenols 5, 3.3, and 1.3 mg TAE/g raw materials) and (total flavonoid 0.81, 1.04 and 0.44 mg QE/g raw materials) for alcoholic, flavonoid and anthocyanin extracts, respectively. All extracts illustrated high antioxidant potential. PH, thermal study and storage which carried to detect the remaining activity of the plant extracts show that antioxidant activity reduced with increasing the time of boiling, storage and different pH values.

Keywords: Storage, PH, Temperature, Antioxidant capacity, Antioxidant activity, Phytoconstituents, Eruca sativa, Rocket

1. Introduction
Nowadays, great interest has been devoted to the consumption of fresh vegetables and fruits since they are source of naturally occurring antioxidants; herbs fruit and vegetables are used as food provides a wide scope for adding value to local products. In fact, secondary plant metabolites, which represent most antioxidant properties, have evolved according to their interactions with the environment [1, 17]. Therefore phytoconstituents composition and respective biological activities are important to understand the therapeutic potential of medicinal herbs [2, 31]. Studies show that drug activities are due to secondary compounds such as phenols, alkaloids, tannins, saponins, carbohydrates, glycosides, flavonoids, steroids, etc. [3, 31]. In the past, there has been increasing interest in bioavailability and activity of phenolic compounds and flavonoids in plants. It possesses antioxidant compounds known to have direct antioxidant and free radical-scavenging activities and reduces various diseases, such as cancer, coronary heart disease and immune disorders [4, 7, 17]. When the balance between the productions of ROS exceeds the antioxidant capability of the target cell produce Oxidative stress results [5, 1]. Diet takes a vital and important role in the formation of antioxidants by providing necessary antioxidants such as vitamins C, E and β-carotene. Arugula or rocket (Eruca sativa) is an edible annual plant in the Brassicaceae family used as a leaf vegetable for its fresh peppery flavor. Other common names include garden rocket or simply rocket (British,
Australian, South African, Irish and New Zealand English). Eruca sativa, which is widely popular as a salad vegetable, is a species of Eruca native to the Mediterranean region, but it is widely distributed all over the world. It is thought that the characteristic pungent or bitter flavour of rocket salad may be related to the presence of glucosinolates (GSLs) [6, 33]. Rocket salad has high commercial value as a fresh cut ready to eat salad and is important because of its sensory and nutritional characteristics [7, 27]. E. sativa is a permanent or semi-permanent herb, used in Indian, European and Italian cooking. Traditionally, rocket salad considered as laxative, tonic, diuretic, gastrointestinal, emollient, depurative, astringent, rubefacient, and stimulant [8, 32]. Rocket leaves are source of compound that is active biologically including vitamin c, polyphenols, carotenoids, fiber, and glucosinolates [9, 33].

2. Methods

2.1. Plant materials
The acquisition of freshly harvested rockets from local farms in the Kurdistan region of Iraq (the village of Deleb Dohuk) where the missiles were examined in terms of their health and safety. Cold water used for washing. Four groups were prepared. Three groups for storage and final group for fresh work.

2.2. Chemicals
All chemicals are from Sigma.

2.3. Preparation of plant extracts

2.3.1 Alcoholic extract  Ethanol extract was prepared according to procedure of [5]. Fresh rocket leaf about (30 gm) mixed with 200 ml (70%) ethanol in water bath at 40 °C for 4 h. to get (8.74 g) of extract.

2.3.2 Flavonoids extract Method of [10, 15, 28] used to prepare the extract. Alcoholic extract about (5 gm) dissolved in (100 ml) distilled water, 125 ml of (1%) lead acetate was added and (50 ml) of methanolic (1%) lead acetate. Precipitate dissolved in [25 ml acetone + 5 ml (2M HCl)] with stirring, to get (1.60 g) of flavonoid extract.

2.3.3 Anthocyanin extract Rocket leaves (5gm) mixed with 50 ml methanol (1% HCl in methanol) using by procedure of [15, 4]. Then put in ice and shaking was done for day (12 h.) to obtain (0.94 g) of anthocyanin extract.

2.3.4 Total phenol content  To determine Total phenolic compound content method of [11] was used. Leaves (1µl) containing 100 mg samples were taken and completed volume to 50 ml by distilled water then 1 ml of Folin-Ciocalteu added. The previous procedure was used standard tannic acid solutions (0–3000 mg/50ml) to get standard curve. Results were expressed (mg TAE/g) extract, absorbance readings were taken at 760 nm which is shown in table (2).

2.3.5 Total flavonoid content Method described by [8] used to determine flavonoid content. Extract (0.1 gm/ml) in methanol about (0.5ml) followed by adding 1.5ml of methanol, then aluminum chloride1% was added and 1M potassium acetate and added. Results were expressed as milligrams of quercetin as standard control (mg QE/g) of extract which is shown in table (2).

2.4. Parameters of antioxidant activity
Fresh Rocket leaves and extracts are subjected to several methods to find antioxidant
activity.

2.4.1. **β-Carotene- linoleic acid assay** Marco’s method [12, 24] used when (2mg) of beta-carotene dissolved in chloroform (10 ml) and 1 ml of this solution was added to (0.02 gm) of linoleic acid and (0.20 gm) of Tween 20 then 50 ml of aerated distilled water was added and (5ml) of this was added to 0.2 ml of (0.01gm/ml) extracts or positive control antioxidants (α-tocopherol), absorbance measured at 470 nm at intervals which is shown in table (3).

2.4.2. **Reducing power** According to the method of [13, 34, 35] rocket leaves extracts with different concentrations (0.0001, 0.00025, 0.0005, 0.00075 and 0.001) gm in 1 ml methanol added phosphate buffer (0.2 M, pH 6.6) (2.5 ml), 3 ml of 1% \( \text{K}_3\text{Fe(CN)}_6 \), and 10% trichloroacetic acid about (2.5 ml) were added after incubation then 2.75 ml of the solution added to 2.5 ml of distilled water and 0.5 ml of 1% ferric chloride. Absorbance of the final solution was measured at 700 nm and vitamin c used as positive control which is shown in table (3).

2.4.3. **Scavenging of \( \text{H}_2\text{O}_2 \)** Rocket leaves capacity to \( \text{H}_2\text{O}_2 \) scavenge by methods of [14, 26, 30] using the calibration curve between concentrations and absorbance at 230 nm of standard vitamin c, Results expressed (mg AAE/g) which is shown in table (3).

2.4.4. **Total antioxidant capacity** Samples of alcoholic, flavonoids, and anthocyanin extracts of rocket leaves by method of [9, 15, 17, 29] calibration curve of \( \alpha \)-tocopherol at 695 nm was used to detect concentration from Beer’s Law which is shown in table (3).

2.5. **Temperature, pH and storage effecting on the antioxidant capacity**

Rocket leaves and three extract heats to 50 ºC and 100 ºC for (60 and 120 min) then reduced antioxidant capacity was measured using total antioxidant capacity method. For acidity stability, samples were incubated at different pH medium value (3, 5, 7, 9 and 11) then the reduced antioxidant capacity was detected. Plant and extracts stored in the dark place at 5 ºC, and the antioxidant capacity was measured after month (30 days) over a period of three month (90 days). \( \alpha \)-tocopherol used as control[16, 33].

2.6. **Statistical analysis**

Anova and Graph Pad Prism 5 program was used, measurement done by triplet. Using (SAS, 2000). Means comparison was done by Duncan’s Multiple Ranges Test under 1%.

3 Results and Discussion

3.1 Preliminary analysis:

Phytochemical screening of freshly rocket leaves (Eruca sativa) extracts was shown in Table (1). Preliminary analysis of secondary metabolites carried out from 3 rocket leaves extracts. The results showed that saponins are only present in alcoholic extracts of fresh leaves. The three extracts are rich source of glycoside, tannins and polyphenols, alkaloids, flavonoids and phytosterols (Table 1). Comparative phytochemical analysis of extracts indicated that Crude oil contains a small percentage of plant compounds. Previous study related to vegetable plant content of seeds leaves and crude oil reported similar results[12, 17, 31]. Therefore, found few amounts of secondary metabolites that have antioxidant properties in E. sativa.
Table 1. Phytochemical analysis of 3 rocket leaves extracts

| Reagents                  | Plant | Eth. ext. | F. ext | A. ext. | References |
|---------------------------|-------|-----------|--------|---------|------------|
| Ninhydrin test            | +     | +         | +      |         | [15]       |
| Molish test               | +     | +         | +      |         | [15]       |
| Alkaloid test: Dragnedoff | -     | -         | -      |         | [15]       |
| Hager                     | -     | -         | -      |         |            |
| Wagner                    | -     | -         | -      |         |            |
| Saponin test              | +     | -         | -      | -       | [14]       |
| Flavonoid test            | +     | +         | +      |         | [2]        |
| Phenol test               | +     | +         | +      |         | [13]       |
| Tannins test              | +     | +         | +      |         | [5]        |
| Glycoside test (Before hydrolysis) | +     | +         | +      | [31]    |
| Glycoside test (after hydrolysis) | +     | +         | +      | [31]    |

3.2 Content of total phenol and Flavonoid in Freshly harvested rocket leaves was shown in Table (2).

Table 2. Extraction yield, Content of total phenol and Flavonoids in Freshly harvested rocket leaves.

| Sample                   | Yield % | Total Phenol (mg TAE/g) | Total flavonoids (mg QE/g) |
|--------------------------|---------|-------------------------|----------------------------|
| Fresh rocket leaf        | -       | 8.00                    | 0.80                       |
| Alcoholic extract        | 29.13   | 5.0                     | 0.81                       |
| Flavonoid extract        | 25.2    | 3.3                     | 1.04                       |
| Anthocyanin extract      | 18.8    | 1.3                     | 0.44                       |

Preliminary screens relieved that E. sativa plant are full in phenolics which indicate medicinally important plants [18, 33]. These results were agreed with that obtained in the study; therefore, Folin-ciocalteu method estimate present of phenolic content from E. sativa. Results illustrate that freshly harvested rocket leaves are good source of phenolics 8.00 mg TAE/g extract. Alcoholic and flavonoid’s extract also contained significant amount of phenolics 5.0, mg TAE/g, but anthocyanin extract contained 1.3 mg TAE/g of phenolics. Results indicated that Rocket leaf is a rich source of phenols that enhance their consumption in most areas led to that people will consume a whole plant (leaves, stems, seeds) such as fresh salad [19, 20]. Results indicate that flavonoid extract are the highest content of flavonoids (1.04 mg QE/g), alcoholic and fresh rocket leaf are following which contained equal amounts of total flavonoids content (0.81mg QE/g) and (0.80 mg QE/g), respectively. The reason is the presence of phenolic compounds [15]. In anthocyanin extract the amount of Total flavonoids (0.44 mg QE/g) was lower which indicate the presence of anthocyanins only.

3.3 Yield of antioxidant activity was shown in Table (3)
Table 3. Average values of antioxidant of 3 extracts of rocket leaves (E. sativa) at conc. = 0.001 µg/ml, based on several methods

| Sample          | Beta-Carotene-linoleic acid assay % AA | Reducing Power assay R.P. % | Scavenging of H$_2$O$_2$ (mg AAE/g) equivalent | Total antioxidant capacity (µmole/ml) equivalent |
|-----------------|---------------------------------------|-----------------------------|-----------------------------------------------|-----------------------------------------------|
| Alcoholic extract | 76.6                                  | 62.6                        | 218                                           | 95.5                                          |
| Flavonoids extract | 80.2                                  | 70.09                       | 222                                           | 160.2                                         |
| Anthocyanin extract | 74.4                                  | 39.8                        | 237                                           | 174.2                                         |
| Synthetic antioxidant | 80.90                                | 96.2                        | 195                                           | 189.5                                         |

3.4 Activity of 3 extracts and rocket leaves (E. sativa) in several methods

3.4.1 Beta-Carotene-linoleic acid
Results in table 3 and figure (1) indicated that the active compound extracts to antioxidant activity are flavonoid extract (80.2%) followed by alcoholic extract (76.6%). With respect to the structure of these compounds, the presence of hydroxyl and methoxylene on their aromatic rings gives them high antioxidant effectiveness [21, 22]. Anthocyanin extracts showed antioxidant activity of (74.4%). The obtained results were agreed with the reports of (2014) who confirmed that E. sativa is a good source of antioxidant compounds especially rutin and Kaempferol [22, 31]. These compounds are the origin of secondary metabolites which give antioxidant activity of rocket plant. Recent studies suggest that alcohol extract from seeds of rocket reduces antioxidants and protective effect on renal disorders produced by mercury chloride [32]. Studies have reported that health-enhancing effects of E. sativa are partly linked to their effective antioxidant properties [6, 23, 31].

Figure 1. Antioxidant activity of 3 rocket leaves extracts
*Duncan's Multiple Rang Test was used at 1% level based.

3.4.2 Reducing power assay
Reducing power of rocket leaves extracts were evaluated and compared to vitamin c. The results in Figure (2) showed the reducing power of E. sativa extracts. Reducing was increased with high concentration. Flavonoid extract was potential reducing agent (70.9%) followed by alcoholic (62.6%) and anthocyanin extract (39.8%). At high concentration, flavonoid extract showed a high capacity for donating a proton, but, anthocyanin extract was the weakest because it has few phenols. In (2007) research revealed high concentration of total phenols as potent reducing power in seeds of rocket [24, 32].

![Graph showing reducing power of 3 rocket leaves extracts compared to ascorbic acid.](image)

Figure 2. Reducing power of 3 rocket leaves extracts compared to ascorbic acid.

*Duncan's Multiple Rang Test was used at 1% level based.

3.4.3 Scavenging of hydrogen peroxide
Free radical H₂O₂ scavenging potential results in Table 3 indicated that anthocyanin extract had highest scavenging potential at the concentration of 237 mg AAE/g) equivalent followed by flavonoid and alcoholic extracts (222 and 218), respectively. H₂O₂ is a low-effective agent, but in biological systems it is also emulsified to give free hydroxyl radicals, produce of more active radicals from the hydroxyl group spoils the natural balanced level in biological systems and thus causes toxicity in cells even if they are minor. Therefore, eliminating the excess amount of H₂O₂ is very necessary for antioxidant defense inside body [10, 25, 31] and reported that the present of phenolics in methanol extracts of different parts of E. sativa (whole plant) which qualitatively analyzed by chromatographic technique and NMR found quercetin triglucosides in E. sativa.

3.4.4 Total antioxidant capacity
To determine total capacity of three rocket leaves extracts as antioxidant was subjected according to [21]. Figure (3) show that anthocyanin extract was high activity among all at different concentrations especially at 0.0005 µg/ml followed by flavonoid extract compared to vitamin c. This results may be too presence of secondary metabolites [5]. Alcoholic extract possess degree of antioxidant because of phenolic compounds acts as reduction compounds [18].
3.5    Effect of temperature, pH, and storage on the antioxidant capacity

3.5.1    Temperature impact on the antioxidant capacity

Results shown in figure (4) improved that antioxidant reduced with increasing temperature. This reduction was reached to 28.5% for alcoholic extract and to 31.5% for anthocyanin extract when incubated at 100 °C for 120 min. Antioxidant capacity of flavonoid extract was reduced from 160.2 % to 90.2%; this results agree with other reports [25, 26, 33] described that shelf life of rocket 5–6 days, if rocket stored at lower temperatures increased shelf life under cold temperature [3].

![Figure 3](image1)

**Figure 3.** Total antioxidant capacity of 3 rocket leaves extracts. *Duncan's Multiple Rang Test was used at 1% level based.

3.5.2    Effect of pH on the antioxidant capacity

The antioxidant capacity of 3 rocket leaves extracts are found in figure (5); the antioxidant capacity of all extracts decreased gradually with increasing pH up to 5, followed by continuous fluctuation at alkaline pH, indicating strong dependence of antioxidant capacity of extract to the pH of the system. At pH 3.00 slight effect was noticed in alcoholic extract (from 95.5% to 91.7%) as well as anthocyanin extract (from 174.2% to 117.7%) comparing to vitamin C. This is because of phytochemicals content polyphenolic compounds [23].

![Figure 4](image2)

**Figure 4.** Temperature impact on the antioxidant capacity of 3 rocket leaves extracts. *Duncan's Multiple Rang Test was used at 1% level base
3.5.3 **Effect of storage on the antioxidant capacity**

Storage stability of 3 rocket leaves extracts was found at term of 30 days over duration of 90 days. Results are shown in figure (6). The extracts were frozen over a 30 days period. The antioxidant capacities of all extracts were progressively reduced with minimum value during 90 days period. The antioxidant capacity of anthocyanin extract was constant by storage for 30 days (from 174.5 % to 174.25) and slightly reduced after 60 days only (from 174.2 to 160.5) as the same to the antioxidant capacity reducing of vitamin C. The % reduce in antioxidant activity after 90 day was about 43, 41, 47 and 57.25 % for anthocyanin, flavonoid, alcoholic, and ascorbic acid, respectively. Storage conditions can reduce goodness of rocket leaves from reaps to consumption [19, 27, 33]. A study confirmed that the fresh rocket have a short shelf life, indicating yellowing of rocket leaves during 4 to 8 days store at low temperatures (5 LC) [11].

**Figure 5.** Effect of pH on the antioxidant capacity of 3 rocket leaves extracts.

* Duncan's Multiple Rang Test was used at 1% level base

**Figure 6.** Storage impact on the antioxidant capacity of 3 rocket leaves extracts

* Duncan's Multiple Rang Test was used at 1% level base

4 **Conclusion**

In conclusion, rocket leaves harvested from Kurdistan region of Iraq (Dilbe Duhok village) possess a high level of natural antioxidants and phytochemicals like flavonoids and anthocyanin which are excellent natural antioxidants and active free radical scavenger acts as natural defense system for the body. The antioxidant capacity of all extracts decreased with increasing the time of boiling and gradually reduced by storage during 90 days period.
References

[1] Ahmad I M, Abdalla M Y, Mustafa N H, Qnais E Y and Abdulla F A 2009 Datura aqueous leaf extract enhances cytotoxicity via metabolic oxidative stress on different human cancer cells. *Jordan J. Biol. Sci.* 2 9-14

[2] Al-Khrazraji S 1991 *Biopharmacological study of Artemisia herba alba.* M.Sc. Thesis University of Baghdad

[3] Amodio M L, Derossi A, Mastrandrea L and Colelli G 2015 A study of the estimated shelf life of fresh rocket using a non-linear model *J. of Food Eng.* 150 19–28

[4] Andersen Q M and Markham K R 2006 *Flavonoids chemistry, biochemistry and applications* (New York) P 471-553

[5] Banso A 2009 Phytochemical and antibacterial investigation of bark extracts of Acacia nilotica. *J. Med. Plants Res.* 3 082-085

[6] Barillari J, Canistro D, Paolini M, Ferroni F, Pedulli GF, et al 2005 Direct antioxidant activity of purified glucroerucin, the dietary secondary metabolite contained in rocket (Erucia sativa Mill.) seeds and sprouts *J. Agr. Food Chem.* 53 2475-2482

[7] Bennett R N, Rosa E A S, Mellon F A and Kroon P A 2006 Ontogenic profiling of glucosinolates, flavonoids, and other secondary metabolites in Erucia sativa (salad rocket), Diplotaxis erucoides (wall rocket), Diplotaxis tenuifolia (wild rocket), and Bunias orientalis (Turkish rocket) *J. Agr. Food Chem.* 54 4005–4015

[8] Chang C, Yang M, Wen H and Chern J 2002 Estimation of total flavonoid content in propolis by two complementary colorimetric methods *J. Food Drug Anal.* 10 178-182

[9] Delouee S A W and Urooj A 2007 Antioxidant properties of various solvent extracts of mulberry (Morus indica L.) leaves *Food Chem.* 102 1233-1240

[10] De Oliveira BH, Nakashimab T, Filhoc JS and Frehsea FL 2001 HPLC Analysis of Flavonoids in Eupatorium littorale *J. Braz. Chem. Soc.* 12 243-246

[11] Ferrante A, Incrocci L, Maggini R, Serra G, and Tognoni F 2004 Colour changes of fresh-cut leafy vegetables during storage *Food Agri. and Environment* 2 40–44

[12] Gulfraz M, Sadiq A, Tariq H, Imran M, Qureshi R and Zeenat A 2011 Phytochemical analysis and antibacterial activity of Erucia sativa seed Pak. *J. Bot.* 43 1351-1359

[13] Gayon P R 1972 *Plantphenolics 1stEd*, Oliver and Boyed (Edinburge) P 254

[14] Haddad D 1965 *The chemistry of Vegetable drugs* Part 2 (Egypt: Cairo state University Press) P 27

[15] Harborne J B 1984 Phytochemistry Methods (New York: Wiley) P 1-70

[16] Hawk P B, Oser B L and sumerson H W 1954 *Practical physiological chemistry* 13th ed, McGraw-Hill, (Newyork) p 57-58

[17] Heimler D, Isolani L, Vignolini P, Tombelli S and Romani I 2007 Polyphenol Content and Antioxidative Activity in Some Species of Freshly Consumed Salads *J. Agric. Food Chem.* 55 1724-1729

[18] Javanmardi J, Stushnoff C, Locke E and Vivanco J M 2003 Antioxidant activity and total phenolic content of Iranian Ocimun accessions *Food Chem.* 83 547-550

[19] Kader A A 2002 *Quality parameter of fresh-cut fruit and vegetable products* O. Lamikanra Ed Fresh-cut fruits and vegetables (New York: Washington) Sci. tech. and market p 11–20

[20] Koukounaras A, Siomos S A and Sfakiotakis E 2007 Postharvest CO2 and ethylene production and quality of rocket (Erucia sativa Mill.) leaves as affected by leaf age and storage temperature *Postharvest Bio. and Tech.* 46 167–173

[21] Kumar V and Chauhan S 2008 Mulberry: Life enhancer *J Med Plants Res.* 2 271-278

[22] Lachman J, Hamouz K, Sulc M, Orsak M, Pivec V, Hejtmankova A, Dvorak P and Cepl J 2009 Cultivar differences of total anthocyanins and anthocyanidins in red and
purple-fleshed potatoes and their relation to antioxidant activity Food Chem. 114 836–843
[23] Lin J Y and Tang C Y 2007 Determination of total phenolics and flavonoid contents in selected fruits and vegetables, as well as their stimulatory effects on mouse splenocyte proliferation Food Chem. 101 140–147
[24] Marco G J 1968 A rapid determination method for evaluation of antioxidants J. Amer Oil Chem. Soc. 45 594-598.
[25] Nielsen T, Bergström B and Borch E 2008 The origin of off-odours in packaged rucola (Eruca sativa) Food Chem. 110 96–105
[26] Oktay M, Gulcin I and Kufrevioglu 2003 Determination of in vitro antioxidant activity of fennel (Foeniculum vulgare) seed extracts Lebensm.-Wiss.U.-Technol 33 263-271
[27] Pasini F, Verardo V, Cerretani L, Caboni M F and D’Antuono L F 2011 Rocket salad (Diploptaxis and Eruca spp.) sensory analysis and relation with glucosinolate and phenolic content J. of the Sci. of Food and Agr. 91 2858–2864
[28] Peach k, Tracey M V 1955 Modern Methods of Plant Analysis (Germany: Springer-Verla Berlin)
[29] Prieto P, Pineda M and Aguilar M 1999 Spectrophotometric quantitation of antioxidant capacity through the formation of a phosphomolybdenum complex: specific application to the determination of vitamin E Anal. Biochem. 269 337–341
[30] Ruch R J, Cheng S J and Klaunig J E 1989 Prevention of cytotoxicity and inhibition of intracellular communication by antioxidant catechins isolated from Chinese green tea Carcinogen. 10 1003-1008
[31] Sadiq A, Hayat M Q and Mall S M 2014 Qualitative and Quantitative Determination of Secondary metabolites and Antioxidant Potential of Eruca sativa J. Nat. Prod Chem. 2 2329-6836
[32] Sarwar A M, Kaur G, Jabbar Z, Javed K and Athar M 2007 Eruca sativa seeds possess antioxidant activity and exert a protective effect on mercuric chloride induced renal toxicity Food Chem. Toxicol. 45 910-920
[33] Spadafora D N, Amaro L A, Pereira A J, Müller T C, Pintado M and Rogers J H 2016 Multi-trait analysis of post-harvest storage in rocket salad (Diploptaxis tenuifolia) links sensorial, volatile and nutritional data Food Chem. 211 114–123
[34] Su X S, Wang Z Y and Liu J R 2009 In vitro and in vivo antioxidant activity of Pinus koraiensis seed extract containing phenolic compounds Food Chem. 117 681–686
[35] Tsai S Y, Huang S J and Mau J L 2006 Antioxidant properties of hot water extracts from Agrocybe cylindracea Food Chem. 98 670–677
[36] Umamaheswari M and Chatterjee T K 2008 In vitro antioxidant activities of the fracion of Coccinia grandis L. leaf extract Afr. J. of Tradi. 5 61-73
[37] Yildirim A, Mavi A and Kara A A 2001 Determination of antioxidant and antimicrobial activities of Rumex crispus L. extracts J. Agr. and Food Chem. 49 4083–4089