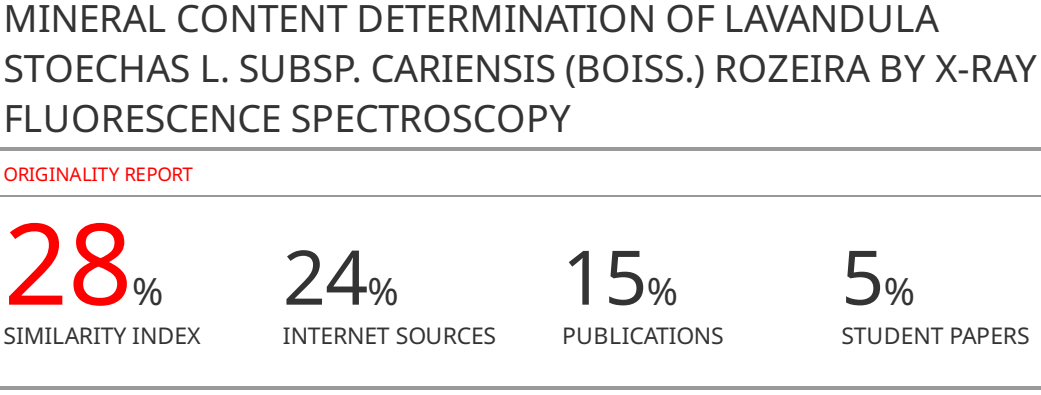
**Original Research Article**

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**MINERAL CONTENT DETERMINATION OF *LAVANDULA STOECHAS* L. SUBSP. CARIENSIS (BOISS.) ROZEIRA  BY X-RAY FLUORESCENCE SPECTROSCOPY**

**ABSTRACT**

**Background and objective:**

Medicinal herbs are sources of bioactive plant secondary metabolites such as phenolic acids, flavonoids, iridoids, tannins, anthracenes, alkaloids, terpenes Herbs and herbal extracts are important sources for minerals that can create health effects in human diet. The infusion and decoction prepared from *Lavandula stoechas* L., known as Karabaşotu in Türkiye, are used in traditional medicine for its analgesic, sedative, expectorant and urinary antiseptic properties. The objective of the present work wasto comparatively determine the mineral content of dried aerial parts *L. stoeachas* L. subsp. *cariensis* and  its water extract which is prepared by 2% infusion.

**Methods:**

The aerial parts of *Lavandula stoechas* L., were air-dried and ground into fine powder. The water extract was prepared as 2% infusion and evaporated until dryness. The water extract and the plant powder wereanalyzed for heavy metals and trace elements by Spectro-IQ II instrument equipped with X-ray fluorescence.

**Results:**

The analyzed samples differed significantly in terms of mineral contents. The ground powdered  aerial parts of *L. stoechas* L. subsp*. cariensis* and its water extract are characterized by high contents of potassium, calcium, sodium, chlorine, phosphor and magnesium. Iron in powdered plant material (576.6) was found to be almost ten times higher than the water extract (51.7 ppm). Microelements such as copper (78.8 ppm) and zinc (3169 ppm) were accumulated higher in the water extract of *L. stoechas* L. subsp. *cariensis*.

**Conclusion:**

The mineral content of the water extract and the powdered aerial parts of *L. stoechas* L. subsp. *cariensis* are quantitatively determined by X-ray fluorescence spectroscopy for the first time.

**Keywords:***Lavandula stoechas*, mineral, X-ray fluorescent analysis

**INTRODUCTION**

Mediterranean population has always been a depository for the knowledge of ethnobotany. Among mediterranean countries, Lamiaceae, Asteraceae and Apiaceae families are the most common families which have plant species used as herbal remedy. In the treatment of various diseases, medicinal plants are used in the form of herbal teas and extracts1-4.*Lavandula* L. genus (Lamiaceae) is composed of 39 species and commonly known as lavender. The economically valued *Lavandula* species are *L. angustifolia*, *L. stoechas*, *L. latifolia* and the hybrid *L*. x *intermedia*. Eastern european countries such as Bulgaria and Russia grow large quantities of *L. angustifolia*. The fragrant flowers and aerial parts of lavender are used in the preparations of herbal medicines. Flowers and leaves have been used as hydrolate against acne, headache, and sleep disturbance, as beeswax cream against insect bites, headache, and muscle pain, and as a tea against anxiety. Dried flowers have been used mainly as a clothes moth repellent. Traditionally lavender is used for a variety of conditions of nervous system including depression and fatigue. Lavender is also used for headache and rheumatism. The German Comission E monograph suggests 1-2 teaspoons (5-10 g) of the herb taken as herbal tea 4-12.

*Lavandula stoechas* L. subsp. *cariensis* known as Karabaşotu is used in Turkish folk medicine for its analgesic, expectrorant, wound healing and urinary antiseptic properties13,14. In a systematic review of *L. stoechas*, it is reported to have antiinflammatory, anticonvulsant, sedative, antispasmodic, hepatoprotective and nephroprotective activities. The ethnomedicinal uses of *L. stoechas* in mediterranean countries are reported in a phytopharmacological review by Ez zoubi *et al*. *L. stoeachas* flowering branches are usually prepared as infusion and decoction and traditionally used as analgesic, anticonvulsant, antispasmodic, carminative, expectorant and for heartburn, sea-sickness, epilepsy and migraine in Algeria, Greece, Morocco, Portugal, Spain and Türkiye. In addition to terpenes, phenolic acids, flavonoids, tannins, coumarins have been identified in *L. stoechas*15-16.

In the present work, *L. stoechas* subsp. *cariensis* collected from Birgi, Ödemiş-İzmir was identified for its mineral content by XRF spectroscopy which is a sensitive, simple and rapid technique for multielelemental determinations in plant samples.  The heavy metals and even the trace elements might contribute to its pharmacological activities. Minerals along with the organic matrix are separately extracted into the liquid medium. The extractibility of minerals may differ according to solvent used and the conditions of extraction techniques. For this purpose, to detect the differences in metal content, plant powder and its water extract prepared by 2% infusion was comparatively analysed.

**MATERIALS AND METHODS**

**Plant material and extract preparation**

The aerial parts of *L. stoechas* L. subsp. *cariensis* (Boiss.) Rozeira were collected from Birgi village, Odemis, Izmir. Professor Cenk Durmuşkahya from İzmir Katip Çelebi University collected and authenticated the plant. The voucher specimen was deposited with number 1439 in the herbarium of Pharmacognosy Department, Faculty of Pharmacy, Ege University. The plant materials were air dried at room temperature and ground into fine powder. The water extract was prepared as 2% infusion by distilled water and after the filtration from Whatman filter No.1 paper, water was evaporated to dryness by rotary evaporator to gain the dried water extract.

**Mineral Content by X-ray Fluorescence Spectroscopy**

The samples were analyzed for their mineral constituents. Analyses were conducted by Spectro-IQ II instrument equipped with X-ray fluorescence (XRF) technology at a resolution of 145eV at 10000 pulses for the silicone drift detector (SDD). Brag crystal polarized the primary beam and highly ordered pyrolitic graphite (HOPG) was the target. About 300 s duration at a voltage of 25 kV and 50 kV and 0.5 with 1.0 mA current and 1mA helium were process conditions17.

**RESULTS AND DISCUSSION**

The analyzed powdered drug (LS) and its water extract (LSW) differed significantly in terms of mineral contents. LS and LSW were characterized by high contents of macronutrients such as K, Ca, Na, Mg. The mineral contents were determined after three replicates and the mean concentrations were reported for dry weight (dw) of the samples. In both samples K was the major element with a concentration of 16800 ppm and 14920 ppm for LS and LSW samples respectively. As shown in Table 1., in LS sample, K>Ca>Si>Cl>Al>P>Na>S>Mg were the major elelements with descending concentration, whereas LSW sample had the constituents as K>Cl>Na>P>S>Ca>Mg>Si>Al . From Na to U, 45 elements are investigated in the samples As,Ga, Se and Ge concentrations were lower than 1 ppm in both samples. Pb, Cd and Hg were present at higher concentrations in the water extract, but much lower in the powder. Zn and Cu which have both curative and toxic effects in minute quantities werefound to be present at higher concentrations in the water extract with 3169 ppm and 78.8 ppm, respectively.

Aerial parts of *L. stoeachas* from Algeria were previously investigated for mineral content by atomic absorbtion-emission spectrometry. K, Mg, Na and trace elements such as Fe, Zn, Cu and Mn contents were established per 100 g of the dried weight. As a result similar to our study, K was the main mineral with a value of 14511.69 ppm. Unlike our results, Ca was not detected in Algerian plant sample, but as trace elements Fe, Zn, Mn and Cu were detected at values of 1592, 57.3,63.63 and 6.55 ppm respectively18. Mineral contents may differ according to growth area, plant vegetation period and soil characteristics. *L.stoechas* subsp. *cariensis* collected from Aydın region at different altitudes and land conditions were analysed for mineral content. The major mineral, similar to our results was found to be K with 20000-37000 ppm.Fe content varied between 466-891 ppm whereas Zn content was detected between 63-93 ppm19. The elemental compositions of samples from Aydın varied significantly from the obtained results in the present study.

**Table 1.** Mineral contents of *L. stoechas* L. subsp. *cariensis* (Boiss.) Rozeira

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Z***  ***(Atomic number)*** | **Symbol** | **Element** | **LS (ppm)** | **LSW (ppm)** |
| **11** | Na | Sodium | 189 | 2340 |
| **12** | Mg | Magnesium | 1629 | 1076 |
| **13** | Al | Aluminum | 2616 | 443 |
| **14** | Si | Silicon | 5828 | 658.1 |
| **15** | P | Phosphorous | 2069 | 2165 |
| **16** | S | Sulfur | 1837 | 1623 |
| **17** | Cl | Chlorine | 3201 | 6630 |
| **19** | K | Potassium | 16800 | 14920 |
| **20** | Ca | Calcium | 9257 | 1476 |
| **22** | Ti | Titanium | 82.7 | 22.5 |
| **23** | V | Vanadium | 6.5 | 5.9 |
| **24** | Cr | Chromium | <5.1 | <5.1 |
| **25** | Mn | Manganese | 167.8 | 197.3 |
| **26** | Fe | Iron | 576.6 | 51.7 |
| **27** | Co | Cobalt | <3 | <3 |
| **28** | Ni | Nickel | <0.2 | <0.2 |
| **29** | Cu | Copper | 30.7 | 78.8 |
| **30** | Zn | Zinc | 64.4 | 3169 |
| **31** | Ga | Gallium | <1 | <1 |
| **32** | Ge | Germanium | <1 | <1 |
| **33** | As | Arsenic | <1 | <1 |
| **34** | Se | Selenium | <1 | <1 |
| **35** | Br | Bromine | <0.7 | 467 |
| **37** | Rb | Rubium | 14.9 | 225 |
| **38** | Sr | Strontium | 20.6 | 664 |
| **39** | Y | Yttrium | 3 | 38.2 |
| **40** | Zr | Zirconium | <510 | <510 |
| **42** | Mo | Molybdenum | 13.8 | 1236 |
| **47** | Ag | Silver | 27.8 | 3640 |
| **48** | Cd | Cadmium | <5.3 | 639 |
| **49** | In | Indium | <5.1 | <5.1 |
| **50** | Sn | Tin | <6.1 | <6.1 |
| **51** | Sb | Antimony | <6.1 | <6.1 |
| **52** | Te | Tellurium | <7.1 | <7.1 |
| **53** | I | Iodine | <7.1 | <7.1 |
| **55** | Cs | Cesium | <12 | <12 |
| **56** | Ba | Barium | 86 | <8.1 |
| **57** | La | Lanthanum | <10 | <10 |
| **58** | Ce | Cerium | <12 | <12 |
| **80** | Hg | Mercury | <2 | 146.8 |
| **81** | Tl | Thallium | 448.4 | 531.8 |
| **82** | Pb | Lead | 3.3 | <2 |
| **83** | Bi | Bismuth | <2 | <2 |
| **90** | Th | Thorium | <2 | 56.4 |
| **92** | U | Uranium | <3 | 33.3 |

**LIMITATIONS OF THE STUDY**

**CONCLUSION**

Herbs and herbal extracts are used as raw materials in various fields such as pharmaceuticals, agronomics, food, sanitary, cosmetics and perfume industries to replace synthetic products. The mineral content of the water extract and the powdered aerial parts of *L. stoechas* L. subsp. *cariensis* are quantitatively determined by X-ray fluorescence spectroscopy for the first time. In Mediterranean region, *L. stoechas* is usually prepared by infusion or decoction and traditionally used as analgesic, anticonvulsant, sedative, antidiabetic, expectorant, antispasmodic *etc*. Plant secondary metabolites such as phenolics, flavonoids, terpenes, iridoids, coumarins are previously reported for the plant. Experimental studies for different pharmacological effects might also be conducted in terms of its rich mineral content. The minerals found in higher concentrations might attract the scientists to conduct more mineral content and activity related analyses to identify the power of macronutrients and trace elements. The mineral constituents of the plants differ according to growth area and soil characteristics. The minerals of *L. stoechas* L. subsp. *cariensis* collected from other regions of Türkiye will be comparatively analyzed by XRF spectrometry in our further studies.

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**CONFLICT OF INTEREST**

The authors declare no conflict of interest for the  present study.

**AUTHORS CONTRIBUTION**

Husniye Kayalar: study supervision, interpretation of data, manuscript writing; Zehra Sinem Yılmaz : XRF analysis, Cenk Durmuşkahya: collection and authentication of plant material; Umit Toktaş: methodology, sample preparations.

**REFERENCES**

1-Meddour R, Sahar Q. The contribution of protected areas to human health. A case study from Djurdjura Biosphere Reserve (Algeria), with new or rarely Reported Medicinal Plants Curr. Pers. MAPs, 2023; 6(1):7-26. *http://doi.org/ 10.38093/cupmap.1243327*

2-Bulut G, Tuzlacı E. An ethnobotanical study of medicinal plants in Turgutlu (Manisa-Turkey). J Ethnopharmacol. 2013; 7,149(3):633-47. *http://doi: 10.1016/j.jep.2013.07.016.*

3-Gras A, Hidalgo O, D'Ambrosio U, Parada M, Garnatje T, Vallès J. The Role of Botanical Families in Medicinal Ethnobotany: A Phylogenetic Perspective. Plants (Basel). 2021; 15,10(1):163. *http://doi: 10.3390/plants10010163.*

4-Savvides AM, Stavridou C, Ioannidou S, Zoumides C, Stylianou A. An Ethnobotanical Investigation into the Traditional Uses of Mediterranean Medicinal and Aromatic Plants: The Case of Troodos Mountains in Cyprus. Plants (Basel). 2023; 2, 12(5):1119. *http://doi: 10.3390/plants12051119.*

5-Habán M, Korczyk-Szabó J, Čerteková S, Ražná K. Lavandula Species, Their Bioactive Phytochemicals, and Their Biosynthetic Regulation. Int J Mol Sci. 2023 ;16, 24(10):8831. *http://doi: 10.3390/ijms24108831.*

6-Batiha GE, Teibo JO, Wasef L, Shaheen HM, Akomolafe AP, Teibo TKA, Al-Kuraishy HM, Al-Garbeeb AI, Alexiou A, Papadakis M. A review of the bioactive components and pharmacological properties of *Lavandula* species. Naunyn Schmiedebergs Arch Pharmacol. 2023; 396(5):877-900. *http://doi: 10.1007/s00210-023-02392-x*.

7-Stanev S, Zagorcheva T, Atanassov I. Lavender cultivation in Bulgaria – 21st century developments, breeding challenges and opportunities. BJAS Bulgarian Journal of Agricultural Science,2016; 22, 4:584–590 : [*https://www.researchgate.net/publication/308084650*](https://www.researchgate.net/publication/308084650)

8-Kara, N., Baydar, H. Determination of Lavender and Lavandin Cultivars (*Lavandula* sp.) Containing High Quality Essential Oil in Isparta, Turkey. *Turk. J. Field Crops,2013; 18*, 58-65. *https://www.researchgate.net/publication/295809760*

9-Lis-Balchin M.  Lavender. *The Genus Lavandula*, Taylor & Francis, New York, 2002.

10-Vijulie I, Lequeux-Dincă, A-I,  Preda M, Mareci A, Matei E. Could Lavender Farming Go from a Niche Crop to a Suitable Solution for Romanian Small Farms? Land 2022; 11, 662 [*https://doi.org/10.3390/land11050662*](https://doi.org/10.3390/land11050662)

11-Crișan I, Ona A, Vârban D, Muntean L, Vârban R, Stoie A, Mihăiescu T, Morea A. Current Trends for Lavender (*Lavandula angustifolia* Mill.) Crops and Products with Emphasis on Essential Oil Quality. Plants (Basel). 2023;12, 12(2):357.*https:// doi: 10.3390/plants12020357*

12-[Blumenthal](https://www.google.com.tr/search?hl=tr&tbo=p&tbm=bks&q=inauthor:%22Mark+Blumenthal%22&source=gbs_metadata_r&cad=4) M, Busse [WR](https://www.google.com.tr/search?hl=tr&tbo=p&tbm=bks&q=inauthor:%22Werner+R.+Busse%22&source=gbs_metadata_r&cad=4) (eds),The Complete German Comission E Monographs: Therapeutic Guide to Herbal Medicines. American Botanical Council. 1998.

13-Baytop, T., Türkiye’de Bitkilerle Tedavi, 2021. Nobel Tıp, Ankara

14-Sahinler SS, Yılmaz BS, Sarıkurkcu C, Tepe B. The importance of *Lavandula stoechas* L. in pharmacognosy and phytotherapy. IJSM, 2022; 9, 3: 360-376. [*https://doi.org/10.21448/ijsm.1098975*](https://doi.org/10.21448/ijsm.1098975)

15-Sepideh M, *Lavandula stoechas* L: A systematic review of medicinal and molecular perspectives, Der Pharmacia Lettre, 2016; 8 (13):56-58.

16-Ez zoubi, Y, Bousta, D, Farah AA. Phytopharmacological review of a Mediterranean plant: *Lavandula stoechas* L. Clin Phytosci, 2020; 6, 9 [*https://doi.org/10.1186/s40816-019-0142-y*](https://doi.org/10.1186/s40816-019-0142-y)

17-Kayalar H, Durmuşkahya C, Hortooglu Z S, Mineral Compositions of Some Selected Centaurea species from Turkey, Asian Journal Of Chemistry 2014; 26, 16: 5317-5318 [*https://doi.org/10.14233/ajchem.2014.16353*](https://doi.org/10.14233/ajchem.2014.16353)

18-Noureddine A, Gherib A, Bakchiche B, Carbonell-Barrachina AA, Cano-Lamadrid M, Noguera-Artiaga L, Chemical composition, mineral content ansd antioxidant capacity of phenolic extracts and essential oils of *Lavandula stoechas* L. St. Cerc. St. CICBIA 2019, 20, 3:423-437.[*https://www.researchgate.net/publication/336370459*](https://www.researchgate.net/publication/336370459)

19-Uygun U, Kilimci N, Küçük Kaya S, Yavaş İ. Investigation of some chemical and biochemical properties of locally grown *Lavandula stoechas cariensis.* CBU J. Of Sci. 2017; 13,1:63-69. [*http://dx.doi.org/10.18466/cbujos.302643*](http://dx.doi.org/10.18466/cbujos.302643)