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Exploring the Nutritional Benefits and Conservation Status of Underutilized Wild Edible Plants in Rural Punjab

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Abstract: Wild edible plants hold immense potential for enhancing food security, nutritional diversity, and ecological sustainability, particularly among Indigenous communities. This study evaluates the nutritional composition, medicinal relevance, and conservation status of four underutilized wild species: *Chenopodium album, Amaranthus viridis, Digera muricata,* and *Tribulus terrestris*. A meta-analysis of existing literature revealed significantly positive effect sizes *for C. album, T. terrestris*, and *A. viridis*, with overall pooled estimates of 30.63, 39.84, and 7.16, respectively. Nutritional profiling showed *A. viridis* had the highest protein (35.11%) and fibre (14.04%) content, while *T. terrestris* was richest in calcium (1600 mg/100g) and carbohydrates (50%). *C. album* emerged as a key source of iron (45 mg/100g), zinc (51 mg/100g), and magnesium (160 mg/100g). Though *A. viridis* and *T. terrestris* are listed as “Least Concern” on the IUCN Red List, C. album and D. muricata remain unevaluated, highlighting critical gaps in conservation data. Integrating these nutrient-rich species into local food systems can not only improve dietary health but also support agro-biodiversity and preserve traditional knowledge systems.

Keywords: Nutrition, Diversity, Sustainable diets, Underutilized species

Indigenous peoples living in rural areas have developed profound knowledge of local biodiversity and sustainable food systems over millennia. Their traditional practices reflect a deep connection with the environment, fostering the conservation and sustainable use of natural resources, including wild edible plants. However, the encroachment of industrial agriculture, globalization and cultural disruptions have led to significant changes in their food systems. Industrialized food production and changing dietary patterns have contributed to the simplification of traditional diets, which has exacerbated nutritional deficiencies and increased health risks in these communities. These issues are further compounded by social and economic disadvantages, leaving indigenous populations more vulnerable to food insecurity and health challenges. One often overlooked aspect of indigenous food systems is the use of wild edible plants. Indigenous people living in rural areas have developed a profound understanding of biodiversity and sustainable food practices over generations. This traditional ecological knowledge is particularly valuable in the face of ongoing cultural disruptions and the global expansion of industrialized food systems. These pressures have led to the erosion of traditional diets, contributing to growing nutritional deficiencies and health problems in indigenous communities (Kuhnlein et al., 2009, Ghosh-Jerath et al., 2015).

Research indicates that *Chenopodium album* (Bathua) is rich in vitamins A and C, calcium, and iron, and possesses notable antioxidant and anti-inflammatory properties (Choudhary et al., 2020). *Amaranthus viridis* is also highly valued for its protein and micronutrient content, making it an important food source in regions affected by protein-energy malnutrition (Ganjare and Raut 2019). The decline in the utilization of these plants poses significant challenges for both nutrition and conservation. Habitat loss and the promotion of monocultures threaten the survival of these vital species. Integrating these plants back into local diets could enhance food security while promoting biodiversity conservation efforts (Subedi et al., 2006). This study examines the nutritional profiles, medicinal uses, and conservation status of five underutilized wild edible plants traditionally consumed by indigenous communities: *Chenopodium album, Amaranthus viridis, Digera muricata, and Tribulus terrestris*. These plants are often overlooked in modern food systems despite their significant health and ecological value.

MATERIAL AND METHODS

An extensive literature survey was conducted through the Web of Science database (http://apps.webofknowledge .com/), Google Scholar (http://scholar.google.com). To retrieve articles from the databases, the following search terms were used: “*Chenopodium album*” / “*Tribulus terrestris*” / “*Amaranthus viridis*” / “*Digera muricata*” OR “nutrient” / “medicinal” / “macronutrient” / “micronutrient” / “vitamins” / “nutritional profile” / “mineral composition/ “N” / “P” / “K” / “Ca” / “Mg” / “S” / “NPK”/ “Zn” / “Fe” / “protein” / “Calcium” / “Sulphur. To find pertinent information, references to connected articles were also examined. Peer-reviewed journal articles published from 2000and few articles from 1900 were shortlisted following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2017 and Fig. 1). We screened the retrieved articles and retained those that met the following four inclusion criteria: (i)The study contains nutritional profile of plant (ii) The study excluded other quality attributes such appearance, textural qualities, aroma, dimensions, hue, splitting, and illness incidence in favor of concentrating on quality criteria that were associated with the mass concentration of nutritionally significant elements. Software called JASP was used to analyze the data and standard error. Responses that did not overlap with zero in the 95% CI were considered significant ($p< 0.05$).

RESULTS AND DISCUSSION

Overview of analysed data: The forest plot illustrates the effect sizes and corresponding confidence intervals for individual studies included in the meta-analysis. Most studies investigating *Chenopodium album* in Figure 2 reported positive effect sizes, indicating a generally beneficial impact of the treatment or intervention. Notably, studies such as Poonia and Upadhayay (2015), Yadav and Sehgal (1999), and Yadav and Sehgal (1999.2) demonstrated large and statistically significant effect sizes, as their confidence intervals do not cross the zero-effect line. However, Pandey and Gupta (2014), reported non-significant results as their confidence intervals crossed the zero-effect line, suggesting uncertainty regarding the true effect. The overall effect size, represented by the diamond shape at the bottom of the plot, was estimated to be 30.63, with a confidence interval ranging from -2.19 to 63.44, as calculated using a random-effects model. While this suggests a generally positive effect, the wide confidence interval reflects a high degree of variability

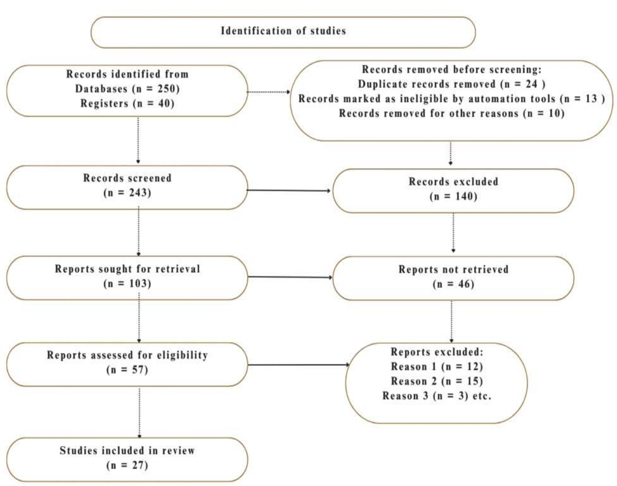

Fig. 1. Schematic diagram of identifying studies for analysis

among the included studies, potentially indicating heterogeneity in study design, interventions, or outcomes. This variability should be explored further to better understand its impact on the overall findings.

The forest plots presented in Figures 3, 4, and 5 summarize the effect sizes and 95% confidence intervals for studies evaluating the impact of *Tribulus terrestris, Digera muricata, and Amaranthus viridis*, respectively. In Figure 3, most studies on *Tribulus terrestris* report positive effect sizes, suggesting a generally beneficial impact of the intervention. Khalid et al. (2023) and Saeed et al. (2024) report strong and statistically significant results, with effect sizes of 21.33 [20.74, 21.92] and 220.00 [198.87, 241.13], respectively. These narrow confidence intervals that do not cross zero indicate high precision and reliability. However, studies such as Tkachenko et al. (2020) report an effect size of 0.00 [–0.20, 0.20], while 'Semerdjieva et al. (2019.4) shows very wide confidence intervals, indicating non-significant or highly uncertain results. The pooled effect size using a random-effects model was 39.84 [–2.19, 81.88], suggesting a positive trend with substantial heterogeneity. In Figure 4, which evaluates D. muricata, most studies also report positive outcomes. Verma et al. (2016) and Saeed et al. (2024) demonstrate strong effects with values of 24.10 [23.98, 24.22] and 220.00 [198.87, 241.13], respectively. Conversely, Gupta et al. (2005) and Saeed et al. (2024) report non-significant findings, The pooled effect size for Digera muricata was 50.69 [6.19, 95.19], indicating a significant overall effect. Lastly, Figure 5 shows the effect sizes for Amaranthus viridis. Studies such as Gupta et al. (2005.1), Umar et al. (2011), and Xarvier et al. (2018) report statistically significant and precise outcomes with effect sizes of 35.11 [32.76, 37.46], 21.05 [19.33, 22.77], and 24.54 [24.13, 24.95], respectively. However, several studies including Sarker and Oba (2019), and Achigan-Dako et al. (2014) show minimal or non-significant effects with confidence intervals that cross zero. The pooled estimate from the random-effects model for *Amaranthus viridis* was 7.16 [1.08, 13.25], indicating a statistically significant, though more modest, overall effect.

Nutritional Profile of Plants: Based on the combined data (Figure 2, 3, 4, 5), *Chenopodium album* exhibited a moderate fat content of 2.5% and a protein level of 12%. Its carbohydrate content was 25%, and it also contained 5% crude fibre. Mineral analysis revealed substantial amounts of potassium (400 mg/100g), magnesium (160 mg/100g), and calcium (150 mg/100g). Additionally, C. album was rich in iron (45 mg/100g) and manganese (1.2 mg/100g), indicating its potential to contribute to dietary micronutrient intake, particularly in relation to oxygen transport and antioxidant defense. *Tribulus terrestris* showed a high carbohydrate content of 50% and a protein level of 10%, making it a valuable source of plant-based energy and protein. Although its fat content was relatively low (1.1%), it contained significant levels of calcium (1600 mg/100g), magnesium (130 mg/100g), and potassium (300 mg/100g), all essential for bone development, muscle function, and cardiovascular health. Iron content was also notable at 9.2 mg/100g, along with trace amounts of zinc and copper. *Digera arvensis* presented a balanced nutritional profile, with 15% crude fibre, 8.75% protein, 48% carbohydrates, and 1.5% fat. It was moderately rich in minerals such as calcium (145 mg/100g), potassium (350 mg/100g), and magnesium (120 mg/100g). Although its iron content (6 mg/100g) and copper (0.5 mg/100g) were lower compared to the other species, it still contributes to the intake of essential micronutrients. *Amaranthus viridis* stood out as the most nutrient-dense species, with the highest recorded protein content (35.11%) and crude fibre (14.04%). It also contained 0.47% fat and 7.67% carbohydrates. Mineral analysis showed good levels of magnesium (100 mg/100g), potassium (310 mg/100g), and calcium (140 mg/100g), along with iron (20 mg/100g) and manganese (1.0 mg/100g). These values highlight its potential as a functional food with significant nutritional benefits, especially for addressing protein and micronutrient deficiencies.

Recent assessments from globally recognized conservation databases such as the IUCN Red List and

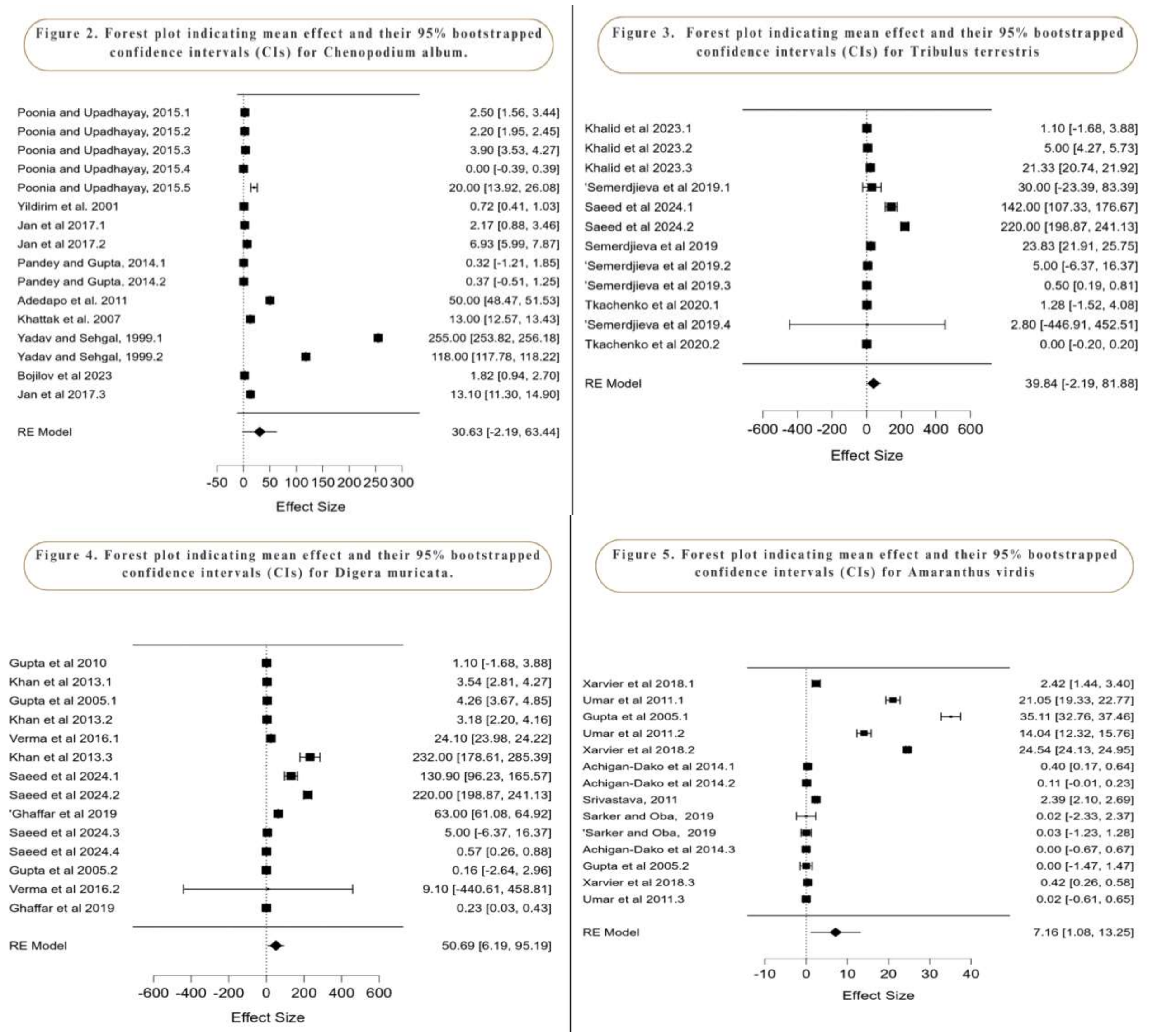

Fig. 2-5. Forest plot indicating mean effect and their 95% bootstrapped confidence intervals (CIs) for *Chenopodium album, Tribulus terrestris, Digera muricata and Amaranthus virdis*

Table 1. Nutritional composition of four wild edible plants (per 100 g dry weight), showing macronutrient and micronutrient values in *Chenopodium album, Tribulus terrestris, Digera arvensis,* and *Amaranthus viridis*

Plant name / Nutrient dose	*Chenopodium album*	*Tribulus terrestris*	*Digera arvensis*	*Amaranthus viridis*
Crude fibre (%)	5	1.3	15	1.93
Fat (%)	2.5	1.1	1.5	0.47
Carbohydrate (%)	25	50	48	7.67
Protein (%)	12	10	8.75	2.11
Ash (%)	4	4.6	8	1.85
Zn (mg)	51	1	2	2
Mg (mg)	160	130	120	100
P (mg)	80	70	90	85
K (mg)	400	300	350	310
Na (mg)	10	15	12	11
Ca (mg)	150	1600	145	140
Cu (mg)	0.8	0.6	0.5	0.4
Mn (mg)	1.2	1.1	1.3	1
Fe (mg)	45	9.2	6	20

Plants of the World Online (POWO) indicate that *Tribulus terrestris* and *Amaranthus viridis* are currently classified as species of “Least Concern.” This status reflects their wide distribution, ecological adaptability, and stable population trends, suggesting that they are not facing immediate threats to their survival. In contrast, the conservation status of *Chenopodium album* and *Digera arvensis* (syn. *Digera muricata*) remains largely undocumented or unassessed by major international conservation authorities. These species are not currently evaluated in the IUCN Red List, and their population data are sparse in databases such as the Global Biodiversity Information Facility (GBIF). Despite their traditional use and nutritional value, limited ecological studies have been conducted on their habitat dynamics, population trends, or potential threats. This knowledge gap highlights the urgent need for targeted conservation research to determine their vulnerability, especially in regions where natural habitats are increasingly being modified by agricultural intensification and urban expansion. Integrating these lesser-known wild edibles into conservation planning and biodiversity monitoring could help ensure their long-term sustainability, while also preserving traditional ecological knowledge associated with their use.

The nutritional and medicinal relevance of underutilized wild edible plants is increasingly recognized in sustainable food system research. This study evaluated *Chenopodium album*, *Amaranthus viridis*, *Digera arvensis*, and *Tribulus terrestris*, confirming their potential in addressing nutritional deficiencies and preserving traditional food knowledge. *Chenopodium album* is known for its high levels of micronutrients such as calcium, iron, and zinc, along with antioxidants and phenolics. Singh et al. (2023) documented its antimicrobial and anti-inflammatory properties, affirming its nutritional and therapeutic relevance. *Amaranthus viridis* displayed the highest protein and fibre content among the studied plants. Silva et al. (2021) highlighted its phenolic and flavonoid bioaccessibility and strong antioxidant activity, supporting its role as a functional food. Although *Digera arvensis* is less researched, Gupta et al. (2010) demonstrated its good nutritional potential and traditional usage in rural diets. Its incorporation into community-based nutrition strategies could support food security efforts, especially in undernourished populations. *Tribulus terrestris* stood out for its exceptionally high calcium content and saponin-rich phytochemistry. Saeed et al. (2024) emphasized its pharmacological roles, including anti-inflammatory and potential anti-obesity effects, making it a multipurpose nutraceutical candidate. While *A. viridis* and *T. terrestris* are listed as “Least Concern” by the IUCN, the absence of conservation data for *C. album* and *D. arvensis* warrants ecological assessments. Promoting the cultivation and integration of these species into local food systems can address malnutrition, enhance biodiversity, and preserve indigenous agricultural practices

CONCLUSION

This study highlights the nutritional significance, medicinal potential, and conservation relevance of five underutilized wild edible plants traditionally consumed by Indigenous communities: *Chenopodium album*, *Amaranthus viridis*, *Digera muricata*, and *Tribulus terrestris*. Meta-analysis and nutritional profiling revealed that these species are rich in essential macro- and micronutrients, particularly protein, iron, calcium, and dietary fibre—making them valuable contributors to food and nutritional security. Among them, *Amaranthus viridis* and *Tribulus terrestris* demonstrated the highest protein and mineral contents, while *Chenopodium album* showed considerable micronutrient density. Despite their traditional importance, *Chenopodium album* and *Digera muricata* remain underrepresented in global conservation assessments, emphasizing the need for further ecological monitoring. Reintegration of these plants into contemporary diets and farming systems could address micronutrient deficiencies, support sustainable food systems, and conserve traditional ecological knowledge. Overall, this study advocates for the recognition and revitalization of wild edible plants as viable components of climate-resilient and culturally respectful food strategies.

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