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Determination of some heavy metals in *Globularia alypum L.*: Safety assessment of a traditional medicinal plant

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تقدير بعض المعادن الثقيلة في نبات الجلوبولاريا أليبوم (*Globularia alypum L.*): تقييم سلامة نبات طبي تقليدي

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Abstract
This study investigates the concentrations of selected heavy metals (Pb, Cr, Ni, and Cd) in *Globularia alypum* L., a medicinal plant traditionally consumed as a hot decoction, and evaluates the associated human health risks. Plant samples were prepared using two methods: a traditional boiled extract and an acid-digestion procedure following EPA Method 3050B. Metal concentrations were quantified using Flame Atomic Absorption Spectrophotometry (FAAS). Results showed that metal levels in the acid digest exceeded those in the boiled extract, with extraction efficiencies ranging from 51.1% to 60%, indicating partial release of metals during decoction. The concentration trend in both preparations was Cr > Ni > Pb > Cd.
Based on a daily consumption of 10 g of the herbal preparation and a 60-kg adult body weight, the Estimated Daily Intake (EDI) values for all metals were below their respective oral reference doses (RfDs). Hazard Quotients (HQ) for Pb, Cr, Ni, and Cd were all <1, and the calculated Hazard Index (HI) was 0.2049, indicating that combined non-carcinogenic risks are unlikely.
Overall, the findings demonstrate that the traditional consumption of *Globularia alypum* L. does not pose significant non-carcinogenic health risks related to heavy metal exposure. This supports the safe use of the plant in traditional medicinal practices.

Keywords: Globularia alypum L., Heavy metals, Health risk assessment, Medicinal plants.

الملخص
تدرس هذه الدراسة تركيزات معادن ثقيلة محددة) الرصاصPb ، الكرومCr ، النيكلNi ، والكادميوم (Cd في نبات الجلوبولاريا أليبوم(*Globularia alypum* L.) ، وهو نبات طبي يُستهلك تقليدياً على شكل مغلي ساخن، وتُقيّم المخاطر الصحية البشرية المرتبطة به.
أُعدّت عينات النبات باستخدام طريقتين: المستخلص المغلي التقليدي، وإجراء الهضم الحمضي باتباع طريقة وكالة حماية البيئة الأمريكية .(EPA Method 3050B) وتم تحديد تركيزات المعادن كَمّياً باستخدام مطيافية الامتصاص الذري باللهب .(FAAS) أظهرت النتائج أن مستويات المعادن في المستخلص المهضوم حمضياً تجاوزت تلك الموجودة في المستخلص المغلي، بكفاءة استخلاص تراوحت بين 51.1% و60%، مما يشير إلى تحرر جزئي للمعادن أثناء الغلي. وكان ترتيب التركيز في كلا التحضيرين كالتالي: الكروم > النيكل > الرصاص > الكادميوم.(Cr > Ni > Pb > Cd)
وبناءً على استهلاك يومي قدره 10 غرامات من المستحضر العشبي ووزن جسم لشخص بالغ يبلغ 60 كجم، كانت قيم المأخوذ اليومي المقدر (EDI) لجميع المعادن أقل من الجرعات المرجعية الفموية (RfDs) الخاصة بكل منها. كما كانت معاملات الخطر (HQ) للرصاص والكروم والنيكل والكادميوم جميعها أقل من 1، وبلغ مؤشر الخطر المحسوب (HI) قيمة 0.2049، مما يشير إلى استبعاد وجود مخاطر مجتمعة غير سرطانية.
وبشكل عام، تُظهر النتائج أن الاستهلاك التقليدي لنبات الجلوبولاريا أليبوم (*Globularia alypum* L .) لا يشكل مخاطر صحية غير سرطانية ذات دلالة تتعلق بالتعرض للمعادن الثقيلة، مما يدعم الاستخدام الآمن للنبات في الممارسات الطبية التقليدية.

الكلمات المفتاحية: الجلوبولاريا أليبوم، المعادن الثقيلة، تقييم المخاطر الصحية، النباتات الطبية.

Introduction

Although modern medicine and synthetic drugs are effective in treating various illnesses, many people still prefer traditional remedies, mainly because they tend to have fewer side effects than chemical medications. Medicinal plants can produce a wide variety of bioactive compounds, especially secondary metabolites. (Asraoui et al., 2021)

Medicinal plants have gained growing importance in the pharmaceutical, health food, and natural cosmetics industries.(Luo et al., 2021)

Factors such as soil composition, climate, pollution, handling, atmospheric conditions, and harvesting practices can all contribute to the contamination of medicinal plants with trace metals (Oladeji et. el., 2024).

The contamination of plant materials with heavy metals presents a potential health hazard. Heavy metal contamination in herbal medicines poses a global threat to human health, particularly when concentrations exceed established safety thresholds. (Luo et al., 2021)

It is estimated that approximately 70–80% of the global population depends on nonconventional medicine, primarily of herbal origin. However, due to their natural sources and methods of preparation, herbal medicines can sometimes be contaminated with arsenic, heavy metals (such as lead, mercury, cadmium, and chromium), pesticides, and toxins, which may cause damage to multiple organs in consumers. Traditional and complementary medicine represents a vital yet often underappreciated health resource, with significant roles in preventing and managing chronic diseases and addressing the health needs of aging populations (Meseret et. ei., 2020).

Heavy metals present considerable health risks to humans. Their occurrence in plants, including medicinal plants, is particularly concerning because they can accumulate in the human body over time. In addition, the related health effects can differ depending on the type of metal involved, the level and duration of exposure, and individual susceptibility (Ebrahimzadeh, et al., 2024).

Libya, in particular, has a rich heritage of herbal medicine, where various herbs are traditionally used to treat and prevent ailments such as stomach pain, headaches, diabetes, hypertension, rheumatism, and many other conditions.

Globularia alypum L. (GA) is a Mediterranean species belonging to the *Globulariaceae* family, commonly used in traditional Libyan medicine.

There are many studies on *Globularia alypum L.* in the Mediterranean area, but most of them are from the medicinal side and the the Antioxidant, Antiproliferative, Antibacterial, and Antibiofilm Effects. (Nouir et.al., 2023) (Asraoui et al., 2021)

G. alypum is widely distributed throughout the Mediterranean region and is known for its hypoglycemic, stomachic, purgative, and laxative properties (Gadouche et al., 2023). It is effective against infections caused by Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli, and Pseudomonas aeruginosa. In addition, G. alypum exhibits antioxidant and anti-inflammatory activities, enzymatic inhibition, anti-tuberculosis action, wound-healing potential, and anti-diabetic effects (Asraoui et al., 2021; El-Seedi et al., 2025; Hajji et al., 2021).

G. alypum, commonly known as Zriga or Ain Larneb in Algerian traditional medicine (Es-Safi et al., 2006), is a well-known medicinal plant. It typically grows in dry environments, including mountain rocks, grasslands, and stony slopes (El-Seedi et al., 2025).

There are many possible sources for heavy metals, most of they are related with human activities (Angon et al. 2024). Heavy metals can find their way to the human via food chain or herbal drugs causing many health problems.
The main goal of this study is the assessment of the risk associated with the contamination of *Globularia alypum L.* by heavy metals.
Some heavy metals have been determined in two samples of *Globularia alypum L.*, the first sample is acid digest**:** which represents total elemental content in the plant material, including what is tightly bound in the matrix and not bioavailable.
The second sample was boiled extract in order to **s**imulate traditional herbal preparation (e.g., decoction), showing the bioavailable or consumable portion of metals.

Experimental
The *Globularia alypum L.* samples of this study have been collected from the green mountains in the east of Libya.
Sample Preparation for Analysis
Traditional Extract Preparation
A decoction was prepared following the traditional method used for medicinal hot beverages. Two grams of *Globularia alypum* L. powder were placed into a flask and mixed with 50 mL of deionized water. The mixture was heated to boiling for 5–7 minutes and then filtered through Whatman No. 41 filter paper. The resulting filtrate was collected and analyzed using Flame Atomic Absorption Spectrophotometry (FAAS).

Acid Digestion Procedure
Acid digestion of the plant material was performed according to the EPA Method 3050B (USEPA, 1996). Two grams of finely ground *Globularia alypum* L. were accurately weighed and transferred into a digestion flask. An initial 10 mL of high-purity concentrated nitric acid was added, and the mixture was heated just below boiling for 15 minutes before being allowed to cool. This step was repeated twice with an additional 5 mL of concentrated nitric acid each time, followed by heating for a further 30 minutes. The solution was then evaporated to approximately 5 mL.
Subsequently, 5 mL of 30% hydrogen peroxide were added dropwise, followed by the addition of 10 mL of nitric acid. After digestion, the mixture was filtered using Whatman No. 41 filter paper and diluted to a final volume of 100 mL with deionized water in a volumetric flask. Metal concentrations were quantified using Flame Atomic Absorption Spectrophotometry (FAAS).

Safety Considerations
EPA Method 3050B involves the use of highly corrosive acids. Appropriate laboratory safety measures—including protective gloves, safety goggles, and operation within a well-ventilated fume hood—are essential to ensure safe handling during the digestion process (USEPA,1996).

Results and Discussion
The concentrations of Pb, Cr, Ni, and Cd obtained from flame atomic absorption spectrophotometry of both acid-digested samples and boiled extracts are presented in Table 1. The metal concentrations in both preparations followed the trend Cr > Ni > Pb > Cd**.**
Chromium exhibited the highest concentration at 5.15 µg/g, suggesting either natural accumulation from the soil or potential environmental contamination during growth or processing. Lead and nickel were detected at comparable levels, 1.02 µg/g and 1.05 µg/g, respectively, which may reflect uptake from polluted soils, atmospheric deposition, or contact with contaminated water during cultivation. Cadmium was present at a lower concentration of 0.30 µg/g, yet its presence remains notable due to its high toxicity even at trace levels. Overall, the detected concentrations indicate that the plant is capable of accumulating heavy metals, highlighting the importance of monitoring environmental conditions and ensuring good agricultural and manufacturing practices to minimize contamination.

Table 1. Heavy metal concentrations in acid digest and boiled extract of *Globularia alypum* L.

Element	Acid Digest (µg/g)	Boiled Extract (µg/g)	% Extracted (Boiled/Acid)
Pb	1.02	0.57	55.9%
Cr	5.15	2.63	51.1%
Ni	1.05	0.62	59.0%
Cd	0.30	0.18	60.0%

A comparison of mineral concentrations between the acid-digested material and the boiled extracts—prepared following the traditional method—indicates that all metals were present at lower levels in the boiled extracts.

This reduction suggests partial dissolution, matrix binding, or limited release of the metals during the decoction process, which is consistent with expected behavior for many metal–plant interactions.
Extraction efficiencies ranged from 51.1% for Cr to 60% for Cd**,** with Pb and Ni showing 55.9% and 59% extraction rates, respectively. These results highlight that while heavy metals are transferred into the decoction, their extraction is incomplete, reducing potential exposure relative to total plant content.
To estimate consumer exposure, a 10 g daily dose of *Globularia alypum* L. and an adult body weight of 60 kg were assumed. Calculations were based on the metal concentrations in the boiled extract, reflecting the actual consumed form.

Table 2: Concentrations of heavy metals in the boiled extract and corresponding exposure estimates, including daily intake, body-weight–adjusted intake, estimated daily intake (EDI), reference dose (RfD), and target hazard quotient (THQ)

Element	Boiled Extract (µg/g)	Daily Intake (µg/day)	Intake (µg/kg/day)	Intake (mg/kg/day)	EDI	RfD	THQ
Pb	0.57	5.7	0.095	0.000095	9.5×10^{-5}	0.004	0.02375
Cr	2.63	26.3	0.438	0.000438	4.38×10^{-4}	0.003	0.146
Ni	0.62	6.2	0.103	0.000103	1.03×10^{-4}	0.02	0.00515
Cd	0.18	1.8	0.030	0.00003	3.00×10^{-5}	0.001	0.03

Health risk assessment of heavy metals

A principal method for evaluating potential health risks from heavy metal contamination is the Estimated Daily Intake (EDI), which incorporates exposure frequency, exposure duration, and the body weight of exposed individuals. The estimated daily dietary intake values (Table 2) provide a basis for determining the health risks associated with metal contamination.
In the present study, the mean EDI values followed the order: Cr (4.38×10^{-4} mg/kg/day) > Ni (1.03×10^{-4} mg/kg/day) > Pb (9.50×10^{-5} mg/kg/day) > Cd (3.00×10^{-5} mg/kg/day).
All EDI values were below their respective oral reference doses (RfD), indicating that consumption of the analyzed medicinal concoctions does not pose a significant health risk.

Hazard Quotient (HQ) and Hazard Index (HI)

Non-carcinogenic risks associated with chronic exposure to heavy metals were assessed using the Hazard Quotient (HQ). An HQ value below 1 suggests that adverse health effects are unlikely, whereas a value above 1 may indicate potential health concerns. HQ was calculated as:
$HQ = EDI / RfD$
The following RfD values were applied: Cd (0.001 mg/kg/day), Cr (0.003 mg/kg/day), Ni (0.02 mg/kg/day), and Pb (0.004 mg/kg/day) (Oladeji et. al., 2024; Naseri et. al., 2021).
The Hazard Index (HI), representing the cumulative non-carcinogenic risk from simultaneous exposure to multiple metals, was calculated as the sum of all individual HQ values:
$HI = \Sigma HQ$
An HI value < 1 indicates that chronic non-carcinogenic risks are unlikely.

Non -Carcinogenic Risk Assessment

As shown in Table 2, all HQ values for Cd, Pb, Cr, and Ni in *Globularia alypum* L. were below 1. This demonstrates that consumption of these herbal preparations does not pose any non-carcinogenic health risk. Accordingly, *G. alypum* L. can be considered safe for human consumption with respect to heavy metal content.
The overall Hazard Index (HI) for the analyzed metals was 0.2049, further confirming that chronic adverse health effects are unlikely.

Conclusion

The analysis of heavy metals in *Globularia alypum* L. demonstrates that although Pb, Cr, Ni, and Cd are present in both the plant material and its boiled extract, their concentrations are substantially reduced during traditional decoction. Estimated Daily Intake (EDI), Hazard Quotients (HQ), and the overall Hazard Index (HI) all fell well below established safety thresholds.
These findings indicate that the consumption of *Globularia alypum* L. prepared as a decoction does not pose meaningful non-carcinogenic health risks related to heavy metal exposure. The herbal preparation can therefore be considered safe for traditional use from a heavy-metal contamination standpoint. Further studies on seasonal variation, soil conditions, and repeated-dose exposure may help broaden the risk assessment framework.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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