Phytochemical Analysis, HPLC Profiling and Anti-oxidant Potential of *Euphorbia nivulia* Buch.-Ham

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Authors’ contributions

This work was carried out in collaboration among all authors. Author MY designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MMUlH supervised the study and Author SI, RR, KA managed the analyses of the study. Authors MH, MAK, MA managed the literature searches. Authors MKS and UN reviewed the literature and manuscript. All authors read and approved the final manuscript.

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ABSTRACT

*Euphorbia nivulia* (EN) one of the members of *Euphorbiaceae* family, is a medicinal plant of Cholistan Desert (Punjab, Pakistan) that is traditionally used for a number of diseases. The plant is

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enriched with many phyto-constituents including flavonoids, triterpenes and polyphenols. In present study, crude extract as well as various fractions were assessed for phytochemical analysis, HPLC profiling, radical scavenging property and total phenolic and flavonoid contents. Hydro-alcoholic (70%) crude extract of EN was subjected to fractionation using different solvents including n-hexane, chloroform, butanol and aqueous. After performing the phytochemical screening and HPLC profiling, antioxidant activity was estimated by using DPPH and FRAP assays. Total flavonoid and phenolic contents were also estimated. HPLC analysis confirmed the presence of flavonoids and polyphenols like quercitin, gallic acid, caffeic acid, vanillic acid, benzoic acid, chlorogenic acid, syringic acid and ferulic acid in crude extract as well as butanol and aqueous fractions. Results revealed that butanol fraction showed maximum phenolic (143.26±2.65 mg/g GA/g) and crude extract showed maximum flavonoid (69.80±1.212 mg/g Q) contents. Maximum antioxidant potential was displaced by butanol fraction which was IC_{50}=0.04±0.02 by DPPH and 1193.77±12.4 μmol TE/ml by FRAP respectively. Current study is the first information about the HPLC profiling of phenolic compounds in EN and its antioxidant potential that could be a step forward towards ethno-pharmacological based phyto-medicine.

Keywords: Euphorbia nivulia; antioxidant; polyphenols; flavonoids; HPLC.

1. INTRODUCTION

Free radicals and/or reactive oxygen species (ROS) are produced by numerous physiological and biochemical metabolic processes in the body and are involved in some beneficial functions such as cell signaling, redox regulation and defense against pathogenic microorganisms. But their overproduction can damage the macromolecules of the body such as lipids, proteins and nucleic acid. This leads to the pathogenesis of degenerative diseases like aging, diabetes mellitus, Parkinson disease, Alzheimer disease, cataracts, rheumatoid arthritis, and cardiovascular as well as respiratory disorders [1]. Antioxidants are molecules that neutralize these harmful ROS by inhibiting oxidative chain reaction, preventing lipid peroxidation, reducing free radical concentration and chelating metal ions [2]. Even in low concentrations antioxidants prevent or slow down the oxidation of the substrate significantly [3]; and provide shelter against many pathological and physiological processes caused by free radical reactions [4]. Complex antioxidant system which constitute non-enzymatic antioxidants such as albumin, β-carotene, α-tocopherol, bilirubin, vitamin C, uric acid, flavonoids and glutathione and, enzymatic antioxidants (catalase, superoxide dismutase) present in the living organisms interact with reactive species which are deleterious to human life [5]. Some synthetic commercial antioxidants i.e. propyl gallate, butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA), which have been widely used in pharmaceuticals and food industry for the preservation of food products, are found to be toxic and carcinogenic [6,7,8,9]. Impact of oxidative stress on human health and increasing safety concerns about synthetic antioxidants, shift the focus of the scientific community to search for new safe and feasible natural antioxidants. Vegetables, cereals, fruits, and mushrooms have been screened worldwide; however, medicinal plants are more potent source of natural antioxidants [10,11,12,13]. Thus, there is a growing interest in the antioxidant prospective of phytochemicals [14]. In this capacity, besides nutritional importance, medicinal plants can provide health benefits which are associated with their secondary metabolites such as polyphenolic and flavonoid compounds [15,16]. These flavonoid and phenolic compounds are established universally as antioxidants or free radical scavengers and act as reducing agents, metal chelators and singlet oxygen quenchers [17]. Owing to these properties they show antioxidant, anti-carcinogenic, anti-diabetic, anti-viral, antimicrobial, anti-inflammatory and anti-mutagenic activity [8]. Plants/herbs belonging to Euphorbiaceae family are reported to have antioxidant bioactive molecules like triterpenes and flavonoids, both of which are reported to possess hepatoprotective and antioxidant activity [18,19]. Out of approximately 195 of species, Euphorbia nivulia (EN) has been recorded from India. It is enrich in various phyto-constituents including flavonoids and polyphenolics. Both of which are reported to possess antioxidant activity [20].

The present work was aimed to investigate the phyto-constituents and evaluate the antioxidant potency of the aerial parts of EN.
2. MATERIALS AND METHODS

All chemicals /solvents used were of analytical grade and purchased from Sigma Aldrich, B.D. H. and Merck. Solid DPPH, ammonium molybdate, sodium phosphate, sulphuric acid, potassium ferricyanide, trichloroacetic acid, ferric chloride, methanol, ascorbic acid, quercitin, gallic acid, pyrogallol, brilliant green, ferrous sulphate, hydrogen peroxide, Folin-Ciocalteu reagent, sodium bicarbonate, microplate reader, DMSO, spectrophotometer (DAD 8453 Agilent), laboratory centrifuge model (YJ03-043-4000).

2.1 Experimental Design

2.1.1 Preliminary phytochemical screening

Preliminary qualitative phytochemical screening of EN crude extract (ENCr) as well as its four fractions i.e. Hexane (ENHF), Chloroform (ENCF), Butanol (ENBF) and Aqueous (ENAF) to identify the phyto-constituents like alkaloids, glycosides, flavonoids, tannins, saponins and phenols, etc., was carried out by using standard conventional procedures [21].

2.1.2 Antioxidant activity

Antioxidant activity of the crude extract and its various fractions was measured by DPPH reagent method. A mixture of 90 µl of 0.3mM DPPH solution and 10 µl of sample solution was mixed and incubated for 30 min at room temperature in dark in 96-well plate. Absorbance was measured at 517 nm by using LT-4500 96-well microplate reader, Labtech, UK. Absorbance of blank and standard were also measured. Both positive and negative controls were included in the triplicated assays. The percentage of total inhibition of DPPH radicals was measured by using the equation given below:

\[
\text{Inhibition} (\%) = \left( \frac{\text{Abs of blank} - \text{Abs of sample}}{\text{Abs of blank}} \right) \times 100
\]

Antioxidant activities of the samples after suitable dilutions were determined and IC\(_{50}\) values were calculated using EZ-Fit Enzyme Kinetics Software (Perrella Scientific Inc. Amherst, USA) [22].

2.1.3 Total Phenolic Content (TPC)

Total phenolic content was determined using Folin–Ciocalteu’s methods. Briefly colorimetric method was used with some modifications. An aliquot of 0.3 mL (various concentrations) extract was mixed with 2.25 ml Folin–Ciocalteu’s phenol reagent. After 5 min, 20 to 25 ml of Na\(_2\)CO\(_3\) (6%) was added. The solution was allowed to stand for 90 min. After wards absorbance was measured at 725 nm. TPC was calculated using the standard calibration curve (ranging from 0-200 µg/mL) and data was expressed as milligram gallic acid equivalent per gram of dry extract (mg of GAE/g of DE). Assays were carried out in triplicates [23].

2.1.4 Total flavonoid content

Total flavonoid content was measured by modified colorimetric method. A calibration curve was established using Quercetin as standard, 1mg/ml in methanol, ranging from 0 to 100 µl (0-100 µg). All solutions were made in methanol. 100 µl of sample solution was mixed with 25 µl of 1% sodium nitrite solution and allowed to stand for 5 min, followed by the addition of 10 µl of 10% aluminum chloride solution and again allowed to react for 5 min. Finally, 35 µl of 4% sodium hydroxide solution was added and mixture was diluted with 30 µl of methanol. Absorbance was measured at 510 nm. TFC was calculated using the calibration curve equation and expressed as milligram quercetin equivalent per gram of dry extract (mg of QE/g of DE) [24].

2.1.5 HPLC analysis of phenolic compounds

Hydrolysis of Euphorbia nivulia extracts was performed as described previously [25]. The test samples (50 mg) of each extract were dissolved in 24 ml methanol and were homogenized. 16 mL distilled water was added followed by 10 mL of 6M HCl. Mixtures were then thermostated for 2 hr at 95°C. The final solution was filtered using 0.45 µm nylon membrane filter (Biotech, Germany) prior to high performance liquid chromatography (HPLC) analysis.

Separation of plant samples on gradient HPLC (LC-10A, SHIMADZU, JAPAN) was performed using shim-pack CLC-ODS (C118), 25cm X 4.6 mm, 5 µm column. Chromatographic separation was carried out using as mobile phase gradient: A (H\(_2\)O: Acetic acid-94:6, pH = 2.27), B (acetonitrile 100%). The gradient used was 15% solvent B (0-15 min), 45% solvent B (15-30 min) and 100% solvent B (35-45 min) with 1 mL/min flow rate. UV- visible detector (λ max 280 nm) was used for separation of phenolic compounds. Identification of phenolic compounds was established by comparing the retention time and
UV-Visible spectra of the peaks with those previously obtained by injection of standards. Quantification was performed by external calibration.

2.1.6 Assay of total antioxidant capacity (TAC)/ reducing power assay

Total antioxidant capacity was measured by ferric reducing ability of tissue (FRAP) method. This method is based on the ability of tissue in reducing Fe $^{3+}$ to Fe $^{2+}$ in the presence of TPTZ (2,4,6-tri[2-pyridyl]-s-triasine). The reaction between Fe $^{2+}$ and TPTZ gives a blue complex with the maximum absorbance at 593 nm [26]. Fe-reducing power of plant extract was determined by the method of Nile and Park with slight modifications [27]. The reaction flask consists of 100 mL extract, 0.5% v/v dimethyl sulfoxide, and 5 mL of potassium ferric cyanide (1 mM) solution which was incubated for 30 min in water bath. Finally, the reaction was terminated using 3 mL of trichloro acetic acid (TCA) (10%) solution. The upper portion of the reaction mixture (5 mL) was mixed with 5 mL of potassium ferric cyanide (1 mM) solution which was incubated for 30 min in water bath. Finally, the reaction was terminated using 3 mL of trichloro acetic acid (TCA) (10%) solution. The upper portion of the reaction mixture (5 mL) was mixed with 5 mL distilled water, and 1 mL FeCl$_3$ solution (0.01%). The absorbance of the sample was measured at 593 nm spectrophotometrically after cooling for 10 min at room temperature, using an appropriate blank solution. The calibration curve was constructed using Trolox (100–2000 μM) and the results were expressed in μmol Trolox/g extract. All values were taken in triplicates, and mean ± SD values were calculated.

3. RESULTS AND DISCUSSION

In last four decades, researchers have expressed a great zeal in phyto-constituents as potential source of medicinal agents because plants have been used as medicines from ancient times. Polyphenols or phenolic compounds constitute the largest group of secondary plant metabolites in plants possessing key properties for their adaptation to the environment [28,29]. Thousands of phenolic compounds occur in the medicinal herbs. Typical phenolic compounds in the plant were of several major types, including phenolic acids, flavonoids, tannins, coumarins, lignans, quinones, stilbenes, and curcuminoids. For example, more than 4,000 kinds of flavonoids and hundreds of coumarins and lignans have been reported as naturally occurring constituents [30,31]. In present study, preliminary phytochemical screening showed the presence of different compounds including phenols, flavonoids and tannins. Results for presence of various phytochemicals like alkaloids, glycosides, flavonoids, phenols, saponins, tannins and carbohydrates in crude as well as various fractions are presented in Table 1. Our findings showed that crude extract and polar fractions contain phenols, flavonoids and tannins. These results are again confirmed by the TPC, TFC and HPLC analysis and correspond with the available research data of EN and other Euphorbia species [32,33]. Our findings showed that polar fractions, in current study, exhibited highest phenolic and flavonoid content. These results are in accordance with previous data that showed that phenolic compounds being polar in nature are found in polar fractions [34]. In current study, ENBF exhibited highest phenolic content (143.26±2.65 mg/g GA) followed by ENCr (125.6±1.32 mg/g GA), ENAF (96.53±2.01 mg/g GA), ENCF (38.27±3.21 mg/g GA) and ENHF (15.49±1.92 mg/g GA) as shown in Fig. 2 (A). Unlike phenolic content, highest flavonoid content was exhibited by ENCr as shown in Fig. 2 (B). It was 31.65±1.224, 26.85±0.934 and 19.63±1.136 mg/g Q possessed by ENCF, ENAF, ENBF and ENHF respectively. In the same way, EN has very good antioxidant activity as depicted by DPPH and FRAP assays. Results of DPPH are shown in Fig. 1 (A). Butanol fraction was found to have highest radical scavenging activity followed by ENCr, ENCF, ENAF and ENHF with IC$_{50}$ values of 0.04±0.02, 0.14±0.019, 0.29±0.007, 0.338±0.021 and 0.58±0.008μg/ml respectively when compared with rutin as standard (0.014±0.009μg/ml). Ferric reducing ability power assay was employed to investigate antioxidant potential of EN extract and its various fractions. The FRAP values expressed as μmol Trolox equivalents (TE/g) of dry weight of extract are shown in Fig. 1 (B). Among the fractions and crude extract of EN, butanol fraction showed maximum FRAP value (1193.77±12.4 μmol TE/ml) while minimum was showed by hexane fraction (365±9.28 μmol TE/ml). While, ENCr, ENAF and ENCF showed FRAP values 708.810±10.30, 708.320±13.0 and 366.75±5.76 μmol TE/ml respectively. These are widely used methods to evaluate the free radical scavenging activity and reducing power of various plant species in short period of time [35]. According to results of both assays the polar fraction and butanol fraction (ENBF) showed maximum antioxidant potential. Chromatographic fingerprinting and quantitative sketching of EN crude extract and its various fractions was done. HPLC confirmed the presence of a number of
polyphenols in crude as well as butanol and aqueous fractions of EN. These include quercitin, gallic acid, caffeic acid, vanillic acid, benzoic acid, chlorogenic acid, cinnamic acid, coumaric acid, syringic acid and ferulic acid. HPLC Chromatograms of EN crude extract, butanol and aqueous fractions are depicted in Fig. 3, 4 and 5 while quantity of each polyphenolic compound is mentioned in Table 2, 3 and 4 respectively. Moreover, our results showed a direct relationship between antioxidant activity and total phenolic content which proved that antioxidant activity of plants may be attributed to the presence of phenolic compounds in them [36,37]. Polyphenols have got high importance due to their antioxidant ability to prevent oxidation [38,39]. Pharmacological activities of many plants, fruits and vegetables are due to the presence of natural antioxidants especially of these phenolic acids and flavonoids. Antioxidants significantly decrease the adverse effect of reactive species and at the same time antioxidant therapy has great impact in the treatment of many other diseases including microbial infections, cancer, AIDS and heart diseases [40,41,42].

Table 1. Preliminary phytochemical evaluation of various fractions of EN extract

| Test                  | ENC | ENHF | ENCF | ENBF | ENAF |
|-----------------------|-----|------|------|------|------|
| **Carbohydrates**     |     |      |      |      |      |
| Fehling’s Test        | +   |      | +    | +    | +    |
| **Alkaloids**         |     |      |      |      |      |
| Hager’s Test          | +   |      |      |      |      |
| Mayer’s Test          | +   |      |      |      |      |
| Wagner’s Test         | +   |      |      |      |      |
| **Glycosides**        |     |      |      |      |      |
| Keller Kiliani Test   | +   |      |      |      |      |
| **Phenolic Compounds**|     |      |      |      |      |
| FeCl₃ Test            | +   |      | +    | +    | +    |
| **Flavonoids**        |     |      |      |      |      |
| Alkali Test           | +   |      |      | +    | +    |
| **Tannins**           |     |      |      |      |      |
| FeCl₃ Test            | +   |      |      | +    | +    |
| **Saponins**          |     |      |      |      |      |
| Froth Test            |      |      |      |      |      |

Fig. 1. Antioxidant activity using DPPH and FRAP assays of EN crude extract and its various fractions
Table 2. Qualitative and quantitative analysis of phenolic compounds in ENCr fraction using HPLC

| Compounds     | RT (min) | Area (mV.s) | Quantity (ppm/mg) |
|---------------|----------|-------------|-------------------|
| Quercetin     | 3.36     | 27.85       | 1.47              |
| Gallic acid   | 4.58     | 27.59       | 0.99              |
| Caffeic acid  | 12.85    | 9.55        | 0.43              |
| Syringic acid | 16.26    | 9.78        | 0.24              |
| m-coumaric acid | 20.14    | 16.67       | 0.19              |
| Ferulic acid  | 22.15    | 17.43       | 1.25              |
| Cinnamic acid | 25.38    | 2.97        | 0.11              |

Table 3. Qualitative and quantitative analysis of phenolic compounds in ENBF fraction using HPLC

| Compounds     | RT (min) | Area (mV.s) | Quantity (ppm/mg) |
|---------------|----------|-------------|-------------------|
| Quercetin     | 3.26     | 37.86       | 2.13              |
| Gallic acid   | 4.6      | 61.19       | 2.19              |
| Caffeic acid  | 12.49    | 33.71       | 1.55              |
| Benzoic acid  | 14.34    | 24.51       | 2.59              |
| Chlorogenic acid | 15.56    | 23.83       | 1.85              |
| Syringic acid | 16.85    | 18.9        | 0.47              |
| p-coumaric acid | 17.93    | 52.81       | 0.68              |
| m-coumaric acid | 20.38    | 83.84       | 1.58              |
| Ferulic acid  | 22.43    | 17.18       | 1.22              |
| Cinnamic acid | 25.44    | 46.69       | 1.63              |

Table 4. Qualitative and quantitative analysis of phenolic compounds in ENAF fraction using HPLC

| Compounds     | RT (min) | Area (mV.s) | Quantity (ppm/mg) |
|---------------|----------|-------------|-------------------|
| Quercetin     | 3.23     | 35.47       | 1.87              |
| Gallic acid   | 4.48     | 34.6        | 1.24              |
| Caffeic acid  | 12.2     | 17.74       | 0.81              |
| Vanillic acid | 13.58    | 19.62       | 1.22              |
| Benzoic acid  | 14.7     | 14.97       | 1.57              |
| Chlorogenic acid | 15.32    | 11.82       | 0.92              |
| Syringic acid | 16.14    | 13.04       | 0.32              |
| Ferulic acid  | 22.02    | 34.57       | 2.48              |

Fig. 2. Total phenolic and flavonoid content of EN crude extract and its various fractions
Fig. 3. HPLC chromatogram of ENCr fraction

Fig. 4. HPLC chromatogram of ENBF fraction

Fig. 5. HPLC chromatogram of ENAF fraction
4. CONCLUSION

The results of this study are first information about the HPLC profiling of phenolic compounds in EN. Present study also revealed that EN is very rich in polyphenolic compounds including phenolic acids and flavonoids with excellent antioxidant properties which may be a potential therapeutic agent for various degenerative diseases. Moreover, the study gives basis for the standardization, development and isolation of these useful phenolic compounds.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

It’s not applicable.

ETHICAL APPROVAL

It’s not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Phaniendra A, Jestadi DB, Periyasamy L. Free radicals: properties, sources, targets, and their implication in various diseases. Indian Journal of Clinical Biochemistry. 2015;30(1):11-26.
2. Zhou K, Yu L. Effects of extraction solvent on wheat bran antioxidant activity estimation. LWT-Food science and Technology. 2004;37(7):717-721.
3. Marques SS, Tóth IV, Magalhães LM, Reis S, Segundo MA. High-sensitivity programmable flow method for assessment of total antioxidant capacity in biological samples. Microchemical Journal. 2016;124: 261-266.
4. Zhou X, Yuping Z, Zhao H, Liang J, Zhang Y, Shi S. Antioxidant homoisoflavonoids from Polygonatum odoratum. Food Chemistry. 2015;186:63-68.
5. Ramakrishna H, Murthy SS, Divya R, MamathaRani D, Panduranga Murthy G. Hydroxy radical and DPPH scavenging activity of crude protein extract of Leucas linifolia: A folk medicinal plant. Asian J Plant Sci Res. 2012;2(1):30-35.
6. Sasaki YF, Kawaguchi S, Kamaya A, Ohshita M, Kabasawa K, Iwama K, Taniguchi K, Tsuda S. The comet assay with 8 mouse organs: results with 39 currently used food additives. Mutation Research/ Genetic Toxicology and Environmental Mutagenesis. 2002;519(1-2):103-119.
7. Chen RZ, Tan L, Jin CG, Lu J, Tian L, Chang QQ, Wang K. *Extraction, isolation, characterization and antioxidant activity of polysaccharides from Astragalus membranaceus. Industrial Crops and Products. 2015;77:434-443.
8. Ye F, Liang Q, Li H, Zhao G. Solvent effects on phenolic content, composition, and antioxidant activity of extracts from florets of sunflower (Helianthus annuus L.). Industrial Crops and Products. 2015;76: 574-581.
9. Wattanasiritham L, Theerakulkait C, Wickramasekara S, Maier CS, Stevens JF. Isolation and identification of antioxidant peptides from enzymatically hydrolyzed rice bran protein. Food Chemistry. 2016; 192:156-162.
10. Cai Y, Luo Q, Sun M, Corke H. Antioxidant activity and phenolic compounds of 112 traditional Chinese medicinal plants associated with anticancer. Life Sciences. 2004;74(17):2157-2184.
11. Li HB, Wong CC, Cheng KW, Chen F. Antioxidant properties in vitro and total phenolic contents in methanol extracts from medicinal plants. LWT-Food Science and Technology. 2008;41(3):385-390.
12. Albouchi F, Hassen I, Casabianca H, Hosni K. Phytochemicals, antioxidant, antimicrobial and phytotoxic activities of Allium sativum (Mill.) S. leaves. South African Journal of Botany. 2013;87: 164-174.
13. Baba SA, Malik AH, Wani ZA, Mohiuddin T, Shah Z, Abbas N, Ashraf N. Phytochemical analysis and antioxidant
activity of different tissue types of Crocus sativus and oxidative stress alleviating potential of saffron extract in plants, bacteria, and yeast. South African Journal of Botany. 2015;99:80-87.

14. Noda Y, Anzai K, Mori A, Kohno M, Shinmei M, Packer L. Hydroxyl and superoxide anion radical scavenging activities of natural source antioxidants using the computerized JES-FR30 ESR spectrometer system. Iubmb Life. 1997;42(1):35-44.

15. Ksouri R, Megdiche W, Debez A, Falleh H, Grignon C, Abdelly C. Salinity effects on polyphenol content and antioxidant activities in leaves of the halophyte Cakile maritima. Plant Physiology and Biochemistry. 2007;45(3-4):244-249.

16. Falleh H, Msilini N, Oueslati S, Ksouri R, Magne C, Lachaâl M, Karray-Bouraoui N. "Diplotaxis harra and Diploptaxis simplex organs: Assessment of phenolics and biological activities before and after fractionation. Industrial Crops and Products. 2013;45:141-147.

17. Chew YL, Goh JK, Lim YY. Assessment of in vitro antioxidant capacity and polyphenolic composition of selected medicinal herbs from Leguminosae family in Peninsular Malaysia. Food Chemistry. 2009;116(1):13-18.

18. Lanhers MC, Fleurentin J, Dorfman P, Mortier F, Pelt JM. Analgesic, anti-inflammatory and anti-inflammatory properties of Euphorbia hirta. Planta Medica. 1991;57(03):225-231.

19. Evans WC, Evans D, Trease GE. Trease and Evans Pharmacognosy, Saunders/Elsevier; 2009.

20. Sunitha S, Nagaraj M, Varalakshmi P. Hepatoprotective effect of lupeol and lupeol linoleate on tissue antioxidant defence system in cadmium-induced hepatotoxicity in rats. Fitoterapia. 2001;72(5):516-523.

21. Baba H, Onanuga A. Preliminary phytochemical screening and antimicrobial evaluation of three medicinal plants used in Nigeria. African Journal of Traditional, Complementary and Alternative Medicines. 2011;8(4).

22. Shimada K, Fujikawa K, Yahara K, Nakamura T. Antioxidative properties of xanthan on the autoxidation of soybean oil in cyclodextrin emulsion. Journal of Agricultural and Food Chemistry. 1992;40(6):945-948.

23. Chlopicka J, Pasko P, Gorinstein S, Jedryas A, Zagrodzki P. Total phenolic and total flavonoid content, antioxidant activity and sensory evaluation of pseudocereal breads. LWT-Food Science and Technology. 2012;46(2):548-555.

24. Wolfe K, Wu X, Liu RH. Antioxidant activity of apple peels. Journal of Agricultural and Food Chemistry. 2003;51(3):609-614.

25. Pak-Dek MS, Osman A, Sahib NG, Saari N, Markom M, Hamid AA, Anwar F. "Effects of extraction techniques on phenolic components and antioxidant activity of Mengkudu (Morinda citrifolia L.) leaf extracts. Journal of Medicinal Plants Research. 2011;5(20):5050-5057.

26. Benzie IF, Strain JJ. The ferric reducing ability of plasma (FRAP) as a measure of "antioxidant power": The FRAP assay. Analytical Biochemistry. 1996;239(1):70-76.

27. Nile SH, Park SW. Chromatographic analysis, antioxidant, anti-inflammatory, and xanthine oxidase inhibitory activities of ginger extracts and its reference compounds. Industrial Crops and Products. 2015;70:238-244.

28. Oh MM, Trick HN, Rajashekar C. Secondary metabolism and antioxidants are involved in environmental adaptation and stress tolerance in lettuce. Journal of Plant Physiology. 2009;166(2):180-191.

29. Kaurinovic B, Vastag D. Flavonoids and phenolic acids as potential natural antioxidants. Antioxidants, IntechOpen; 2019.

30. Iwashina T. The structure and distribution of the flavonoids in plants. Journal of Plant Research. 2000;113(3):287.

31. Xiao C, Yang S, Hong X. The chemistry of traditional Chinese medicines. Shanghai Science and Technology Publishing House, Shanghai. 2000;36:505-507.

32. Thorat BR, Bolli V. Review on Euphorbia nerifolia Plant. Biomedical Journal of Scientific & Technical Research. 2017;1(6):1723-1732.

33. Younus M, Hasan MM, Abbas K, Sarwar G. Pharmacognostic and physicochemical screening of Euphorbia nivulia Buch.-Ham. Pakistan Journal of Pharmaceutical Sciences. 2019;32(3).

34. Mahayasih PGMW, Elya B, Hanafi M. Fractionation and antioxidant activity potency of the extract of Garcinia lateriflora Blume var. javanica Boerl leaf. AIP
35. Ebrahimzadeh MA, Ehsanifar S, Eslami B. Sambucus ebulus elburensis fruits: A good source for antioxidants. Pharmacognosy Magazine. 2009;5(19): 213.

36. Velioglu Y, Mazza G, Gao L, Oomah B. "Antioxidant activity and total phenolics in selected fruits, vegetables, and grain products. Journal of Agricultural and Food Chemistry. 1998;46(10): 4113-4117.

37. Sun J, Chu YF, Wu X, Liu RH. Antioxidant and antiproliferative activities of common fruits. Journal of Agricultural and Food Chemistry. 2002;50(25):7449-7454.

38. Khasawneh MA, Elwy HM, Fawzi NM, Hamza AA, Chevidenkandy AR, Hassan AH. Antioxidant activity, lipoygenase inhibitory effect and polyphenolic compounds from Calotropis procera (Ait.) R. Research Journal of Phytochemistry. 2011;5(2): 80-88.

39. Jaafar HZ, Ibrahim MH, Karimi E. Phenolics and flavonoids compounds, phenylanine ammonia lyase and antioxidant activity responses to elevated CO2 in Labisia pumila (Myrsinaceae). Molecules. 2012;17(6):6331-6347.

40. Di Carlo G, Mascolo N, Izzo AA, Capasso F. Flavonoids: old and new aspects of a class of natural therapeutic drugs. Life Sciences. 1999;65(4):337-353.

41. Yao LH, Jiang Y, Shi J, Tomas-Barberan F, Datta N, Singanusong R, Chen S. Flavonoids in food and their health benefits. Plant Foods for Human Nutrition. 2004;59(3):113-122.

42. Mradu G, Saumyakanti S, Sohini M, Arup M. "HPLC profiles of standard phenolic compounds present in medicinal plants. International Journal of Pharmacognosy and Phytochemical Research. 2012;4(3): 162-167.