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## A review on taxonomic and use diversity of the family Amaranthaceae in Ethiopia

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### Abstract

This work reviews literature on taxonomic and use diversity of the family Amaranthaceae in Ethiopia in order to organize the available information and to identify gaps in knowledge. Flora of Ethiopia and Eritrea Volume 2 part 1 recognizes 20 genera and over 50 species in the family. A maximum of 33 species of Amaranthaceae are registered in Sidamo Region and a minimum of eight species are registered in Arsi and Welega Regions. In species wise distribution *Achyranthus aspera* and *Cyathula cylindrica* are widely distributed. *Achyranthus aspera* and *Amaranthus caudatus* are highly used as medicine and *Amaranthus caudatus* and *Amaranthus graecizans* are highly used as food in different ethnic groups in Ethiopia. Some of them are very promising food crops in arid region due to their resistance to heat, disease, and pests. These groups are neglected and underutilized species and are drought tolerant, grow fast and are easily cultivated. Since the dawn of history, amaranth has served civilizations as staple grain. Now, in its quest for health and variety, American consumers are discovering the natural nutrition, exciting textures and unique flavor of this grain so some species of the genus *Amaranthus* are cultivated for their grains or leaves. *Amaranthus* has various health benefits and medicinal properties including those which are very useful in preventing a retarded growth in children, increase the flow of breast milk, valuable in preventing a premature old age, important in all bleeding tendencies, considered highly beneficial in treatment of gonorrhoea and benefits patients with cardiovascular disease. *Amaranthus caudatus* and *Amaranthus dubius* can be toxic if taken as food by humans without proper precaution. Reason for exposure can be accidental contact and any dose is dangerous and effect to toxicity that may lead to other health and life risks. *Amaranthus caudatus* and *Iresine herbstii* have been developed as ornamentals and *Sericocomopsis pallida*, *Amaranthus thunbergii*, *Amaranthus dubius* and *Achyranthus aspera* are used as favorite food for livestock. *Pupalia lappacea*, *Chionothrix latifolia*, and *Chionothrix tomentosa* are also used as forage and for house construction.

**Keywords:** Ethiopia, Amaranthaceae, taxonomic diversity, use diversity

### Introduction

Amaranthaceae comprise about 70 genera and 1000 species and most of its members are annual and perennial herbs, together with some shrubs or small trees, sometimes climbing which have adapted to salty soils, arid environments and altered human settlements, in which they profit from high nitrogen concentrations. Leaves are simple, alternate or opposite. Flowers are bisexual or unisexual (monoecious or dioecious), usually regular and the seed is globose to ovoid or lens-shaped. They largely originate in the Steppes of Central Asia, although some of the most common *Amaranthus* species are of American origin; they were used in America for making both flour and drinks, and also in rituals, due to their alkaloid content [15, 33]. The family includes species of ornamentals such as *Celosia cristata* and *Amaranthus caudatus*, and species of economic interest. However, a number of species are considered invasive or parasite and certainly, some are listed among the world's worst weeds, e.g. *Amaranthus muricatus* [12, 14, 35, 52].

Amaranthaceae species are able to tolerate highly arid habitats and very salty soils thanks to a series of specific adaptations. These include extremely high seed production—ranging between 13,000 and 50,000 seeds per plant, depending on the richness of the soil [30] and a fruit dispersal mechanism involving the whole plant, e.g. tumbleweed. Both mechanisms are intended to ensure plant survival during arid periods and in hostile environments. The tolerance of some species to accumulate high arsenic concentrations in different parts of its organism, without exhibiting decreased growth, contributes to their use as toxic-fixatives in highly polluted soils [44].

### Taxonomic diversity of Amaranthaceae in Ethiopia

Twenty genera and 51 species of Amaranthaceae several of which are highly variable are recognized in Ethiopia. From these species, *Amaranthus graecizans* has three subspecies; *Amaranthus hybridus*, *Amaranthus lividus* and *Digera muricata* have two subspecies each while *Cyathula prostrate* and *Achyranthes aspera* have two varieties each [50]. All the genera of the Amaranthaceae family and their corresponding species in Ethiopia are mentioned as follows.

**Celosia** is a genus with annual or perennial herbs, sometimes woody below and erect to scandent. Leaves are alternate, entire, or lobed and flowers in axillary or terminal. Their seeds are black and shining in all species and about five species; *C. anthelminthica*, *C. schweinfurthiana*, *C. polystachia*, *C. trigyna* and *C. argentea* are found in Ethiopia [50].

**Amaranthus** is a genus that includes annual more rarely perennial herbs that are glabrous or covered with short and gland-like or multi-cellular hairs. They can be monoecious or dioecious. Leaves are alternate with long petioles and entire or wavy. Flowers are unisexual and seeds are usually compressed, black, and shiny. About eleven species are recorded in Ethiopia. The most important characters for identifying the species are the form of the inflorescence, the number and shape of the tepals particularly those of the female flowers and their length in relation to the bracteoles, and the ripe capsules and seeds. Many of the species in this genus are edible and some are cultivated for their leaves [50]. This genus include *A. caudatus*, *A. hybridus* (American missionaries have introduced this crop and introductions of grain producing types have also been made through the formal agricultural research system and subspp. *hybridus* and *cruentus* are both recorded from Ethiopia), *A. spinosus*, *A. dubius* (hybrids between *A. spinosus* and *A. dubius* are said to occur freely where these two species occur together. Apart from the spines of *A. spinosus*, the two species are very similar), *A. tricolor*, *A. thunbergii*, *A. graecizans* (subsp. *thellungianus*, *graecizans* and *silvestris* are included under this species. The above three subspecies appear to meet and mingle in Ethiopia largely than anywhere else), *A. sparganiocephalus*, *A. lividus* (has two subspecies; subspp. *lividus* and *polygonoides*), *A. viridis* and *A. palmeri*.

**Digera** is a genus with annual herbs with an entire and alternate leaves. Flowers are in spike-like axillary bracteates. Fruit is a hard indehiscent nut let enclosed by persistent perianth and falling together with the sterile flowers and bracteoles. One variable species in tropical Asia and Africa is with 2 subspecies, one further divided into 2 varieties in Ethiopia [50]. *D. muricata* is public sale herb, simple or branched from near the base and stem and branches glabrous or sparingly hairy with two varieties; var. *muricata* and *trinervis*.

**Pleuropterantha** is a genus with small shrubs or shrubby perennials. Leaves are entire and alternate. Flowers are axillary, and each bract is with a central fertile flower and two highly modified sterile lateral flowers, the whole looking like a single flower. Sterile flowers develop into broad wings in fruit and the fruit is a hard, indehiscent nut let enclosed by the persistent perianth and falling together with the wing-like sterile flowers and bracteoles. This genus is with three species confined to SE Ethiopia and Somalia and only *P. revollii* is found in Ethiopia [50].

**Sericostachys** is a genus containing woody climber with opposite branches and entire leaves. Inflorescence is an open panicle of spikes. Stamens are five, united into a cup-like base with very short pseudostaminodes. Ovary is with one ovule and sterile flowers reduced to 12 hair-like appendages alternating with very small pseudostaminodes. In fruit, the appendages grow into long plumose hairs and the fruit is a thin-walled capsule enclosed by and falling with the persistent perianth, sterile flowers, and bracteoles. This is a monotypic genus with *S. scandens* confined to Africa [50].

**Sericocomopsis** is a genus with small bushy shrubs with entire, opposite leaves and branches covered with multi-cellular or star-shaped hairs. Flowers are in spike-like bracteate inflorescences and all are fertile, occasionally solitary but usually 2-3 flowers in each cluster. Stamens are five and united below and ovary is with one ovule. Only *Sericocomopsis hildebrandtii* and *S. pallida* are occurring in Ethiopia [50].

**Centemopsis** is a genus with annual or perennial herbs with opposite and entire leaves. Inflorescences are terminal on stem and branches, spike-like or a head with flowers solitary or paired in the axil of each bract. Flowers are all fertile and bisexual. This genus has 12 species, all in tropical Africa and only *C. kirkii* is found in Ethiopia [50].

**Lopriorea** is a genus with perennial herb or low sub-shrub with opposite leaves and branches and all parts glabrous except inflorescence. Leaves can be entire and sessile. Inflorescence is a dense rounded or ovate head with one or two fertile flowers within the axil of each bract. A monotypic genus with *L. ruspolii* confined to a small area [50].

**Cyathula** is a genus that includes annual or perennial herbs. Leaves are opposite and entire and inflorescences are terminal as heads or spike-like with bracts. The ultimate division is in a group of three fertile flowers. Spines of modified flowers are at first very small, developing rapidly in fruit. About 25 species in the tropics of both Old and New Worlds; *C. prostrate* (with two varieties; var. *prostrata* and *pedicellata*), *C. achyranthoides*, *C. polycephala*, *C. cylindrical*, *C. uncinulata*, *C. orthacantha* and *C. erinacea* are registered in Ethiopia [50].

**Pupalia** is a genus with herbs or sub-shrubs and leaves are entire and opposite. Inflorescences are terminal, bracts each holding a triad of a single fertile flower with a modified sterile flower on each side. Fertile flowers have five stamens fused at the extreme base forming a fleshy disc, ovary is with one ovule, and seed is ovoid to oblong-ovoid. This genus is with four species in the tropics (one species extending to the subtropics) of the Old World from West Africa to Malaysia and the Philippines; *P. micrantha*, *P. grandiflora* and *P. lappacea* occur in Ethiopia [50].

**Volkensinia** is a genus containing small shrub or bushy perennial with entire opposite leaves and branches and stems are with jointed minutely barbed hairs. Inflorescences are narrow with compact, opposite and spherical clusters of fertile and sterile flowers. Capsule is thin walled, with a firm cap-like apex. Monotypic genus with *V. prostrata* confined to Ethiopia [50].

**Psilotrichum** is a genus with perennial herbs or sub-shrubs whose stems are erect or prostrate to climbing. Leaves are

entire, opposite or sometimes at least alternate. Flowers are solitary in the axil of each bract and seed is ovoid and brown. This is mainly African genus of about 14-18 species, some of which are also found in tropical Asia. This genus appears to have a centre of diversity in Somalia where six of the 12 species are endemic. The present account gives *P. gnaphalobryum*, *P. amplum*, *P. gloveri*, *P. elliotii* and *P. schimperi* in the Flora area but further collecting in Sidamo, Bale and Hararge could find additional taxa <sup>[50]</sup>.

**Chionothrix** - is a genus that includes small to large shrubs or small trees. Leaves are opposite, entire and covered with simple or star-shaped hairs. All flowers are fertile and solitary in the axil of each bract and each is with two bracteoles. They have five stamens and ovary is with one ovule. This genus has two species only, one in Somalia and *C. latifolia* in Ethiopia <sup>[50]</sup>.

**Nothosaerva** is a genus with annual herb in which leaves and branches are opposite or alternate. Flowers are small, solitary in the axils of scarious bracts and each flower with two very small bracteoles and seeds are round and compressed. This genus is monotypic with *N. brachiata* widespread throughout much of the Old World <sup>[50]</sup>.

**Aerva** is a genus containing perennial herbs sometimes flowering in the first year which are prostrate to erect. Leaves and branches are opposite or alternate and entire; flowers are small and solitary and seed is compressed, some-what round or kidney-shaped and black. It is mainly African genus with about 10 species in the tropics and *A. javanica* and *A. lanata* are found in Ethiopia <sup>[50]</sup>.

**Achyranthes** is a genus with herbs sometimes shrubs or small trees and leaves are opposite and entire. Inflorescence is a narrow spike, flowers at first crowded, later spaced out and solitary in axils of bracts. Fruits are sharply bent downwards along the inflorescence axis. There are about 6 species in the warm temperate and tropical regions of the world and only *A. aspera* with var. *pubescens* and *sicula* are found in Ethiopia <sup>[50]</sup>.

**Centrostachys** is a genus which includes aquatic perennial herb and leaves are opposite and entire. Flowers are solitary and sessile in the axils of bracts and spike elongating as the flowers open and mature. These flowers are all fertile, at first spreading, in fruit bent down along the inflorescence axis.

This genus is monotypic having only *C. aquatic* (aquatic or sub-aquatic) <sup>[50]</sup>.

**Pandiaka** is a genus with annual or perennial herbs and leaves opposite. Flowers are solitary in axils of bracts, firm, papery, or horny. This genus has 12 species confined to tropical Africa and only *P. angustifolia* is recorded for Ethiopia <sup>[50]</sup>.

**Alternanthera** is a genus with herbs which are prostrate or erect to scrambling or floating. Leaves are entire and opposite, flowers are solitary or clustered which are bisexual and solitary in the axils of the bracts, and seeds are lens-shaped. It is a large genus of around 200 species, chiefly in the tropics of the New World and 4 species (*A. pungens*, *A. caracasana*, *A. nodiflora* and *A. sessilis*) are found in Ethiopia <sup>[50]</sup>.

**Gomphrena** is a genus that includes herbs in which leaves are entire and opposite. Flowers are solitary in the axil of each bract and seed is compressed and ovoid. A large genus with about 100 species, mostly in tropical America but with several in Australia; *G. celosioides* and *G. globosa* are found in Ethiopia, the former is an introduced weed, and the later is a cultivated ornamental <sup>[50]</sup>.

#### Distribution of members of the family Amaranthaceae in Ethiopia

Members of Amaranthaceae are widespread and cosmopolitan in distribution but most abundant in tropics, subtropics, and warm-temperate regions, evidently absent from alpine and arctic regions. Centers of diversity for Amaranthaceae are southwestern North America, Central America, South America, and Africa south of the Sahara Desert. Most species occur in tropical Africa and North America <sup>[51]</sup>. Some species are considered weeds, but a number of others are popular garden ornamental plants, especially species of *Alternanthera*, *Amaranthus* and *Celosia*. Amaranths are probably among the most promising unexploited food and fodder crops <sup>[9, 17]</sup>.

Amaranthaceae is widely distributed all over the fourteen administrative regions of Ethiopia (according to the previous administrative system of the country). According to <sup>[50]</sup> a minimum of eight and a maximum of thirty-three species are registered in these administrative regions. Arsi and Welega administrative regions have eight species each while in Sidamo administrative region thirty-three species of Amaranthaceae are registered (Figure 1).

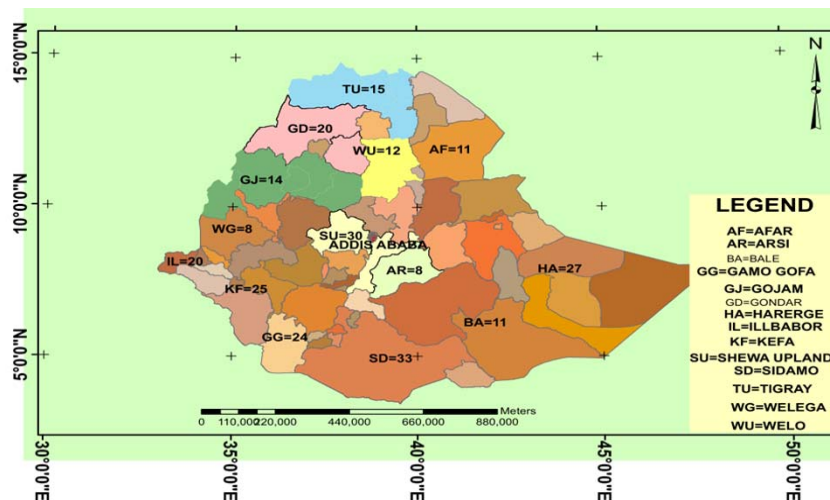


Fig 1: Number of Amaranthaceae species in Floristic Regions of Ethiopia.

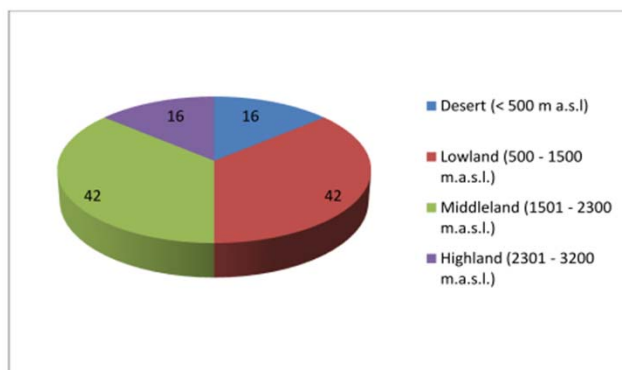
The lists of Amaranthaceae species distributed among different regions of Ethiopia are indicated in Table 1.

**Table 1:** List of Amaranthaceae species distributed in different regions of Ethiopia

Region	List of Amaranthaceae species found in the region	Amt of spp.
Afar	<i>C. argentea, A. dubius, A. thunbergii, A. graecizans, S. pallida, C. cylinderica, P. lappaceae, A. javanica, A. lanata, A. pungens, A. sessilis</i>	11
Arsi	<i>C. schweinfurthiana, A. hybridus, A. spinosus, C. polycephala, C. cylinderica, C. uncinulata, A. aspera, A. sessilis</i>	8
Bale	<i>C. schweinfurthiana, A. thunbergii, C. achyranthoides, C. polycephala, C. cylinderica, P. lappaceae, A. sessilis, P. gnaphalobryum, C. latifolia, A. javanica, A. aspera,</i>	11
Gamo Gofa	<i>C. anthelminthica, C. polystachia, C. argentea, A. hybridus, A. dubius, A. graecizans, A. sparganiocephalus, D. muricata, S. hildebrandtii, S. pallida, C. prostrata, C. cylinderica, C. orthacantha, P. micrantha, P. lappaceae, V. prostrate, P. gnaphalobryum, P. elliotii, N. brachiata, A. javanica, A. lanata, A. aspera, A. nodiflora, A. sessilis</i>	24
Gojam	<i>C. schweinfurthiana, C. trigyna, C. argentea, A. spinosus, C. polycephala, C. cylinderica, C. uncinulata, P. micrantha, P. schimperii, A. javanica, A. aspera, C. aquatic, A. nodiflora, A. sessilis</i>	14
Gondar	<i>C. anthelminthica, C. schweinfurthiana, C. trigyna, C. argentea, A. caudatus, A. hybridus, A. spinosus, A. tricolor, A. graecizans, A. lividus, C. polycephala, C. cylinderica, C. uncinulata, C. orthacantha, P. micrantha, P. schimperii, A. lanata, A. aspera, C. aquatic, A. sessilis</i>	20
Hararge	<i>C. polystachia, A. caudatus, A. hybridus, A. spinosus, A. dubius, A. thunbergii, A. graecizans, A. sparganiocephalus, A. viridis, A. palmeri, D. muricata, P. revoilii, S. pallida, G. celosioides, C. cylinderica, C. uncinulata, C. orthacantha, P. lappaceae, P. gnaphalobryum, P. amplum, P. gloveri, C. latifolia, A. javanica, A. lanata, A. aspera, A. pungens, A. sessilis,</i>	27
Illubabor	<i>C. schweinfurthiana, C. trigyna, C. argentea, A. caudatus, A. dubius, A. viridis, C. prostrata, C. achyranthoides, C. polycephala, C. uncinulata, P. micrantha, P. grandiflora, P. elliotii, A. lanata, A. aspera, C. aquatic, P. angustifolia, A. sessilis, G. celosioides, G. globosa</i>	20
Kefa	<i>C. schweinfurthiana, C. polystachia, C. trigyna, C. argentea, A. caudatus, A. hybridus, A. spinosus, A. graecizans, A. lividus, S. scandens, S. pallida, C. achyranthoides, C. polycephala, C. cylinderica, C. uncinulata, C. orthacantha, P. lappaceae, P. elliotii, N. brachiata, A. lanata, A. aspera, A. pungens, A. sessilis, G. celosioides, G. globosa</i>	25
Shewa Upland	<i>C. schweinfurthiana, C. polystachia, C. argentea, A. caudatus, A. hybridus, A. spinosus, A. dubius, A. tricolor, A. thunbergii, A. sparganiocephalus, A. lividus, A. viridis, A. palmeri, D. muricata, S. pallida, C. polycephala, C. cylinderica, C. uncinulata, C. orthacantha, P. lappaceae, V. prostrate, P. gnaphalobryum, A. javanica, A. lanata, A. aspera, C. aquatic, P. angustifolia, A. pungens, A. sessilis, G. globosa,</i>	30
Sidamo	<i>C. anthelminthica, C. schweinfurthiana, C. polystachia, C. trigyna, C. argentea, A. caudatus, A. hybridus, A. dubius, A. thunbergii, A. graecizans, A. sparganiocephalus, A. lividus, D. muricata, S. hildebrandtii, S. pallida, C. kirkii, L. ruspoli, C. cylinderica, C. uncinulata, C. orthacantha, C. erinaceae, P. grandiflora, P. lappaceae, P. gnaphalobryum, P. elliotii, P. schimperii, C. latifolia, N. brachiata, A. javanica, A. lanata, A. aspera, A. pungens, G. celosioides,</i>	33
Tigray	<i>C. argentea, A. caudatus, A. hybridus, A. spinosus, A. palmeri, C. cylinderica, C. uncinulata, C. orthacantha, P. lappaceae, A. javanica, A. lanata, A. aspera, A. pungens, A. nodiflora, A. sessilis</i>	15
Welega	<i>C. schweinfurthiana, C. trigyna, A. lividus, C. uncinulata, P. grandiflora, P. elliotii, A. lanata, A. aspera</i>	8
Welo	<i>C. polystachia, C. argentea, A. spinosus, A. tricolor, D. muricata, S. scandens, S. pallida, C. cylinderica, P. lappaceae, P. gnaphalobryum, A. aspera, C. hybridus</i>	12

When we consider species wise distribution *Achyranthes aspera* is widely distributed in all regions except in Afar and *Cyathula cylindrica* is distributed in the same way except in Illubabor. On the other hand, *Centemopsis kirkii*, *Cyathula erinacea* and *Lopriorea ruspoli* are found only in Sidamo while *Pleuropterantha revoilii* *Psilotrichum amplum* and *Psilotrichum gloveri* are exceptional for Hararge.

According to [48] the Ethiopian ecological zones (agro-ecologies) are divided into six as desert (< 500 meter above sea level), lowland (500 - 1500 meter above sea level), middle land (1501 - 2300 meter above sea level), highland (2301 - 3200 meter above sea level), wurch (3201 - 3700 meter above sea level), and Alpine wurch (> 3700 meter above sea level). When we see the distribution of Amaranthaceae species in Ethiopia based on this information there are plenty of species in the lowland and middle land but no species is registered in the wurch and alpine wurch. The following pie chart shows this clearly (Figure 2).



**Fig 2:** Distribution of Amaranthaceae species with respect to agro - ecological zones

### Use diversity of Amaranthaceae in Ethiopia

Different species of Amaranthaceae can be used as food, medicine, forage and construction material. Species of Amaranthaceae are neglected and underutilized species (NUS). This refers to a category of non-commodity cultivated and wild species, which are part of a large agro-biodiversity portfolio today falling into disuse for a variety of agronomic, genetic, economic, social and cultural factors. NUS are traditionally grown by farmers in their centers of diversity, where they support nutrition security and other livelihood goals of local communities while contributing to meet their socio-cultural needs and traditional uses. Until recently, these species have been largely ignored by research and development, becoming less competitive than well-established major crops and losing gradually their diversity and associated traditional knowledge [29].

### Amaranthaceae species used as food in Ethiopia

Since the dawn of history, amaranth has served civilizations as staple grain. Now, in its mission for health and variety, American consumers are discovering the natural nutrition, exciting textures and unique flavor of this grain. By sourcing reliable supplies and milling this grains into functional form they have added the quality and scale that will support the industry's 21<sup>st</sup> century introduction of Ancient Grain. With functionality across a wide range of applications—from breads and pizza crusts to breakfast cereal and bar—it's no wonder this Ancient Grain is making waves all over again [49]. Many of Ancient Grain products are also naturally gluten-free, offering a new world of flavor and nutrition for our

gluten-free applications. Amaranth grains are very small, light-colored grains with an appealing mild flavor. Native to the Americas and prized by the Aztec civilization, it was a dietary staple and a revered symbol of the culture. Amaranth flour works well in a variety of applications, such as baked goods and pasta cereals. Amaranth protein quality is among the highest relative to other grains. It also has comparatively more calcium and iron. Products made with amaranth have a moist, creamy texture and a neutral flavor. This provides it an increased shelf life due to moisture retention [22].

Many of the species in the genus *Amaranthus* are edible. Some are cultivated for their leaves (e.g. *A. tricolor* and *A. lividus*), while others, particularly *A. hybridus* and *A. caudatus* are important grain crops. In Ethiopia, the seed of *A. caudatus* is used as food by Gumuz tribesmen, and in making local beer. It is also noted as cultivated plant and the seed used to prepare porridge in Sidamo nation [26]. Amaranth is easy to grow, nutrient rich and underutilized pseudo cereal that can play an important role in actions against hunger and malnutrition that occur due to low rainfall conditions. This plant is broad-leaved non-grass plant that produces significant amounts of edible cereal-like grains. It is an under-exploited plant with an exceptional nutritive value. A grain amaranth is very versatile as a food ingredient and can diversify farming enterprise; as it can be expected to prevent food depletion and to feed the world [41]. Amaranth grows rapidly and has a high tolerance to arid conditions and poor soils where traditional cereals cannot be grown. It has been touted as a miracle grain, a super grain, and the grain of the future [40, 20]. The main species are *Amaranthus caudatus*, *Amaranthus cruentus* and *Amaranthus hypochondriacus*. *Amaranthus caudatus* has long been grown as a food crop in Ecuador, Peru, Bolivia and Argentina. *Amaranthus caudatus* has also been grown in East Africa (Ethiopia, Kenya, Eritrea, Uganda) as grain and vegetable crops [49, 53]. The seeds, although barely bigger than *Eragrostis tef* seed (0.9 - 1.0 mm in diameter), occur in massive numbers to a plant and are pale-white, golden, pink, red or dark-brown colored [16].

Amaranth with an excellent seed quality and the greatest potential for use as a food ingredient is now grown as a grain crop in such widely scattered regions as the mountains of Ethiopia, the hills of South India, the Nepal Himalaya, and the plains of Mongolia [5]. Amaranth seeds with their phenomenal nutritional profile provide several important nutrients that are often difficult to incorporate into a restrictive diet. The seeds contain large amounts of dietary fiber, iron, and calcium. They also have high amounts of lysine, methionine and cysteine, combined with a fine balance of amino acids, making them an excellent source of high quality, balanced protein, which is more complete than the protein found in most grains. In addition to its outstanding nutritional value, amaranth is also very low in sodium and contains no saturated fat [22]. Amaranths are being used in breakfast food, bakery products, gluten-free foods, and extruded foods. For making a leavened food, they must be blended with wheat [18]. Amaranth meal, or flour, is especially suitable for where it can be used as a sole or predominant cereal ingredient. Grains are toasted and popped, ground into flour, or boiled for gruel. The leaves can be used as a tasty leafy vegetable meal, often preferred to spinach by some people [49]. In East African countries and Peru *Amaranthus caudatus* leaves are boiled and consumed as vegetable like those of other amaranth species. Seeds are used as food in Konso (South Western part of Ethiopia) while young branches of a stalk are eaten in South Omo by the Ari people [11]. The seeds are also used for

preparation of local beverage known as 'Chaqa' in Konso. In Ethiopia, cooked seeds are added into porridge, and ground seeds are mixed with *Eragrostis tef* flour to prepare pancake-like bread (Injera in Amharic language). The plant is very common and semi-domesticated on farm fields in Konso and South Omo. Some farmers have started to cultivate and intercrop the species on their farm fields near their homestead. The Konso people calls amaranth *Passa* and its name varies from place to place in Ethiopia. It is also called *Lishalisho*, *Aluma* and *Ferenjitef* in Amharic; *Iyaso* and *Jolili* in Oromo language; *Zapina* in Arigna and *Gegabsa* in Wolayita [26]. In Guraferda and Jimma, the people use amaranth to make alcoholic drink named 'Borde', unleavened bread called 'Kita' or prepare a thin porridge 'Atmit' for babies and mothers who recently gave birth. Easy-to-grow nutrient rich foods such as amaranth can help improve food security and reduce malnutrition among communities that heavily depend on subsistence agriculture specifically in the African context. In this regard, production of value-added food product from under-utilized raw material is the way to reward the valuable nutrients to the society by changing the amaranth into value added food products [4]. Study about amaranth has significant contribution towards encouragement of amaranth cultivation via creating a value-chain on production of amaranth-based value-added products, which, in turn can contribute to food security, and improvement of nutritional quality. Although distribution of amaranth species used as cereal grains and product development with ancient grain has been reported for several countries, no such investigation has been conducted in East African countries. Owing to the scarcity of information on amaranth-containing composite flours and their rheological properties, different studies provide useful information on practical application for the formulation of value added products [4].

In addition to be used as leaf vegetable and grain, *Amaranthus* can be used as forage for livestock. The seeds are ground into flour, popped like popcorn, cooked into a porridge, and made into a confectionery called 'alegría'. The leaves can be

cooked like spinach, and the seeds can be germinated into nutritious sprouts. The leaves and tender stems are cut and cooked or sometimes fried in oil, and mixed with meat, fish, cucurbit seeds, groundnut, or palm oil. Dishes with amaranth are eaten with the main dish of cereals or tubers. Traditionally in arid regions, the leaves are dried and the leaf powder is used in sauces during the dry season [29]. Plants constitute an alternative source of proteins in the human diet, with advantages over animal proteins because of their low content of saturated fats and absence of cholesterol. Amaranth leaves have a high content of essential micronutrients. They are a very good source of vitamins including vitamin A, vitamin K, vitamin B<sub>6</sub>, vitamin C, riboflavin, and folate, and dietary minerals including calcium, iron, magnesium, phosphorus, potassium, zinc, copper, and specially manganese. One cup of amaranth leaves, that are cooked, boiled, and drained contain 73% of vitamin A daily value requirement, 90% vitamin C, 28% calcium and 17% iron. The leaves are not as rich in protein, as they only contain 2.8 g of protein [29]. The seeds are also nutrient-rich. One cup of boiled amaranth seeds provides 5.2 g of fiber (women require 21-25 g/day; men require 30 to 38 g/day). It is somewhat rich in zinc (2 mg/cup) meeting a quarter of the 8 mg of zinc needed per day for women. A cup of boiled amaranth contains 5 mg of iron (18 mg is the requirement for women; 8 mg for men per day) [29]. The leaves of *Amaranthus caudatus* are eaten as a vegetable like those of other amaranth species, e.g. in Peru and Ethiopia. Seeds can be sprouted for use as a nutritious vegetable. Harvest residues are used for feeding livestock and for thatching [11]. Young plants of *A. hybridus* subsp. *hybridus* are often collected while fields are weeded and are cooked and eaten as a leafy vegetable. It is also an important famine food as it will quickly germinate and grow where flash floods have passed. Since the leaves are boiled and eaten and the seeds ground for flour *A. hybridus* subsp. *cruentus* is probably always cultivated or a relic of cultivation [3]. The details of Amaranth usage as a food are mentioned in Table 2.

**Table 2:** Members of Amaranthaceae used as food in Ethiopia

No	Scientific name	Local name	Habit	Parts used	Where in Ethiopia	Source
1	<i>Amaranthus caudatus</i>	Gegebsa (G) Chaqa (Kon), Lishalisho, Aluma or Ferenjitef (Am), Iyaso or Jolili (Oro), Zapina(Ar), Gegabsa (Wel)	H	Se	Derashe, Kucha, Konso, Gamo, Sidamo, Shankila Amhara, Oromia	1, 46 43, 8 37, 38
2	<i>Amaranthus hybridus</i>	Tsunata (Ber), Chatila (Maj) Katila (Me)	H	Le, Se	Berta, Sheko, Konso Kefficho, Majangir, Gambella	8, 7 38
3	<i>Amaranthus dubius</i>	Cayo (Som), Aluma (Am), Hamli assama or Hamli ferenji (T)			Somali Amhara, Tigray	46, 8 38
4	<i>Amaranthus graecizans</i>	Horoqota (D) Zapina(Ham) Rasuta(Kon)	H	Young leaves	Derashe, Kucha, Gamo, Hamar, Konso	46, 2 4, 38
5	<i>Amaranthus spinosus</i>	Amugnaeder (Anu)	H	Le	Anuak, Komo, Nuer	38
6	<i>Amaranthus thunbergii</i>	Raafuu (Oro)	H	Le	Borana pastoralists	13
7	<i>Amaranthus viridis</i>	Passa (Kon)	H	Young shoots	Konso	46, 38
8	<i>Achyranthes sp.</i>	Atebetere (Am)	H	Le	Amhara	43
9	<i>Celosia argentea</i>	Torchata/ Torcha (H) Horbaita (Kon)	H	Le	Hamar Konso	2, 4

**Keys:** Habit; T - Tree, S - Shrub, H - Herb, C - Climber; Parts used; R - Root, Le - Leaves, Se - Seed; Local names; Amh - Amharic, Anu - Anuak, Ar - Arigna, Ben - Bena, Ber - Berta, D - Derashe, G - Gamo, Ham - Hamar, Kaf - Kafficho, Kon - Konso, Maj - Majangir, Me - Me'en, Nu - Nuer, Oro - Affan Oromo, Sha - Shankila, She - Sheko, Sid - Sidamo, Tig - Tigrigna, Wel - Welaita, Za - Zay.

Figure 3 shows usage of different Amaranthaceae species as food by different ethnic groups in Ethiopia.

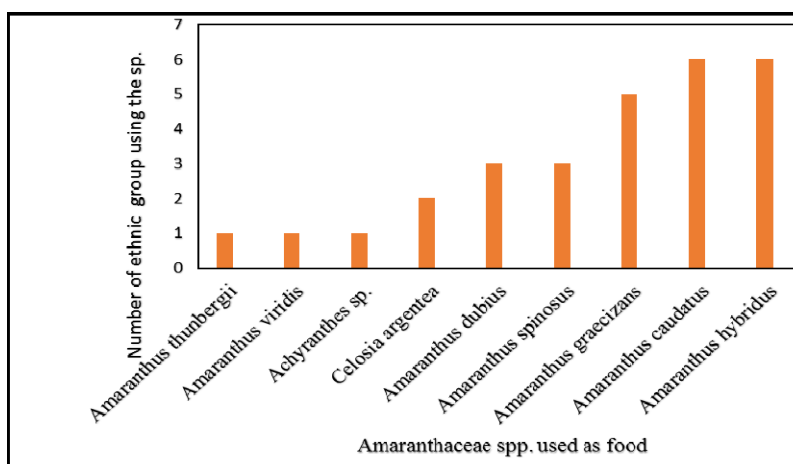


Fig 3: Amaranthaceae species used as food by different Ethnic groups in Ethiopia

### Amaranthaceae species used as medicine

Amaranthaceae species have various health benefits and medicinal properties including those which are very useful in preventing a retarded growth in children, increase the flow of breast milk, valuable in preventing a premature old age, important in all bleeding tendencies, beneficial in treatment of leucorrhoea, considered highly beneficial in treatment of gonorrhoea and benefits patients with cardiovascular disease [26]. In Ethiopia, the root is used as a laxative, and the seed for expelling tapeworms and for treating eye diseases, amoebic dysentery, and breast complaints. *Amaranthus caudatus* and *Amaranthus sylvestris* are used as tapeworm expectorant. *Celosia argentea* seeds are used against diarrhea, while the flowers are used against dysentery and menstruation problems [26].

*Achyranthes aspera* called *Ambulale* (in Zay language) and *Dergu Arba* (in Oromo language) and *Telenj* (in Amharic), is a climber, leaves of which are used to treat skin wounds [28]. It is also used to treat Nasal infection, ophthalmic infection and minor bleeding in ethnoveterinary [39]. The leaves of *Achyranthes aspera* named as *Dumugelo*, *Dalecha* or *Debes* (in Berta ethnic group language) are boiled with water and drunk to treat fever and leaf rubbed between palms and applied to the affected area to treat wound caused by spider defecation [21]. *Amaranthus caudatus* is one of the medicinal plants mainly found in the home gardens around Wolayta. Its seeds are used for this purpose and because of this; it is one of the protected herbs [43]. The details of Amaranthaceae species usage as medicine are mentioned in Table 3.

Table 3. Members of Amaranthaceae used as medicine (below)

No.	Scientific name	Local name	Hab.	Parts used	Used to treat	Where in Ethiopia	Source
1	<i>Amaranthus caudatus</i>	Lishalisho or ferenjitef, Bahir tef (Am), Iyaso, Bertefi or jolili (Oro), Gagabsa(Wel)	H	Le, Se	Tapeworms, eye diseases, amoebic dysentery, breast complaints, jaundice or liver disease and kidney diseases, Diarrhoea (in humans & livestock), intestinal disorders	Amhara, Oromia and Welayita	26, 43 6, 55 27
2	<i>Amaranthus sylvestris</i>	Aluma (Am), Rafu (Oro) Birnaheo (T)	H	Le, Se	Tapeworm expectorant	Amhara, Oromia and Welayita	26
3	<i>Celosia argentea</i>	No	H	Se, Flower	Diarrhea, Dysentery, and menstruation	Amhara, Oromia and Welayita	26
4	<i>Achyranthes aspera</i>	Ambulale( Za), Dergu arba or Sariti (Oro), Dumugelo, Dalecha or Debes (Ber), Telenji or Etse-tekeze (Amh), Michelle (T)	H	Le R	Skin wounds, Fever, Spider infection, Herpes zoster, Blood clotting, Itching sore, Minor bleeding, Omphalitis, Epistaxis, Nose-bleeding, Tonsillitis, Eye infection (humans & livestock), Sore throat, Nasal infection, Anthrax (both humans and livestock), Urine retention, Snake bite, Babesia (livestock), Paralysis, Anthrax, Blackleg and Mastitis (livestock), Abdominal pain in woman after birth, RH case (Shotelay-Amharic), Foot strain, Retained placenta, Stomach ulcer, scorpio bite, cold, sprain	Around Lake Ziway, Benishangul, Akaki, Ada'a Wereda, Debre Libanos, Tigray	28, 21 35, 38 45, 46 24, 33 53, 54 23, 27 31, 56
5	<i>Cyathula cylindrical</i>	Abnet or Yemogn fikir (Amh), Derguu (Oro)	H	Le, Se	Epistaxis, Minor bleeding, Stomachache	Ankober, Ada'a District	37, 33
6	<i>Aerva lanata</i>	Picppicca (Kot)	H	Le	Constipation	Konta	10
7	<i>Amaranthus hybridus</i>		H			Welayita	
8	<i>Amaranthus cruentus</i>		H	Se	Jaundice, Sexual incompetence of male	Tigray, Afar, Oromia	56, 53 56
9	<i>Alternanthera pungens</i>		H	Le, R	Wound, Sudden illness	Tigray, Ada'a District	25, 33
10	<i>Chionothrix latifolia</i>	Garbicha (Oro)	H			Borana Pastoralists	13

**Keys:** Habit; T - Tree, S - Shrub, H - Herb, C - Climber; Parts used; R - Root, Le - Leaves, Se - Seed; Local names; Amh - Amharic, Anu - Anuak, Ar - Arigna, Ben - Bena, Ber - Berta, D - Derashe, G - Gamo, Ham - Hamar, Kaf - Kafficho, Kon - Konso, Kot - konta, Maj - Majangir, Shankila, She - Sheko, Sid - Sidamo, Tig - Tigrigna, Me - Me'en, Nu - Nuer, Oro - Affan Oromo, Sha - Wel - Welaita, Za - Zay.

Figure 4 and Figure 5 shows number of diseases treated by some medicinal species of Amaranthaceae and number of ethnic groups in Ethiopia using Amaranthaceae species as medicine respectively

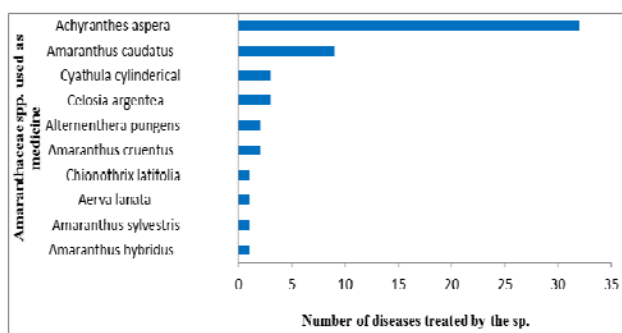


Fig 4: Number of diseases treated by some medicinal species of Amaranthaceae

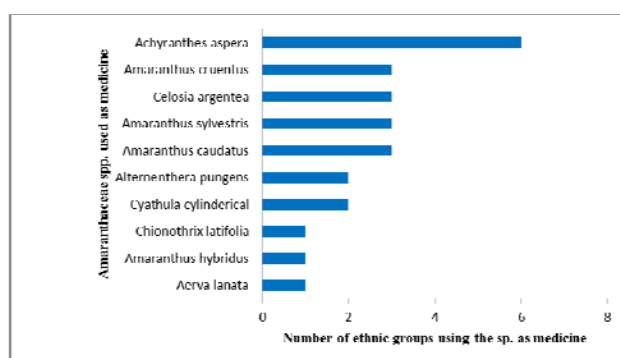


Fig 5: Number of ethnic groups in Ethiopia using Amaranthaceae species as medicine

### Poisonous species of Amaranthaceae

Although *Amaranthus caudatus* and *Amaranthus dubius* are used as food in different ethnic groups of Ethiopia they are reported as poisons in some places. These controversies may occur due to the difference in system of their usage in different ethnic groups. Hence, according to [1] dry seeds of *Amaranthus caudatus* can be nutritional toxic if taken as food by humans. Reason for exposure can be accidental contact, any dose is dangerous, and effect to toxicity which may lead to other health and life risks. All sections of the plant can affect people during or after its fruiting time and it becomes most hazardous during harvesting season and common in middle land especially in cultivated or/and around home dwelling. Likewise, *Amaranthus dubius* is edible wild plant reported to cause health problems and other unwanted effects. Leaf (before flowering) and seeds cause diarrhea when consumed in excess; sore throat, vomiting, and stomach ache [29].

### Ornamental and Miscellaneous uses of Amaranthaceae species

Some species of Amaranthaceae have been developed as ornamentals. For example, *Amaranthus caudatus* and *Iresine herbstii* are used as an ornamental in Addis Ababa. *A. caudatus* is widely grown as an ornamental and called 'Love-lies-bleeding' "or "red-hot cattail," in some places, a name shared with unrelated plants [50]. *Sericocomopsis pallida*, *Amaranthus thunbergii*, *Amaranthus dubius*, *Achyranthes aspera* and other different species of Amaranthaceae are used as favorite forage for different livestock [43]. *Pupalia lappacea* (Hanqarree in Oromo language), *Chionothrix latifolia*

(Garbicha in Oromo language), and *Chionothrix tomentosa* (Gurbi daalati in Oromo language) are used as forage and for house construction in Borana Pastoralists [13].

### Conclusion

Even if there is no an ethnobotanical research on the family Amaranthaceae in Ethiopia, these group of plants are one of the few non-grasses with potential for becoming a cereal-like grain crop. The main species for this are *Amaranthus caudatus* and *Amaranthus graecizans*. Some of them like *Achyranthes aspera* and *Amaranthus caudatus* are also highly used as medicine. However, in most parts of Ethiopia due consideration is not given for these species except in a very limited area and ethnic groups. Hence, proper awareness creation about their use and conservation should be made and their usage for the benefit obtained from them other than being one of the regulators of environmental conditions like other plants should be encouraged.

### Recommendations

- Detail ethnobotanical research should be conducted on the family Amaranthaceae to bring more information.
- Further research should be carried out about the nutritional value or chemical compounds found in selected species of Amaranthaceae now used by different groups of people in Ethiopia.
- Promoting the importance of those Amaranthaceae species that are used as food and medicine by certain groups of the society to alleviate food shortage and health problems.
- Working on the ways of getting improved grain and vegetable Amaranthaceae species varieties through hybridization.
- Encouraging mixed cropping system of selected species of Amaranthaceae.
- Finding ways how to make important species of Amaranthaceae become commercial commodities through dry or wet milling or derivatives (for instance, derivatives for Amaranth starch).
- Storage and shelf life of products should be considered.
- Value of the grain and crop residues for ensilage and direct feeding to livestock should be seen.
- Their usage in natural dyes, pharmaceuticals (for example, laxatives) or materials in their seed that can be used in cosmetics should be considered.

### Author's contribution

The author tried to review all the available literatures in the preparation of this manuscript and read and approved the final manuscript.

### Competing interests

The author declares that there is no conflict of interest.

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