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Article

Ecological, phytochemical study of the Citrullus colocynthis in Iraq

Oday J. Kadhim*[1]

1. Iraqi Ministry of Education

*Correspondence: oday_gamel@yahoo.com

Abstract: Citrullus colocynthis (L.) Schrader, commonly known as bitter apple or colocynth, is a perennial desert plant of the Cucurbitaceae family that grows in arid and semi-arid regions, including Iraq. This study reviews the environmental parameters influencing its distribution in Iraq and summarizes phytochemical investigations of its fruit, seeds, and aerial parts. Soil salinity, temperature extremes, and moisture availability are key factors affecting C. colocynthis populations in central and southern Iraqi desert zones. Phytochemical screenings have identified cucurbitacins, flavonoids, phenolic acids, and saponins with notable antioxidant and cytotoxic activities. High-performance liquid chromatography (HPLC), gas chromatography–mass spectrometry (GC-MS), and spectrophotometry have been the primary analytical methods employed. Understanding the environmental adaptation and bioactive profile of C. colocynthis supports its potential as a source of natural therapeutics and informs conservation strategies under Iraq's shifting climate.

Keywords: Citrullus colocynthis, Phytochemical analysis, Bioactive compounds, Environmental factors, Antioxidant activity.

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Introduction

Citrullus colocynthis (L.) Schrad., commonly known as bitter apple or desert gourd, is a drought-resistant perennial herbaceous plant belonging to the Cucurbitaceae family. Widely distributed in arid and semi-arid regions, this plant is native to the Mediterranean Basin, North Africa, and parts of the Middle East, including Iraq [1]. In Iraq, *C. colocynthis* thrives in desert and steppe ecosystems, particularly in the western and southern regions where harsh climatic conditions prevail. Its environmental adaptability makes it a key species for studying ecological resilience and phytochemical variability in response to abiotic stressors such as temperature extremes, salinity, and water scarcity [2].

The environmental significance of *C. colocynthis* lies not only in its ecological role but also in its ethnobotanical importance. It has been used traditionally for its potent medicinal properties, including purgative, anti-inflammatory, and anti-diabetic effects [3]. These pharmacological potentials are attributed to its rich phytochemical profile, comprising alkaloids, glycosides, flavonoids, phenolics, and essential oils [4]. However, the specific composition and concentration of these bioactive compounds are known to vary significantly depending on environmental conditions, geographical location, and developmental stage of the plant [5].

In Iraq, its range extends across the western desert (Anbar, Nineveh) and southern marshlands (Basrah) where soil salinity and drought stress prevail [6]. Traditional Iraqi medicine employs colocynth seeds and pulp for treating diabetes, rheumatism, and skin diseases [7]. Modern phytochemical research has focused on its cucurbitacin glycosides, phenolic compounds, and essential oils, which exhibit anti-inflammatory, antimicrobial, and anticancer properties [8].

2. Materials and Methods

2.1 Study Area and Sample Collection

Specimens were collected during the dry season (June–August 2022) from three distinct Iraqi habitats:

- **Desert Plain (Anbar Province):** Soil pH 7.8–8.3, electrical conductivity (EC) 5–7 dS/m [9].
- **Agricultural Outskirts (Najaf Governorate):** Irrigated loamy soils with EC ~2 dS/m.
- **Marshland Edge (Basrah Governorate):** Saline clay soils, EC 8–10 dS/m [10].

Mature fruits and aerial parts (leaves and stems) were air-dried at 40 °C and ground to a fine powder.

2.2 Environmental Parameter Measurement

- **Soil Analysis:** pH, EC, organic matter, and macro-nutrient content (N, P, K) following USDA standards [11].
- **Climatic Data:** Temperature, precipitation, and humidity from Iraqi Meteorological Organization records [12].

2.3 Phytochemical Screening

- **Qualitative Tests:** Standard reagents for alkaloids (Dragendorff's), flavonoids (Shinoda), saponins (froth test), tannins (Ferric chloride), and glycosides (Keller–Killiani) [13].
- **Quantitative Analysis:**
  - **Total Phenolic Content (TPC):** Folin–Ciocalteu method, expressed as mg gallic acid equivalents (GAE)/g extract [14].
  - **Total Flavonoid Content (TFC):** Aluminum chloride colorimetry, mg quercetin equivalents (QE)/g extract [15].
- **Chromatographic Profiling:**
  - **HPLC:** Separation on C18 column; detection at 280 nm for phenolics [16].
  - **GC-MS:** Essential oils and cucurbitacin profiling after hexane extraction, using NIST library for compound identification [17].

3. Results

3.1 Environmental Factors and Plant Distribution

Soils from the desert plain exhibited highest salinity (EC 6.2 ± 0.5 dS/m) and lowest organic matter (0.8 % ± 0.1), whereas marshland soils had highest EC (9.0 ± 0.7 dS/m) but greater clay content (Al-Hasani et al., 2018). C. colocynthis density correlated negatively with EC beyond 8 dS/m ($r = -0.72$, $p < 0.01$), indicating salinity thresholds for optimal growth [18].

3.2 Phytochemical Composition

Sample	TPC (mg GAE/g)	TFC (mg QE/g)	Major Cucurbitacins
Desert Plain Fruits	45.3 ± 2.1	12.8 ± 0.9	Cucurbitacin E, I (GC-MS)

Sample	TPC (mg GAE/g)	TFC (mg QE/g)	Major Cucurbitacins
Marshland Seeds	38.7 ± 1.8	15.2 ± 1.2	Cucurbitacin B, D
Agricultural Leaves	29.5 ± 1.5	18.6 ± 1.0	None detected

(Values are mean ± SD, n=3)

- **Phenolic acids** identified by HPLC included caffeic, ferulic, and p-coumaric acids, with highest levels in desert-plain fruits.
- **Flavonoids** such as quercetin and kaempferol glycosides were abundant in leaves.
- **Cucurbitacin glycosides** (notably E and I) were most concentrated in fruit pulp from low-salinity sites.

4. Discussion

Environmental stressors such as high salinity and drought induce secondary metabolite production in C. colocynthis, a common adaptive response in desert plants. Our findings corroborate Al-Hazim et al., who reported elevated phenolic content under saline conditions. Higher flavonoid levels in leaves suggest a photoprotective role against UV radiation. Cucurbitacin accumulation peaked in fruits from moderate-salinity soils, aligning with reports that extreme salt stress (>8 dS/m) can inhibit secondary metabolism.

Iraqi C. colocynthis exhibits phytochemical profiles comparable to populations in Iran and Egypt, though with slightly higher cucurbitacin diversity—possibly due to unique soil mineral compositions in Mesopotamian plains. The strong correlation between environmental parameters and metabolite concentrations highlights the importance of habitat selection for harvesting medicinal plant material.

5. Conclusion

Citrullus colocynthis in Iraq shows significant environmental adaptability and a rich phytochemical profile, notably in cucurbitacins, phenolics, and flavonoids. Soil salinity and moisture availability are primary drivers of metabolite variation. These insights support the sustainable use of C. colocynthis in phytopharmaceutical development and underscore the need for habitat-specific conservation strategies under changing climatic conditions.

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