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Systematic Review

Nutritional Status and Toxicological Characteristics: Review on Wild Edible Plants in Ethiopia

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Abstract

Most of the rural communities depend on wild edible plants for fulfilling their dietary requirements. They believe that all wild edible plants are safe to them. This is because the awareness about available nutrients and toxic ingredients is known little. Some of these incredible food sources may have toxic elements. A better sympathetic on the nutritional status and toxic elements are required to enhance agricultural development, natural resource management, and food security policies in alleviating malnutrition. Therefore, this review literature compiled the scientific findings on the potential WEPs nutritional values and toxicological characteristics. Numerous scientific research findings were assessed from electronic databases. Thus, 65 locally available wild edible plant species were included in the review. Most plants were a good source of nutrients and energy. Scholars recommended further processing (cooking, drying, roasting etc.) to reduce the high contents of toxic elements for few vegetables and fruits. WEPs were found significant to combat deficiency diseases in food-insecure rural areas. It will use as the basis for policymakers in drafting sustainable food programs to alleviate food insecurity and malnutrition in the future.

***Keywords**: Malnutrition; Nutritional Value; Rural Community; Toxic Elements; Wild Edible Plants*

Introduction

Ethiopia has a wide range of topography, edaphic factors, rainfall and spectrum of habitats enhanced the diversity of over 6500 higher flora species [1]. It is one of the 34 global hotspot areas [2] and the fifth largest floral country in tropical Africa [1]. Wild edible plants (WEPs) are the available food in the wildlife but not cultivated as a crop in the agricultural field [3]. Human beings have been used over 7000 wild edible plants in history as rituals, spiritual, cultural and sources of food [4]. WEPs are survival guarantees of macronutrient and micronutrient sources during drought and famine seasons [5]. However, its richness in biodiversity, citizens faces the challenge of food insecurity and malnutrition in each year [6].

Fruits and vegetables are used to treat various diseases; cardiovascular disease, stroke, diabetes, cancer, and other chronic diseases [7]. Many scholars noted the nutritional value of *Amaranthus, Opuntia, Utrica*, and *Ficus* species. The leaves of *Nasturtium officinale* and *Mentha spicata* L. are used to enhance blood circulation and lower blood pressure respectively. The leaves of *Urtica* species alleviate tuberculosis [8]. *Fruits from Opuntia* are known for the treatment of chronic diseases [9]. *Amaranthus* species are rich with exclusive

nutritional compositions of micronutrients and macronutrients [10]. Among this genus, *Amaranthus spinosus* is a nutritious plant that contains nearly all essential nutrients [11]. The high content of nutrients and bioactive in *Urtica dioica* L. is used to treat various diseases. This includes anti-proliferative, anti-inflammatory, antioxidant, analgesic, immune-stimulatory, anti-infectious, hypotensive, antiulcer activities, and cardiovascular disease [12].

Various rural communities inherent all chemical constituents of fruits, vegetables, seeds, tubers, or others are safe for health [13]. However, an excessive intake of certain minerals can lead to health-related problems [10]. A deficiency of a single mineral can lead to lethal to health [14]. These can saponins, oxalates, glycosides, flavonoids, tannins, phytate, anthocyanin, cyanogen, and enzyme inhibitors [15]. Secondary metabolites and toxic elements have attracted scholars' attention in recent years [16]. Many of them are not harmful to the organisms themselves but toxic to humans. They interfere with absorption, digestion, utilization, or overall processes in our body [15].

Higher oxalate content interferes with the absorption of calcium ion. It results in kidney stones [17]. Like Oxalic acid, Phytate reduces calcium and iron absorption and form insoluble salts in our body. The consumption of saponin-containing plant foods reduces the uptake of certain nutrients and membrane destabilization. High Protease and tannin content inhibits the absorption of digestive end products in the small intestine. Cyanide also inhibits the respiratory system [18]. Flavonoids cause inflammatory stress in our body [19]. Polyphenols have antioxidant activity in the body [20]. Certain plant alkaloids in our food can cause infertility [21]. Likewise, several wild edible plants' accidental poisoning has been recorded in Ethiopia [22]. Therefore, a better sympathetic on the nutritional status and toxic ingredients in WEPs are required to enhance agricultural development, natural resource management, and food security policies in the community.

Methods

Search strategy

This Systematic Review was carried out under the guideline of PRISMA [23]. Studies that reported on the nutritional value and toxicity level of WEPs in Ethiopia were considered for this systematic review.

Data collected from journals, published books, and different electronic databases. The author searched many databases to get appropriate studies published in Web of Science, ProQuest, PubMed Central, Google Scholar, PubMed, Science Direct, Scopus, and others using titles related to WEPs in Ethiopia. After identification and downloaded, the author screened all known WEPs reference lists as much as possible by giving prime emphasis on local research findings. The gray literature of unpublished duplicated articles and that did not go ahead with the title were removed. Full text of articles screened that were eligible on locally available wild edible plant species. This review excluded studies that are unavailable in the local. Lastly, the author approved full-text studies for the final synthesis until 22, 08, 2020.

Inclusion and exclusion criteria

This systematic review was compiled on the most common WEPs (n = 65) and excluded those that were unavailable in the local. For unavailable research data on the exact species found in local, the author subjected to search studies carried outside the country. The author included studies published in the English language for simplicity and clarity.

Data extraction and quality assessment

The author used an extraction format and containing information: name of author/s, year of publication, year of study, and study area. In this review, the primary outcome was WEPs' nutritional status, toxicity level, and importance for food security in Ethiopia.

Species identification methods

WEPs were identified based on the book entitled "flora of Ethiopia and Eritrea" and "Useful trees of Ethiopia." All the under reviewed WEPs are referenced locally edible by numerous authors shown in table 1. Identification was also in close collaboration with Botany stream Lecturers and Researchers, Department of Biology, Woldia University. The author pressed the specimens, identified the species with their best photo, and deposited them at Woldia University for future reference.

The scientific name	Family	Common name	Ha	Pu	Mode of consumption	Recommendations are given for WEPs	Ref.
Adenia ellenbeckii Harms.	Passifloraceae	----------	H	L	Leaves are edible raw vegetable	High consumption can lead to health problem/ oxalic acid	[18]
Amaranthus caudatus L.	Amaranthaceae	Aluma	H	L	Cooked leaves are edible	Good source of nutrients. Consumption should be taken with a limited amount	[18]
Amaranthus dubis Thell.	Amaranthaceae	Aluma	H	L	Similar to *A.caudatus*	Good source of nutrients. It should be with a limit	[24]
Amaranthus graecizans L.	Amaranthaceae	Aluma	H	L	Similar to *A.caudatus*	Rich in the entire nutrient elements	[18]
Amaranthus hybridus L.	Amaranthaceae	Aluma	S	L	Similar to *A.caudatus*	Large quantity can interfere with digestion and assimilation	[25]
Amaranthus spinosus L.	Amaranthaceae	Ferenj Aluma	H	L	Similar to *A.caudatus*	Should be taken with a limit	[25]
Amaranthus tricolor L.	Amaranthaceae	Aluma	H	L	Similar to *A.caudatus*	The same as *A.hybridus*	[25]
Amaranthus viridis L.	Amaranthaceae	Aluma	H	L	Similar to *A.caudatus*	*Similar to Amaranthus dubis*	[25]
Balanites aegyptiaca (L.) *Del.*	Balanitaceae	Beddenno	H	F	Fruits are edible in raw	Suggest their potency in fighting malnutrition	[18]
Berberis lyceum Royle.	Berberidaceae	Gewo	S	F	raw or cooked fruits are edible	Can be used separately or in amalgamation foods	[26]
Boucerosia indica (Wight&Arn).	Asclepiadaceae	Gumudo	H	Ag	Succulent stem with flower is edible	Contain appreciable amount of macro and micronutrients	[27]
Caralluma edulis (Edgew.)	Asclepiadaceae	Gumudo	H	L	The raw succulent stem is edible	Capable of providing energy to the consumers	[28]
Caralluma tuberculata N.E.Br.	Asclepiadaceae	Gumudo	H	Ag	Similar to *Caralluma edulis*	It contains a good amount of nutrients	[29]
Carissa spinarum L.	Apocynaceae	Agam	S	F	Raw or ripen fruits are edible	Source of nutrient for rural poor communities	[30]
Casimiroa edulus L.	Rutaceae	Kazamora	T	F	Its fruits are edible in raw	Much more beneficial food source than common fruits	[31]
Celosia argentea L.	Amaranthaceae	----------	H	L	The Arial part is edible	Similar to *Adenia ellenbeckii*	[18]
Coccinia abyssinica (Lam.) Cong.	Cucurbitaceae	Anchote	C	Tu	Its tuber is edible	A good supplement of vitamins and minerals	[18]

Coccinia grandis (L.) Voigt	Cucurbitaceae	Werqbmeda	C	F	Fruits are edible in raw	Similar to *Adenia ellenbeckii*	[18]
Commelina diffusa Burm. f.	Commelinaceae	Sindelit	H	L	Raw leaves are edible vegetable	Good source of nutrients to combat malnutrition	[24]
Corchorus trilocularis L.	Tiliaceae	Ged mide	H	L	Young leaves are edible in raw	Similar to *Adenia ellenbeckii*	[18]
Cucumis dipsaceus Ehrenb Ex.	Cucurbitaceae	Yamorami-sa	C	L	raw/cooked vegetable is edible	Good source of nutrients to combat malnutrition	[24]
Cyperus esculentus L.	Cyperaceae	Gicha/Guma	H	Tu	eaten in raw or cooked form	A rich source of oil and mineral for growth and development	[33]
Cyperus rotundus L.	Cyperaceae	Gicha	H	Tu	Similar *to Cyperus esculentus*	Similar to *Cucumis dipsaceus*	[24]
*Diospyros mespeliformis*A.	Ebenaceae	Ayeh	T	F	Raw fruits are edible	Suggest their potency in fighting malnutrition	[34]
Dovyalis abyssinica (A.Rich.) Warb	Flacourtiaceae	Kosim	S	F	Ripen fruits are edible in raw	Not advice to eat more of its fruits at once	[35]
Ficus auriculata (Lour.)	Moraceae	----------	T	F	Similar to *Ficus sur* Forssk	Good dietary sources	[36]
Ficus carica L.	Moraceae	Beles	T	F	Similar to *Ficus sur* Forssk.	Ensure dietary diversity and food security	[37]
Ficus palmata Forssk.	Moraceae	Quella Beles	T	F	Similar to *Ficus sur* Forssk.	Ensure dietary diversity and food security	[37]
Ficus sur Forssk.	Moraceae	Shola	T	F	Ripen fruits are edible in raw	Can improve nutrition and tackle food insecurity	[38]
Ficus sycomorus L.	Moraceae	Bamba	T	F	Similar to *Ficus sur* Forssk.	Improve dietary diversity and tackle food insecurity	[38]
Grewia bicolor Juss.	Tiliaceae	Somaya	T	F	Ripen fruits are edible in raw	A cheap source of nutrients to combat malnutrition	[24]
Grewia tenax (Forssk.) Fiori.	Tiliaceae	Hoba	T	F	Ripen fruits are edible in raw	Can provides essential nutrients	[15]
Justicia flava (Vahl) Vahl.	Acanthaceae	Matoya	H	L	Leaves are edible vegetable	Similar to *Adenia ellenbeckii*	[18]
Justicia ladanoides Lam.	Acanthaceae	Telenje	H	L	Arial parts are edible	Similar to *Adenia ellenbeckii*	[18]
Lantana camara L.	Verbenaceae	Yewofqolo	S	F	Fruits are edible in raw form	Cheap source of nutrients to combat malnutrition	[24]
Momordica dioica Roxb.ex Willd	Cucurbitaceae	Wof techj	C	F	Fruits are edible in raw	Adequate nutrition for growth and development	[40]
Moringa oleifera Lam.	Moringaceae	Shiferaw	T	L	Cooked leaves are edible	Good nutritional and supplement food	[41]

Moringa stenopetala (Bak.f.)	Moringaceae	Shiferaw	T	L	Similar to *Moringa oleifera*	Potential resource of macro-nutrients, micronutrients	[42]
Morus alba L.	Moraceae	Nech enjori	T	F	Similar to *Morus nigra*	Promising sources of essential nutrients	[37]
Morus nigra L.	Moraceae	Tikur enjori	T	F	Fruits are edible in raw form	The source of nutrients may have a hallucinogenic effect	[43]
Nasturtium officinale W.T.Aiton	Brassicaceae	Guguble	H	Ag	Mostly cooked or edible in raw	An outstanding source of iodine and protein	[26]
Opuntia Ficus indica (L.) Miller	Cactaceae	Bahrqul-qu-al	S	F	Ripen fruits are edible	Efficient functional food and promote better health	[43]
Opuntia hyptiacantha	Cactaceae	Bahrqul-qu-al	S	F	Ripen fruits are edible in raw	Efficient functional food to prevent chronic disease	[53]
Opuntia streptacantha	Cactaceae	Bahrqul-qu-al	S	F	Ripen fruits are edible in raw	Efficient to prevent chronic disease and malnutrition	[53]
Oxalis stricta L.	Oxalidaceae	Ye-bereche-w	H	Ag	Arial shoots are edible in raw	Can be used separately or in amalgamation foods	[26]
Oxygonum sinuatum (Meisn.) Dammer.	Polygonaceae	----------	H	L	Raw or cooked leaves are edible vegetable	The same as *Cucumis dipsaceus*	[24]
Pentarrhinum insipidum E.Mey	Apocynaceae	Gumudo	H	Ag	Succulent stem are edible in raw	Good source of nutrients	[18]
Physalis peruviana L.	Solanaceae	Nech-awet	H	F	Similar to *Physalis micrantha*	Good source of essential nutrients but must be with a limit	[45]
Portulaca oleracea L.	Portulacaceae	----------	H	L	Raw leaves and shoots edible	Have the potential to provide essential nutrients	[28]
Portulaca quadrifida L	Portulacaceae	----------	H	L	Used as salad/vegetable	Nutrients should be with a limit	[18]
Rosa abyssinica L.	Rosaceae	Kega	S	F	Raw or ripen fruits are edible	Good dietary sources	[43]
Rubus Fruticosus L.	Moraceae	Enjori	S	F	Raw fruits are edible	Packed with numerous nutrients essential for health	[44]
Sclerocarya birrea (A.Rich.) Hochst.	Anacardiaceae	----------	T	F	The fruits are edible in a raw state	Good supplementary food	[34]
Sisymbrium officinale (L) Scop.	Brassicaceae	Senafich	H	L	Cooked leaves are edible	A key source of nutrients for human consumptions	[26]
Solanum nigrum L.	Solanaceae	Tikur awit	S	F	Similar *to Physalis peruviana*	Can increase dietary diversity and tackle food insecurity	[46]
Solanum torvum SW.	Solanaceae	Awit	S	F	Similar to *Physalis peruviana*	Possesses most of the nutrients required for healthy growth	[47]

Syzygium guineense (Willd.) DC.	Myrtaceae	Doqma	T	F	Raw ripen fruits are edible	Valuable sources of nutrients in solving nutritional problems	[48]
Tamarindus indica L.	Fabaceae	Humer	T	FS	Ripen fruits and seeds are edible	Can improve dietary diversity and tackle food insecurity	[49]
Utrica dioica L.	Utricaceae	Samma	H	L	Cooked leaves are edible	Nutrients are warranted	[49]
Vitex doniana Sweet.	Verbenaceae	Plem	T	F	Ripen fruits are edible	The same as *Cucumis dipsaceus*	[38]
Ximenia americana L.	Olacaceae	Enkoy	T	F	Ripen fruits are edible	The same as *Cucumis dipsaceus*	[50]
Ximenia caffra Sond.	Oleaceae	----------	T	F	Fruits are edible in raw form	Valuable sources of food but should with a limit	[48]
Ziziphus jujuba Mill.	Rhamnaceae	Kurkura	T	F	Fruits are common edible in raw	Medicinal plant with various nutritional values	[51]
Ziziphus mucronata Willd.	Rhamnaceae	ado-qurqura	T	F	Fruits are edible in raw	Enhance cardiovascular health and metabolism	[51]
Ziziphus spina-Christi (L.) Desf).	Rhamnaceae	Kurkura	T	F	Similar to *Ziziphus mucronata*	Appreciable source of nutrients	[52]

Table 1: *List of common wild edible plants of Ethiopia with their route of consumption.*

Keys: *Parts used (Pu) habit (Ha), Tree (T), Leaf (L), Fruit and leaf (FL), Leaves and seeds (LS), Fruits and Seeds (FS), Climber (C), Flower (Fr), Stem (St), Above ground (Ag), Arial shoot with leaves (As), Tuber (Tu), Reference (Ref), Common name in Amharic (α), Injera is a local name for traditional food in Ethiopia.*

Result

References in review

A total of 252 research findings, literature review, and Published books were identified and downloaded for the first time. Forty-two of the references were removed due to the absence of a full-length article. Then, 190 full-text articles were screened for further processing. Sixty-eight (68) of them were removed by their title, abstract, and for their insufficient data source. Fifty-seven references (57) of 122 were used only for the checkup of exact species for its habit, taxonomy, and economic importance. Finally, the most popular WEPs (n = 65) in the community were included.

Wild edible plants of Ethiopia with their route of consumption

Locally available WEPs (65) are described in table 1 below. All of them were from 30 different plant families. Amaranthaceae and Moraceae are found with the highest number of species each (8) followed by Cucurbitaceae (4). Solanaceae, Tiliaceae, Asclepiadaceae, Rhamnaceae, and Cactaceae are represented by three species each. Verbenaceae, Acanthaceae, Apocynaceae, Brassicaceae, Cyperaceae, Moringaceae, Olacaceae, and Portulacaceae were found with two species each. The rest of the plant families are represented by one species each (See also figure 1). Regarding the habit of their diversity, 26 plant species (40%) are found herbs followed by 14 shrub species (21.5%) and 23 tree species (35.4%). The rest of the two were climbers (3.08%). Dominant wild edible plant parts consumed were from fruits, 34 (52.31%), followed by leaves, 22 (33.85%). The other edible plant parts were: above-ground parts (7.69%), tubers (4.62%) and fruits and seeds (1.54%) recorded.

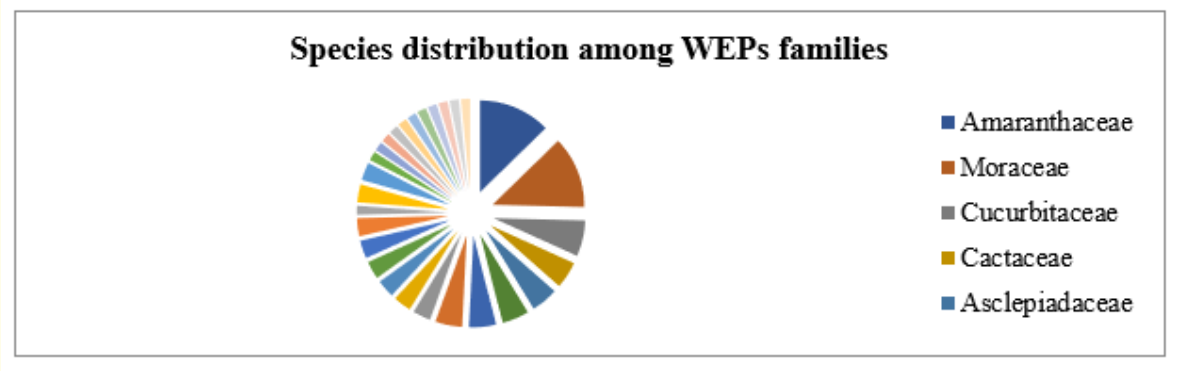

Figure 1: *Distribution of WEPs with plant families in the study.*

Discussion

Ethiopia is fortunate to the great diversity of higher flora species and wild edible plants. Local residents depend on WEPs as supplementary food to curve food insecurity and increase dietary diversity. This is common when sudden drought exists or household food security is in short supply. This was in agreement with [5] who notified that wild edible plants are natural gift to alleviate food insecurity and malnutrition. However, the local communities believe that all wild edible plants are safe to them. The awareness of wild edible plants about their safety (free from toxic ingredients) and available nutrients (essential macronutrients, micronutrients, minerals, and vitamins, etc.) is known little or not at all [54]. Hence, this review was the first attempt to compile the nutritional and toxicological characteristic of potential wild edible plants, and thus suggest the recommended species to sustainable food security in North Wollo, Ethiopia. It will be a baseline review and provide relevant information for policy-makers and managers in future.

Nutritional constituents of the under reviewed wild edible plants were both nutritionally important species and some toxic species that can affect health. The minimal toxicity range varies from one species to the other WEPs (See table 1). This was in line with minimal and maximal toxicity dose reported by several authors [18,55-57]. For instance, the minimal lethal toxicity dose of oxalate for humans is about 5 g for an adult man [55]. Another research by [56] revealed the daily intake of 450 mg of oxalic acid interferes with various metabolic processes. He further explained that an in-take of 4 - 9 mg/100g of phytic acid decreases iron absorption in the body. Research done by [57] argues the consumption of a high level of dietary tannin (12 mg/100g) can reduce the absorption of protein and damages the intestinal walls. Similarly, [18] noted the presence of high oxalic acid in *Adenia ellenbeckii*, *Celosia argentea, Coccinia grandis*, *Corchorus trilocularis*, *Justicia flava,* and *Justicia ladanoides*. Amaranthus species are a good source of nutrients. He also argues high consumption of these WEPs can lead to health problems (Table 1).

According to [58], ant-nutritional factors can impair the digestion of various nutrients in the body. Thus, it is necessary to determine whether they contain the right amount of nutritional, anti-nutritional factors and toxic elements before consumption. Some scholars like [59] recommended further processing (cooking, drying, fermentation, germination, and others) to reduce the high contents of toxic minerals and anti-nutritional factors in vegetables and fruits. Moderate consumption is recommended in some wild edible plants with the accumulation of nitrites, oxalate, and other poisonous elements/compounds [34]. For this reason, consumption of some wild plants as a raw salad or cooked should be with a limited amount.

Conclusion

Large bodies of research findings, review work of literature, and published books have revealed supplement food sources to rural communities. Consumers inherit all wild edible plants that are nutritionally safe to them. Despite the fact, the latest research revealed toxic elements found in some wild edible fruits and vegetables. Likewise, several wild edible plants' accidental poisoning has been recorded in Ethiopia. This review article is thus endeavored to bring all research findings into a single manuscript. This will creates awareness to the consumers and other stakeholders to get assured nutritional information. Some wild edible plants containing high toxic elements that need further processing can reduce it and might not pose a health problem. In general, most wild edible plant nutrition is good to combat malnutrition and food insecurity when other household foods are in short supply or during drought seasons. Researchers should be motivated in-depth experiments on the local wild edible plants' nutritional values.

Ethics Approval and Consent to Participate

Not applicable.

Consent for Publication

No need for consent for publication.

Availability of Data and Materials

The datasets generated and analyzed within this article are available and included in the manuscript.

Competing Interests

The author declares that no competing interests.

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Author Contribution

The author did this article from start to end by himself and approved the final manuscript.

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