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REVIEW

Gundelia tournefortii L. (Akkoub): a review of a valuable wild vegetable from Eastern Mediterranean

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Abstract *Gundelia tournefortii* L. (Asteraceae) is an artichoke-like wild edible vegetable that grows in the semi-arid climate of the East Mediterranean. Due to its high cultural and economic values for culinary and therapeutic uses, this plant is exposed to overharvesting driven by household consumption and trade, threatening the survival of natural populations. Some limited data on the nutrient composition of *G. tournefortii* exists indicating presence of folic acid and several essential amino acids. Research on seed germination reports that mechanical scarification, gibberellic acid, and cold stratification are all effective treatments for seed dormancy breaking and therefore to propagate plants from seed. Successful vegetative propagation from the plant meristems is also available. However, despite some exceptions, the species is still not widely cultivated due to its thorny habit and complex seed germination requirements, and the ability to ensure seed germination under natural field conditions remains to be addressed.

Keywords *Gundelia tournefortii* · Wild edible vegetables · Traditional food · Mediterranean diet · Micronutrients · Propagation

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Introduction

Wild edible plants constitute a valuable source of food, as well as a way for local communities to diversify their diet, especially during famines and times of scarcity in regions heavily affected by climate change. Moreover, wild edible plants are also recognized to have high levels of micronutrients that significantly contribute to addressing malnutrition and associated diseases (Pinela et al. 2017; Ceccanti et al. 2018; Sulaiman et al. 2022). These plant resources also provide an alternative source of income for local communities, particularly with the increasing popularity of traditional and organic food in the Global North.

In addition, the cultivation of wild edible vegetables can provide food and income to indigenous populations while offering strong conservation benefits to those species exposed to overharvesting. This strategy is applied to many valuable species that are threatened due to extensive overexploitation, and it

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guarantees a support to agricultural entrepreneurship to bridge the gap between the increasing human population and food availability (Vernon et al. 2011; Shelef et al. 2017; Ceccanti et al. 2018). The present progress in the food production rate will not be sufficient to eradicate hunger either by 2030 or 2050 (FAO 2017). Therefore, the introduction of new crops from wild edible plants is considered a key option for a more resilient, sustainable, biodiverse, and community-driven new "green revolution" (Ulian et al. 2020). It is now well recognized that 'nutrition and biodiversity converge to a common path leading to food security and sustainable development' and that 'wild species and intra species biodiversity have key roles in global nutrition security' (PAR platform for agrobiodiversity research and FAO 2010). The literature offers many successful examples of wild plant species with very high crop recruitment potential, one of which is *Gundelia tournefortii* (Asteraceae).

G. tournefortii L. is an artichoke-like vegetable that grows in the semi-arid climates of the East Mediterranean. Vernacular names of *G. tournefortii* include Akkoub and Kaa'ub (Arabic); Hakuvit Hagalgal (Hebrew), and Kenger (Turkish). The plant is famous for its importance in the traditional diet and medicinal use and as a source of income for rural communities (Lev-Yadun and Abbo 1999). It continues to be mainly gathered for consumption and trade from the wild. In Lebanon, Jordan, Turkey and other countries in the region, *G. tournefortii* stands among the most important wild edible plants, which led to its overharvesting. The tender floral heads are collected before flowering and cooked in many ways. In Lebanon, the plant is used to prepare omelettes and several traditional dishes with olive oil or lamb fat and meat (Batal and Hunter 2007; Baydoun et al. 2023). The addition of yoghurt and chickpeas along with other ingredients is also common in Akkoub plates. The ethnobotanical use of this plant dates back to more than 2000 years ago as indicated in the Babylonian Talmud and other Biblical writings (Boi 2012).

This study reviews the taxonomy, distribution, propagation, and ethnobotanical use categories of *G. tournefortii,* as well as provides some preliminary original research data on nutritional analyses conducted on plant material collected from the Shouf Biosphere Reserve (SBR) in Lebanon. This study was conducted based on a collaborative initiative in the framework of the project "Restoring the traditional Mediterranean diet through the conservation of wild edible plants'' led by the Royal Botanic Gardens, Kew (RBG Kew) in the United Kingdom (https://www.kew.org/science/our-science/projects/restoring-mediterranean-diet) in collaboration with the National Agricultural Research Center (NARC) in Jordan and the Shouf Biosphere Reserve (SBR) in Lebanon.

Methods

This study was primarily based on exhaustive research on peer-reviewed literature using as main sources the Web of Science platform, the Scopus academic literature database, information retrieved from seed banks and institutions working on seed conservation and propagation of *G. tournefortii*.

Results and discussion

The following section constitutes a review of the key findings of several investigations on *G. tournefortii* that gather botanical, ecological, and ethnobotanical information along with those of propagation experiments conducted by different research institutions.

Plant description

Life form A spiny perennial herb, hemicryptophyte, resembling other spiny plants belonging to the Asteraceae family, such as thistles (e.g., Cirsium Mill.), teasels (e.g., *Dipsacus* L.), and eryngos *(Eryngium* Tourn. ex L.) (Hind 2013), featuring a thick rootstock that gets replenished with new roots each spring (Hind 2013; Lev-Yadun and Abbo 1999).

Morphological characteristics It grows up to about 20–50 cm, although it can occasionally reach almost 100 cm at lower altitudes and wetter conditions. It has upright, sometimes branched stems, glabrous or hairy to densely hairy; when dry, old stems become tumbleweeds (Hind 2013; Lev-Yadun and Abbo 1999). Roots, stems, and leaves produce milky latex (Hind 2013). *Leaves* are alternate, sessile, or base decurrent with spiny wings, lower-most leaves around 7–30×4–16 cm, with a lanceolate or lanceolate-elliptic lamina, pinnatifid to pinnatisect; uppermost leaves are bracteate/involucrate, from

Fig. 1 Inflorescence of *Gundelia tournefortii* L. (Akkoub) (Photo: P. Gomez Barreiro, RBG Kew)

glabrous to thin arachnoid pubescent or glabrescent, with prominent venations, the secondary ones being whitish, and the middle primary often purplish (Hind 2013). Inflorescences (Fig. 1) are solitary, compound (known as "capitulum"), bracteate, dense globular to ovoid in shape, around 2–5 × 2–4 cm, composed of aggregations of single-flowered capitula subtended by a single spiny bract and two subsidiary bracts; the compound inflorescence bracts are spiny, ovate-acuminate, scarcely or markedly exceeding the inflorescence, arachnoid pubescent or glabrescent, with glabrescent/glabrous apices that prolong into a flattened spine around 5–7 cm long, brownish-purple towards the base (Hind 2013). Primary aggregated capitula (e.g., "secondary" capitula) are 7–17 mm long, containing 5–7 or more primary capitula, with single-flowered central and subsidiary capitula, the central being hermaphrodite and functionally female, and the subsidiary being functionally male (Hind 2013). The corollas are around 7–10 mm long, rusty brown, purplish, or yellow on the outside, and pale yellow or greenish (very rarely white) on the inside; the corolla lobes are narrowly lanceolate, 3–4 × 1 mm, glabrous on the inside. The style is brownish, while the anthers are dark yellow and 4–6 mm long (Hind 2013).

Fruits and seeds Dispersal units, also known as "disseminules" (Fig. 2) have a peculiar shape, resembling a turbinate cupule, obovoid to tetragonal in shape, 10–16 × 5–9 × 7 mm, green or purplish when fresh and becoming woody with age; the external compartments of the male capitula become hollow once the dispersal unit forms, and they show horizontal or oblique apical apertures (Fig. 2d) (Hind 2013). The fruit is a sub-compressed cypsela (longitudinal view in Fig. 2e), around 6 × 3 mm, with the pappus being a short corona of 1.5–2 mm, with fimbriate or

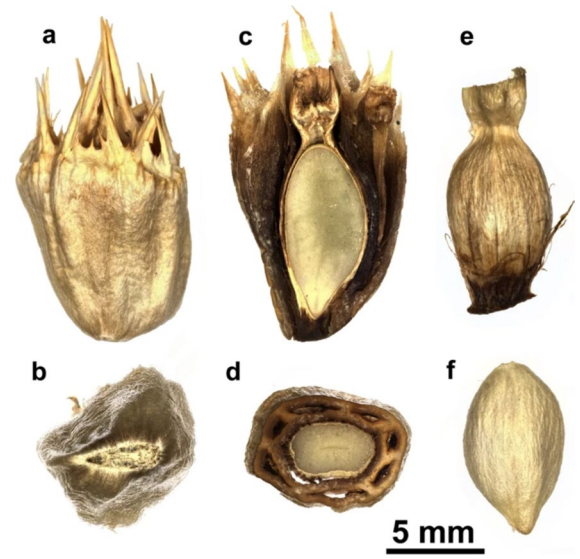

Fig. 2 Fruit and seed morphology of *Gundelia tournefortii.* Image originally published in Mattana et al. (2022) under a Creative Commons Attribution 4.0 International Licence (http://creativecommons.org/licenses/by/4.0/). No changes were made from the original publication

entire margins. Seeds are ovoid in shape, pale sand in colour, around 8 × 4 × 2 mm (Fig. 2f) (Hind 2013).

Flowering and fruiting habit: Flowering occurs from February/March to June; fruiting occurs between June and August (Hind 2013; Lev-Yadun and Abbo 1999). The inflorescences are insect-pollinated, mainly bees and other members of the Apidae family, or nectar-feeding beetles (Hind 2013). Disseminules are dispersed once the above-ground parts of the plant dry and detach from the root system, becoming a tumbleweed propelled by the wind and able to spread the dispersal units over long distances (Hind 2013).

Distribution and habitat

The most reliable native distribution range reported for Akkoub includes Cyprus, Lebanon, Palestine, the Sinai Peninsula (Egypt), Syria, and Turkey The plant was introduced in Algeria, where it is currently found as non-native (Hind 2013). *G. tournefortii* is typical of the Mediterranean scrubland eco-region (garrigue), where it can be found in different habitats, such as rocky limestone or igneous outcrops; steppes;

open areas in pine or oak woodlands; fallow or cultivated fields; roadsides are the main habitats of *G. tournefortii*. The main altitudinal range is between 100 and 2500 m of altitude, but this species can also grow at sea level (Hind 2013). Figure 3 shows a map of the native range of the species including the areas of introduction of the species; moreover, GPS markers indicating the locations of the institutions that store seed accessions of *G. tournefortii* are displayed. Each GPS marker is accompanied by the Genesys identification code of each institution: in black JOR105 = the Jordan National Agricultural Research Center (Jordan); in light blue ISR002 = the Israel Gene Bank for Agricultural Crops (Israel); in red GBR004 = the MSB of RGB Kew (UK); in green AZE015 = the Azerbaijan Genetic Resources Institute).

Uses

Food

The plant is edible, and it constitutes a source of wild food largely employed in Levantine cuisine: tender leaves, inflorescences, and stems are typically fried with eggs, sautéed in olive oil, used in stews, cooked with yoghurt, or as an ingredient of kibbeh (a type of fried meatballs) (Asadi-Samani et al. 2013).

Akkoub is typically cooked with plenty of chopped onion and garlic and served with rice; its taste may resemble the one of artichokes (Asadi-Samani et al. 2013). Early in the year, growing plants are cut at the base and thorns are removed. Leaves, stems, roots, and particularly the undeveloped flower heads are eaten. The base of the young leaves is used by Bedouin tribes to make Akkoub soup. Foraging Akkoub is a long-standing tradition (over 2000 years) (Lev-Yadun and Abbo 1999), and its collection and processing for culinary purposes often constitute a communal activity, mostly carried out by women (Hind 2013, Lev-Yadun and Abbo 1999). Harvesting Akkoub is complicated due to the plant's spiny habit and the difficulty to access wild populations since they grow in mountainous areas; however, once collected, Akkoub is frozen and used all-year round. Fruits and seeds are also edible, and the whole dispersal unit can be ground and roasted to be used as a coffee substitute. Moreover, seeds are used to extract an edible oil whose fatty acid composition is similar to soybean and sunflower oils (Khanzadeh et al. 2012).

Medicine

In folk medicine, the plant is believed to possess nutritive and healing benefits: different plant parts (stem, leaves, roots, and fruits) could be used to prepare a decoction (internal use) for diabetes, epilepsy, fever, cold, cough, kidney pains, stomach, and intestinal diseases (Asadi-Samani et al. 2013; Baydoun et al. 2015; Abu-Lafi et al. 2019).

Fig. 3 Map showing the native distribution range (green) and the non-native range (indigo) of *Gundelia tournefortii* according to the Plants of the World Online (POWO). GPS markers indicate the locations of the institutions where seed accessions of *G. tournefortii* are stored

A decoction of the latex (external use) is traditionally used against vitiligo, edema, toothache, and inflammation (Baydoun et al. 2015). Latex is also used as chewing gum due to its antiseptic properties, and in Lebanon it is applied to burn off warts, dry up sores, as an emetic, and against snake bites (Asadi-Samani et al. 2013). Scientific research shows that Akkoub has antioxidant, hepatoprotective, antibacterial, and anticancer effects (Abu-Lafi et al. 2019; Asadi-Samani et al. 2013).

A study from 2019 (Abu-Lafi et al. 2019) indicated that Akkoub contains six different phytochemicals exhibiting anticancer activity (sitosterol, stigmasterol, lupeol, gitoxigenin, α-amyrin, and artemisinin). Kenger herbal coffee, a coffee substitute obtained from the roots and disseminules of *G. tournefortii*, has been of interest for the potential prevention of oxidative stress-related diseases such as neurodegenerative diseases and cancer (Gezici and Sekeroglu 2021).

Fodder

Despite the spiny foliage, the plant is used as fodder for sheep, goats, and camels (Hind 2013; Lev-Yadun and Abbo 1999), even though over consumption is not advisable because of the toxic effects of hydrocyanic acids on cattle (Asadi-Samani et al. 2013) (Fig. 4).

Conservation status

The species is not reported as threatened as a whole, but its survival in the wild is locally jeopardized in different areas, mostly due to overexploitation, but also land clearance and herbicide use (Hind 2013).

Fig. 4 Akkoub prepared for cooking (Photo: N. Hani, SBR)

It has been recorded as Endangered in Cyprus (Hind 2013), while in the Jordan Plant Red List One it is reported as Vulnerable, and plant collection is prohibited both in Israel and Palestine, although illegal collection is still very common, also due to the poor economic conditions of some families (Eghbariah 2019; Fullilove 2022; Vitek et al. 2017). In Lebanon, Bedouin communities and Syrian refugees are the main foragers of Akkoub.

Seed collection and conservation

Harvesting

Fruits can be collected directly from the plants in July–August by separating them from the mother plant with pruning shears, and they are handled with gloves to avoid damaging the hands (Asadi-Samani 2013; Hind 2013; Lev-Yadun, and Abbo 1999).

Processing and handling

Fruits are separated from debris and plant parts both manually (wearing gloves) and through sieving (Hind 2013, Lev-Yadun and Abbo 1999, Vitek et al. 2017).

Storage and viability

Seeds are orthodox and therefore, after appropriate drying, they can be stored at temperatures below zero for long term conservation (SER, INSR, RBGK, Seed Information Database (SID) 2023). Nine seed accessions of *G. tournefortii* are currently conserved at the Millennium Seed Bank (MSB) of the Royal Botanic Gardens, Kew (RBG Kew) in the United Kingdom, and they are the only seed accessions conserved in the UK for this species. Origins of conserved material are Cyprus, Israel, Jordan, and Lebanon. The Genesys database (Genesys PGR (genesys-pgr.org) reports a total of 31 seed accessions conserved in different countries by various institutions: the MSB of RBG Kewin the UK (9 accessions), the Israel Gene Bank for Agricultural Crops—Agricultural Research Organisation, Volcani Center (6 accessions), the Jordan National Agricultural Research Center (NARC) (13 accessions), the Western Regional Plant Introduction Station of the Washington State University (USA)

(2 accessions, one from Armenia and one from Turkey), and the Azerbaijan Genetic Resources Institute (1 accession).

Propagation

Given this high cultural value, *G. tournefortii* has been subject to many research efforts focusing on developing propagation methods in recent years. In the past two decades, the plant has been cultivated in Israel and Palestine to meet market demands without leading wild populations to the brink of extinction; however, cultivation is difficult due to the thorny habit of the plant, hence it still remains limited (Vitek et al. 2017). It is widely acknowledged that the overall most effective way to propagate Akkoub is through seeds, even though vegetative propagation is also performed (Hind 2013).

Seeds

Dormancy and pre-treatments

Several investigations suggest the presence of physiological seed dormancy sensu Baskin and Baskin (2014) (Willis et al. 2014) for this species (Abu-Qaoud and Alkoni 1995; Mattana et al. 2022; Owies et al. 2004; Shibli et al. 2009; Vaisi et al. 2018). Mattana et al. (2022) highlighted a mechanical (capitulum-imposed) and hormonal (embryo) component of physiological dormancy for high-altitude populations from Lebanon (Fig. 5).

Fig. 5 Akkoub harvest in Lebanon (Photo: N. Hani, SBR)

Germination, sowing and planting

Several investigations suggested the use of gibberellic acid for overcoming seed dormancy and promoting germination of this species (Owies et al. 2004; Vaisi et al. 2018; Shibli et al. 2009; Vaisi et al. 2018; Shatnawi et al. 2022). Vian and Farhad (2021) also found that seed freezing resulted in a high germination percentage of seeds in petri dish.

Mattana et al. (2022), recommend a cold stratification of the capitula and their subsequent incubation at low temperatures (5–15°C). Dried seed lots stored at the Kew's Millennium Seed Bank are reported to reach at high germination percentages, with or without the removal of covering structures, when incubated in the range 10–20 °C (SER, INSR, RBGK, Seed Information Database (SID) 2023). Moreover, the use of Gamma radiation was also found to have a significant effect on germination (Shatnawi et al. 2022) (Fig. 6).

Vegetative propagation

Vegetative propagation and cultivation are complicated for this plant due to its thorny habit, and information on propagation techniques is lacking. Nevertheless, Shatnawi and co-investigators (2022) have recently been able to obtain rapid shoot multiplication from the plant meristems on Murashige and Skoog (MS) basal medium containing 6-Benzyladenine and Indole-3-butyric acid.

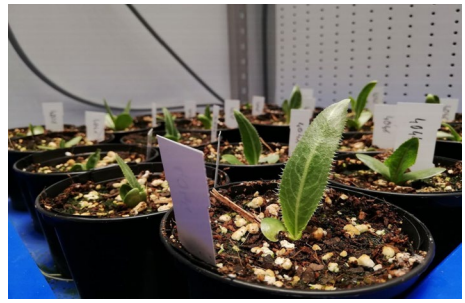

Fig. 6 Propagation of Akkoub at Kew's Millenium Seed Bank (Photo: N. Hani, SBR)

Nutritional analyses

Research reports the detection of a range of free amino acids in *G. tournefortii* inflorescences harvested from both Lebanon and Jordan (Taylor et al. 2019). These included seven of the eight essential amino acids, which were detected in all samples analysed: threonine, lysine, valine, tryptophan, leucine, phenylalanine, and isoleucine. In this study, proline was one of the principal amino acids detected in the *G. tournefortii* inflorescences analysed (Taylor et al. 2019). Proline has an important role in plant growth and differentiation across life cycle (Kavi Kishor et al. 2015) while in humans it has a role in collagen synthesis so can benefit tissue regeneration (Patriarca et al. 2021).

However, additional investigations are needed to further evaluate the nutritional composition of *G. tournefortii* from different geographic regions and those harvested at different times. If further research shows *G. tournefortii* to be a good source of different nutrients, this species could have a potential role in supplying inexpensive and readily available food for people living in rural areas. This could be especially relevant if food preparations of *G. tournefortii* are complemented with high protein ingredients such as egg or yoghurt commonly used in the recipes of traditional Lebanese recipes (Batal and Hunter 2007).

It should also be noted that available data on the nutrient composition of *G. tournefortii* is currently limited and additional research to further examine the nutritional value would enhance understanding of the role of this plant in the diet (Fig. 7).

Trade

Mainly between March and May, local gatherers (sometimes even whole families) swarm the hills in search of this spiny plant either for fun, personal use, or economic benefit. Depending on the country and the local climatic conditions the harvesting season can change, for instance in Jordan the core season to collect Akkoub for consumption (leaves and inflorescences) is between mid-February and the end of March. Sometimes local gatherers drive distances of more than 100 km to find locations where the plant is still abundant, due to wild populations' decline and picking bans (Lev-Yadun and Abbo 1999).

Fig. 7 Heeba (National Agricultural Research Center) and Nijad (Shouf Biosphere Reserve) sampling Akkoub edible parts (Photo: P. Gomez Barreiro, RBG Kew)

Plants are collected in large amounts from the wild because they are sold at high prices in local markets of different cities (Amman, Damascus, Haifa, etc.), or along roadsides interconnecting the main towns (Lev-Yadun and Abbo 1999; Vitek et al. 2017). Commercial picking takes place in the early morning, so that plants can be sold in local village markets during the afternoon (Lev-Yadun and Abbo 1999).

Conclusion

G. tournefortii is a valuable wild edible vegetable from Eastern Mediterranean that continues to provide food, medicine, and income to local communities, being also an integral part of their cultural identity. Unfortunately, the plant is exposed to extensive overharvesting that brought its wild populations to the brink of extinction. For this reason, many efforts have been made to implement effective propagation and cultivation techniques for *G. tournefortii*, even though further investigation is required to ensure an abundant and high-quality production in the future, especially considering the current increase of global food prices.

Therefore, the progress in tackling Akkoub's conservation and propagation issues, will contribute to fulfill the vision of the Food and Agriculture Organization of the United Nations (FAO) to create 'A world free of hunger and malnutrition, and one in which food and agriculture contribute to improving the living standards of all, especially the poorest, in an economically, socially and environmentally sustainable manner' (FAO 2017).

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Author contributions NH, SB, and TU wrote the manuscript. KA and LS participate in the manuscript development, mainly with inputs related to Jordan and Lebanon. NSE did the field work in Lebanon and the cultivation trials. EM did the propagation work and research. KS did the propagation work in the nursery in Lebanon. SB and NA made the corrections and additions to the whole manuscript. All authors revised the manuscript.

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Declarations

Conflict of interest The authors declare no competing interests.

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Abu-Qaoud

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