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Eco-Friendly Solutions: Integrating Wild Vegetables for Sustainable Agriculture, Food Security and Human Health

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WILD vegetables play an essential role in the diets of people around the world. Using wild plants for sustenance is one of the survival techniques, and it is strongly related to a strong component of customs and culture.The prevalence of malnutrition, non-communicable diseases associated with diet, and poverty worldwide has led to the investigation of wild crops (Spider plant, sorrel, kohila and Chinese yam) as a potential solution for a wholesome food crop to deal with these problems. For centuries, wild vegetables have been a primary source of micronutrients for humans, supplying essential vitamins and minerals necessary for maintaining good health and bolstering immunity against infections. This has resulted in millions of people relying on them as a dietary staple. Wild vegetables are characterized by their resilience and low maintenance requirements, making them superior to traditional cultivated varieties. Additionally, they are an abundant source of essential nutrients. Therefore, their potential to address micronutrient malnutrition and ensure food security is significant. Since wild plants frequently naturally adapt to a variety of environmental circumstances, they are more resistant to the negative effects of climate change. Wild vegetables are an excellent source of nourishment due to the abundance of accessible components with the ability to stand against different abiotic stresses like salinity, drought, and heavy metals. They can make significant contributions to people's diets around the world. Natural selection has refined the genetic diversity of wild crops over millennia, enabling them to flourish in a variety of environmental situations.Genes that confer resistance to abiotic stressors such as heat, salinity and drought are present in wild relatives. To increase the robustness of cultivated cultivars, these genes have been effectively introgressed.

Keywords: Vitamins, Minerals, Malnutrition, Abiotic stresses, Wild vegetables.

1. Introduction

The living, edible components of herbaceous plants are known as vegetables. It could contain plant elements including roots, stems, leaves, fruits, or seeds that are edible raw or cooked. Because they make up the majority of the world's staple foods, vegetables are a crucial component of the diet of human beings (Satter *et al*., 2016). Its nutritional significance and vital biochemicals are widely recognized, as it can store substantial quantities of fatty acids, proteins, dietary fiber, vitamins and minerals (Saikia *et al*., 2013 and Satter *et al*., 2016). It is recommended to consume more of it because it may lower the chance of developing illnesses like obesity, cancer, diabetes and coronary heart disease, and it is crucial for a balanced diet (Stangeland *et al*., 2009 and Aworh, 2018). Because of the potential nutritional and medicinal benefits of wild plant species to diversify the human diet, there has been a resurgence of interest in them in the past few years (Afolayan and Jimoh,

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2009; Ng *et al*., 2012). Wild leafy vegetables are grown for sustenance in underdeveloped nations, especially in locations where there is food insecurity. In wealthy nations, people generally ignore these kinds of vegetables. Perhaps the most important aspect in determining whether a person or family can sustain nutritional health, become malnourished, or perish is understanding of these wild animals. In addition, wild vegetables have a significant influence on the economy due to the fact that they are used in the production of meals, fibers, medications, and in a variety of ceremonies (Flyman and Afolayan, 2006). The definition of "wild vegetable" refers to plant species that are not raised for commercial purposes. According to Chadha and Oluoch (2003), including wild vegetables into dietary habits has been promoted as the most practical and sustainable way to achieve this, since they are efficient sources of several important micronutrients, both in terms of unit cost of production and per unit area (Flyman and Afolayan, 2006). This is because the best method to accomplish this goal is to include wild veggies in diets. There are several traditional wild vegetables around the world that are important for agriculture, health, and nutrition. Due to their unique flavors, textures, and other sensory qualities, these vegetables have the ability to diversify dietary patterns (Uusiku *et al*., 2010).

Climate change is a pressing concern in modern times because it contributes to the occurrence of natural disasters such as droughts, floods, and other such calamities, as well as to the depletion of freshwater resources, it thus lowers the quantity of calories that can be produced (Ghorai *et al*., 2023). Following the onset of COVID-19 pandemic, disruptions in overall economic activities and then within the supply chains for food have seriously compromised the sustainable livelihood and the nutritional and alimentary security of households in agri-food systems and agriculture in underdeveloped nations (Rajput *et al*., 2021 and Singh *et al*., 2023a). These disruptions have occurred as a direct result of the outbreak of the COVID-19 pandemic (Laborde *et al*., 2020; Mahmud and Riley, 2021 and Balana *et al*., 2021). Together with the International Fund for Agricultural Development (IFAD), UNICEF, the World Food Programme (WFP) and the World Health Organization (WHO), FAO published the most recent edition of the State of Food Security and Nutrition in the World 2019 (WHO, 2019) in July 2019. This FAO flagship publication provides new evidence that the world's hunger rate has been rising during the previous three years, approaching more than 820 million in 2018, which is equivalent to one in every nine people. As a result, the number of individuals who experience persistent hunger has increased to levels similar to those seen a decade ago (Boliko, 2019). At the moment, the world has to deal with both undernutrition (like being thin, short and underweight) and over nutrition (like being overweight and obese) (Alemu, 2020). In addition, nearly three billion people worldwide lack access to proper nutrition due to the rising costs of nutrient-dense foods and the ongoing expansion of income disparities (FAO, 2021). On the other hand, consuming diets of poor quality leads to micronutrient deficiencies, which in turn leads to an illnesses that are not communicable and metabolic syndrome (Willett *et al*., 2019). Only 103 crops out of 30 thousand edible plants are responsible for 90 percent of the world's food supply (FAO, 2019). More than half of the diet composed of plants that humans eat is made up of three primary crops: wheat, rice, and maize (FAO, 2018). In order to increase the number of wholesome food sources, it is imperative and widespread to employ locally accessible, extremely versatile and underutilized crops. (Mustafa *et al*., 2021). Given the current worldwide pandemic and climate change-related problems, this is extremely crucial.

The primary aim of study is to summarize how adding wild vegetables to agricultural systems might support ecological resilience and socioeconomic development while also improving food security, nutritional diversity and sustainable food production.

2. Significance of wild vegetables in food and nutritional security

Wild vegetables include necessary nutrients, vitamins, and minerals. They frequently have distinct nutritional profiles that complement conventional crops, offering a greater range of nutrients required for a healthy and balanced diet (Fig.1). Wild vegetables are considered to be a great supplier of vitamin C, beta-carotene, and various mineral constituents, including macro elements such as Na, K, Ca, Mg, and P, as well as trace elements like Fe, Zn, Cu, Mn, Cr, and Ni. These nutrients are widely recognized for their significant role in promoting human health (Saikia *et al*., 2013). Apart from their nutritional importance, many wild vegetables include compounds with potential therapeutic qualities. Natural phenolic and flavonoid molecules, which are secondary metabolites of plants, have an aromatic ring with at least one hydroxyl group. Because phenolic substances include hydroxyl groups, which allow them to function as effective electron donors, they have significant antioxidant qualities. In biological systems, phenolic compounds have been shown to scavenge oxygen, break down peroxides, inactivate metals, and block free radicals. This can aid in preventing the burden of oxidative disease. The utilization of natural antioxidants sourced from wild vegetables is crucial in safeguarding the body against the detrimental effects of free radicals (Cote *et al*., 2010; Bendary *et al*., 2013; Tungmunnithum *et al*., 2018 and Aryal *et al*., 2019). Eating wild vegetables that are rich in phenolic and flavonoid components with potent antioxidant effects has been linked to a lower risk of heart disease, cancer, diabetes, and neurological illnesses, according to a number of epidemiological studies (Yen *et al*., 2000 and Oberoi *et al*., 2015). The table 1 contains a description of various types of wild vegetables. Moreover, providing seasonal wild vegetables throughout the off-season will improve accessibility, provide food stability and make the household year-round food secure. There is ample evidence that wild vegetables may supply the nutrients needed for human physiology. It has been demonstrated that they are more nutritious than common veggies like spinach and cabbage (Bvenura and Afolayan, 2015). A growing number of people on the planet, climate change, and other issues that have an impact on agricultural output make food security a pressing worldwide concern. In order to feed a growing global population and maintain food security, more food must be produced with fewer resources, which is a topic of great global interest. Food insecurity as well as malnutrition can be decreased by cultivating wild vegetables in household gardens and encouraging eating of them (Borelli *et al*., 2020).

3. Utilization of wild relatives vegetables and Crop plants for management of abiotic stresses

The main environmental variables that restrict plant dispersion in nature and lower crop yields globally are abiotic stresses, primarily salinity and drought (Singh *et al*., 2023b). Climate shocks will affect the cost and accessibility of wholesome, nutrient-dense foods, rendering them unaffordable for marginalized and vulnerable populations (Campbell *et al*., 2016). According to estimates, 70% of people in Asia, Africa, and the Asia-Pacific region will have poorer nutrition and food security as a result of ongoing climate change (SADC, 2020). The ability of wild vegetables to adapt to varying environmental conditions has been developed over their evolutionary history. Studies have revealed that some wild vegetables have characteristics like heat tolerance, pest resistance and drought resistance. These adaptive qualities can be useful in creating food systems that are climate change resilient, especially in areas that are susceptible to its effects (Kapazoglou *et al*., 2023).

Some plants are naturally adapted to a variety of abiotic stresses. Examples of these plants include halophytes, or salt-tolerant plants found on saline soils; gypsophytes, or plants adapted to gypsum soils; and xerophytes, or drought-resistant plants found in arid and semi-arid regions. One of the most prevalent ways that plants respond to stress is by synthesizing osmolytes, or suitable organic solutes (Flowers and Colmer, 2008; Hussain *et al*., 2008; Türkan and Demiral, 2009). Osmolytes are low-molecular-weight, highly soluble organic substances that, even in large quantities, do not disrupt regular metabolism (Vicente *et al*., 2016). They are diverse chemically, containing soluble sugars like trehalose, sucrose, fructose, or glucose, polyols like glycerol, sorbitol, mannitol, and several isomers and derivatives of inositol, and some amino acids like proline and quaternary ammonium compounds (QACs) like glycine betaine (GB) (Sairam and Tyagi, 2004; Bartels and Sunkar, 2005).

Table 1. The following is a compilation of different categories of wild vegetables.

SN	Scientific name	Common name/ Local name	Edible part
Araceae			
1	*Amorphophallus paconiifolius*	Olkasu	Whole plant
2	*Lasia spinosa*	Seng mora	Whole plant
3	*Polygonum microcephalum*	Madhu saleng	Twigs
Amaranthaceae			
4	*Amaranthus viridis*	Khutura	Twigs
5	*Alternanthera sessilis*	Bhiringijhar	Whole Plants
6	*Celosia argentea*	Bhulki	Twigs
7	*Digera muricata*	Lehasuwa	Leaves and shoots
8	*Derringiaamaranthoides*	Hanthai	Tender shoots
Cleomaceae			
9	*Cleome gynandra*	Spider plant	Stems and leaves
Compositeae			
10	*Enhydra fluctuans*	Helencha	Leaves, young plant parts
Cucurbitaceae			
11	*Bryonia dioica*	Red bryony	Young shoots with little leaves
Dioscoreaceae			
12	*Dioscorea hamiltonii*	Pit kanda	Rhizome
13	*Dioscorea oppositifolia*	Sika kanda	Rhizome
14	*Dioscorea pentaphylla*	Mitnikanda	Rhizome
Fabaceae			
15	*Cassia tora*	Sano tapre	Leaves and seeds
16	*Abrus precatorius*	Gunja / Haripatti	Leaves
17	*Crassocephalumcrepidioides*	Fireweed	Leaves
Lamiaceae			
18	*Leucas aspera*	Chanrongan	Fresh leaves
Nymphaceae			
19	*Nymphaea stellata*	Shapla	Stems
Oxalidaceae			
20	*Oxalis corniculata*	Saru	Whole plant
21	*Oxalis debilis* var. *corymbosa*	Tengasi	Whole plant
Plantaginaceae			
22	*Limnophilaaromaticoides*	Finger grass	Leaves
Portulacaceae			
23	*Talinum triangulare*	Bilatipaleng	Leaves
Pontederiaceae			
24	*Monochoria vaginalis*	Pickerelweed	Leaves
Polygonaceae			
25	*Rumex papillaris*	Sorrel	Basal leaves
26	*Rumex pulcher*	Fiddle Dock	Leaves
27	*Persicariamicrocephala*	Delap	Leaves
Polypodiaceae			
28	*Dryopteris filix-mas*	Dhekishak	Stems and leaves
Saururaceae			
29	*Houttuynia cordata*	Saru Tengasi	Whole plant
Solanaceae			
30	*Solanum nigrum*	Kaalo Bihin	Roots and fruits
31	*Solanum torvum*	Turkey gooseberry	Fruits
32	*Physalis peruviana*	Cape gooseberry	Leaves
Verbenaceae			
33	*Clerodendrum indicum*	Bapnem-ai	Tender shoots
34	*Clerodendrum serratum*	Phelanriho	Ripe fruits
Zingiberaceae			
38	*Achasma nigra*	Tora	Stem
39	*Zingiber zerumbet*	Shampoo zinger	Rhizome and flowers

A significant food production constraint is drought, particularly in light of global climate change. In plants from arid environments, proline is one of the most prevalent and well-researched compatible solutes that builds up in response to water stress. According to reports, the quantities of proline in three desert species- *Calotropis procera, Senna holosericea, and Aerva japonica*-increased as water stress increased (Vicente *et al*., 2016). The C_4 photosynthetic mechanism of *cleome gynandra* plants allows them to adapt well to a wide range of habitats, mainly in warm climates (Raju and Rani, 2016). Mishra *et al*. (2011) found that plants can survive in hot, dry regions with a variety of soil types, including semiarid, humid, and subhumid ones, thanks to their photosynthetic pathway and mechanism. In order to effectively assimilate carbon, the C_4 photosynthetic pathway uses the principal CO_2-fixing enzyme, phosphoenolypyruva carboxylase, to distill CO_2 near to ribulose-1,5-biphosphate carboxylase/oxygenase (Sommer *et al*., 2012). There are some genes that are responsible for this, but these are still unknown. Plant growth is clearly inhibited by salt stress, which has two well-known components: osmotic stress and ion toxicity. According to Flowers and Colmer (2008), halophytes are plants that have evolved to thrive and complete their life cycle in environments where the soil salinity is at least 200 mM NaCl. Their capacity to collect Na^+ and Cl^- in the vacuole, where their levels are far lower in the cytoplasm and prevent metabolic processes from being inhibited, is the primary mechanism underlying their salt tolerance (Kapazoglou *et al*., 2023). Plants such as *Arthrocnemumfruticosum*, *Camphorosmaannu*, *Lepidiumcrassifolium*, *Limonium gmelini* subsp. *hungarica*, *Inula crithmoide* and *Plantago craasifolia* can thrive in saline environments, increasing sodium and total soluble carbohydrate levels in their roots.There are a few different ways in which wild vegetables can be categorized, some of which include their botanical family, habitat, nutritional content, and culinary application.

I. Drought Stress

According to several studies food crops are particularly vulnerable to the detrimental effects of drought throughout their vegetative, pre-anthesis, and terminal stages of growth (Fig 2). Common physiological impacts of drought on plants include wilting, decreased leaf area and abscission, decreased transpiration, and higher pH of leaf sap (Fghire *et al*., 2015; Turner *et al*., 2001). The reduction in turgidity also has a negative impact on cell proliferation. Different researchers found that water flows via the xylem is similarly hindered. Lower levels of mitosis and expansion limit cell elongation in drought (Naz *et al*., 2016; Akram *et al.,* 2017). Drought stress at the start of the reproductive cycle reduces flower output (Ondrasek and Rengel, 2021; Singh *et al*., 2023c). Reduced nutrient absorption and damage to photosystems I and II, leading to lower assimilate synthesis, are both caused by water deficiency in plant tissues (Farooq *et al.,* 2020). Due to the decline in Rubisco activity, photosynthate synthesis is limited under severe drought (Bota et al., 2004). Stressful environments lead to an overabundance of reactive oxygen species (ROS), including O_2^{-2}, hydroxyl radicals (OH^-), and hydrogen peroxide (H_2O_2). These ROS can cause oxidative damage to essential cellular components, including membrane lipids, proteins, enzymes, pigments and nucleic acids (Sari et al. 2024). Oxidative metabolism in peroxisomes, mitochondria, and chloroplasts produces reactive oxygen species (ROS), which harm DNA, proteins, chlorophyll and membrane function (Sade *et al*., 2011). In addition, photosynthetic electron transport adapts to the availability of carbon dioxide in chloroplasts and changes in photosystem II are noted under water deficiency situations (Bhatla and Lal, 2018). Enzymes, including those responsible for regulating cytoplasmic viscosity, are vulnerable to the elevated concentration of solutes that occurs during drought (Bhatla and Lal, 2018).Since the activity of the Calvin cycle enzyme ribulose phosphatase is detrimentally increased during drought, starch synthesis is reduced.

II. Salinity Stress

Worldwide, people have concerns about a rise in salinity-affected areas (Ghazaryan *et al.*, 2018 and Van Zelm *et al.,* 2020). This problem is mostly caused by inefficient irrigation and water management (Singh *et al*., 2022). Salinity water may move upstream to areas where freshwater was previously present due to sea level rise. Water quality in an estuary can be lowered by salinity intrusion, making the water unfit for drinking, industrial, or agricultural use (Liu and Liu, 2014). Plants are unable to thrive in soils and irrigation water that are excessively salty (Ghazaryan *et al*., 2023 and Singh *et al.* 2023d). One of the most prevalent effects of saltiness on plants is osmotic stress (Abdel and Faiyad, 2024). Meanwhile, salinity-induced ionic stress stunts plant development (Van Zelm *et al*. 2020, Horie *et al*., 2012; Anirudh *et al*., 2020; Singh *et al*., 2024a). The negative impacts are more apparent in metabolic and physiological systems (Kamran *et al*., 2020 and Mohamed, 2020). Salinity causes chaos on plants, causing abscission, increased density and succulence, lower leaf area and index, shoot necrosis, and shorter internode lengths (Singh *et al*., 2024a; 2024b). Extreme stress can lead to cell death, and salinity slows growth.

4. Wild plants and soil health

Through a number of processes, wild plants significantlyinfluence the characteristics of the soil.Wild plants help to build soil organic matter through the breakdown of plant leftovers. This organic matter improves soil fertility, structure, and water retention ability (Lal, 2004). They contribute significantly to nutrient cycling by absorbing nutrients from the soil and integrating them into their tissues. When plant tissues disintegrate, nutrients are released into the soil, promoting future plant growth (Wardle *et al*., 2004). The root systems help hold soil particles together, which reduces erosion and improves soil stability. Furthermore, the canopy cover supplied by wild plants can intercept rainfall, lowering the erosive impact on the soil surface (Schlesinger and Pilmanis, 1998).Wild plants help various soil microbial communities by supplying organic matter and habitat. These microbial communities are critical to nutrient cycling, soil structure maintenance and general soil health (Bardgett and Wardle, 2010).

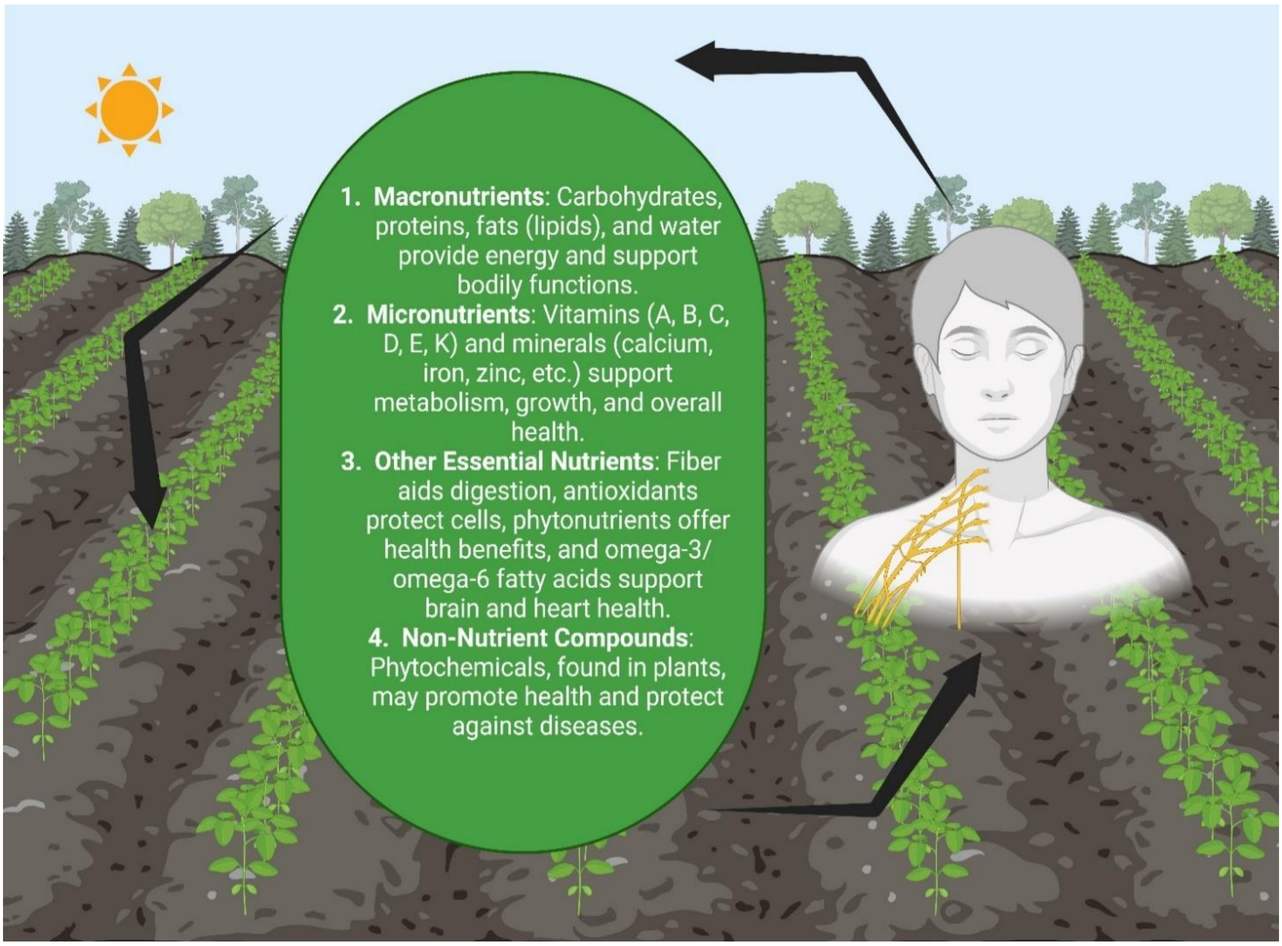

Fig. 1. A simplified scheme with traditional usage and the most characteristic biological attributes of wild plant.

5. Chemical nutrition of wild vegetables: risks and benefits for human health and the environment

In comparison to cultivated forms, wild vegetables frequently have a greater spectrum of vitamins, minerals and phytochemicals, as well as a larger nutritional diversity. For example, a study on edible wild greens revealed that they were high in minerals like calcium, iron, and magnesium as well as important elements like vitamins A, C and K (Nandal and Bhardwaj, 2014). Furthermore, bioactive substances like flavonoids, phenolic acids and carotenoids, which have been linked to a number of health advantages like antioxidant and anti-inflammatory qualities, are frequently found in higher concentrations in wild vegetables (Table2).

Heavy metal contamination is a major hazard for wild vegetables, especially those grown in urban or industrial environments (Vardumyan *et al*., 2024). A class of metals and metalloids known as heavy metals have comparatively large densities and are hazardous even at ppb concentrations. Pb, As, Hg, Cd, Zn, Ag, Cu, Fe, Cr, Ni, Pd and Pt are a few examples. Studies have found higher levels of heavy metals such as lead, cadmium, and mercury in wild vegetables obtained from contaminated locations, which pose health hazards when consumed (Satter *et al*., 2016). Certain wild vegetables contain naturally occurring toxins or anti-nutrients that can be toxic if consumed in high quantities or improperly cooked. For example, oxalates in some wild greens may cause kidney stones or interfere with mineral absorption (García-Herrera *et al*., 2020). For example, while *S. nigrum* has been used as a medication or food for thousands of years and has been linked to a wide range of pharmacological activity, there have been little studies on the plant's safety and adverse effects. When normal persons consume the regularly used dose of S. nigrum (30-60 g), harmful and adverse effects are uncommon. Overdose, on the other hand, can result in poisoning, with symptoms including headache, abdominal discomfort, vomiting, diarrhea, pupil dilatation, arrhythmia, coma, and others (Mo *et al*., 2014). According to Agbaire and Emoyan (2012), anti-nutritional factors can disrupt metabolic pathways and negatively impact nutrient growth and bioavailability. Phytate and oxalates can form chelates with metallic ions including Cd, Mg, Zn and Fe, resulting in poorly soluble compounds that are not easily absorbed by the gastrointestinal tract. Green leafy vegetables are crucial for revenue production and sustenance, as they provide essential nutrients and vitamins at the lowest cost. However, they include anti-nutritional components that limit the availability of essential nutrients. Oxalates, phytates, and nitrates are found in commonly consumed dwarf copper plant and spider plant (Mwanri *et al.*, 2018). Unsustainable collection of wild vegetables can have a negative impact on local ecosystems and biodiversity. Overharvesting of particular species can result in population decreases and possibly extinction, upsetting ecological balance and diminishing ecosystem resilience. Habitat destruction and fragmentation caused by wild vegetable harvest, such as deforestation or land clearing, lead to wildlife habitat loss and ecosystem deterioration. Conservation activities are critical to mitigating these effects and encouraging sustainable harvesting techniques (Rist *et al*., 2010).

6. Categorization of wild vegetables

Leafy Vegetables

The current category comprises of plants that are predominantly cultivated for their foliage. The aforementioned vegetables are frequently rich in essential nutrients such as iron, calcium, and vitamins.

6.1 *Cleome gynandra* (Spider plant)

It is an erect, branched herbaceous annual plant that can grow up to 1.5 meters in height (Vorster *et al*., 2002). The leaves have three to seven leaflets and are complex and palmate. The stem has longitudinal parallel lines and is grainy but barely hairless. It originated in sub-Saharan Africa and Southeast Asia, according to Bala *et al*. (2010), Munene *et al*. (2018), and Shilla *et al*. (2019). Healthy eating, food security, and overall wellbeing may be facilitated by this plant’s nutritional and medicinal properties. (Moyo and Aremu, 2022). This vegetable is ideal for farming systems in arid regions where drought frequency is expected to rise as a result of climate change (Frischen *et al*., 2020) because of its resilience to drought and high nutritional content (Cernansky, 2015). In rural parts of several African countries, spider plant is a crucial leafy vegetable for achieving family food security (Van Wyk and Gericke, 2000; Vorster *et al*., 2002; Mabhaudhi *et al*., 2017).

Table 2. Wild vegetables chemical nutrition and benefits on Human health.

Vegetables	Nutritional Content	Health Functions
Cleome gynandra (Spider plant)	Vitamins (A and C), protein, fibre, minerals (Ca, Fe, Zn, K, Mg, Na), violaxanthin, a and b-carotene, a, b, and g -tocopherol, bcryptoxanthin and luteolin.	Anti-inflammatory, anti-bacterial,antimicrobial, anticancer, antioxidant, antiallergenic, antispasmodic, antihyperglycemic and cytotoxicity properties.
Lasia spinosa (Kohila)	Protein, fibre, vitamins (C and E), alkaloids, carbohydrates, flavonoids, polyphenols, beta-carotene and lycopene.	Anti-hyperglycemic, anti-hyperlipidemic, anti-nociceptive activity, antioxidant activity , anthelmintic, anti-inflammatory, anti-diarrheal, gastro-protective activity.
Alternanthera sessilis(Dwarf copper leaf)	Vitamin B_1 and B_2, minerals (Ca, Na, Fe, Zn, K, Mg, Cu), Vanillic acid, Quercetin, Carotenoids.	Cardiovascular Disease, Renal diseases and hepatoprotective effects, hypertension, cholesterol lowering and hyperlipidemia.
Solanum tovrum(Turkey berry)	Protein, crude fat, carbohydrate, minerals (Fe, Zn, Cu, Mn, Ca, Mg, Na, K), vitamins (E, B and C), fibre, saponins, tannins, flavanols, terpenoids/steroids and glycosides,.	Cardio protection and heart related diseases treatment, nephro-protection, anti-inflammatory, analgesic action, anti-ulcers and anti-microbial activities.
Solanum nigrum (Black nightshade)	Protein, fibre, minerals (Ca, Na, Fe, Zn, K, Mg, S, Mn), mannose, glucose, galactose, arabinose, gallic acid and ursolic acid.	Antitumor, anti-inflammatory, antioxidant, antibacterial, neuroprotective activities. To cure eucorrhea, sore throat, toothache, dermatitis, eczema, carbuncles and furuncles.
Dioscorea oppositifolia(Chinese yam)	Minerals (K, S, Ca, Mg, Fe,Zn, Cu, Mn), mannan, allantoin, diosgenin, dopamine, batatasine, phytic acid, abscisin II, amino acids, glucoprotein, choline, ergosterol, campesterol, dioscorin, saponins, starch, non-starch polysaccharides, flavonoids, ascorbic acid, polyphenols.	Antioxidant, antiinflammatory, antidiabetic, anticancer, prebiotic activity, neuroprotective, antihyperlipidaemic, gastroprotective and fertility-enhancing activity.
Nymphaea stellata (Blue lotus)	Minerals (Na, K, P, Ca), Astragalin, corilagin, gallic acid, gallic acid methyl ester, isokaempferide, kaempferol, quercetin and nymphayol.	Tumor inhibition, antidiabetic, antihepatotoxic effect, cholinergic activity, analgesic, anti-inflammatory and antimicrobial activity.

Flavonoids, vital ions, polyphenols, and terpenoids are among the dietary polyphenolic phytochemicals found in the leaves that help maintain good health (Chataika *et al*., 2022; Moyo and Aremu, 2022).The oil from the seeds contains a lot of polyunsaturated fats, which are highly beneficial to health and may also be produced by manual pressing (Mnzava, 1990). It has been established that this specific source is both widely accessible and reasonably priced (Uusiku *et al*., 2010; Aworh, 2015). It is also high in protein (23.4%), fiber (8.3%), and other important minerals. It is also high in important vitamins, including A and C. In the research conducted by Moyo *et al*. (2018), it was found that *C. gynandra*leaves contain greater amounts of calcium, iron, phosphorus, potassium, and vitamin C in comparison to commercially available vegetables such as cabbage and swiss chard. The leafy parts of the plant are the most commonly consumed edible component (Van Wyk and Gericke, 2000). Fresh leaves can be dried and then stored in a jar for eating in the winter and spring (Mashmaite*et al*., 2022).

It is possible to preserve dried leaves for up to a year and as long as three to four months, according to studies by Faber *et al.* (2010) and Steve *et al.* (2017). Despite its potential advantages, the technology is presently underutilised and disregarded on a global scale. The current stage of development for this cultigen as a cultivated crop is in its infancy, primarily due to insufficient understanding regarding its availability, affordability, nutritional value, and potential health benefits (Mashmaite *et al*., 2022).

6.2 *Lasia spinosa* (Kohila)

L. spinosa is a plant that can thrive in both aquatic and terrestrial environments. It has short-stemmed spiny and an underground rhizome. Usually found in wetlands, open marshes, wet woodlands, or places where water is always standing, this plant (Keating, 2002). This is a large, strong, one-meter-tall marsh plant with leaves that are 20–30 cm in length and deeply divided into 4-6 sets of slender side lobes. The petiole is between thirty and forty centimeters long. Hiong (2009) describes the veins below the skin of the petiole and peduncle as having a prickly texture. The plant, which originally came from India, has since made its way to New Guinea, China, and the peninsula of Malaysia (Hossain *et al*., 2021). The plant is gathered from its natural habitat for the purpose of utilizing its consumable foliage and diverse medicinal properties. In certain instances, it is also grown as a vegetable crop in proximity to the edges of ponds (Lakshmi *et al*., 2020 and Shen *et al*., 2020). Regarding their biological properties, this plant's sensitive leaves and rhizomes, used as a vegetable and in traditional medicine, have been suggested for a number of diseases (Hossain *et al*., 2021). Numerous reports have been published regarding the medicinal and economic properties of *L. spinosa*. According to Temjenmongla and Yadav (2005), this plant is frequently used to cure a variety of illnesses, including colic, TB of the lymph nodes, lymph node enlargement, rheumatism/rheumatoid. arthritis, bruises, snake bites, and insect bites. It may also be useful in the treatment of uterine cancer, pulmonary inflammation, bleeding cough, constipation, sore throat, and blood purification (Das et al., 2009). Rhizomes, which are underground stems of plants, are commonly utilized as a treatment for haemorrhoids in Sri Lanka and Malays (Hossain *et al*., 2021). They are also believed to provide protection against the aforementioned conditions due to their significant fiber content and antioxidant compounds. L. spinosa includes proteins (17.6 kcal/100 g), lipids (1.16 kcal/100 g), carbs (35.7 kcal/100 g), dietary fiber, calcium, provitamin A, carotenoids, phenolics, and flavonoids, including flavonoid glycosides and flavonoid aglycones, according to a nutritional analysis of the plant (Gautam, 2001, Kumar *et al*., 2013, Rahman *et al*., 2014, Ummalyma and Devi, 2019and Sharifi-Rad *et al*., 2020).

6.3 *Alternanthera sessilis* (Dwarf copper leaf)

This leafy medicinal plant, which is edible, belongs to the Amaranthaceae family. The Latin words "alterno," which means alternate, and "anthera," which means flowers, are the roots of the name "Alternanthera". The species name "sessilis" refers to the inflorescences, which are without a stalk (Hwong *et al*., 2022). This s also known as dwarf copperleaf and gudrisag, although its common name is sessile joyweed. (Hyde *et al*., 2021 and Quattrocchi, 2012). According to Bhuyan *et al*. (2018), it is believed that the plant's origin can be traced back to tropical regions of the Americas. Subsequently, it has spread extensively to other tropical and subtropical regions across the globe. This plant species thrives in draw-down zones of water bodies or in water with a maximum depth of 1 meter. It grows in a manner that can be partly emergent and partly floating, or it can produce floating plant mats (Walter *et al*., 2014). The plant is characterized by a herbaceous nature and a stem that ranges in colour from yellowish-brown to light-brown. The leaves exhibit a sessile morphology and can be classified as linear-oblong or elliptical in shape. The flower is characterized by small axillary sessile heads that are typically white with a pinkish tint. The bracteoles of the flower measure approximately 1 cm in length. The fruit of the flower is an orbicular utricle that is 1.5 mm in length (Walter *et al*., 2014). There are numerous uses for the shoots and leaves of this specific plant in local communities all around the world. They are eaten raw or cooked, and they are also used as ingredients in traditional recipes. In India, it is customary to eat young leaves and stems as a vegetable (Quattrocchi, 2012).

Based on the color of its aerial component, *A. sessilis* can be categorized as a red or green cultivar (Othman *et al*., 2016; Tan and Kim, 2013). Native populations in many areas have long utilized the plants as their primary source of medicine and food. The green-colored cultivar has been used to treat asthma, hypertension, diarrhea, wound healing, and discomfort. Conversely, the red-colored cultivar has been employed in the prevention of liver and cardiovascular illnesses (Hwong *et al*., 2022). This substance's numerous phytochemical elements, such as polyphenols, or terpenes, alkaloids, and carotenoids, are responsible for its strong antioxidant action. Its nutritional constituents, including unsaturated fatty acids, vitamin C, and E, further support its diverse bioactive characteristics. The compound demonstrates a range of biological activities, including antimicrobial and anthelmintic impacts, anti-diabetic qualities, the ability to decrease cholesterol, analgesic and anti-inflammatory effects, and anti-cancer properties (Hwong *et al*., 2022). There is a great deal of promise for this edible weed as an effective food and substitute ingredient in supplements, nutraceuticals, and medicinal products. This is because to its rich nutritional content, which includes unsaturated fatty acids and antioxidant vitamins, as well as a variety of phytochemical components, especially polyphenol (Hwong *et al*., 2022).

Fruit Vegetables

6.4 *Solanum tovrum* (Turkey berry)

*Solanum torvum*is a diminutive shrub with a broad distribution throughout Thailand. It is colloquially referred to as "Turkey berry." It is an upright, spiky shrub with numerous branches that is about 4 metres tall and evergreen (Ismail and Tuan, 2023). This plant species is indigenous to Africa and the West Indies, and is also grown through cultivation (Adjanohoun *et al*., 1996). The plant exhibits an upright shrub that stands approximately 4 metres tall. It possesses expansive branches, white flowers, and yellow stamens (Nguelefack *et al*., 2008 and Mohan *et al*., 2009). The fruit of this plant is consumable and can be found in most markets. It is often prepared as a vegetable and is considered a crucial component in Thai cooking. The fruit and leaves of this plant contain a significant amount of alkaloids, which make them suitable for medicinal or ritualistic use. The immature fruits of this plant are grown in tropical regions for their pungent flavor (Agrawal *et al*., 2010). The fruits of *Solanum torvum* are widely used as an antihypertensive medication in traditional medicine (Fui, 1992*)*. According to Sivapriya and Sriniwas (2007), the material has antioxidant qualities. It also has anti-platelet aggregation and cardiovascular health-related actions (Nguelefack *et al*., 2008). Additionally, it has been shown to have a tranquilizer, digestive, hemostatic, and diuretic properties (Zhu *et al*., 2003), and it exhibits anti-microbial action against human beings and clinically isolates (Chah *et al*., 2000 and Wiart *et al*., 2004). Along with sterols, triterpenes, and flavanoids, it also includes a steroidal glycoside called torvoside H and a sulfated isoflavonoid called torvanol A. Dietary polyphenols were selected because they are thought to be an important source of chemicals for in silico testing towards SARS-CoV family receptors.The mechanistic inhibitory activities of TBF polyphenols, particularly genistin, on COVID-19 were examined in the study carried out by Govender *et al*. in 2022.

6.5 *Solanum nigrum* (Black nightshade)

It is classified under the Solanaceae family and is commonly referred to as garden nightshade. Perennial black nightshade, or *Solanum nigrum*, is a deciduous shrub with a limited lifespan (Mandal *et al*., 2003). Though its origin may be traced back to Eurasia, people from that continent were said to have introduced it to the Americas, Australia, and South Africa. The initial discovery occurred at that location. The plant can be found in a number of nations, including Europe, South America, North America, Peru, Colombia, Brazil Afghanistan, Bhutan, Bangladesh, Iraq, Indonesia, Iran, Pakistan, Japan, and other areas (Mandal *et al*., 2003). It is an annual plant that can reach heights of 25–100 cm. The stems and entire plant are coated in coarsely pubescent, angular, simple pubescent hairs. The fruit exhibits a spherical shape and possesses a lacklustre, dark brown exterior. Its diameter measures between 8 to 10 millimetres. The dimensions of the leaves are 4-10cm in length and 3-7cm in width. The leaves are covered with trichomes and have an ovate shape with cuneate bases. They are coarsely dentate with an obtuse apex (Chen *et al*., 2022). This plant is classified as a weed and contains toxic components that can be harmful to both livestock and humans. The mature berries and cooked leaves of certain edible varieties are consumed as sustenance in certain regions, while various components of the plant are utilized as a customary remedy (Chen *et al*., 2022).

Natural substances with a variety of structural patterns and advantageous qualities can be found in abundance in *S. nigrum*. It contains flavonoids, phenylpropanoids, organic acids, steroids, alkaloids, and their glycosides, among other things. The primary bioactive substances in *S. nigrum* are steroidal compounds, which are made up of steroidal saponins (Rawani *et al*., 2013 and Aburjai *et al*., 2014) and steroidal alkaloids (Xiao and Zeng, 2000 and Rawani *et al.*, 2017). They have a variety of pharmacological effects, including anticancer, anti-inflammatory, and antiviral effects. It is beneficial in treating rheumatoid arthritis, gout, and skin diseases. It is also used to treat tuberculosis, managing nausea, and disorders affecting the nervous system (Chen *et al*., 2022).

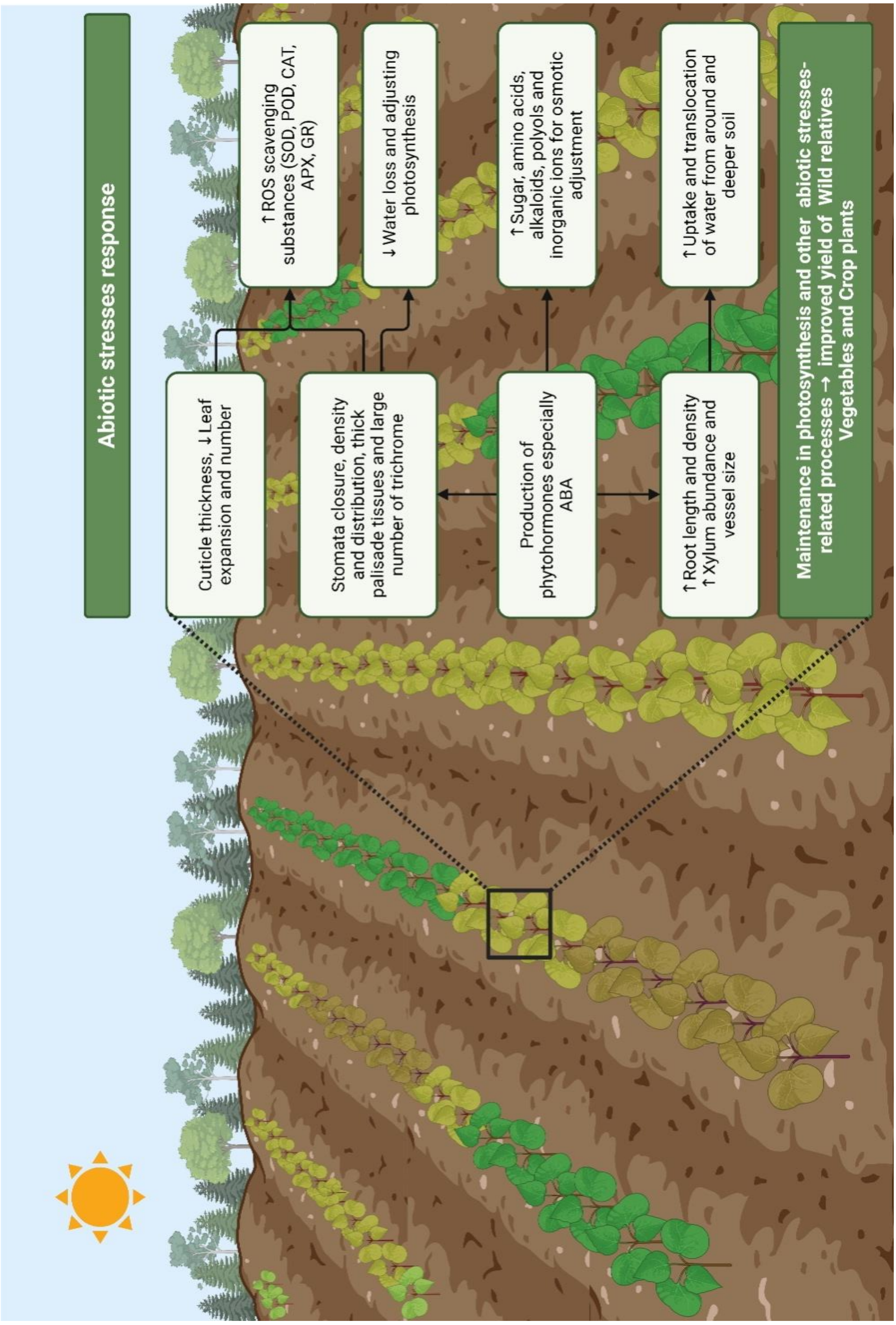

Fig. 2. Adopation of wild plants under different abiotic streeses.

Other Vegetables

6.6 *Dioscorea oppositifolia*(Chinese yam)

It is a deciduous perennial creeping and twining vine that can be found from Myanmar to the Eastern Himalaya, South India, Sri Lanka, and Sri Lanka (Govaerts *et al*. 2006). The plant is typically found in its natural habitat along the edges of forests, in riparian zones, and in areas that have been disturbed or are considered ruderal. According to Tu (2002), it is also found in urban settings, on hill slopes, in marshes, along stream banks, close to drainage routes, and next to fencerows. The optimal growth conditions for this species involve partial shade, although it is capable of withstanding both full sunlight and complete shade. It may be cultivated in considerably colder temperatures than other yams since it is frost-tolerant (Lim, 2016). A thick, elongated, sparsely hairy vine that twines and creeps to a height of 3 to 4 metres. The stem is thin, terete, glabrous, purple, and bears bulbils in the leaf axils clockwise (from left to right). Cylindrical, 50–90 cm long and tuber root-like. A basal stem's alternate leaves are opposed above the centre, seldom three to a whorl, on long petioles (Paul *et al*., 2014). These broad, ovate-triangular, 7-9 nerved leaves have an acuminate apex, a cordate base, and an entire margin. Growing in paniculate or spicate inflorescences, the small, 4 mm, unisexual, white (greenish-yellow), cinnamon-scented blooms are 3-9 cm long and 2-7 cm wide (Lim *et al*., 2016). It is commonly used in soups, warm, steaming rice bowls, and the Japanese noodle dishes totoroudon and totoro soba. It is slimy and utilized in the batter of foods like okonomiyaki as a binding and thickening ingredient. The tubers are cooked and used in curries in Odisha, India (Kumar *et al*. 2012). Numerous chemical components have been identified in the rhizome, including starch, non-starch polysaccharides, flavonoids, polyphenols, mannan, an allantoin, diosgenin, dopamine, batatasine, phytic acid, amino acids, glucoprotein, ergosterol, dioscorin, saponins, and minerals like potassium, sulphur, calcium, magnesium, iron, zinc, copper, manganese, and others. These findings have been reported by various studies (Yuan, 2008, Zhou *et al*., 2008, Park *et al*., 2010, Jiang, 2011 and Lee *et al*., 2011). Additionally, *D. oppositifolia* tubers are used to make herbal tonics. This substance has a stimulating effect on the stomach and spleen, as well as impacting the lungs and kidneys. According to Poornima and Ravishankar (2007), eating tubers is said to have therapeutic benefits and is used to treat conditions like emotional instability, frequent or excessive urination, asthma, dry coughs, poor appetite, and chronic diarrhea.

6.7 *Nymphaea stellata* (Blue lotus)

It is a member of the Nympheaceae family. According to Wiart (2006), stellata signifies star-shaped in Latin, and nymphala signifies water nymph in GreekIt goes by numerous colloquial names in India, but the common name is Indian blue water lily or Indian water lily. Naturally occurring or artificially cultivated, *N. stellata* is a perennial aquatic rooting plant that is frequently found in tanks and ponds in warmer parts of India, especially the Eastern Ghats. It has been cultivated for centuries throughout Southeast Asia, especially in the vicinity of temples (Slocum, 2005 and Raja *et al*., 2010). In fields of rice that have been unused during the Southwest monsoon, *N. stellata* is grown. After seeds or roots are harvested, they are air dried and kept in storage. Although it requires three to four years for the blue water lily to flower, seeds can be planted and grown. You can plant the seed in the summer or spring. The plant N. stellata has stems that are frequently reddish violet and grows from a cone-shaped tuberous rhizome with little white pithy roots. Rhizomes are around the size of an egg, short, upright, stout, fleshy, unbranched and pyriform. Round, flask-shaped seeds with a diameter of less than 1 mm are contained in the globose, 6.5 cm, glabrous, 2.5–3 cm in diameter fruit. It produces numerous seeds and berries that are hairy along their longitudinal rows, ellipsoid-globose in shape, and black with a white aril (Stephens and Dowling, 2002). Rhizomes, fruits, leaf petioles, roots, flowers, tubers, and seeds are all used by people in a variety of ways as edible parts. Due to the rhizomes' high starch content and pleasant taste when cooked, it has also been cultivated for food in Sri Lanka (Venu, 1999). The rhizomes are protected by a thin coating that, when it dries, develops horns. A cotton-like material covers the covering itself, especially near the apex. The rhizome is loaded of starch and tastes much better than yam when cooked or served with curry. When consumed either raw or roasted, the roots and rhizomes are thought to be nutrient-rich. It is a prominent and popular medicinal herb that is used as an aphrodisiac, bitter tonic, menorrhagia, blenorrhagia, diabetes, inflammation, liver illnesses, urinary disorders, menstrual issues, and as an aphrodisiac (Raja *et al*., 2010). Flowering parts of the plant contain flavonoids, acid such as gallic acid, quercetin, astrgalin and kaempferol. There have been reports of the antihepatotoxic and antihyperlipidaemic effects (Das *et al*., 2012).

Conclusions

One of the main obstacles to the general acceptance and use of wild vegetables has been found to be a lack of knowledge regarding their nutritional advantages as well as the preparation and preservation methods. Wild vegetables have a higher nutritional density than cultivated vegetables. This is due to the fact that wild plants often grow in various environments, gaining access to a diverse variety of minerals and nutrients from the soil. In order to thrive in various environmental situations, wild vegetables have evolved special adaptations. Desirable qualities including drought resistance, pest and disease tolerance and improved flavor or aroma compounds can be produced as a result of these adaptations. It has been found that wild vegetables have a significant antioxidant capacity because they contain phytochemicals like the flavonoids and phenolic compounds. Antioxidants may help reduce the chance of chronic diseases such as coronary artery disease, cancer, and neurological problems in addition to supporting the body's defense against oxidative stress. In order to generate crop varieties with improved resistance to abiotic stress, breeding initiatives that use wild crops as significant genetic resources can help provide food security and sustainable agriculture in the face of changing environmental conditions.It is crucial to keep in mind that scientific investigation of wild plants is still underway, and more research is required to completely comprehend their nutritional makeup, health advantages, and potential hazards. Therefore, it is wise to get advice from medical professionals or nutritionists before include wild plants in your diet.

Conflicts of interest

There are no conflicts to declare.

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References

Abdel-Azeiz E, Faiyad R (2024). Mitigation The Deleterious Effect of Salinity on Faba Bean by Cobalt and Bio-stimulants. Egyptian Journal of Soil Science 64(1), 181-192. 10.21608/ejss.2023.2 38554.1667.

Aburjai TA, Oun IM, Auzi AA and Hudaib MM (2014). Volatile oil constituents of fruits and leaves of *Solanum nigrum* L. Growing in Libya. Journal of Essential Oil Bearing Plants 17(3), 397–404. https://doi.org/10.108 0/0972060X.2014.895 194.

Agbaire PO, Emoyan OO (2012). Nutritional and anti-nutritional levels of some local vegetables from Delta State, Nigeria. African Journal of Food Science and Technology 6(1), 8-11.

Adjanohoun JE, Aboubakar N, Dramane K, Ebot ME, Ekpere JA, Enoworock EG (1996). *Traditional medicine and pharmacopoeia-contribution to ethnobotanical and floristic studies in Cameroon*. CNPMS. Porto-Novo, pp. 50–52

Afolayan AJ, Jimoh FO (2009). Nutritional quality of some wild leafy vegetables in South Africa. International Journal of Food Sciences and Nutrition 60(5), 424–431. https://doi.org/10.1080/09637480701777928

Agrawal AD, Bajpei PS, Patil AA, Bavaskar SR (2010). *Solanum torvum* Sw. – A phytopharmacological review. Pharmacia Lettre2(4**),** 403–407

Alemu EA (2020). Malnutrition and its implications on food security. In Zero hunger. Springer International Publishing pp, 509–518.https://doi.org/10.1007/978-3-319-95675-6_32

Aryal S, Baniya MK, Danekhu K, Kunwar P, Gurung R, Koirala N (2019). Total phenolic content, flavonoid content and antioxidant potential of wild vegetables from Western Nepal. Plants8(4), 96. https://doi.org/10.3390/plants8040096

Aworh OC (2018). From lesser-known to super vegetables: The growing profile of African traditional leafy vegetables in promoting food security and wellness. Journal of the Science of Food and Agriculture98(10), 3609–3613. https://doi.org/10.1002/jsfa.8902

Babbar N, Oberoi HS, Sandhu SK (2015). Therapeutic and nutraceutical potential of bioactive compounds extracted from fruit residues. Critical Reviews in Food Science and Nutrition55(3), 319–337. https://doi.org/10.1080/10408398.2011.653734

Bala A, Kar B, Haldar PK, Mazumder UK, Bera S (2010). Evaluation of anticancer activity of *Cleome gynandra* on ehrlich's ascites carcinoma treated mice. Journal of Ethnopharmacology 129(1), 131–134. https://doi.org/10.1016/j.jep.2010.03.010

Balana BB, Oyeyemi MO, Ogunniyi AI, Fasoranti A, Edeh H, Andam KS (2021). Have households' livelihoods and food security rebounded from COVID-19 shocks in Nigeria? Results from a follow-up phone survey. IFPRI Discussion. https://doi.org/10.2499/p15738coll2 p. 134805

Bardgett RD, Wardle DA (2010). Aboveground-belowground linkages: biotic interactions, ecosystem processes, and global change. Oxford University Press.

Bartels D, Sunkar (2005). Drought and salt tolerance in plants. Critical Reviews in Plant Sciences 24(1), 23-58.https://doi.org/10.1080/07352680590910410.

Bendary E, Francis RR, Ali HMG, Sarwat MI, El Hady S (2013). Antioxidant and structure–activity relationships (SARs) of some phenolic and anilines compounds. Annals of Agricultural Sciences 58(2), 173-181. https://doi.org/10.1016/j.aoas.2013.07.002.

Bhuyan B, Baishya K, Rajak P (2018). Effects of *Alternanthera sessilis* on liver function in carbon tetra chloride induced hepatotoxicity in Wister rat model. Indian Journal of Clinical Biochemistry 33(2**)**, 190-195. https://doi.org/10.1007/s12291-017-0666-1.

Boliko MC (2019). FAO and the situation of food security and nutrition in the world. Journal of Nutritional Science and Vitaminology65, S4-S8. https://doi.org/10.3177/jns v.65.S4.

Borelli T, Hunter D, Powell B, Ulian T, Mattana E, Termote C, Pawera L, Beltrame D, Penafiel D, Tan A, Taylor M (2020). Born to eat wild: An integrated conservation approach to secure wild food plants for food security and nutrition. Plants9(10),1299.https://doi.org/10.339 0/plants9101299.

Bvenura C, Afolayan AJ (2015). The role of wild vegetables in household food security in South Africa: A review. Food Research Internation*al*76, 1001-1011.https://doi.org/10.1016/j.foodres.2015. 06.013.

Campbell BM, Vermeulen SJ, Aggarwal PK, Corner-Dolloff C, Girvetz E, Loboguerrero AM, Ramirez-Villegas J, Rosenstock T, Sebastian L, Thornton PK, Wollenberg E (2016). Reducing risks to food security from climate change. Global Food Security11, 34-43.https://doi.org/10.1016/j.gfs.20 16.06.002.

Cernansky R (2015). The rise of Africa's Super vegetables. Nature522(7555**)**, 146-148. https://doi.org/10.1038/522146a.

Chadha ML, OluochMO (2003). Home-based vegetable gardens and other strategies to overcome micronutrient malnutrition in developing countries. Food Nutrition and Agriculture 32, 17-23.

Chah KF, Muko KN, Oboegbulem SI (2000). Antimicrobial activity of methanolic extract of Solanum torvum fruit. Fitoterapia71(2), 187-189. https://doi.org/10.1016/s0367-326x(99)00139-2

Chataika BY, Akundabweni LS, Sibiya J, Achigan-Dako EG, Sogbohossou DEO, Kwapata K (2022). Major production constraints and spider plant [*Gynandropsisgynandra* (L.) briq.] traits preferences amongst smallholder farmers of northern Namibia and central Malawi. Frontier in Sustainable Food System 6.doi: 10.3389/fsufs.2022.831821

Chen X, Dai X, Liu Y, Yang Y, Yuan L, He X, Gong G (2022). *Solanum nigrum*Linn.:An insight into current research on traditional uses, phytochemistry and pharmacology. Frontiers in Pharmacology13, 918071. https://doi.org/10.3389/fphar.2022.918071.

Côté J, Caillet S, Doyon G, Sylvain JF, Lacroix M (2010). Bioactive compounds in cranberries and their biological properties. Critical Reviews in Food Science and Nutrition50(7), 666–679. https://doi.org/10.1080/10408390903044107.

DasDR, Sachan AK, Mohd S, Gangwa SS (2012). *Nymphaea stellata*: A potential herb and its medicinal importance. Journal of Drug Delivery and Therapeutics 2(3).https://doi.org/10.22270/jddt.v2i3.173

Das HB, Majumdar K, Datta BK, Ray D (2009). Ethnobotanical uses of some plants by Tripuri and Reang tribes of Tripura. Natural Product Radiance,8:172–180.

Faber M, Oelofse A, Van Jaarsveld PJ, Wenhold FAM, Jansen Van Rensburg WSJ (2010). African Leafy vegetables consumed by households in the Limpopo and KwaZulu-Natal provinces in South Africa. South African Journal of Clinical Nutrition 23(1), 30–38. https://doi.org/10.1080/16070658.2010.11734255

FAO, IFAD, UNICEF, WFP, WHO (2021). The state of food security and nutrition in the world 2021. transforming food systems for food security, improved nutrition and affordable healthy diets for all. Rome, Italy). 10.4060/ cb4474en.

Flowers TJ, Colmer TD (2008). Salinity tolerance in halophytes. New Phytologist945-963.https://doi.org/10.1111/j.1469-137.2008.02531.x.

Flyman MV, Afolayan AJ (2006). The suitability of wild vegetables for alleviating human dietary deficiencies. South African Journal of Botany 72(4), 492–497. https://doi.org/10.1016/j.sajb.2006.02.003

Food and Agriculture Organization. 2016. Methods for estimating comparable rates of food insecurity experienced by adults throughout the world.

Food and Agriculture Organization. 2019. The state of the world's biodiversity for food and agriculture. FAO Commission on Genetic Resources for Food and Agriculture Assessments (Rome, Italy). http://www.fao.org/3/CA3129EN/CA3129EN.pdf Retrieved March 05, 2023.

Frischen J, Meza I, Rupp D, Wietler K, Hagenlocher M (2020). Drought risk to agricultural systems in Zimbabwe: A spatial analysis of hazard, exposure, and vulnerability. Sustainability 12(3), 752. https://doi.org/10.3390/su12030752

Fui (1992). Knowledge and use of forest product as traditional medicine: The caseof the forest dwelling communities. In; K Shaari, AA Kadir, AR Ali (Eds.). Proceedings of the Conference on Medicinal Products from Tropical Rain Forest, Forest Research Institute of Malaysia pp. 355-400

García-Herrera P, Morales P, Cámara M, Fernández-Ruiz V, Tardío J, Sánchez-Mata MC (2020). Nutritional and phytochemical composition of Mediterranean wild vegetables after culinary treatment. Foods, 289(12),1761.

Gautam AK (2001). The wealth of India: An encyclopedia of India's raw material resources. Pakistan Journal of Biological Sciences 15(5), 449–507

Ghazaryan K, Harutyunyan A, Khachatryan H, Singh A, Minkina T, Rajput V, Movsesyan H (2023). Study of tolerance and phytodesalination potential of wheat, oat, emmer, and barley for sustainable saline agriculture. Applied Ecology and Environmental Research 21(5), 4853–4882. https://doi.org/10.15666/aeer/2105_48534882

Ghazaryan KA, Movsesyan HS, Khachatryan HE, Ghazaryan NP (2018). Geochemistry of potentially toxic trace elements in soils of mining area: a case study from zangezur copper and molybdenum combine, Armenia. Bulletin of Environmental Contamination and Toxicology, 101(6), 732–737. https://doi.org/10.1007/s00128-018-2443-0

Ghorai T, Sharma A, Jana D, Jana S (2023). Implications of climate change on fisheries and food security. Springer Nature Singapore, pp. 75–84.

Govaerts R, Wilkin P, Raz L, Tellez-Valdes O (2006). World checklist of *Dioscoreaceae*. The Royal Botanic Gardens, Kew. http://apps.kew.org/wcsp/

Govender N, Zulkifli NS, Badrul Hisham NFB, Ab Ghani NS, Mohamed-Hussein ZA (2022). Pea eggplant (*Solanum torvum* Swartz) is a source of plant food polyphenols with SARS-CoV inhibiting potential. Peer J10, e14168. https://doi.org/10.7717/peerj.14168

Hiong YY (2009). Antioxidant activity and total phenolic contents in *Cucurbita moschtata, Lasia spinosa* and

Limnocharis flava. School of Food Science and Nutrition, University Malaysia Sabah.

Hossain R, Quispe C, Herrera-Bravo J, Islam MS, Sarkar C, Islam MT, Martorell M, Cruz-Martins N, Al-Harrasi A, Al-Rawahi A, Sharifi-Rad J, Ibrayeva M, Daştan SD, Alshehri MM, Calina D (2021). *Lasia spinosa* chemical composition and therapeutic potential: A literature-based review. Oxidative Medicine and Cellular Longevity 1602437. https://doi.org/10.1155/2021/1602437.

Hussain TM, Ch T, Hazara M, Sultan Z, Saleh BK, Gopal GR (2008). Recent advances in salt stress biology a review. Biotechnology and Molecular Biology Reviews3(1), 8-13.https://doi.org/10.3390%2Fcells10082023.

Hwong CS, Leong KH, Aziz AA, Junit SM, Noor SM, Kong KW (2022). *Alternanthera sessilis*: Uncovering the nutritional and medicinal values of an edible weed. Journal of Ethnopharmacology115608.https://doi.org/10.1016/j.jep.2022.115608.

Hyde M, Wursten B,Ballings P, Palgrave Coates M (2021). Flora of Zimbabwe: Species information: *Pinus patula*. Flora of Zimbabwe. https://www. Zimbabwe flora. co. zw/speciesdata/species. php.

Ismail A, Tuan Anuar TAF (2023). *Solanum torvum* for hypertension: A systematic review. Research Journal of Pharmacognosy 10(2), 75–84

Jiang QQ, Gao WY, Li X, Zhang JZ (2011). Characteristics of native and enzymatically hydrolyzed*Zea mays* L., *Fritillaria ussuriensis* Maxim. and *Dioscorea opposita*Thunb. Food Hydrocolloids 25(3), 521–528. https://doi.org/10.1016/j.foodhyd.2010.08.003.

Kapazoglou A, Gerakari M, Lazaridi E, Kleftogianni K, Sarri E, Tani E, Bebeli PJ (2023). Crop wild relatives: A valuable source of tolerance to various abiotic stresses. Plants12(2), 328.https://doi.org/10.3390/plants12020328.

Keating RC (2003). Anatomy of the monocotyledons, IX, *Acoraceae* and *Araceae*. Clarendon Press. Cutler, Oxford University Press, pp. 1–327.

Kumar M, Mondal P, Borah S, Mahato K (2013). Physico-chemical evaluation, preliminary phytochemical investigation, fluorescence and TLC analysis of leaves of the plant *Lasia spinosa* (Lour.) Thwaites. International Journal of Pharmacy and Pharmaceutical Sciences5(2), 306–310.

Kumar S, Jena PK, Tripathy PK (2012). Study of wild edible plants among tribal groups of Simlipal Biosphere Reserve Forest, Odisha, India; with special reference to *Dioscorea* species. International Journal of Biological Technology 3(1), 11–19

Laborde D, Martin W, Swinnen J, Vos R (2020). COVID-19 risks to global food security. Science 369(6503), 500–502. https://doi.org/10.1126/science.abc4765

Lakshmi MA, Priya GV, Rao BG (2020). Morpho-anatomical feature and phytochemical assessments of *Lasia spinosa* (L)Thwaites. Indian Journal of Pharmaceutical Sciences 82(5), 891–901. https://doi.org/10.36468/pharmaceutical-sciences.718.

Lal R (2004). Soil carbon sequestration impacts on global climate change and food security. Science, 304(5677), 1623-1627.10.1126/science.1097396.

Lee SY, Ganesan P, Ahn J, Kwak HS (2011). *Lactobacillus acidophilus* fermented yam (*Dioscorea opposite*Thunb.) and its preventive effects on gastric lesion. Food Science and Biotechnology 20(4), 927–932. https://doi.org/10.1007/s10068-011-0128-0.

Lim TK (2016). *Dioscorea oppositifolia*. In Edible medicinal and non-medicinal plants, Modified Stems, Roots, Bulbs. Springer Netherlands, pp. 275–290.

Liu WC, Liu HM (2014). Assessing the impacts of sea level rise on salinity intrusion and transport time scales in a tidal estuary, Taiwan. Water 6(2), 324-344. https://doi.org/10.3390/w6020324.

Mabhaudhi T, Chimonyo VGP, Modi AT (2017). Status of underutilised crops in South Africa: Opportunities for developing research capacity. Sustainability9(9),1569. https://doi.org/10.3390/su9091569.

Mahmud M, Riley E (2021). Household response to an extreme shock: Evidence on the immediate impact of the Covid-19 lockdown on economic outcomes and well-being in rural Uganda. World Development140, 105318. https://doi.org/10.1016/j.worlddev.2020.105318.

Mandal S, Vishvakarma P, Verma M, Alam MS, Agrawal A, Mishra A (2023). *Solanum nigrum* Linn: An analysis of the medicinal properties of the plant. Journal of Pharmaceutical Negative Results1595–1600.

Martins N, Calina D (2020). Diet, lifestyle and cardiovascular diseases: Linking pathophysiology to cardioprotective effects of natural bioactive compounds. International Journal of Environmental Research and Public Health 17(7), 2326. https://doi.org/10.3390/ijerph17072326.

Maruga Raja, MK, Sethiya NK, Mishra SH (2010). A comprehensive review on *Nymphaea stellata*: A traditionally used bitter. Journal of Advanced Pharmaceutical Technology and Research 1(3), 311. https://doi.org/10.4103/0110-5558.72424

Mashamaite CV, Manyevere A, Chakauya E (2022). Cleome gynandra: A wonder climate-smart plant for nutritional security for millions in semi-arid areas. Frontiers in Plant Science13,1003080. https://doi.org/10.3389/fpls.2022.1003080

Mishra SS, Moharana SK, Dash MR (2011). Review on *Cleome gynandra*. International Journal of Research in Pharmacy and Chemistry1(3), 681-689.

Mnzava NA (1990). Studies on tropical vegetables. part 2: Amino and fatty acid composition in seed of cleome (*Gynandropsisgynandra* (L.) briq) selections from Zambia. Food Chemistry 35(4), 287–293. https://doi.org/10.1016/0308-8146(90)90018-Y.

Mo LJ, He D, Zhou CR, Ling LL (2014). Experimental study on acute toxicity of raw *Solanum nigrum* and *Solanum nigrum* juice. China Health Care Nutrition 5, 2889–2890. 10.3969/j.issn.1004-7484(x).2014.05.610

Mohammed Abdus Satter MMA, Khan MMRL, Jabin SA, Abedin N, IslamMF, Shaha B (2016). Nutritional quality and safety aspects of wild vegetables consume in Bangladesh. Asian Pacific Journal of Tropical Biomedicine6(2), 125–131. https://doi.org/10.1016/j.apjtb.2015.11.004

Mohamed MS (2020). Studying the effect of spraying magnetized fulvate and humate solutions on phosphorus availability in sandy soil cultivated by Faba Bean (*Vicia faba* L.). Egyptian Journal of Soil Science 60(4), 409-423.

Mohan M, Jaiswal BS, Kasture S (2009). Effect of *Solanum torvum* on blood pressure and metabolic alterations in fructose hypertensive rats. Journal of Ethnopharmacology126(1), 86–89. https://doi.org/10.1016/j.jep.2009.08.008

Moyo M, Aremu AO (2022). Nutritional, phytochemical and diverse health-promoting qualities of *Cleome gynandra*. Critical Reviews in Food Science and Nutrition 62(13), 3535–3552. https://doi.org/10.1080/10408398.2020.1867055

Moyo M, Amoo SO, Aremu AO, Gruz J, Šubrtová M, Jarošová M (2018). Determination of mineral constituents, phytochemicals and antioxidant qualities of *Cleome gynandra*, compared to *Brassica oleracea* and *Beta vulgaris*. Frontier in Chemistry5. doi: 10.3389/fchem.2017.00128.

Munene AK, Nzuve F, Ambuko J, Odeny D. 2018. Heritability analysis and phenotypical characterisation of spider plant (*Cleome gynandra* l.) for yield. Advances in Agriculture 8568424. https://doi.org/10.1155/2018/8568424

Mustafa MA, Mabhaudhi T, Massawe F (2021). Building a resilient and sustainable food system in a changing world – A case for climate-smart and nutrient dense crops. Global Food Security28, 100477. https://doi.org/10.1016/j.gfs.2020.100477

Mwanri AW, Mamboleo TF, Msuya JM, Gowele VF (2018). Oxalate, phytate and nitrate content in African nightshade, spider plant and amaranths at different stages of maturity. African Journal of Food Science, 12(11),316-22.

Nandal U, Bhardwaj RL (2014). The role of underutilized fruits in nutritional and economic security of tribals: A review. Critical Reviews In Food Science and Nutrition, 54(7), 880-890.

Ng XN, Chye FY, Ismail MA (2012). Nutritional profile and antioxidative properties of selected tropical wild vegetables. International Journal of Food Science19(4), 1487.

NguelefackTB,Mekhfi H, Dimo T, Afkir S, Nguelefack-Mbuyo EP, Legssyer A, Ziyyat A (2008). Cardiovascular and anti-platelet aggregation activities of extracts from *Solanum torvum* (Solanaceae) fruits in rat. Journal of Complementary and Integrative Medicine 5(1), 1–13. https://doi.org/10.2202/1553-3840.1105

Othman A, Ismail A, Hassan FA, Yusof BNM, Khatib A (2016). Comparative evaluation of nutritional compositions, antioxidant capacities, and phenolic compounds of red and green sessile joyweed (*Alternanthera sessilis*). Journal of Functional Foods21,263–271. https://doi.org/10.1016/j.jff.2015.12.014

Park JH, Ahn J, Kwak HS (2010). Physicochemical properties of Dioscorea oppositaThunb. solution fermented by *Lactobacillus bulgaricus*. Korean Journal for Food Science of Animal Resources30(5),773-779.https://doi.org/10.5851/kosfa.2010.30.5.773

Paul C, Debnath A, Debnath B (20140. *Dioscorea oppositifolia* Linnaeus (Dioscoreaceae)-a new distributional record for Tripura, India. Pleione8(1), 184–187.

Poornima GN, Ravishankar R (2007). In vitro propagation of wild yams, *Dioscorea oppositifolia* (Linn.) and *Dioscorea pentaphylla* (Linn.). African Journal of Biotechnology6(20), 2348–2352. 10.5897/AJB2007.000-2368.

Quattrocchi U (2012). CRC world dictionary of medicinal and poisonous plants: Common names, scientific names, eponyms, synonyms, and etymology (5 volume Set). CRC Press.

Rahman A, Siddiqui SA, Oke-Altuntas F, Okay S, Gül F, Demirtas I (2019). Phenolic profile, essential oil composition and bioactivity of *Lasia spinosa* (L.) Thwaites. Brazilian Archives of Biology and Technology 62. https://doi.org/10.1590/1678-4324-2019170757

Rajput VD, Singh A, Minkina T, Rawat S, Mandzhieva S, Sushkova S, Upadhyay SK (2021). Nano-Enabled Products: Challenges and Opportunities for Sustainable Agriculture. Plants 10(12), 2727. https://doi.org/10.339 0/plants10122727.

Raju AJ and Rani DS (2016). Reproductive ecology of *Cleome gynandra* and *Cleome viscosa* (Capparaceae). PhytologiaBalcanica 22(1)

Rawani A, Ghosh A, Chandra G (2013). Mosquito larvicidal and antimicrobial activity of synthesized nano-crystalline silver particles using leaves and green berry extract of *Solanum nigrum*L.Acta Tropica128(3), 613–622. https://doi.org/10.1016/j.actatropica.2013.09.007

Rawani A, Ray AS, Ghosh A, Sakar M, Chandra G (2017). Larvicidal activity of phytosteroid compounds from leaf extract of *Solanum nigrum* against *Culex vishnui* group and *Anopheles subpictus*. BMC Research Notes 10(1), 135. https://doi.org/10.1186/s13104-017-2460-9

Rist L, Shaanker RU, Milner-Gulland EJ, Ghazoul J (2010). The use of traditional ecological knowledge in forest management: an example from India. Ecology and Society 1,15(1).

Sade B, Soylu S, Soylu E (2011). Drought and oxidative stress. African Journal of Biotechnology, 10(54), 11102-11109.

Saikia P, Deka DC (2013). Mineral content of some wild green leafy vegetables of North-East India. Journal of Chemical and Pharmaceutical Research 5(3), 117–121.

Sairam RK, Tyagi A (2004). Physiology and molecular biology of salinity stress tolerance in plants. Current Science 407-421.

Sari D, Ferroudj A, Dávid S, El-Ramady H, Faizy S, Ibrahim S, Mansour H, Brevik E, Solberg S, Prokisch J (2024). Drought Stress Under a Nano-Farming Approach: A Review. Egyptian Journal of Soil Science 64(1) 135-151. 10.21608/ejss.2023.239634.1668

Satter MMA, Khan MMRL, Jabin SA, Abedin N, Islam MF, ShahaB (2016). Nutritional quality and safety aspects of wild vegetables consume in Bangladesh. Asian Pacific Journal of Tropical Biomedicine, 6(2), 125-131.

Sharifi-Rad J, Rodrigues CF, Sharopov F, Docea AO, Can Karaca A, Sharifi-Rad M, Kahveci Karıncaoglu D, Gülseren G, Şenol E, Demircan E, Taheri Y, Suleria HAR, Özçelik B, Nur Kasapoğlu K, Gültekin-Özgüven M, Daşkaya-Dikmen C, Cho WC,

Shen YN, Xiao D, Hu XX, Chen HY, Lin YF, Qing Z, Chen BS, Wen RH (2020). First report of leaf spot on *Lasia spinosa* Caused by *Fusarium fujikuroi* in China. Plant Disease 104(9), 2525–2525. https://doi.org/10.1094/PDIS-01-20-0013-PDN

Schlesinger WH, Pilmanis AM (1998). Plant-soil interactions in deserts. Biogeochemistry, 42(1-2), 169-187. 10.1023/a:1005944025725

Singh A, Sharma R, Rawat S, Singh AK, Rajput VD, Fedorov Y, Chaplygin V (2022). Nanomaterial-plant interaction: Views on the pros and cons. Toxicity of Nanoparticles in Plants 47–68. https://doi.org/10.1016/b978-0-323-90774-3.00015-5

Singh A, Rajput VD, Varshney A, Ghazaryan K, Minkina T (2023a). Small tech, big impact: Agri-nanotechnology journey to optimize crop protection and production for sustainable agriculture. Plant Stress 10, 100253. https://doi.org/10.1016/j.stress.2023.100253

Singh A, Rajput VD, Tawaha AFM, Al Zoubi OM, Habeeb T, Rawat S, Minkina T (2023b). A review on crop responses to nanofertilizers for mitigation of multiple environmental stresses. Ecological Engineering & Environmental Technology 24(7), 280–296. https://doi.org/10.12912/27197050/169313

Singh A, Sharma R, Rajput VD, Ghazaryan K, Minkina T, Al Tawaha ARM, Varshney A (2023c). Green synthesis of nanofertilizers and their application for crop production. Nanotechnology in the Life Sciences 205–231. https://doi.org/10.1007/978-3-031-41329-2_8

Singh A, Rajput VD, Sharma R, Ghazaryan K, Minkina T (2023d). Salinity stress and nanoparticles: Insights into antioxidative enzymatic resistance, signaling, and defense mechanisms. Environmental Research 235, 116585. https://doi.org/10.1016/j.envres.2023.116585.

Singh A, Sengar RS, Rajput VD, Al-Ghzawi AL, Shahi UP, Ghazaryan K, Habeeb T (2024a). Impact of salinity stress and zinc oxide nanoparticles on macro and micronutrient assimilation: unraveling the link between environmental factors and nutrient uptake. Journal of Ecological Engineering 25(2), 1–9. https://doi.org/10.12911/22998993/172947

Singh A, Rajput V, Varshney A, Sharma R, Ghazaryan K, Minkina T, El-Ramady H (2024b). Revolutionizing crop production: nanoscale wonders - current applications, advances, and future frontiers. Egyptian Journal of Soil Science 64(1), 0–0. https://doi.org/10.21608/ejss.2023.246354.1684

Sivapriya M, Leela S (2007). Isolation and purification of a novel antioxidant protein from the water extract of Sundakai (*Solanum torvum*) seeds. Food Chemistry 104(2), 510–517. https://doi.org/10.1016/j.foodchem.2006.11.060.

Slocum PD (2005). Waterlilies and lotuses. Species, cultivars, and new hybrids. Timber Press.

Sommer M,Bräutigam A, Weber AP (2012). The dicotyledonous NAD malic enzyme C_4 plant *Cleome gynandra* displays age-dependent plasticity of C_4 decarboxylation biochemistry. Plant Biology 14(4), 621-629.https://doi.org/10.1111/j.1438-8677.2011.00539.x

Southern African Development Community. 2020. Regional indicative strategic development plan (RISDP) 2020–2030 (Gaborone, Botswana: SADC FANR Directorate).

Stangeland T, Remberg SF, Lye KA (2009). Total antioxidant activity in 35 Ugandan fruits and vegetables. Food Chemistry113(1), 85–91. https://doi.org/10.1016/j.foodchem.2008.07.026

Stephens KM, Dowling RM (2002). Wetland plants of Queensland: A field guide. CSIRO Publishing.

Tan KK, Kim KH (2013). *Alternanthera sessilis* red ethyl acetate fraction exhibits antidiabetic potential on obese type 2 diabetic rats. Evidence-Based Complementary and Alternative Medicine:eCAM, 845172. https://doi.org/10.1155/2013/845172

Temjenmongla A, Yadav AK (2006). Anticestodal efficacy of *Lasia spinosa*. Extract against experimental Hymenolepisdiminuta. Infections in rats. Pharmaceutical Biology 44(7), 499–502. https://doi.org/10.1080/13880200600878486

Tu M (2002). Element stewardship abstract for *Dioscorea oppositifolia* L. *The Nature Conservancy*. http://wiki.http://bugwood.org/Dioscorea_oppositifolia.

Tungmunnithum D, Thongboonyou A, Pholboon A, Yangsabai A (2018). Flavonoids and other phenolic compounds from medicinal plants for pharmaceutical and medical aspects: An overview. Medicines 5(3), 93. https://doi.org/10.3390/medicines5030093

Türkan I, Demiral T (2009). Recent developments in understanding salinity tolerance. Environmental and Experimental Botany 67(1), 2-9.https://doi.org/10.1016/j.envexpbot.2009.05.008

Ummalyma SB, Devi RS (2019). *Lasia spinosa*: wild nutraceutical for formulation of future drugs. Apple Academic Press, pp. 265–282

Uusiku NP, Oelofse A, Duodu KG, Bester MJ, Faber M (2010). Nutritional value of leafy vegetables of sub-Saharan Africa and their potential contribution to human health: A review. Journal of Food Composition and Analysis 23(6), 499–509. https://doi.org/10.1016/j.jfca.2010.05.002

Van Wyk B, Gericke N (2000). People's plants. A guide to useful plants of southern Africa. http://www.theeis.com/data/literature/Indigenous%20Green%20Leafy%20Vegetables.pdf.

Vardumyan H, Singh A, Rajput, V, Minkina T, El-Ramady H, Ghazaryan K (2024). Additive-Mediated Phytoextraction of Copper-Contaminated Soils Using

Medicago lupulina L. Egyptian Journal of Soil Science 64(2), 599–618. https://doi.org/10.21608/ejss.2024.266169.1714.

Venu P (1999). Environmental impact assessment: Some considerations on evaluation of flora—An overview. In Proceedings of the Indian National Science Academy. Part, B. Biological sciences, New Delhi, 65(5), 257–274

Vicente O, Al Hassan M, Boscaiu M (2016). Contribution of osmolyte accumulation to abiotic stress tolerance in wild plants adapted to different stressful environments. In; N. Iqbal (ed). Osmolytes and plants acclimation to changing environment: emerging omics technologies, pp.13-25.10.1007/978-81-322-2616-1_2.

Vorster HJ, Van Rensburg WSJ, Van Zijl JJB, Van den Heever E (2002). Germplasm management of African leafy vegetables for the nutritional and food security needs of vulnerable groups in South Africa. progress report. Agricultural Research Council-Vegetable and Ornamental Plants (ARC-VOPI).

Walter TM, Merish S, Tamizhamuthu M (2014). Review of Alternanthera sessilis with reference to traditional Siddha medicine. International Journal of Pharmacognosy and Phytochemical Research 6(2), 249–254.

Wardle DA, Bardgett RD, Klironomos JN, Setala H, Van Der Putten WH, Wall DH (2004). Ecological linkages between aboveground and belowground biota. Science. 11, 304(5677), 1629-33. 10.1126/science.1094875.

Wiart C (2006). Medicinal plants of Asia and the Pacific. CRC Press.

Wiart C, Mogana S, Khalifah S, Mahan M, Ismail S, Buckle M, Narayana AK, Sulaiman M (2004). Antimicrobial screening of plants used for traditional medicine in the state of Perak, Peninsular Malaysia. Fitoterapia75(1), 68–73. https://doi.org/10.1016/j.fitote.2003.07.013.

Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen , Garnett T, Tilman D, DeClerck F, Wood A, Jonell M, Clark M, Gordon LJ, Fanzo J, Hawkes C, Zurayk R, Rivera JA, De Vries W, Majele Sibanda L, Murray CJL (2019). Food in the Anthropocene: The EAT-lancet commission on health diets from sustainable food systems. *Lancet* 393(10170), 447–492. https://doi.org/10.1016/S0140-6736(18)31788-4

World Health Organization. (2019). The state of food security and nutrition in the world 2019: Safeguarding against economic slowdowns and downturns

Xiao GW, Zeng HP (2000). Isolation, purification and identification of polysaccharides from black nightshade (*Solanum nigrum*). Chinese Traditional and Herbal Drugs 31(3), 162–164.

Yen GC, Chuang DY (2000). Antioxidant properties of water extracts from Cassia tora L. in relation to the degree of roasting. Journal of Agricultural and Food Chemistry48(7), 2760–2765. https://doi.org/10.1021/jf991010q.

Yuan SL (2008). Research advances on chemical compositions and bioactivities of *Dioscorea opposite*Thunb. (Chinese yam). Food Research and Development, **3:**176–179.

Zhu ZY, Gao L, Wang JK (2003). Illustrated handbook for medicinal materials from nature in Yunnan. Yunnan Science and Technology Press,p. 121.