Libyan Med J. 2026;18(8):501-510
https://doi.org/10.69667/lmj.26806
Libyan Medical Journal
https://lmj.ly/index.php/ojs/index eISSN: 3107-0426

Original article

Estimating the Minerals, Nitrogen, and Phosphorus Contents and Antibacterial Investigation of Fruits and Leaves of Lotus edulis Plant Extracts

Hamad Hasan[1]*, Rabeea Abdullah[2], Salma Bounawara[1], Zuhir Akrim[3], Salima Tahier[4]

[1]Chemistry Department, Faculty of Science, Omar Al-Mukhtar University, Libya
[2]Higher Institute of Medical and Sciences Technology, Cyrene, Libya
[3]Pharmacology and Toxicology Department, Faculty of Pharmacy, Omar Al-Mukhtar University, Libya
[4]Botany Department, Faculty of Science, Omar Al-Mukhtar University, Libya
Email. hamad.dr@omu.edu.ly

Keywords:
Lotus Edulis, Minerals, Antibacterial Activity, Leaves, Fruits.

ABSTRACT

The present study investigated the mineral composition and antibacterial activity of leaves and fruits of Lotus edulis collected from Al-Marj, northeastern Libya. Mineral analysis revealed significant variations between plant organs, with potassium and nitrogen predominating in leaves (1319 ppm and 673.5 ppm, respectively) compared to fruits (919 ppm and 249 ppm). Phosphorus was slightly higher in fruits (111.91 ppm) than in leaves (98.96 ppm), while sodium and calcium were consistently greater in leaves. Antibacterial assays demonstrated concentration-dependent inhibition against selected bacterial strains. Leaf extracts exhibited stronger activity than fruit extracts, particularly against Bacillus cereus and Escherichia coli, with inhibition zones ranging from 14–8 mm and 10–5 mm, respectively. Notably, leaf extracts inhibited Pseudomonas aeruginosa (15–8 mm), whereas fruit extracts showed no effect. Neither organ extract produced detectable inhibition against Staphylococcus aureus. These findings highlight organ-specific mineral distribution and suggest that L. edulis leaves contain bioactive compounds with promising antibacterial potential. Further phytochemical characterization and standardized assays are recommended to identify active constituents and validate antimicrobial efficacy.

Introduction

Medicinal and edible plants remain an important source of nutrients and biologically active substances. Their value does not depend on a single class of compounds; rather, it reflects the combined contribution of primary nutrients, mineral elements and secondary metabolites. Minerals such as potassium, calcium, sodium and phosphorus participate in osmotic regulation, membrane function, energy transfer and structural processes in plants, while nitrogen is a fundamental component of amino acids, proteins, nucleic acids and many specialized metabolites. The concentration of these constituents can vary considerably between plant organs because leaves and fruits have different physiological roles and because mineral allocation is influenced by soil conditions, plant age, season and water availability [1].

The genus Lotus belongs to the family Fabaceae and includes annual and perennial species distributed widely in Mediterranean and temperate regions. Lotus edulis L. is an annual Mediterranean legume with edible young pods. As a member of Fabaceae, it is also of interest from a nutritional and ecological perspective because legumes form symbiotic associations that influence nitrogen acquisition. Despite this potential, the chemical composition and biological activity of L. edulis collected from Libya have received little direct investigation. Available studies on the genus indicate that Lotus species may contain flavonoids, tannins, coumarins and other phenolic constituents, although their abundance differs according to species, genotype, organ and extraction procedure [2].

Interest in plant-derived antibacterial substances has increased alongside the continuing problem of antimicrobial resistance. Plant extracts can contain chemically diverse constituents capable of affecting bacterial membranes, enzymes, energy metabolism or cellular targets. Their apparent activity, however, is strongly dependent on extraction solvent, extract concentration, test organism and assay conditions [3]. Evidence from other Lotus species supports the antimicrobial potential of the genus. Girardi et al. for example, detected tannins, coumarins and flavonoids in extracts from several Lotus taxa and reported species- and cultivar-dependent antimicrobial effects. Likewise, an ethanolic extract of L. corniculatus showed activity against several bacterial strains, including Escherichia coli and Pseudomonas aeruginosa [6]. For L. edulis specifically, flavonol glycosides with biological activity have been isolated, supporting further assessment of this species as a source of bioactive compounds [4].

Received: *21-06-2026 -* ***Accepted:*** *19-08-2026 -* ***Published:*** *26-08-2026*

Libyan Med J. 2026;18(8):501-510
https://doi.org/10.69667/lmj.26806
Libyan Medical Journal
https://lmj.ly/index.php/ojs/index eISSN: 3107-0426

Al-Jabal Al-Akhdar in northeastern Libya is distinguished by a Mediterranean climate and comparatively rich plant diversity. Evaluating local edible plants from this region can therefore provide baseline information on their chemical composition and potential biological uses. The estimate the plant contents were taken place in different studies carried out in Libya [5 -42]. Accordingly, the present study determined sodium, potassium, calcium, phosphorus and nitrogen in the leaves and fruits of L. edulis collected near Al-Marj and evaluated aqueous extracts of the two organs against Staphylococcus aureus, Bacillus cereus, Pseudomonas aeruginosa and Escherichia coli. By examining mineral composition and antibacterial response together, the work aims to provide an initial chemical and biological profile of a locally occurring and understudied species. The use of different instruments, such as a flame photometer, Spectrophotometer, HPLC, GC-Mass, X-ray, and others, in many studies in Libya was established on different environmental samples [43 -110]. In this study, the Flame photometer and Spectrophotometer instruments were used.

Methods

Sampling

In this study, the leaves and stems of Lotus edulis plants were selected, and the samples were collected from different locations around Al-Marj farms. The study area is located on the second terrace of El- Jabal El- Akhdar mountain. The climate of the study area is comparable to that of El-Jabal El-Akhdar, with a mean temperature of about 15 °C in winter and 24 in summer. The average rainfall ranges between 200- 300 mm.

Sample extraction

10 grams of each dried sample were taken and transferred to a beaker containing 100 ml of distilled water; the mixture was mixed. Then the extraction was carried out by an evaporator system at 75 °C. After two hours, the mixture was filtered; the filtrate was used to determine the selected minerals [6-10].

Determination of Minerals

The sodium and potassium, calcium contents measured by a Flame Photometer (JENWAY Flame Photometer) according to the method described by some studies [60-70]. Nitrogen and phosphorus were estimated by spectrophotometer methods by Vanadate and Nisler reagents , respectively in central lab of Faculty of Science, Omar Al- Mukhtar University.

Results

Minerals

The contents of sodium , potassium ,calcium phosphorus and Nitrogen in leaves and fruits of the studied plant showed wide variations , where the higher concentrations were recorded for potassium of (1419 and 1233 ppm) in leafs and Fruits , respectively , follows by Nitrogen (652.25 and 262.20 ppm) in leaves and fruits , respectively. On the other side the contents of phosphorus , sodium and calcium were fluctuated as following : 85.09 , 30.36 and 10.76 ppm in leaves and 85.04 , 22.36 and 8.76 ppm in fruits ,Generally there are relative increase in the minerals contents in leaves comparing with their values fruits of the studied plant except for nitrogen ,Table 1.

Table 1. Contents (ppm) of minerals (Na, K, Ca, P and N) in fruits and leaves of the studied samples

Plant part	Sodium	Potassium	Calcium	Phosphorus	Nitrogen
Leaves	26.36	1319	10.76	98.96	673.5
Fruits	11.36	919	8.776	111.91	249

Antibacterial activity

The antibacterial activity of the studied extracts showed effect of fruits and leaves of plant against Bacillus Cereus bacteria species, where the effect were decreased according to concentrations of fruits or leaves extracts, the inhibition zones were 14 , 12 , 10 and 8 mm for leaves extracts of concentrations of 0.9 , 0.6 , 0.4 and 0.2 g/ml , on the other side the fruits extract recorded inhibition zone values of 12 ,10 ,9 and 8 mm.

The results of antibacterial of extracts of fruits and leaves showed antibacterial activity against different bacteria species including gram positive bacteria (Staphylococcus aureus) and (Bacillus cereus) , beside gram negative bacteria (Pseudomonas aeruginosa) and (Escherichia coli) species , the results of antibacterial activities are illustrated in the tables of (2-5).Higher concentration of 0.9 g/ml showed higher inhibition zones for Bacillus Cereus ,there are relative increase of the effect of leaves extracts comparing with fruits For the effect of the studied abstracts the results showed the leaves extracts showed higher values of inhibition zones (5 -11 mm) against Escherichia coli comparing with the values of 3-5 mg/l.

***Received**: 21-06-2026 - **Accepted**: 19-08-2026 - **Published**: 26-08-2026*

Libyan Med J. 2026;18(8):501-510
https://doi.org/10.69667/lmj.26806
Libyan Medical Journal
https://lmj.ly/index.php/ojs/index eISSN: 3107-0426

Also all concentrations showed inhibition zones were fluctuated between (12 -16 mm) of leaves comparing with the fruits extract (6-12 mm).

Table 2. Antibacterial activity of leaf and fruit extracts against Staphylococcus aureus

Concentration	Leaves (mm)	Fruits (mm)
0.9 g/mL	–	–
0.6 g/mL	–	–
0.4 g/mL	–	–
0.2 g/mL	–	–

Table 3. Antibacterial activity of leaf and fruit extracts against Bacillus cereus

Concentration	Leaves (mm)	Fruits (mm)
0.9 g/mL	14	12
0.6 g/mL	12	10
0.4 g/mL	10	9
0.2 g/mL	8	9

Table 4. Antibacterial activity of leaf and fruit extracts against Pseudomonas aeruginosa

Concentration	Leaves (mm)	Fruits (mm)
0.9 g/mL	15	–
0.6 g/mL	12	–
0.4 g/mL	10	–
0.2 g/mL	8	–

Table 5. Antibacterial activity of leaf and fruit extracts against Escherichia coli

Concentration	Leaves (mm)	Fruits (mm)
0.9 g/mL	10	7
0.6 g/mL	7	5
0.4 g/mL	7	5
0.2 g/mL	5	3

Discussion

The mineral analysis demonstrates that the leaves and fruits of L. edulis contain all five measured elements, but their distribution is not uniform between organs. Potassium was the predominant measured mineral, reaching 1319 ppm in leaves and 919 ppm in fruits. Nitrogen was the next most abundant measured constituent, with 673.5 ppm in leaves and 249 ppm in fruits. Sodium and calcium were also higher in leaves (26.36 and 10.76 ppm, respectively) than in fruits (11.36 and 8.776 ppm), whereas phosphorus showed the opposite pattern: 111.91 ppm in fruits compared with 98.96 ppm in leaves. Thus, the statement that leaves contained higher values applies to potassium, nitrogen, sodium and calcium, but not to phosphorus.The predominance of potassium is physiologically reasonable. Potassium is highly mobile in plants and contributes to enzyme activation, stomatal regulation, osmotic adjustment and the transport of assimilates. Its high concentration in leaves is consistent with the intensive metabolic and water-regulatory functions of photosynthetic tissue [111-114]. The marked leaf-to-fruit difference in nitrogen may likewise reflect the abundance of photosynthetic proteins,

Received: *21-06-2026 -* ***Accepted:*** *19-08-2026 -* ***Published:*** *26-08-2026*

Libyan Med J. 2026;18(8):501-510
https://doi.org/10.69667/lmj.26806
Libyan Medical Journal
https://lmj.ly/index.php/ojs/index eISSN: 3107-0426

enzymes and nitrogen-containing metabolites in leaves. Legumes can acquire nitrogen through root-associated biological fixation, although the present work did not examine nodulation or fixation rates; consequently, the nitrogen result should not be attributed directly to symbiotic fixation without additional evidence [115].The slightly higher phosphorus concentration in fruits may be associated with the demand of developing reproductive tissues for phosphorylated metabolites, membranes and energy transfer.

Calcium, in contrast, is relatively immobile in the phloem and often accumulates more readily in transpiring vegetative organs than in fruits, which provides a plausible explanation for its higher value in leaves [114]. Sodium occurred at relatively low concentrations in both organs, as expected for a non-halophytic plant, although interpretation requires information about soil salinity and irrigation water that was not included in this study. Differences between the present values and those reported for other plants from Al-Jabal Al-Akhdar may arise from species-specific uptake, soil properties, rainfall, sampling season, organ maturity and analytical preparation [5,19,21–23]. Direct nutritional comparisons should nevertheless be made cautiously because studies may report concentrations on different fresh- or dry-weight bases and may use different digestion and calibration procedures.

The antibacterial findings show a selective, concentration-related response rather than uniform activity against all organisms. Neither the leaf nor fruit extract produced a detectable inhibition zone against S. aureus at any tested concentration. In contrast, B. cereus was inhibited by both organs. Leaf extract zones declined from 14 mm at 0.9 g/mL to 8 mm at 0.2 g/mL, while fruit extract zones ranged from 12 to 9 mm. This general decline with dilution supports a concentration-dependent effect, although the fruit values at 0.4 and 0.2 g/mL (9 mm at both concentrations) indicate that the relationship was not perfectly linear.The clearest difference between plant parts was observed against P. aeruginosa. The leaf extract produced inhibition zones of 15, 12, 10 and 8 mm from the highest to the lowest concentration, whereas the fruit extract showed no detectable inhibition. E. coli was susceptible to both extracts, but the leaf preparation was consistently more active: 10,7,7 and 5 mm compared with 7,5,5 and 3 mm for the corresponding fruit concentrations. Taken together, these results place the observed susceptibility broadly in the order P.aeruginosa (leaf extract only) and B. cereus, followed by E. coli, with S. aureus showing no detectable response under the conditions used.

The stronger activity of the leaf extract may reflect a greater abundance or a different mixture of soluble secondary metabolites in leaves. Flavonoids, tannins and coumarins have been reported in other Lotus species, and antimicrobial effects within the genus vary with taxon and cultivar [116]. Moreover, flavonol glycosides have been isolated from L. edulis itself [117]. Such evidence offers a biologically plausible explanation for the present activity, but it does not identify the active constituents in these extracts. Mineral content alone also cannot explain the antibacterial response. A phytochemical profile, total phenolic and flavonoid measurements, and bioassay-guided fractionation would be required before a mechanism can be assigned.

The activity against P. aeruginosa is noteworthy because the outer membrane and efflux systems of Gram-negative bacteria often restrict the action of many antimicrobial compounds. Nevertheless, the present data also show that a simple Gram-positive/Gram-negative explanation is inadequate: B. cereus was susceptible whereas S. aureus was not, and the two Gram-negative species responded differently. Susceptibility is therefore more likely to depend on the individual strain and on the chemical composition and diffusion behavior of the extract than on Gram classification alone [118].

These findings should be interpreted as preliminary screening evidence. Inhibition-zone diameter is affected not only by antibacterial potency but also by solubility, molecular size and diffusion through agar. Consequently, zones produced by crude extracts cannot be treated as direct measures of minimum inhibitory concentration [118,120]. The manuscript does not report replicate number, measures of variation, statistical testing, positive and negative controls, inoculum standardization or extract yield. The high nominal concentrations (0.2–0.9 g/mL) further limit comparison with purified antimicrobials. Future work should repeat the assays in independent replicates, include a standard antibiotic and solvent control, report mean ± standard deviation, and determine minimum inhibitory and bactericidal concentrations by broth dilution. Chromatographic characterization of the extracts and verification with authenticated bacterial strains would clarify whether the observed inhibition is reproducible and which compounds are responsible.

Within these limitations, the results provide useful baseline data for Libyan L. edulis. The organ-specific mineral pattern and the greater antibacterial activity of the leaf extract support further chemical investigation. At the same time, the absence of activity against S. aureus and the lack of confirmatory dilution assays mean that the extracts should not yet be described as broad-spectrum antibacterial agents.

Conclusion

The results of this study showed the presence of minerals including sodium, potassium, calcium, nitrogen, and phosphorus in the studied plant; also, the extracts showed antibacterial activities against the selected species (Staphylococcus aureus) and (Bacillus cereus) , beside gram negative bacteria (Pseudomonas aeruginosa) and (Escherichia coli) species in this study

***Received**: 21-06-2026 - **Accepted**: 19-08-2026 - **Published**: 26-08-2026*

Acknowledgment
Special thanks for the botany department, Faculty of Science , Omar Al-Mukhtar University ,for their supporting during the establishing the antibacterial investigation in this study.

References
1.Frank J, Fukagawa NK, Bilia AR. "Terms and nomenclature used for plant-derived components in nutrition and related research: efforts toward harmonization". Nutrition Reviews.2000, 78 (6): 451–458.
2.Hassan SA, Tripathi R, Sreejith K . "Plant Metabolites: Methods for Isolation, Purification, and Characterization". Plant Metabolites: Methods, Applications and Prospects (eds Sukumaran ST et al). Singapore: Springer. 2020.
3.Harborne JB, Baxter H, Moss GP, eds. "General Introduction". Phytochemical dictionary a handbook of bioactive compounds from plants (2nd ed.). London: Taylor & Francis. p. vii. 1999.
4.Molyneux RJ, Lee ST, Gardner DR. "Phytochemicals: the good, the bad and the ugly?". Phytochemistry.2007, 68 (22–24): 2973–85.
5.Al-Awjali K, Abdulsalam S, El-Mokasabi F, Akrim Z, Hasan H. Estimate the antioxidant capacity, total phenol contents mineral concentrations, total carbohydrate of Capparis spinosa L. (Kabbar), Ceratonia siliqua L (Kharuwb) and Juniperus phoenicea L (Arar) plants. Attahadi Med J. 2025;2(4):376-84.
6.Aljamal MA, Hasan HM, Al Sonosy HA. Antibacterial activity investigation and anti-biotic sensitive's for different solvents (ethanol, propanol, DMSO and diethyl ether) extracts of seeds, leafs and stems of (Laurus azorica and Avena sterilis) plants. Int J Curr Microbiol App Sci. 2024;13(11):175-90.
7.Hamade MH, Abdelraziq SA, Gebreel AA. Extraction and determination of beta carotene content in carrots and tomato samples collected from some markets at ElBeida City, Libya. EPH Int J Appl Sci. 2019;1(1):105-10.
8.Hasan HM, Ibrahim H, Gonaid MA, Mojahidul I. Comparative phytochemical and antimicrobial investigation of some plants growing in Al Jabal Al-Akhdar. J Nat Prod Plant Resour. 2011;1(1):15-23.
9.Hasan H, Jadallah S, Zuhir A, Ali F, Saber M. Anti-cancer, anti-inflammatory, antibacterial, antifungal, anti-oxidant and phytochemical investigation of flowers and stems of Anacyclus clavatus plant extracts. AlQalam J Med Appl Sci. 2025;8(3):415-27.
10.Hasan H, Zuhir A, Shuib F, Abdraba D. Phytochemical investigation and exploring Citrullus colocynthis extracts as antibacterial agents against some gram and negative bacteria species. AlQalam J Med Appl Sci. 2025;8(3):392-400.
11.Md Zeyaullah R, Naseem A, Badrul I, Hamad MI, Azza SA, Faheem AB, et al. Catechol biodegradation by Pseudomonas strain: a critical analysis. Int J Chem Sci. 2009;7(3):2211-21.
12.Abdull-Jalliel H, B Arous N, Alhoreir M, Hasan H. Using extracts of (Dodder) plant and concentrations of some metals as inhibitors for growth, (Pseudomonas) bacteria isolated from some hospital rooms in Derna and Al bayda. AlQalam J Med Appl Sci. 2025;8(3):1600-11.
13.Abdull-Jalliel H, Sulayman A, Alhoreir M, Hasan H. Antimicrobial effect of some metal concentration on growth of staphylococcus and klebsiella bacteria species. AlQalam J Med Appl Sci. 2025;8(3):1646-56.
14.Hamad MH, Noura AAM, Salem AM. Phytochemical screening, total phenolic, anti-oxidant, metal and mineral contents in some parts of Plantago albicans grown in Libya. World J Pharm Res. 2024;13(3):1-17.
15.Anees AS, Hamad MIH, Hasan H, Mojahidul I. Antifungal potential of 1,2-4 triazole derivatives and therapeutic efficacy of Tinea corporis in albino rats. Der Pharm Lett. 2011;3(1):228-36.
16.Hamad Hasan, Marwa Mohammed, Amal Haroon. Determining contents of antioxidants, total phenols, carbohydrate, total protein, and some elements in Eucalyptus gomphocephala and Ricinus communis plant samples. Libyan Med J. 2015;1(1):222-31.
17.Hamad Hasan, Zuhir Akrim, Farag Shuib, Dala Abdraba. Efficiency of Cynara cornigera fruits on antibacterial, antifungal and its phytochemical, anti-oxidant screening. Libyan Med J. 2025;3(1):120-8.
18.Hamad Hasan, Ashour Sulayman, Ahmed Alehrir. Estimation of amino acid composition, total carbohydrate, and total protein content in Ballota pseudodictamnus plant extracts from Al Jabal Al Akhdar Region, Libya. Libyan Med J. 2025;3(1):266-71.
19.Al-Awjali K, Abdulathim A, El-Mokasabi F, Akrim Z, Hasan H. Antioxidant activity, total phenols and carbohydrate and mineral concentrations of Pistacia lentiscus L. Sp. Pl., Portulaca oleracea L. Sp. Pl. and Rubus sanctus Schreber. Khalij-Libya J Dent Med Res. 2026:48-55.
20.Ben Arous NA, Naser ME, Hamad MAH. Phytochemical screening, anti-bacterial and anti-fungi activities of leafs, stems and roots of C. parviflorus Lam and C. salviifolius L plants. Int J Curr Microbiol App Sci. 2014;13(11):262-80.
21.Anas FAE, Hamad MAH, Salim AM, Azza MH. Phytochemical screening, total phenolics, antioxidant activity and minerals composition of Helichrysum stoechas grown in Libya. Afr J Biol Sci. 2024;3(6):2349-60.

Received*: 21-06-2026 -* ***Accepted****: 19-08-2026 -* ***Published****: 26-08-2026*

22.Naseer RE, Najat MAB, Salma AA, Hamad MAH. Evaluation of metal and mineral contents of leafs, stems and roots of C. parviflorus Lam and C. salviifolius L plants growing at Al Ghabal Al-Khder (Libya). Int J Adv Multidiscip Res Stud. 2024;4(5):191-4.
23.Hamad MAH, Salem AM. Total carbohydrate, total protein, minerals and amino acid contents in fruits, pulps and seeds of some cultivars of muskmelon and watermelon fruit samples collected from Algabal Alkhder region. Sch J Appl Med Sci. 2024;12(1):1-7.
24.Gonaid MI, Ibrahim H, Al-Arefy HM. Comparative chemical and biological studies of Salvia fruticosa, Ocimum basillicum and Pelergonium graveolans cultivated in Al-Jabal Al-Akhdar. J Nat Prod Plant Resour. 2012;6(2):705-10.
25.Rinya FMA, Hamad MAH, Ahlam KA, Hammida MEH. Phytochemical screening of some herbal plants (Men, Origanum and Salvia) growing at Al-Gabal Al-akhder Region-Libya. Afr J Basic Appl Sci. 2017;9(3):161-4.
26.Anas FAA, Hamad MAH, Salim AA, Azza MH. Phytochemical screening, total phenolics, antioxidant activity and minerals composition of Helichrysum stoechas grown in Libya. Afr J Biol Sci. 2024;3(6):2349-60.
27.Haroon A, Hasan H, Wafa AAS, Baset ESM. A comparative study of morphological, physiological and chemical properties of leafs and steam samples of (E. gomphocephala) (Tuart) plant growing at coastal (Derna city) and .... J Res Environ Earth Sci. 2024;9(12):10-8.
28.Hamad MAS, Ali AR. Separation and identification speciation of phenolic compounds in fruits and leafs of some medicinal plants (Juniperus phoenicea and Quercus coccifera) growing at Algabal Al Akhder region, Libya. Indian J Pharm Educ Res. 2016;51(3):299-303.
29.Aisha Ali, Adel Abdulathim, Zuhir Akrim, Nevein Abdel-Hady, Hamad Hasan. Applying different analytical methods (GC-Mass, spectrophotometer, atomic absorption, and flame photometry) for estimation some chemical constituents in leaves and stems of the .... AlQalam J Med Appl Sci. 2026:234-41.
30.Hamad MIH, Safa RM Mousa. Synthesis and (IR and TEM) characterization of leafs and stem nanoparticles of Artemisia plant: comparative study for evaluation of anti-bacterial efficiency. Int J Adv Multidiscip Res Stud. 2024;4(5):195-9.
31.Al-Awjali K, Mohammed E, El-Mokasabi F, Ikraim Z, Hasan H. Using flame photometer and spectrophotometric methods to estimate the minerals, anti-oxidant capacity, total phenol, and total carbohydrate of Nicotiana glauca RC Graham .... Libyan Med J. 2026:1-8.
32.Alaila AK, El Salhin HE, Ali RF, Hasan HM. Phytochemical screening of some herbal plants (Men, Origanum and Salvia) growing at Al-Gabal Al-Akhder region-Libya. Int J Pharm Life Sci. 2017;8(4):5500-3.
33.Hasan H, Mariea FFE, Eman KS. Contents of some chemical compounds of leafs and stems of some herbal plants (Thymy, rosemary, Salvia, marjoram and hybrid tea rose) at Al-Gabal Al-Akhder region. EPH Int J Appl Sci. 2014;6(3):1-8.
35..Hasan H, Ali H, Bader H, Yousef M. The detection of the types and contents of metal oxides and ores in the southern regions of Al-Gabal Alkhder (Libya) areas. AlQalam J Med Appl Sci. 2025:2181-9.
36..Altarkawi A, Mohammed S, Hasan H. Microbial applications of leaves and stems of Matricaria chamomile plant growing at Al-Gabal Al-Khder region. AlQalam J Med Appl Sci. 2025:2088-9.
37..Hasan H, Ali A, Abdel-Hady N. Analysis of fatty acids, phenolic compounds, antimicrobial activity, paper chromatography, and metal and mineral content of the Arbutus pavarii plant. AlQalam J Med Appl Sci. 2025:2021-32.
38..Hasan H, Amhmmid R, Habil Z, Khatab H, Masoud N. Assessment of selected properties and heavy metal concentrations in soil and vegetable samples from regions surrounding Derna city, Libya. Libyan Med J. 2025:463-73.
39.Habil Z, Ben Arous N, Masoud N, Hasan H. Using GC-mass method for determination the hydrocarbon compounds in some vegetable samples at Derna city, Libya. Libyan Med J. 2025:374-83.
40.Mamdouh SM, Wagdi ME, Ahmed MA, Alaa EA, Hamad MIH. Distribution of different metals in coastal waters of Alexandria, Egypt. Egypt Sci Mag. 2010;7(1):1-19.
41.Shanzaq Mohammed, Asmaa Altarkawi, Hamad Hasan. Investigation of the effect of two different solvents (aqueous and alcoholic) on phytochemical screening and antimicrobial activities for the Globularia repens plant. Libyan Med J. 2025:356-65.
42.Mohamed AE, Afnan SA, Hamad MA, Mohammed AA, Mamdouh SM, Alaa RE, et al. Usage of natural wastes from animal and plant origins as adsorbents for removal of some toxic industrial dyes and heavy metals in aqueous media. J Water Process Eng. 2023;55:104192.
43.Mohamed HB, Mohammed AZ, Ahmed MD, Hamad MAH, Doaa AE. The heavy metal pollution and associated toxicity risk assessment in Ajdabiya and Zueitina, Libya. Sci J Damietta Fac Sci. 2024;14(1):16-27.
44.Nabil B, Hamad H, Ahmed E. Determination of Cu, Co and Pb in selected frozen fish tissues collected from Benghazi markets in Libya. Chem Methodol. 2018;2:56-63.
45.Wesam FAM, Hamad MAH. Detection of heavy metals and radioactivity in some bones of frozen chicken samples collected from Libyan markets. Int J Adv Multidiscip Res Stud. 2023;3(3):761-4.

***Received**: 21-06-2026 - **Accepted**: 19-08-2026 - **Published**: 26-08-2026*

46. Wesam FAM, Hamad MAH. Study accumulation of minerals and heavy metals in Ulva algae, Cladophora, Polysiphonia and Laurencia algae samples at eastern north region of Libya coast. GSC Biol Pharm Sci. 2023;23(3):147-52.
47. Citrine E, Hamad H, Hajer Af. Contents of metal oxides in marine sediment and rock samples from eastern Libyan coast, utilizing X-ray method. AlQalam J Med Appl Sci. 2015;1(1):1316-21.
48. Hanan MA, Hamida E, Hamad MAH. Nitrogen, phosphorus and minerals (sodium, potassium and calcium) contents of some algae's species (Anabaena and Spirulina platensis). Int J Curr Microbiol App Sci. 2016;5(11):836-41.
49. Mardhiyah F, Hamad H. Assessment of the contamination by heavy metals in Al-Fatayeh Region, Derna, Libya. AlQalam J Med Appl Sci. 2025;8(3):1081-91.
50. Abdelrazeg A, Khalifa A, Mohammed H, Miftah H, Hamad H. Using melon and watermelon peels for removal of some heavy metals from aqueous solutions. AlQalam J Med Appl Sci. 2025;8(3):787-96.
51. Abdul Razaq A, Hamad H. Estimate contents and types of water well salts by Palmer Roger model affecting corrosion of Al-Bayda city (Libya) network pipes. AlQalam J Med Appl Sci. 2025;8(3):744-53.
52. Abdulsayid FA, Hamad MAH, Huda AE. IR spectroscopic investigation, X-ray fluorescence scanning, and flame photometer analysis for sediments and rock samples of Al-Gabal Al-Akhder coast region (Libya). IOSR J Appl Chem. 2021;14(4):20-30.
53. ALambarki M, Hasan HMA. Assessment of heavy metal contents in air samples collected from area extended between Albayda and Alquba cities (Libya). AlQalam J Med Appl Sci. 2025;8(3):695-707.
54. Al-Nayyan N, Mohammed B, Hamad H. Estimate of concentrations of heavy metals in the and some plant samples collected from (near and far away) of main road between Al-Bayda city and Wadi Al-Kouf region. AlQalam J Med Appl Sci. 2025;8(3):816-26.
55. Hasan HMI. Studies on physicochemical parameters and water treatment for some localities along coast of Alexandria [dissertation]. Alexandria (Egypt): Alexandria University; 2006.
56. Hamad MAH, Hager AA, Mohammed EY. Chemical studies of water samples collected from area extended between Ras Al-Halal and El Haniea, Libya. Asian J Appl Chem Res. 2022;12(3):33-46.
57. Hamad M, Mohammed AA, Hamad MAH. Adsorption and kinetic study for removal some heavy metals by use in activated carbon of sea grasses. Int J Adv Multidiscip Res Stud. 2024;4(6):677-85.
58. Hamad MAH, Hamad NI, Mohammed MYA, Hajir OAA, Al-Hendawi RA. Using bottom marine sediments as environmental indicator state of (Tolmaitha – Toukra) region at eastern north coast of Libya. Sch J Eng Tech. 2024;2(14):118-32.
59. Hamad MIH. Heavy metals distribution at coastal water of Derna city (Libya). Egypt J Aquat Res. 2008;34(4):35-52.
60. Hamad MIH, Mojahid ul Islam. Concentrations of some heavy metals of Al-Gabal Al-Akhdar coast sediment. Arch Appl Sci Res. 2010;2(6):59-67.
61. Hamad MAH, Amira AKA. Estimate concentrations of some heavy metals in some shoes polish samples. EPH Int J Appl Sci. 2016;2(2):24-7.
62. Hamad MAH, Hussien SSM, Basit EEM. Accumulation of some heavy metals in green algae as bio indicators of environmental pollution at Al-Haniea region: Libya coastline. Int J Adv Multidiscip Res Stud. 2024;4(5):188-90.
63. Hamad MIH, Ahmed MA. Major cations levels studies in surface coastal waters of Derna city, Libya. Egypt J Aquat Res. 2009;35(1):13-20.
64. Hamad MIH, Masoud MS. Thermal analysis (TGA), differential thermal analysis (DTA), infrared and X-rays analysis for sediment samples of Toubrouk city (Libya) coast. Int J Chem Sci. 2014;12(1):11-22.
65. Hamad R, Ikraiam FA, Hasan H. Estimation of heavy metals in bones of selected commercial fish from eastern Libyan coast. J Rad Nucl Appl. 2024;9(1):47-51.
66. Hasan HAH. Estimate lead and cadmium contents of some archeological samples collected from ancient cities location (Cyrene and Abolonia) at Al-Gabal Al-Akhder Region, Libya. Univ J Chem Appl. 2021;12(21):902-7.
67. Hasan H, El-maleh C. Evaluation of some heavy metal levels in tissue of fish collected from coasts of Susa region, Libya. Attahadi Med J. 2025;1(1):118-22.
68. Balal A, Obid M, Khatab H, Hasan H. Determination of lead and cadmium marine water and crabs (Pachygrapsus marmoratus) from Tolmitha coast, Libya. AlQalam J Med Appl Sci. 2025;8(3):1670-7.
69. Hamad IH, Nuesry MS. Poly cyclic hydrocarbons levels in some fishes tissues collected from Derna City (Libya) coast. In: International conference on chemical, agricultural and medical sciences; 2014 Dec 4-5; Antalya, Turkey. 2014. p. 52-6.
70. Hamad MAH, Mounera AAE, Baseet ESM, Eman E, Al-Badri M. Identification and detection aromatic and aliphatic hydrocarbons in Epinephelus marginatus fish samples collected from Benghazi coast. Int J Adv Multidiscip Res Stud. 2023;6(3):107-13.
71. Mohammed A, Hamad MAH, Mounera AAE, Eman IHE. Extraction and identification of aliphatic hydrocarbons in marine sediment samples at Benghazi city and Dyriana town coasts (Libya). J Res Humanit Soc Sci. 2023;11(10):168-74.

***Received**: 21-06-2026 - **Accepted**: 19-08-2026 - **Published**: 26-08-2026*

72. Hasan MAH, Muftah HS, Abdelghani KA, Saad SI. Poly aromatic hydrocarbon concentrations in some shell samples at some Tobrouk city coast regions: could oil industry be significantly affecting environment. Ukr J Ecol. 2022;12(3):21-8.
73. Habel AMA, Mohamed NIH, Mohammed MA, Hamad MAH. Levels and sources of aliphatic and polycyclic aromatic hydrocarbons in blue runner fish from Benghazi coast, Libya. Afr J Biol Sci. 2024;6(3):1-10.
74. Hasan HMI, Mohamad ASA. A study of aliphatic hydrocarbons levels of some waters and sediments at Al-Gabal Al-Akhder coast regions. Int J Chem Sci. 2013;11(2):833-49.
75. Salem GM, Aljidaemi FF, Hwisa SA, Hamad MIH, Zaid AA, Amer IO. Occupational exposure to benzene and changes in hematological parameters in East Tripoli, Libya. Nanotechnol Percept. 2024;20(S5):358-64.
76. Habil Z, Ben arous N, Masoud N, Hasan H. Using GC-mass method for determination hydrocarbon compounds in some vegetable samples at Derna city, Libya. Libyan Med J. 2025;17(3):374-83.
77. Hasan H, Habil Z, Ben arous N. Estimate types and contents of phenolic acid in C. parviflorus Lam and C. salviifolius L plants growing at Al-Gabal Al-Hder regions. AlQalam J Med Appl Sci. 2025;8(3):1646-56.
78. Zeyadah MA, Bahnasawy MH, Deedah AM, El-Emam DA, Hasan MA. Evaluation of the contents of aliphatic and aromatic hydrocarbons in sediment from Zueitina harbor coast (Libya), as indicator of petroleum pollution. Egypt J Aquat Biol Fish. 2023;27(6).
79. Hamad R, Ikraiam F, Hasan H. Determination of specific natural radionuclides in bones of some local fish commonly consumed from eastern Libyan coast. J Rad Nucl Appl. 2023;8(3):283-9.
80. Sroor AT, Walley El-Dine N, El-Bahi SM, Hasan HMA, Ali JM. Determination of radionuclides levels and absorbed dose for the rock, plant and water in Gondola-Libya. IOSR J Appl Phys. 2018;10(4):40-9.
81. Hasan H, Ammhmmid R, Khatab H, Ali J, Al kaseh A. Using gamma ray radiation to estimate types and contents of radioactive nuclides in some ported sugar samples, Libya. AlQalam J Med Appl Sci. 2025;8(3):1795-803.
82. Hasan H, Abdelgader I, Emrayed H, Abdel-Gany K. Removal of medical dye safranin from aqueous solutions by sea grasses activated carbon: a kinetic study. AlQalam J Med Appl Sci. 2025;8(3):428-34.
83. Hasan HMA, Alhamdy MA. Adsorption and kinetic study for removal some heavy metals by using activated carbon of sea grasses. Int J Adv Multidiscip Res Stud. 2024;4(6):677-85.
84. Almadani EA, Hamad MAH, Kwakab FS. Kinetic study of adsorption of removal of bromo cresol purple from aqueous solutions. Int J Res Granthaalayah. 2019;7(12):1-10.
85. Alfutisi H, Hasan H. Removing of thymol blue from aqueous solutions by pomegranate peel. EPH Int J Appl Sci. 2019;1(1):111-9.
86. Ahmed ONH, Hamad MAH, Fatin ME. Chemical and biological study of some transition metal complexes with guanine as ligand. Int J New Chem. 2023;10(3):172-83.
87. Hamad MAH, Enas UE, Hanan AK, Hana FS, Somia MAE. Synthesis, characterization and antibacterial applications of compounds produced by reaction between barbital with threonine, glycine, lysine, and alanine. Afr J Biol Sci. 2024;6(4):1-10.
88. Hasan S, Abduljalil O, Mohamed F, Hasan H. Detection of residual pesticides (imidacloprid, aldicarb, metalaxyl, cypermethrin, chlorpyrifos, DDA, and endrin) in peach samples collected from Jabal al Akhder farms, Libya. AlQalam J Med Appl Sci. 2025;8(4):2099-106.
89. Mohamed FH, Salah MIH, Omuthum A, Hasan Hamad. Sensitive and rapid method to estimate residual pesticides in some local and imported apple cultivars collected from eastern north side of Libya. Int J Adv Multidiscip Res Stud. 2023;3(6):100.
90. Hamad MIH, Aaza IY, Safaa SHN, Mabrouk MS. Biological study of transition metal complexes with adenine ligand. In: The 23rd International Electronic Conference on Synthetic Organic Chemistry. Proceedings. 2019;41(1):77.
91. Habib IH, Idres AMA, Hasan HMI. Synthesis, infrared (IR), thermal gravimetric analysis (TGA) characterization and antibacterial activity of some amino acids complexes. Chem Sci Rev Lett. 2014;3(12):1303-16.
92. Hasan HMA, Khalid HAA, Abdulsayid F. Infrared (IR) characterizations and physicochemical properties of Schiff base compound obtained by the reaction between 4-hydroxy-3-methoxy benzaldehyde and 2-amino-3-methylbutanoic acid. J Res Pharm Sci. 2021;7:8-12.
93. Zawia A Asia, Najar AM, Abdusalam AAA, Aeyad T. Synthesis, characterization, biological screening and molecular docking of new Schiff base and its mononuclear complexes with Pb2+, Cd2+, Zn2+ and Cu2+. J Pharm Appl Chem. 2023;8(1):1-9.
94. Hasan HMA, Elmagbari F, Othman A, Hammouda AN. Chemical and biological study of some transition metal complexes with guanine as ligand. Int J New Chem. 2023;10(3):172-83.
95. Hasan HMA, Al-Warad Y. Synthesis, physical properties, infrared (IR) analysis and anti-fungi activity of some valine and metal ion complexes. Int J Multidiscip Sci Adv Technol. 2021;Spec Iss 1:246-54.
96. Hasan H, Abdulathim A, Bunuwarah A. Using atomic absorption spectrometry (AAS) for the determination of aluminum and zinc in wrapped chocolate and chips samples. Attahadi Med J. 2026:32-8.

Received*: 21-06-2026 -* ***Accepted****: 19-08-2026 -* ***Published****: 26-08-2026*

97.Hasan H, Mohamed E, Abdulathim A. Detection of types and contents of natural radionuclides and hazard indexes in vegetable and soil samples at some Al-Marj City locations. Razi Med J. 2026:46-57.
98.Hasan H, Mohamed E, Mohamed R. Evaluation of the contents of manganese and lead and their hazard indices in some coffee brands. AlQalam J Med Appl Sci. 2026:197-204.
99.Hasan H, Abdulalah A, Khalifa M, Saleh M. Assessment of natural radioactivity and health risk indices in commercial tea samples from Libyan markets using gamma-ray spectrometry. AlQalam J Med Appl Sci. 2025:2330-40.
100.Hasan H, Abdulalah A, Khalifa M, Abduinabi H. Assessment of natural radioactive elements and health risk values in imported cocoa samples at some Libyan markets. Libyan Med J. 2025:383-92.
101.Hasan H, Bader H, Ali H, Othman H. Detection of radioactive element contents and their hazard indices in composite soil and rock samples from the southern Al Jabal al Akhdar region (between Aslunta and Al ...). Libyan Med J. 2025:366-37.
102.Hasan H, Khalifa M, Saleh M. Using inductively coupled plasma (ICP) for estimating some heavy metals and elements in some tea samples and calculating their health risk assessment. AlQalam J Med Appl Sci. 2025:2190-201.
103.Hamad MIH, Aaza IY, Safaa SHN, Mabrouk MS. Biological study of transition metal complexes with adenine ligand. Proceedings. 2019;41(1):77.
104.Hasan JA, Hasan HMA. Potential human health risks assessment through determination of heavy metals contents in regularly consumed yogurta in Libya. World J Pharm Pharm Sci. 2024;13(12):100-12.
105.Mamdouh SM, Wagdi ME, Ahmed MA, Alaa EA, Essam AM, Hamad MIH. Rice husk and activated carbon for waste water treatment of El-Mex Bay, Alexandria Coast, Egypt. Arab J Chem. 2016;9(S2):S1590-6.
106..Mamdouh SM, Wagdi ME, Ahmed MA, Alaa EA, Hamad IH. Heavy metals accumulation in sediments of Alexandria coastal areas. Bull Fac Sci. 2012;47(1-2):12-28.
107..Mamdouh SM, Wagdi ME, Ahmed MA, Hamad MIH. Chemical studies on Alexandria coast sediment. Egypt Sci Mag. 2005;2(4):93-102.
108.Hasan H, Alfurjani H, Idres N. Physicochemical characteristics and heavy metal concentrations in marine waters between Tolmitha and Tukra, Libya. Libyan Med J. 2025:502-13.
109.Hasan H, Al Jamal M, Mahmoud A, Al Daik G. Estimation of residual organic matter and heavy metals in some hookah (waterpipe, argileh) samples. AlQalam J Med Appl Sci. 2025:1051-5.
110.Hasan H, Mohammed M, Al Hadad E. Metal pollution and hazard indexes of heavy metal contents for some fish tissues collected from some Libyan coasts. Attahadi Med J. 2025:127-38.
111.Cowan MM. Plant products as antimicrobial agents. Clin Microbiol Rev. 1999;12(4):564–82.
112.Ondua M, Njoya EM, Abdalla MA, McGaw . Anti-inflammatory and antioxidant properties of leaf extracts of eleven South African medicinal plants used traditionally to treat inflammation. J Ethnopharmacol. 2019;234:27–35.
113.de Boer HJ, Kool A, Broberg A, Mziray WR, Hedberg I, Levenfors JJ. Anti-fungal and anti-bacterial activity of some herbal remedies from Tanzania. J Ethnopharmacol. 2005;96(3):461–9.
114.Marschner P, editor. Marschner's mineral nutrition of higher plants. 3rd ed. London: Academic Press; 2012.
115.Peoples MB, Brockwell J, Herridge DF, Rochester IJ, Alves BJR, Urquiaga S, et al. The contributions of nitrogen-fixing crop legumes to the productivity of agricultural systems. Symbiosis. 2009;48:1–17.
116.Girardi FA, Tonial F, Chini SOR, Sobottka AM, Scheffer-Basso SM, Bertol CD. Phytochemical profile and antimicrobial properties of Lotus spp. (Fabaceae). An Acad Bras Cienc. 2014;86(3):1295–1302.
117.Tselepi M, Papachristou E, Emmanouilidi A, Angelis A, Aligiannis N, Skaltsounis AL, et al. Catalytic inhibition of eukaryotic topoisomerases I and II by flavonol glycosides extracted from Vicia faba and Lotus edulis. J Nat Prod. 2011;74(11):2362–2370.
118.Daglia M. Polyphenols as antimicrobial agents. Curr Opin Biotechnol. 2012;23(2):174–181.
119.Salman M, Ali S, Ahmed A, Afridi MS, Rehman AU. Preliminary phytochemical, essential element analysis and antimicrobial activities of ethanolic extract of Lotus corniculatus. Int J Biosci. 2015;7(2):106–115.
120.Balouiri M, Sadiki M, Ibnsouda SK. Methods for in vitro evaluating antimicrobial activity: A review. J Pharm Anal. 2016;6(2):71–79.

***Received**: 21-06-2026 - **Accepted**: 19-08-2026 - **Published**: 26-08-2026*