Int. j. adv. multidisc. res. stud. 2025; 5(1):25-30

Received: 13-11-2024
Accepted: 23-12-2024

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Influence some Environmental Parameters on Growth, Physiological and Chemical Properties of *Ricinus communis* plant at some Al Gabl Al Khder Regions, Libya

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DOI: https://doi.org/10.62225/2583049X.2025.5.1.3612

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Abstract

This study focused on Ricinus communis plants collected from two distinct regions—Al-Bayda and Derna—located in the Al Gabal Al Akhder mountain range in Libya. The objective was to compare various chemical and physiological parameters of the plants from these two locations. Parameters such as leaf area, fresh and dry leaf weight, tree diameter, plant height, chlorophyll a and b, carotenoids, and starch content were analyzed. Additionally, the levels of certain metals and minerals in both plant and soil samples were assessed. The results revealed differences in physiological traits like plant height and leaf area between the two regions. These variations were attributed primarily to environmental factors, including differences in temperature, pressure, location, and soil composition.

Keywords: Environmental, Chemical, Physiological, *Ricinus communis*

Introduction

The ***Ricinus communis***, mostly called as the castor plant, holds significant pharmaceutical value for treatment huge of deasses. Additionally, it characterizes various beneficial properties, antiasthmatic, antidiabetic, hepatoprotective, antifertility, antimicrobial, CNS-stimulating, lipolytic, wound-healing, and insecticidal effects (Rana *et al*., 2012) [17]. These effects to ahuge constituents which mainlay presence in this plant cultivares.Nature is essential to human existence, as emphasized by Kadri *et al*., (2011) [11]. Beyond food, clothing, and shelter, plants provide an indispensable fourth necessity: Good health. The plant kingdom offers a wealth of organic structure's, many of which have medicinal uses. Medicine includes numerous natural crude drugs capable of treating diverse diseases, and Ricinus communis stands out as one such valuable resource (Scarp and Guerci, 1982) [18].

The rising global population has significantly increased the demand for plant-based vegetable oils for both domestic and industrial purposes. Castor oil, derived from the castor plant, is a standout due to its high nutritional value and unique fatty acid compositions. It is rich in ricinoleic acid, with minor components such as stearic, palmitic, and oleic acids. This unique profile makes castor oil a versatile candidate for various applications. In addition to its primary triglyceride, triricinolein, castor oil contains bioactive compounds like carotenoids, tocopherols, tocotrienols, phytosterols, and phenolic compounds, which contribute to its antioxidant, anti-inflammatorys, and oxidative stability properties. Its oil quality is further evidenced by favorable acid, anisidine, iodine, viscosity, and saponification values, although composition can vary based on production location and extraction method (Yeboah *et al*., 2020) [23].

Native to parts of Asia, Ricinus communis grows up to six meters tall and thrives in regions like South Africa, India, Brazil, and Russia (Abdul *et al*., 2018) [1]. Historically, the plant has been cultivated in Ethiopia and tropical Africa. Linnaeus first described the genus Ricinus in 1753. It belongs to the Euphorbiaceae families and is commonly grown in dry regions of India, often in degraded or polluted soils.Castor is well-suited to tropical and subtropical regions, requiring minimal precipitation for satisfactory yields. It exhibits high drought tolerance and can grow in areas with limited water resources, needing 188–897 mm of water during its growing season, often supplemented by irrigation. Optimal growth occurs at temperatures between 20 and 30 °C, while extremes above 40 °C or below 20 °C can hinder growth, female flower production, and leaf development (Severino *et al*., 2012; Goyal *et al*., 2014) [19, 5]. Current invetigations seek to analyze the impact of climate and environmental changes on the physiological and chemical characteristics of plants collected from various locations on the Al Gabal Akhder mountain.

Methadology

The area of study:

The study was conducted in the Al-Gabal Al-Akhder Mountain region, located in eastern Libya, covering the Derna and Al-Bayda areas. The region is situated between latitudes 22° 38′ N and 32° 46′ E (El-Barasi and Saaed, 2013) [4]. Derna experiences a moderate climate throughout the year, influenced by its proximity to the Mediterranean Sea to the north and northeast, and the semi-desert terrain to the south. Al-Gabal Al-Akhder is a limestone plateau, ranging from 700 to 870 meters above sea level, with a gently sloping surface extending southward. The area stretches between longitudes 20° 35′ E and 23° 15′ E, and latitudes 30° 58′ N to 32° 56′ N. The mountain’s landscape is characterized by alternating benches and escarpments, rising to 850 meters above sea level, with two main escarpments that gradually converge towards the east. The landscape is predominantly hilly to mountainous, with wadis cutting through much of the benches, especially the second.

Sampling: Samples selected from the Al-Gabal Al-Akhder and Derna regions in 2023, including the Ricinus communis plant. Locations were selected from both coastal and mountainous areas to study the plants.

Sample Preparation: The leaves and stems of the plants were separated and washed multiple with deionized water. The samples were then dried in a dark, dry place for two weeks. After drying, the samples were ground using a mortar and stored in polyethylene bottles for further analysis.

Meteorological data:

Station	SEP	OCT	NOV	DES
Derna	12.0	59.0	63.0	113.0
Al –Bayda	5.0	39.0	25.0	48.0

Monthly total amount of rain in millimeters (1980-2010)

Station	SEP	OCT	NOV	DES
Derna	71	72	73	76
Albayda	72	69	66	67

The average relative humidity (1980-2010)

Station	SEP	OCT	NOV	DES
Derna	21.3	18.4	14.5	11.1
Albayda	25.5	23.1	19.4	15.9

Average temperature (1980-2010)

Station	SEP	OCT	NOV	DES
Derna	6.3	7.9	9.9	11.6
Albayda	11.2	10.0	11.4	12.9

average wind speed in knots (1980-2010)

Station	SEP	OCT	NOV	DES
Derna	4.5	4.6	4.4	3.3
Albayda	5.9	6.1	6.2	6.0

Average amount of evaporation in millimeters (1980-2010)

Physiological Studies:

The physiological studies aimed to compare the morphological characteristics of Ricinus communis plants collected from Derna and Al-Bayda regions. The parameters analyzed included leaf area, fresh and dry leaf weight, plant length, stem color, leaf color, and stem diameter.

Leaf Area Measurement: To measure leaf area, leaves were placed on graph paper, and their outline was traced with a pen or pencil. The area was then calculated by counting the number of full squares (1 cm²) and partial squares (0.5 cm²), summing the total to determine the leaf surface area in square centimeters.

Leaf Fresh Weight: The fresh weight of leaves was measured by selecting six leaves from each plant and recording their weight in grams per plant.

Leaf Dry Weight: For dry weight estimation, the leaves were dried in an oven at 40°C for 72 hours. The dry weight was then recorded in grams per plant.

Plant Length: Plant height was measured using the Abeny level device, which is known for accurately estimating tree height based on angles and triangulation methods.

Tree Diameter Measurement: Tree diameter at chest height (DBH) was measured using a tape measure, following the method described by Badr El-Din (2006) [2].

Chlorophyll a and b Estimation: Leaf samples (0.2 g) were homogenized in 80% acetone (v/v). The pigment content (mg g^{-1} FW) was calculated using the formulas provided by Lichtenthaler and Wellburn (1983) [15].

Starch Estimation in Leaf Plant Study: To estimate starch content, 0.1 g of dried leaf sample was resuspended in 2.5 ml of distilled water, followed by the addition of 3.5 ml of 52% perchloric acid (PCA) following the same method used for total soluble sugars. The starch quantity was expressed in mg glucose/g DW.

Chemical studies

In this study the studied samples were expressed as the following numbers (1 – 4) as following:

Sample No	Sample Type
1	***Ricinus communs*** leaf(Derna),
2	***Ricinus communs*** stem(Derna),
3	***Ricinus commnus*** leaf(AGabal Al Akhdar)
4	***Ricinus communs stems***(Al Gabal Al Akhdar)

Determination of Metals and Minerals in Plant and Soil Samples

The concentrations of metals such as copper (Cu), iron (Fe), and nickel (Ni) in plant and soil samples were estimated using AAS (Perkin Elmer 800), following the produced outlined by Hasan and Mujahed (2011) [8]. Sodium and potassium contents were determined using a Flame Photometer (JENWAY Flame Photometer) according to

Hasan *et al*. (2011) [8], at the central laboratory of the Faculty of Science, Omar El-Mukhtar University.

Total phosphorus was measured spectrophotometrically based on the procedure by Hasan (2006) [6]. In this method, 0.5 g was designed with 5 ml of HNO3 until near dryness. Then, 10 ml of distilled water was added, and the mixture was heated to reduce its volume. After filtration, the volume was adjusted to 100 ml with distilled water, and the concentrations of sodium and potassium in the plant leaves and stems were determined (Hasan and Islam, 2010).

Estimation of Electrical Conductivity (E.C), pH, and Total Dissolved Solids (TDS) in Soil Samples

To estimate the E.C, pH, and TDS in the soil mixed with water and shacked for 10 minutes. The mixture was then filtered, and the pH was measured using a pH meter (JENWAY). The TDS and E.C values were determined using specialized TDS & EC equipment (JENWAY), at the central laboratory for chemical analysis (Hasan, 2006) [6].

Results and Discussion

Physiological study results

The results of the physiological parameters were given as following:

The comparison between the morphological characteristics of the studied plants was shown in the Tables of (1).

Table 1: Characteristics of ***Ricinus communs*** plant

Characterizes	***Ricinus communs* Derna**	***Ricinus communs* El-Beida**
Leaf area	433	400cm²
Fresh weigh(g)	8.14	13.3
dry weight(g)	2.18	4.64
Coronary coverage	6.65m	9.12m
Colour of stems	green	Green
Colour of leaf	green dark	Green

It has been observed that the plant environment significantly influences herbage quality. However, it also induces other morphological changes and impacts the chemical structure of plant parts. These environmental factors influence the relative proportions of leaves and stems, thereby directly and indirectly affecting plant physiology, morphology, growth, and yield, with photosynthesis being the most severely impacted process (Jing *et al*., 2016) [10].

Some studies have noted that the diverse environmental conditions, including deeply incised valleys, granitic monadnocks, and varying geographical and topographical features, contribute to significant edaphic variation. The region is predominantly covered by ferruginous gravels with sandy clay subsoils, unweathered granite outcrops, kaolinitic clay zones, and bleached sandy soils. These conditions foster diversity in floristic composition, plant adaptability, species grouping patterns, and the structural features of plant communities (Byrne *et al*., 2016) [3].

The study results revealed variations in leaf area between plants growing in different climatic conditions. The coastal plants exhibited a larger leaf area of 433 cm² compared to the 400 cm² of the mountainous plants. In terms of fresh leaf weight, the mountain plant had a higher value of 13.3 g, which decreased to 4.64 g after drying, while the coastal plant's fresh leaf weight was 8.41 g, drying down to 2.18 g. Despite this, the mountainous plants had higher overall leaf weight. The plant height was also greater in the mountainous plants, which reached 9.12 meters, compared to the coastal plants, which grew to 6.65 meters. Regarding leaf color, the mountain plants were green to greenish-red, while the coastal plants had darker green leaves.

Environmental stresses have been shown to trigger a range of plant responses, from altered gene expression and metabolic changes to variations in growth rate and productivity. Plants have evolved mechanisms to mitigate the harmful effects of various abiotic and biotic stresses, including light, drought, salinity, and high temperatures (Shao *et al*., 2008). Furthermore, climate change is having noticeable effects on the life cycle, distribution, and phytochemical composition of global vegetation, including medicinal and aromatic plants. Changes in temperature, wind patterns, and precipitation due to climate change are impacting plant architecture, flowering, fruiting, phytochemical content, and competition with other species (Kumar *et al*., 2017) [13].

Photosynthetic pigment contents

The contents of Chlorop hyll a, Chlorop hyll b, Carotenoids and Starch were recorded in Table (2).

Table 2: Photosynthetic pigment and starch contents of the studied plants

Photosynthetic pigments (mg/ gFW)				Starch contents
Parameters	**Chlorophyll a**	**Chlorophyll b**	**Carotenoids**	**Starch(g /g DW)**
***Ricinus communs*- Derna**	0.267	0.016	11.325	2.17
***Ricinus communs* -alb**	0.118	0.071	49.545	8.32
Average ±SD	**0.15** ± 0.07	**0.056 ± 0.027**	**38.71±18.60**	**5.29± 3.68**

The changes in photosynthetic pigments in the leaves of the studied plants from coastal and mountainous regions highlight the effects of differing climatic and physiological conditions. The contents of *Ricinus communis* from the coastal region (Derna) were found to be higher. Consequently, starch storage in these plants was also higher. Chlorophyll is a crucial photoreceptor in plants, reflecting plant metabolism and growth, and it varies across species. Environmental stresses significantly affect chlorophyll content, and any alterations in chlorophyll levels can substantially impact the morphological and physiological state of plants (Mishra *et al*., 2021) [16]. In contrast, the plants from the mountainous region recorded lower values for these pigments, likely due to stress-induced chlorophyll degradation, which can impair carbon assimilation through chlorophyll photo-bleaching. This degradation may result from the suppression of enzymes responsible for photosynthetic pigment synthesis, such as δ-aminolevulinic acid dehydratase and protochlorophyllide reductase, which are involved in chlorophyll biosynthesis (Mishra *et al*., 2021) [16]. Photosynthetic pigments, including chlorophylls (a, b, and c), carotenoids, anthocyanins, and flavones, have distinct chemical structures. Total leaf pigment content, including chlorophylls and carotenoids, is essential for photosynthesis. The levels of these pigments vary across species and are influenced by internal factors and environmental conditions. Shaikh and Dongare (2008) [20] reported that chlorophyll and carotenoid contents in *Adiantum* species varied with microclimatic conditions. The chlorophyll a/b ratio in terrestrial plants has been used as an indicator of response to light and shade conditions (Vicas *et al*., 2010) [22]. A small proportion of chlorophyll a/b is considered a sensitive biomarker of pollution and environmental stress.

Plants in natural conditions face various adverse factors that disrupt photosynthesis, leading to declines in growth, development, and yield (Kalaji *et al*., 2016) [12]. (Sharma and Hall, 1991) [21]. Enhanced carotenoid content in plants is increasingly important for breeding and genetic engineering efforts (Li *et al*., 2008) [14]. Starch accumulation plays a pivotal role in osmoprotection, osmotic adjustment, carbon storage, and radical scavenging (Parida *et al*., 2002). Ashraf and Harris (2004) and Parida and Das (2005) suggested that the accumulation of carbohydrates, and starchs, under absent aggressive conditions helps maintain ionic balance in the vacuoles.

Minerals and Metal Contents of the Studied Plants

The mineral and metal contents of the studied plants are summarized in Table 3 and Fig 1. The concentrations of various elements fluctuated as follows:

- **Sodium:** The highest sodium concentration (44.93 ppm) was found in the leaves of *Ricinus communis* (Derna), followed by the other samples in the following order: Stems of *Ricinus communis* (Derna) (27.85 ppm), stems of *Ricinus communis* (Al-Bayda) (26.18 ppm), and leaves of *Ricinus communis* (Al-Bayda) (19.13 ppm). The sodium contents in the remaining samples were 13.06, 7.64, and 5.97 ppm, respectively.
- **Potassium:** The highest potassium concentration (447.7 ppm) was recorded in the leaves of *Ricinus communis* (Derna), followed by stems of *Ricinus communis* (Derna) (333.4 ppm), leaves of *Ricinus communis* (Al-Bayda) (290.5 ppm), and stems of *Ricinus communis* (Al-Bayda) (190.5 ppm).
- **Phosphorus:** The highest concentration of total phosphorus (12.7 ppm) was found in the leaves of *Ricinus communis* (Al-Bayda), followed by stems of *Ricinus communis* (Derna) (10.9 ppm), leaves of *Ricinus communis* (Derna) (6.17 ppm), and stems of *Ricinus communis* (Al-Bayda) (3.95 ppm).
- **Nitrogen:** The highest nitrogen concentration (0.704 ppm) was recorded in the leaves of *Ricinus communis* (Derna), followed by stems of *Ricinus communis* (Derna) (0.691 ppm), leaves of *Ricinus communis* (Al-Bayda) (0.542 ppm), and stems of *Ricinus communis* (Al-Bayda) (0.356 ppm).
- **Copper:** The highest concentrations of copper were found in the leaves and stems of *Ricinus communis* (Al-Bayda) (3.26 ppm and 3.0 ppm, respectively), followed by leaves of *Ricinus communis* (Derna) (2.22 ppm) and stems of *Ricinus communis* (Derna) (1.88 ppm).
- **Nickel:** The highest nickel concentration (16.10 ppm) was observed in the stems of *Eucalyptus gomphocephala* (Al-Bayda), followed by leaves of *Ricinus communis* (Derna) (11.10 ppm), stems of *Ricinus communis* (Al-Bayda) (10.26 ppm), stems of *Ricinus communis* (Derna) (7.44 ppm), and leaves of *Ricinus communis* (Al-Bayda) (2.57 ppm).
- **Iron:** The highest concentration of iron (0.395 ppm) was found in the stems of *Ricinus communis* (Derna), followed by stems of *Ricinus communis* (Al-Bayda) (0.245 ppm), leaves of *Ricinus communis* (Al-Bayda) (0.245 ppm), leaves of *Ricinus communis* (Derna) (0.25 ppm), and the lowest concentration (0.095 ppm) in other samples.
- **Calcium:** The highest calcium concentration (58.66 ppm) was found in the stems of *Eucalyptus gomphocephala* (Al-Bayda), followed by leaves of *Eucalyptus gomphocephala* (Al-Bayda) (52.94 ppm), leaves of *Ricinus communis* (Derna) (50.0 ppm), leaves of *Ricinus communis* (Al-Bayda) (47.2 ppm), leaves of *Eucalyptus gomphocephala* (Derna) (32.8 ppm), stems of *Ricinus communis* (Derna) (30.0 ppm), and stems of *Eucalyptus gomphocephala* (Derna) (27.23 ppm). The lowest concentration of calcium was found in the stems of *Ricinus communis* (Al-Bayda) (13.65 ppm).

Table 3: The mineral and metal contents of studied plant samples. (µg/g)

Element	K	Na	p	Fe	Cu	Ni	Ca
1	447.7	44.93	6.17	0.095	2.22	11.13	50
2	333.4	27.85	10.9	0.395	1.88	9.13	30
3	290.5	7.64	12.7	0.027	3	7.44	47.2
4	190.5	13.06	3.95	0.245	3.26	11.10	13.65
Average	189.54	21.39	6.115	0.215	2.72	9.615	39.06
±SD	154.15	12.77	3.767	0.111	0.705	3.386	15.444

Also the contents of Nitrogen of the plant samples were shown in Table (4) and Figures (1&2).

Table 4: The Nitrogen contents of studied samples (ppm)

Samples Plant	Nitrogen
1	0.704
2	0.691
3	0364
4	0.358

The contents of the major minerals sodium, potassium, calcium, phosphorus, and nitrogen in soil samples collected from the studied areas. The minerals and metal contents of the soil samples of the studied were shown in Tables (5).

Table 5: Contents the major minerals of soils of samples locations (ppm)

Minerals / Locations	Ca	K	Na	P	Ni	Fe	Cu	N
Derna	1.57	8	19.9	5.34	0.20	20.93	1.27	0.67
Albayda	0.57	9.85	2.11	4.95	0.55	47.19	0.157	0.120

A comparison of the mineral contents between the two studied areas reveals a discrepancy in mineral percentages. The soil sample from the city of Derna exhibited higher concentrations of calcium, sodium, phosphorus, and copper, with respective values of 1.57, 19.1, 5.34, and 1.27. In contrast, the soil sample from the city of Al-Bayda had the highest concentrations of potassium, nickel, iron, and nitrogen, with respective values of 9.85, 0.55, 47.19, and 0.120.

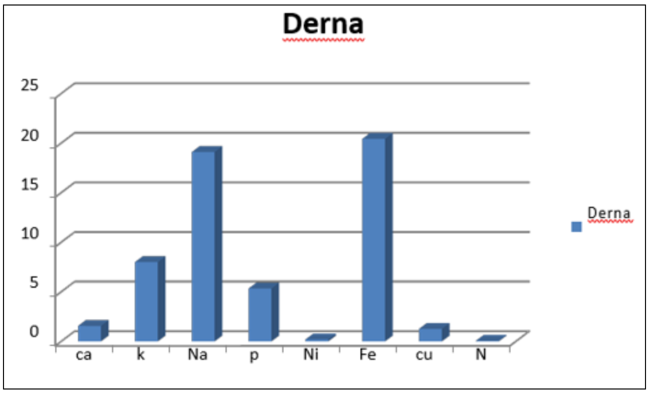

Fig 2: Concentrations (ppm) the contents of the major minerals of the studied soil samples

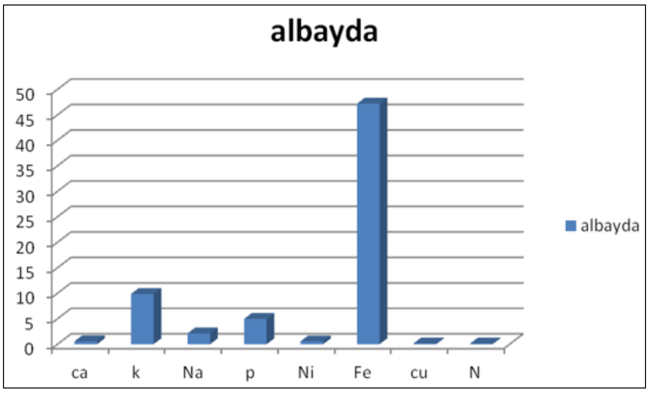

Fig 2: Concentrations (ppm) the contents of the major minerals of the studied soil samples

Conclusion

The results of this study reveal variations in certain chemical constituents, such as antioxidants and total phenols, in the studied plants (Ricinus communis) when comparing samples from the coastal region (Derna) and the mountain region (Al-Bayda). Additionally, the metal and mineral contents showed slight differences between the coastal and mountain samples. However, no significant variations in amino acid contents were observed in the leaf and stem samples from both regions.

Regarding physiological properties, such as leaf area, dry weight, plant length, leaf color, and stem diameter, differences were noted in the leaf color of Ricinus communis, with a greenish-red hue observed in the Derna samples compared to the Al-Bayda samples. Furthermore, the stems of the Al-Bayda samples had a relatively larger diameter compared to those from Derna. A similar trend was observed for the Ricinus communis plant. On the other hand, the leaf area of the Derna samples was larger than that of the Al-Bayda samples.In conclusion, the study attributes the observed changes in physiological and chemical content to variations in temperature, pressure, location, and soil types.

References

1. Abdul WM, Hajrah NH, Sabir JS, Al-Garni SM, Sabir MJ, Kabli SA, *et al*. Therapeutic role of Ricinus communis L. and its bioactive compounds in disease prevention and treatment. Asian Pacific Journal of Tropical Medicine. 2018; 11(3):177.
2. Badr El-Din, Abdel-Wahhab. Measurements of wooden trees and estimation of their sizes, forest mensuration. Knowledge facility. Alexandria 133AM, 2006.
3. Byrne M, Koenders A, Rogerson K, Sampson J, van Etten EJB. Genetic and morphological analysis of multi- steammed plants of tuart (Eucalyptus gomphocephala). Australian Journal of Botany. 2016; 64(8):704-714.
4. El-Barasi YMM, Saaed MWB. Threats to plant diversity in the north eastern part of Libya (El-Gabal ElAkahdar and Marmarica Plateau). Journal of Environmental Science and Engineering. 2013; 2:41-58.
5. Goyal N, Pardha-Saradhi P, Sharma GP. Can adaptive modulation of traits to urban environments facilitate Ricinus communis L. invasiveness. Environmental monitoring and assessment. 2014; 186(11):7941-7948.
6. Hasan HMI. Studies on physicochemical parametres and water treatment for some localities along coast of Alexandria. Unpublished thesis PhD. Thesis. Alexandriea University, 2006.
7. Hamad MI, Hasan Mojahid ul Islam. The concentrations of some heavy metals of Al-Gabal Al-Akhdar Coast Sediment. Archives of Applied Science Research. 2010; 2(6):59-67.
8. Hasan HM, Ibrahim H Habib1, Mariam H Gonaid, Mojahidul Islam. Comparative phytochemical and antimicrobial investigation of some plants growing in Al Jabal Al-Akhdar. J. Nat. Prod. Plant Resour. 2011; 1(1):15-23. Available online at: www.scholarsresearchlibrary.com.
9. Nabil B, Hamad Hasan, Ahmed EL-Denalia. Determination of Cu, Co, and Pb in selected frozen fish tissues collected from Benghazi markets in Libya. Chemical Methodologies. 2018; 2:56-63. Journal homepage: http://chemmethod.com
10. Jing P, Wang D, Zhu C, Chen J. Plant physiological, morphological and yield-related responses to night temperature changes across different species and plant functional types. Frontiers in plant science. 2016; 7:1774.
11. Kadri A, Gharsallah Neji, Damak Mohamed, Gdoura Radhouane. Chemical composition and *in vitro* antioxidant properties of essential oil of Ricinus communis L. Journal of Medicinal Plants Research. 2011; 5(8):1466-1470.
12. Kalaji HM, Jajoo A, Oukarroum A, Brestic M, Zivcak M, Samborska IA, *et al*. Chlorophyll a fluorescence as a tool to monitor physiological status of plants under abiotic stress conditions. Acta physiologiae plantarum. 2016; 38(4):102.
13. Kumar S, Yadav A, Yadav M, Yadav JP. Effect of climate change on phytochemical diversity, total phenolic content and *in vitro* antioxidant activity of Aloe vera (L.) Burm. f. BMC research notes. 2017; 10(1):1-12.
14. Li F, Vallabhaneni R, Yu J. The maize phytoene synthase gene family: Overlapping roles for carotenogenesis in endosperm, photomorphogenesis and thermal stress tolerance. Plant Physiol. 2008; 147:1334-1346.
15. Lichtenthaler H, Wellburn A. Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. Bio Soc Trans. 1983; 11:591-592.
16. Mishra D, Shekhar S, Chakraborty S, Chakraborty N. Wheat 2-Cys peroxiredoxin plays a dual role in chlorophyll biosynthesis and adaptation to high

temperature. The Plant Journal. 2021; 105(5):1374-1389.
17. Rana M, Dhamija H, Prashar B, Sharma S. Ricinus communis L. A review. International Journal of PharmTech Research. 2012; 4(4):1706-1711.
18. Scarpa A, Guerci A. Various uses of the castor oil plant(Ricinus communis L.) a review. Journal of ethnopharmacology. 1982; 5(2):117-137.
19. Severino LS, Auld DL, Baldanzi M, Cândido MJ, Chen G, Crosby W, *et al*. A review on the challenges for increased production of castor. Agronomy Journal. 2012; 104(4):853-880.
20. Shaikh SD, Dongare M. Analysis of photosynthesis pigments in Adiantumlunulatum Burm at different localities of Sindhudurg District (Maharastra). Indian Fern Journal. 2008; 25:83.
21. Sharma PK, Hall DO. J. Plant Physiol.. 1991; 138:614-619.
22. Vicas SI, Laslo V, Pantea S, Bandici G. Chlorophyll and carotenoids pigments from Mistletoe (Viscum album) leaves using different solvents. Analele Universitatii din Oradea, Fascicula Biologie. 2010; 17(2):213-218.
23. Yeboah A, Ying S, LU J, Xie Y, Amoniamma-Dede H, Boateng KG, *et al*. Castor oil (Ricinuscommunis): A review on the chemical composition and physicochemical properties. Food Science and Technology, 2020.