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Phytogeographical and Ethnobotanical Attributes of *Amaranthus* spp. in Malawi

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Abstract

The *Amaranthus* genus, widely distributed across tropical and subtropical regions, is valued for both its nutritional and medicinal properties. This significance led to an investigation into its diversity and traditional applications within Malawi. Between October 2024 and January 2025, a comprehensive study was undertaken, combining phytogeographical mapping and ethnobotanical surveys to assess species distribution and gather insights from local communities about the genus's uses. The phytogeographical analysis utilized the Botanical Research and Herbarium Management System (BRAHMS) to evaluate spatial distribution patterns. Concurrently, the ethnobotanical component collected qualitative data through field interviews with 600 informants. Statistical indicators such as informant consensus factor (FIC), frequency of citation (Fc), fidelity level (FL), and use value (UV) were applied to quantify the relative importance of various species and their traditional applications. This research identified eight species of *Amaranthus* in 5 districts across Malawi. Among them, six species—*A. hypochondriacus* L., *A. hybridus* L., *A. dubius* Mart. Ex Thell., *A. spinosus* L., *A. thunbergii* Moq., and *A. cruentus* L.—were consistently cited by informants for their medicinal utility. Notably, *A. hypochondriacus* L. and *A. hybridus* L. were the most commonly used, with citation frequencies of 13.67% and 10.16%, respectively. *A. hypochondriacus* L. emerged as particularly important, showing a high FIC of 0.97 and the highest FL (86.75%) in relation to its use in managing blood pressure. Its UV was measured at 0.75, and 95.2% of informants reported using it as a decoction to treat ailments affecting the entire household. Furthermore, 88.32% of informants recognized the nutritional value of *Amaranthus* species. Of these, 65% highlighted their high vitamin content, 30% emphasized their protein richness, and 5% associated them with promoting children's growth. Overall, the study confirmed the presence of eight *Amaranthus* species in Malawi. While 23% of the informants used these plants for medicinal purposes, the majority relied on them as a food source. The findings underscore the need for further research into their pharmacological and nutritional properties to enhance understanding and utilization.

Keywords

Amaranthus, Traditional Medicine, Food, Nutritional Properties, Blood Pressure Regulation

1. Introduction

Plants play a vital role in numerous aspects of human life, contributing significantly to health and well-being [1]-[4]. They not only ensure food security but also enhance human nutrition by providing a broad spectrum of essential nutrients—including macronutrients, micronutrients, fiber, and bioactive compounds—which are critical for maintaining health [5]-[7]. These nutrients are essential for the body's proper functioning [5]-[7]. Specific plant groups such as cereals, legumes, and tubers are primary sources of carbohydrates, which are key for energy production. Notably, rice, wheat, and maize supply nearly 50% of the world's caloric intake [8]. Legumes such as lentils and chickpeas provide plant-based proteins, which are particularly important in vegetarian and vegan diets [9].

Fruits and vegetables are rich in essential vitamins (A, C, E, K, and B-complex) and minerals (potassium, magnesium, iron, and zinc) [10] [11]. For example, citrus fruits like oranges are high in vitamin C, which boosts immune function and enhances the absorption of non-heme iron [12] [13]. Plant-derived fibers, especially from fruits, vegetables, whole grains, and legumes, promote digestive health by regulating bowel movements and contribute to lowering the risk of cardiovascular disease, type 2 diabetes, and obesity [13] [14]. Additionally, plants are rich in bioactive compounds such as polyphenols, carotenoids, and flavonoids, which exhibit antioxidant and anti-inflammatory effects [15]. These compounds are associated with reduced risks of chronic diseases, including cancers and neurodegenerative conditions [16].

Despite their global nutritional value, many people still face limited access to food, leading to malnutrition and undernourishment. Africa is the most severely affected continent in terms of hunger, largely due to economic instability [17]. Key contributors to food insecurity include heavy reliance on imported goods, macroeconomic challenges such as currency devaluation, rising costs, and growing national debt [18] [19]. Women and children are the most vulnerable, frequently suffering from acute malnutrition [20] [21].

In Malawi, the United Nations Children's Fund (UNICEF) reported in 2023 that 573,000 children under the age of five are at risk of malnutrition, with 62,000 facing severe acute malnutrition (SAM), also known as wasting [22]. Malnutrition negatively impacts both physical (e.g., stunting, wasting, underweight) and cognitive development [23] [24]. It also compromises immune function, increasing vulnerability to infections such as diarrhea, pneumonia, and malaria. The scale of child malnutrition in Malawi highlights a pressing public health issue [22].

Therefore, it is urgent to develop effective strategies to curb the rising rate of childhood malnutrition in the country. One promising approach involves leveraging the nutritional potential of local plant resources such as *Amaranthus* spp. In Malawi, *Amaranthus*—known as *Bonongwe* in Chichewa and *Belekete* in Tumbuka—is part of the Amaranthaceae family, comprising approximately 60 to 75 species globally [25] [26]. Originally native to the Americas, Amaranth has spread widely, including across Africa and specifically in Malawi [27]. Its leaves and seeds are used for food and medicine, both for humans and animals [27] [28].

Prior to launching in-depth scientific studies into the nutritional potential of Amaranth to combat child malnutrition, it is essential to update this baseline information. It is essential to first gather up-to-date information on their geographical distribution and the traditional knowledge that informs their use in food and alternative medicine by the Malawian population. However, current data on the distribution of *Amaranthus* spp. in Malawi are outdated, with the last records from the National Herbarium dating back to 1933-1991. Consequently, this research focuses on the phytogeographical and ethnobotanical study of *Amaranthus* spp. in Malawi.

2. Methodology

2.1. Study Area

The study was conducted at two main locations: the National Herbarium in Zomba and selected agro-ecological districts where Amaranth is cultivated. These districts included Mzimba (North), Lilongwe and Dedza (Central), and Machinga and Zomba (South). Data collection took place between October 2024 and January 2025. The geographical coordinates of the study districts are detailed in Table 1, and the corresponding investigation sites are illustrated in Figure 1.

Table 1. Geographical coordinates of the investigation and sample collection district in Malawi.

Sample collection site	Geographical coordinates	
	Latitude	Longitude
Mzimba	11˚54'0.00"S	33˚36'0.00"E
Lilongwe	13˚58'00.9"S	33˚47'14.1"E
Dedza	14˚22'40.4"S	34˚19'59.6"E
Machinga	14˚57'36.00"S	35˚31'12.00"E
Zomba	15˚23'9.46"S	35˚19'7.68"E

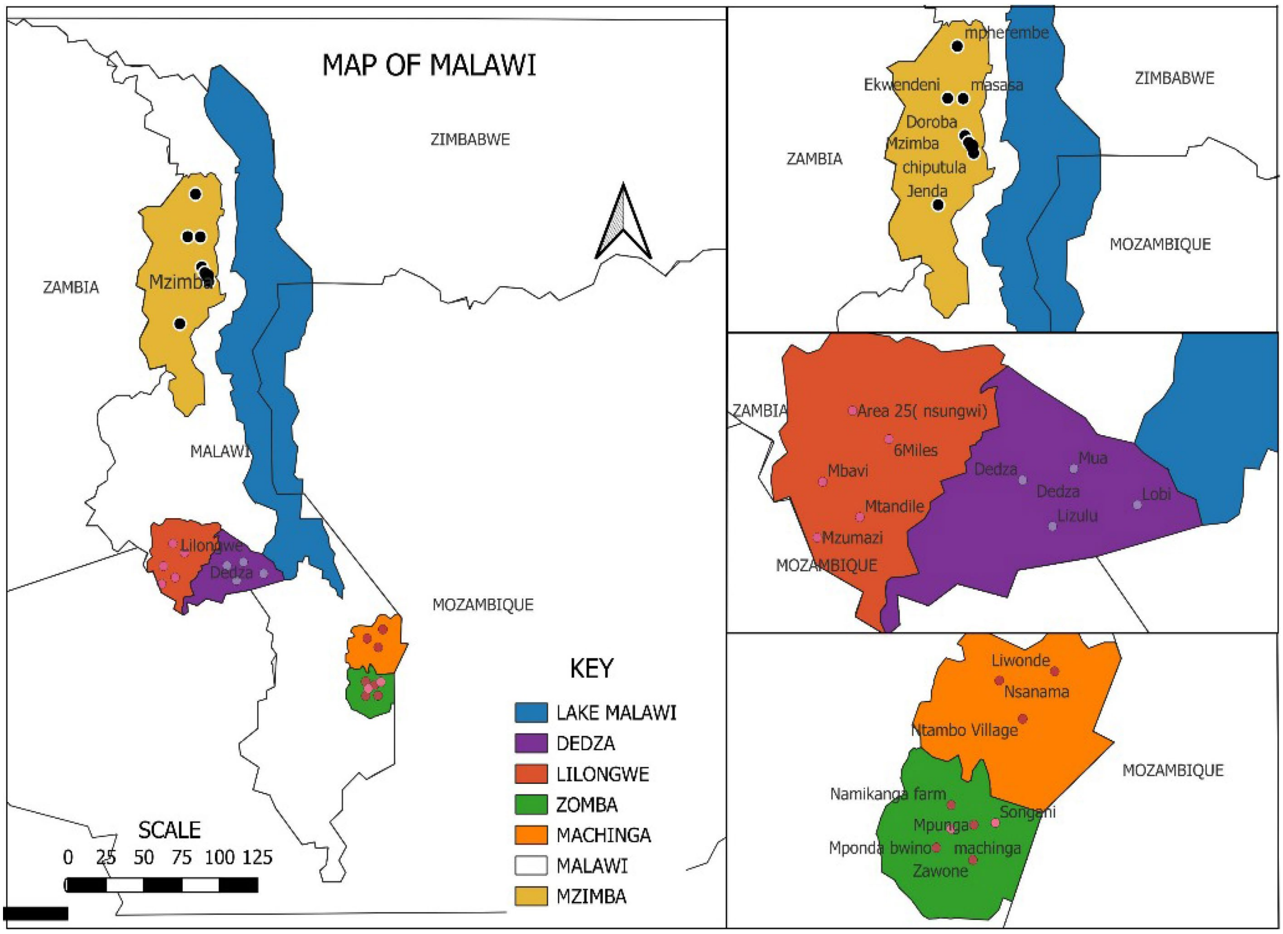


Figure 1. Investigation sites.

2.2. Phytogeographical Study

The phytogeographical investigation of *Amaranthus* spp. in Malawi was conducted following the methodology outlined by Mounirou *et al.* (2019) [29]. This approach involved gathering data from various sources, including published articles, the Map of Life database (https://mol.org/), the Botanical Research and Herbarium Management System (BRAHMS) software, and archival records from the National Herbarium of Malawi located in Zomba.

2.3. Ethnobotanical Survey and Informed Consent

Ethnobotanical surveys were conducted in agro-ecological districts known for *Amaranthus* cultivation, namely Mzimba, Lilongwe, Dedza, Machinga, and Zomba. Data collection focused on informants' demographic profiles and their knowledge, perceptions, and beliefs concerning *Amaranthus* spp., including its medicinal uses, cultivation practices, conservation methods, and nutritional value.

Responses were recorded using KoboToolbox, a digital platform for survey data collection. The questionnaire consisted of a combination of open-ended, semi-closed, and closed questions. A total of 600 informants (farmers, herbalists, vendors, consumers) were selected randomly to participate in the study. There were 458 women and 142 men (**Table 2**).

Table 2. Target group of the informant investigated by district.

Target groups	District					**Total**
	Mzimba	Lilongwe	Dedza	Machinga	Zomba	
Farmers	18	16	10	12	23	**79**
Herbalists	11	14	3	1	6	**35**
Vegetable sellers	11	40	9	19	37	**116**
Consumer	70	50	98	91	61	**370**
Total	**110**	**120**	**120**	**123**	**127**	**600**

2.4. Plant Collection

During the study, Amaranth specimens identified by informants were promptly collected from either their farm plots or natural habitats, with assistance from a research aide. The collected specimens were preserved using a plant press and later submitted to the National Herbarium of Malawi, located in either Zomba or Zolozolo, where they underwent botanical identification to accurately determine their scientific names.

2.5. Statistical Analysis

Data analysis was conducted using Excel 2017. The collected data were summarized by calculating averages and frequencies, and the findings were displayed in tables or figures. For quantitative analysis, the frequency of citation (Fc), informant consensus factor (FIC), fidelity level (FL), and use value (UV) were calculated using the formulas outlined below.

2.5.1. Frequency of Citation (Fc)

To identify the most significant species in the study area, the frequency of citation (Fc) was calculated, following the method described by Ahmad *et al.* (2014) [30]. Fc is the proportion of informants who mentioned a particular species relative to the total number of informants, as defined by Tardío and Pardo-de-Santayana (2008) [31].

$$\text{The Fc}(\%) = \frac{\text{Number of Informants Who Mentioned the Plant Species}}{\text{Total Number of Informants Surveyed}} \times 100$$

where:

Number of Informants Who Mentioned the Plant Species refers to the individuals in the study (e.g., local people, experts, or researchers) who reported using or recognizing the plant species.

Total Number of Informants Surveyed is the total population sampled in the study.

The result is typically expressed as a percentage.

2.5.2. Determination of the Factor of Informant Consensus (FIC)

Agreement among informants about species for a particular remedy was determined by calculating the factor informant consensus (FIC) and fidelity level (FL). In this study, the informant consensus factor (FIC) was used to determine the level of similarity among information delivered by various informants. FIC is also explained as the importance of each medicinal plant use category depending on the homogeneity of the informants' answers [32] (Trotter and Logan, 1986). The FIC was calculated using the following formula [33] (Heinrich *et al.*, 1998):

The FIC is calculated as:

$$\text{FIC} = \frac{\text{Nu} - \text{Nt}}{\text{Nu} - 1}$$

where:

Nu: The total number of use reports (individual mentions of plants used for a specific purpose) for a given category.

Nt: The number of taxa (plant species) cited for this specific category.

When

FIC = 1: Maximum consensus. All informants agree on the use of a single plant for a specific purpose.

FIC close to 0: Low consensus. Informants report a wide variety of plants for the same purpose, indicating either diverse knowledge systems or limited agreement.

Intermediate values (e.g., 0.5 - 0.8) indicate moderate levels of agreement.

2.5.3. Determination of the Fidelity Level (FL)

The fidelity level (FL) was also calculated as a tool to obtain the percentage of informants claiming the use of a certain plant for the same major purpose. It is defined as the ratio between the number of informants who independently claimed the use of a plant species to treat a particular disease (Np) and the total number of informants who mentioned the plants as a medicine to treat any given disease (N) [34]:

$$FL(\%) = \frac{Np}{N} \times 100$$

where:

- Np: The number of informants who mention the plant species for a particular use (e.g., treating fever).
- N: The total number of informants who mention the plant species for any use (including all its uses).

Plant species with high fidelity levels are important to local people for treating ailments. It is noted that the number of times a given plant is mentioned by all of the informants for a specific disease was considered for this factor.

2.5.4. Determination of the Use Value (UV)

The most important medicinal uses of plants were assessed by calculating the use value (UV), which was used to calculate the citation of plants during interviews [35].

The UV is calculated as:

$$UV = Ui/N$$

where:

- Ui: The number of uses mentioned by each informant for a specific plant species;
- N: The total number of informants interviewed about the plant.

High UV: Indicates that the plant is widely recognized and used for various purposes within the community.

Low UV: Suggests that the plant is either less well known or has a narrower range of applications.

The statistical tests were performed using IBM SPSS Statistics 20. The association between *Amaranthus* species and sociocultural groups was analyzed with the chi-square test, while the Kruskal-Wallis test was used to compare UV across multiple regions. The results were statistically significant when $p < 0.05$.

3. Results

3.1. Distribution of *Amaranthus* spp. in Malawi

The distribution of *Amaranthus* spp. is in **Appendix**.

3.2. Demographic Information of the Informants

The demographic information of the investigated population is listed in **Table 3** and Table 4. The minimum age of the informants is 18 years old, while the maximum age is 84 years old, with an average of 35.76 ± 11.09 years old (Table 3). The gender of the most informed population is represented by females, that is above 3/4 (76.33%). The remaining population is male (23.67%). Regarding their education level, above 1/2 (50%) have a low education level (no formal education, 4.38% and primary school, 54.88%) (Table 4).

Table 3. Minimum, maximum, and average of the investigated population.

Variables		District					
		Mzimba	Lilongwe	Dedza	Machinga	Zomba	
Age	Min	18	20	18	18	18	**18**
	Max	74	60	84	62	71	**84**
	Average ± SD	**36.41 ± 12.03**	**35.24 ± 9.35**	**36.63 ± 11.97**	**34.73 ± 9.80**	**36.01 ± 11.90**	**35.76 ± 11.09**

Table 4. Frequency of the gender and education level of the informants.

Variable		District					**Total (%)**
		Mzimba	Lilongwe	Dedza	Machinga	Zomba	
Gender (%)	Male	16.36	22.50	36.67	28.46	14.17	**23.67**
	Female	83.64	77.5	63.33	71.54	85.83	**76.33**
Total		**100**	**100**	**100**	**100**	**100**	**100**
Education level (%)	No formal education	4.55	8.33	1.72	0.81	6.40	**4.38**
	Primary school	48.20	55.00	52.59	58.54	59.20	**54.88**
	Secondary school	39.10	35.00	39.66	38.21	29.60	**36.20**
	University	8.18	1.67	6.03	2.44	4.8	**4.55**
Total		**100**	**100**	**100**	**100**	**100**	**100**

3.3. Knowledge and Use of Amaranth

The rate of informants familiar with Amaranth is presented in Table 5. Except for 10% of the farmers in Dedza district, equivalent to 1.27% of all the farmers, and 4.1% of the consumers, equivalent to 1.1% of all the consumers, that are not familiar with Amaranth, the rest of the farmers, herbalists, vegetable sellers, as well as the consumers, are familiar with them (Table 5). They often acquire the knowledge of Amaranth from various channels, such as family, neighbors or friends, as well as agriculture programs. The majority (93%) learned about Amaranth from their family (Figure 2). 70.89% of the investigated farmers grow Amaranth. Although farming is not the main activity of the herbalists, vegetable sellers, and consumers, some of them, 48.75, 20.69, and 15.68, respectively, are engaged in the growth of Amaranth (Figure 3). Among the 70 species of *Amaranthus* (A) in the world, *A. dubius* Mart. Ex Tell., *A. graecizans* L., *A. hybridus* L., *A. spinous* L., *A. thumbergii* Moq., *A. hypochondriacus* L., and *A. cruentus* L. are found in Malawi (Table 6).

Table 5. Target group familiar with *Amaranthus* spp.

Target group	Response by district	Percentage familiar by district					**Total**
		Mzimba	Lilongwe	Dedza	Machinga	Zomba	
Farmers (%)	Yes	100	100	90	100	100	**98.73**
	No	0	0	10	0	0	**1.27**
	Total	**100**	**100**	**100**	**100**	**100**	**100**
Herbalists (%)	Yes	100	100	100	100	100	**100**
	No	0	0	0	0	0	**0**
	Total	**100**	**100**	**100**	**100**	**100**	**100**
Vegetables seller (%)	Yes	100	100	100	100	100	**100**
	No	0	0	0	0	0	**0**
	Total	**100**	**100**	**100**	**100**	**100**	**100**
Consumers (%)	Yes	100	100	94.9	100	100	**98.9**
	No	0	0	4.1	0	0	**1.1**
	Total	**100**	**100**	**100**	**100**	**100**	**100**

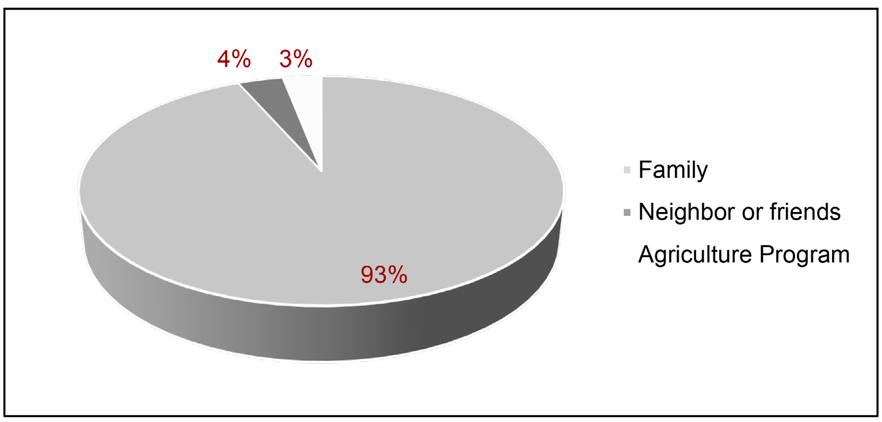
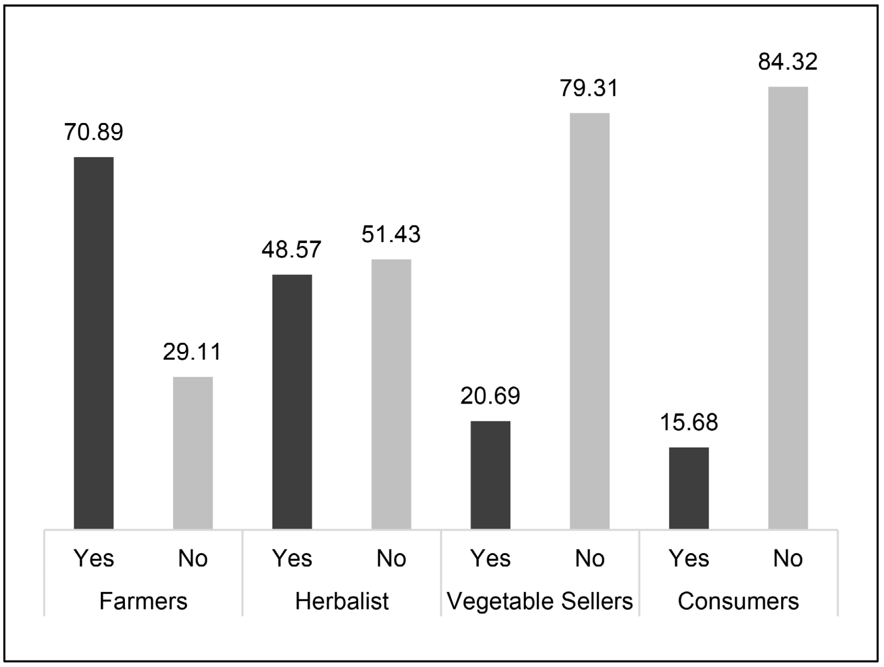


Figure 2. The ways Malawian population learn about *Amaranthus* spp.



NB: Yes implies informant who grows Amaranth; No implies informant who does not grow Amaranth.

Figure 3. Target group that grows *Amaranthus* spp. in percentage.

Table 6. Species of Amaranth identified on the farms and natural habitant-accession and batch number.

Scientific name of *Amaranthus*	District					Accession N˚	Batch N˚
	Mzimba	Lilongwe	Dedza	Machinga	Zomba		
Amaranthus dubius Mart. Ex Thell	x				x	50791	MAL 0002871
Amaranthus graecizans L.	x		x		x	17607	MAL 0002875
Amaranthus hybridus L.	x	x	x	x	x	73081	MAL 0002877
Amaranthus spinosus L.	x	x	x	x	x	66906	MAL 0002922
Amaranthus thunbergii Moq.	x	x	x	x	x	51783	MAL 0002878
Amaranthus hypochondriacus L.	x		x		x	89611	MAL 0070022
Amaranthus cruentus L.	x	x	x			89610	MAL 0076977
Amaranthus australis (A. Gray)	x	x	x			89609	MAL 0070029

NB: x implies presence of Amaranth in the district.

While *A. hybridus* L. and *A. hypochondriacus* L. exhibited different distributions across the study site, *A. dubius* Mart. Ex Tell., *A. graecizans* L., *A. spinosus* L., *A. thumbergii* Moq., and *A. cruentus* L. showed a consistent distribution (Table 7).

Table 7. Distribution of *Amaranthus* spp. across the study area.

Amaranthus spp.	District					Total
	Mzimba	Lilongwe	Dedza	Machinga	Zomba	
Amaranthus dubius Mart. Ex Thell	77.3	-	-	-	22.7	100
Amaranthus graecizans L.	25	-	-	-	75	100
Amaranthus hybridus L.	40.4	21.3	10.6	9.9	17.8	100
Amaranthus spinosus L.	37.5	12.5	7.5	30.5	12.5	100
Amaranthus thunbergii Moq.	38.5	30.8	3	7.7	20	100
Amaranthus hypochondriacus L.	77.6	-	16.3	-	6.1	100
Amaranthus cruentus L.	41.7	33.3	25	-	-	100
Amaranthus australis (A. Gray)	45.9	33.3	20.8	-	-	100

Chi-square tests of the distribution of *Amaranthus* spp. across the investigation sites

	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	108.360[a]	28	0.000
Likelihood ratio	124.773	28	0.000
Linear-by-linear association	6.440	1	0.011
N. of valid cases	301		

NB: a: 24 cells (60.0%) have expected count less than 5. The minimum expect count is 48.

3.4. Description of *Amaranthus* spp.

The morphological characteristics of each species of Amaranth identified are presented in Table 8.

Table 8. Morphological characteristics of *Amaranthus* spp. identified in Malawi.

Species \ Characteristics	Height (m)	Stem	Leaves	Flowers	Inflorescence	Sources
Amaranthus dubius Mart. Ex Thell	0.10 - 2	The plant is erect, branch stems often red or purple, especially at the base.	Alternately arranged, ovate to lanceolate in shape. Usually green but can have reddish or purple tinges along the veins.	Small, inconspicuous flowers that are clustered in dense spikes or panicles. Flowers are typically green to reddish in color.	Produces terminal and axillary spikes. Erect panicles often drooping, dense and branced.	https://www.cabidigitallibrary.org/ https://www.zimbabweflora.co.zw/ https://prota.prota4u.org/

Continued

Amaranthus graecizans L.	0.5 - 1.5	Erect to ascending or decumbent, branched at or distal to base, 0.1 - 0.9 m.	Leaf blade is variable in shape from broadly ovate to narrowly linear lanceolate.	Unisexual, subsessile, with 3 tepals up to 2 mm long, having a short awn; male flowers with 3 stamens; female flowers with superior, 1-celled ovary crowned by 3 stigmas.	Are green axillary clusters bearing male and female flowers.	https://www.plantsofhawaii.org/ https://www.feedipedia.org/ https://prota.prota4u.org/
Amaranthus hybridus L.	0.1 - 2.0	Thick and often ribbed or tinged with red. Surfaces have small fine hairs.	Leaves are alternate, long-stalked, and ovate to rhombic-ovate. Surfaces have small fine hairs.	Are numerous, green, and crowded into finger-like spikes forming a long, dense terminal panicle, with axillary spikes below.	Feel distinctly prickly. Inflorescences in axillary and terminal spikes together often forming extensive terminal, yellowish, green, reddish or purplish panicles up to 45 cm long, the ultimate spike often nodding.	https://www.cabidigitallibrary.org/ https://www.malawiflora.com/
Amaranthus lividus L.	0.06 - 0.6	Stem slender to stout, simple or considerably branched from the base or upwards, ± angular, green to reddish or yellow, quite glabrous or more rarely with 1-few-celled, short hairs above and/or in the inflorescence.	Leaves glabrous or more rarely with scattered few-celled hairs near the base on the lower surface of the primary venation, long-petiolate (petiole frequently longer than the lamina), lamina ovate to rhomboid-ovate, 1 − 8 × 0.6 − 6 cm, shortly cuneate below, the apex usually broad and almost always conspicuously emarginate, mucronulate.	Flowers green, in slender to stout terminal spikes and axillary cymose clusters (in small forms the terminal spike quite often indistinct) or rarely panicles, terminal spikes c. 0.6 to 11 cm long and 0.3 to 2 cm wide, the lower axillary inflorescences of dense cymose clusters up to 2 cm in diameter; male and female flowers intermixed.	Inflorescences of axillary and terminal pseudo-spikes often forming a few-branched panicle. Flower-clusters separate in the flower part leaving the axis visible.	http://worldfloraonline.org/

Continued

Amaranthus spinosus L.	0.3 - 1	Erect or sometimes ascending proximally, much-branched and bushy, rarely nearly simple, 0.3 to 1 m and can reach 2 m; each node with paired, divergent spines (modified bracts) to 1.5 to 2.5 cm.	Petiole ± equaling or longer than blade; blade rhombic-ovate, ovate, or ovate-lanceolate, the leaf blade is between 3 to 10 cm long and ×1.5 to 6 cm wide, base broadly cuneate, margins entire, plane or slightly undulate, apex acute or subobtuse to indistinctly emarginate, mucronulate.	Pistillate flowers: tepals 5, obovate-lanceolate or spatulate-lanceolate, equal or subequal, 1.2 to 2 mm, apex mucronate or short-aristate; styles erect or spreading; stigmas 3. Staminate flowers: often terminal or in proximal glomerules; tepals 5, equal or subequal, 1.7 to 2.5 mm; stamens 5. Utricles ovoid to subglobose, 1.5 to 2.5 mm, membranaceous proximally, wrinkled and spongy or inflated distally, irregularly dehiscent or indehiscent.	Simple or compound terminal staminate spikes and axillary subglobose mostly pistillate clusters, erect or with reflexed or nodding tips, usually green to silvery green. Bracts of pistillate flowers lanceolate to ovate-lanceolate, shorter than tepals, apex attenuate.	https://worldfloraonline.org/
Amaranthus thunbergia Moq.	Up to 0.55	Stems simple or branched, angular, almost hairless below but usually with long multicellular hairs towards the top.	Leaves more or less narrowly elliptic, rhomboid or spathulate, up to 4.5 × 3 cm, almost hairless or thinly hairy below; base often decurrent along the petiole.	Flowers greenish in short axillary clusters, unisexual. Capsule ovoid-ellipsoid, 2.5 to 3.5 mm long, with a short beak.	Inflorescence an axillary cluster up to 1.5 cm in diameter, with male and female flowers intermixed but male flowers most frequent at the top of upper clusters; bracts up to 6 mm long, with long awn. Flowers unisexual, subsessile, with 3 tepals up to 6 mm long, having a long, fine awn; male flowers with 3 stamens; female flowers with superior, 1-celled ovary crowned by 3 stigmas.	https://www.malawiflora.com/ https://prota.prota4u.org/

Continued

Amaranthus hypochondriacus L.	0.4 - 2	Stems usually erect, green or reddish purple, branched, mainly in inflorescences, to nearly simple proximally, 0.4 to 2 m, coarse.	Leaves arranged spirally, simple, without stipules, long-petiolate; blade broadly lanceolate to rhombic-ovate, measuring 218 cm in length and 215 cm in width, attenuate or shortly cuneate at base, obtuse to subacute at apex, mucronate, entire, glabrous to sparsely pilose, pinnately veined.	Flowers unisexual, subsessile; bracteoles 3 - 5 mm long and always longer than the tepals; tepals 5, lanceolate, 1 - 2 mm long with one equal to or longer than the fruit, the other 4 shorter; male flowers with 5 stamens c. 1 mm long; female flowers with superior, 1-celled ovary crowned by 3 thick, spreading stigma branches about 1.7 mm long.	Inflorescence stiff with thick branches, large and complex, consisting of numerous agglomerated cymes arranged in axillary and terminal spikes, the terminal one up to 45 cm long, usually with many lateral, perpendicular, thin branches.	http://tropical.theferns.info/ https://prota.prota4u.org/ http://dev.floranorthamerica.org/Main_Page
Amaranthus cruentus L.	Up to 2	Erect, green or reddish purple, branched distally, 0.4 - 2 m.	Petiole 1/2 as long as to ± equalling blade; blade rhombic-ovate or ovate to broadly lanceolate, with specific dimensions 3 – 15 (−20) × 1.5 – 10 (−15) cm, occasionally larger in robust plants, base cuneate to broadly cuneate, margins entire, plane, apex acute or subobtuse to slightly emarginate, with mucro.	Erect, green or reddish purple, branched distally, mostly in inflorescence, to nearly simple, 0.4 to 2 m.	Terminal and axillary, erect, reflexed, or nodding, usually dark red, purple, or deep beet-red, less commonly almost green or greenish red, leafless at least distally, large and robust.	https://tropical.theferns.info/ https://www.cabidigitallibrary.org/
Amaranthus australis A. Gray	1 - 3	Erect, branched, stout to robust, usually 1.5 to 3 m.	Petiole 1/3 - 2/3 length of blade; blade narrowly lanceolate to narrowly ovate leaves that are 10 to 20 cm long and 1 to 4 cm wide, base cuneate, margins entire, plane, apex acute or long-attenuate to acuminate.	Spring/Summer 5 sepals in staminate flowers, absent in pistillate flowers Petals absent 5 stamens in staminate flowers Unisexual.	Mostly terminal, linear spikes to panicles, usually interrupted.	http://floranorthamerica.org/ http://namethatplant.net/

3.5. Use of *Amaranthus* spp.

The most commonly used part of the Amaranth by the population is the leaf, followed by the seeds (Figure 4). In Malawi, Amaranth is primarily consumed as food, as shown in Figure 5(a) (89.41%), with the leaves being frequently boiled during food preparation in Figure 5(b) (73.56%). The most common dish eaten with Amaranth leaves is Nsima, as shown in Figure 5(c) (81.77%).

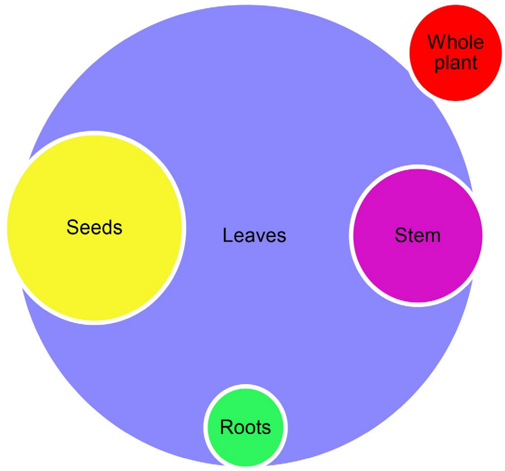


Figure 4. Part of *Amaranthus* spp. that are used.

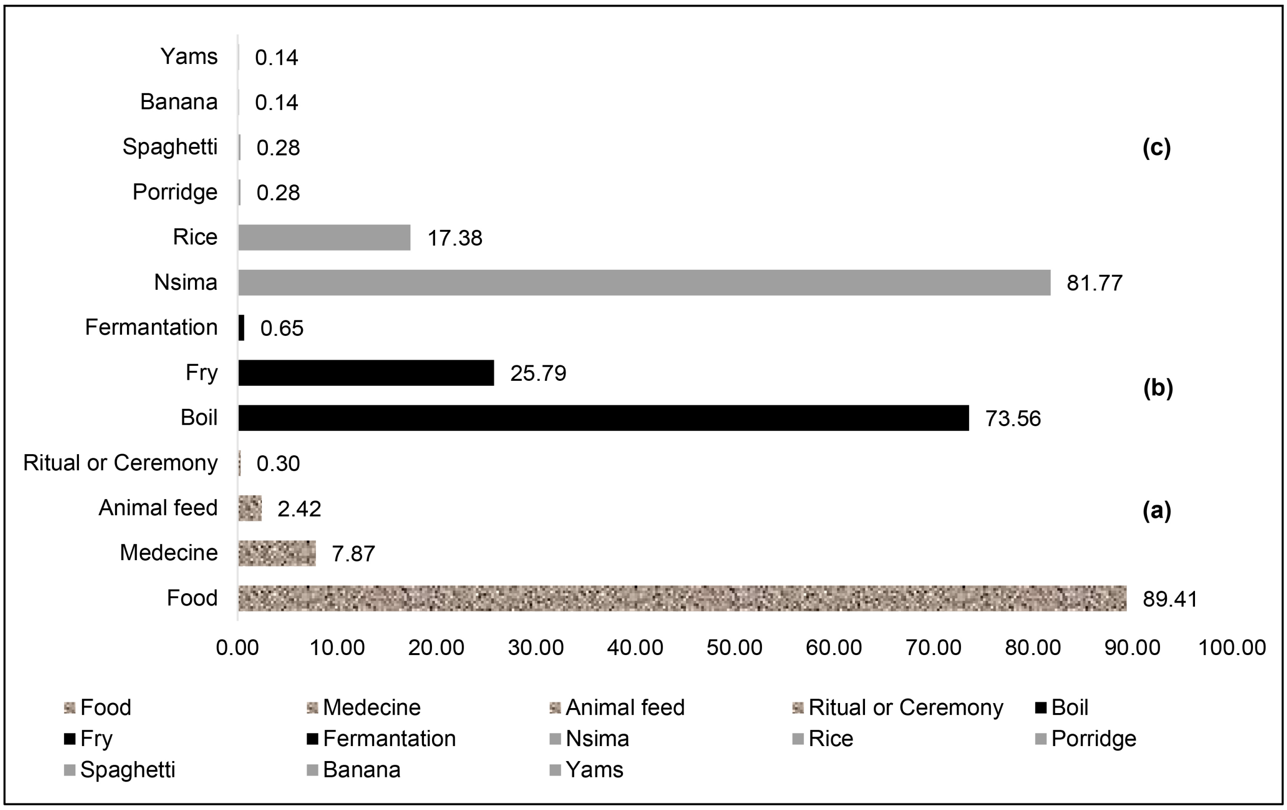


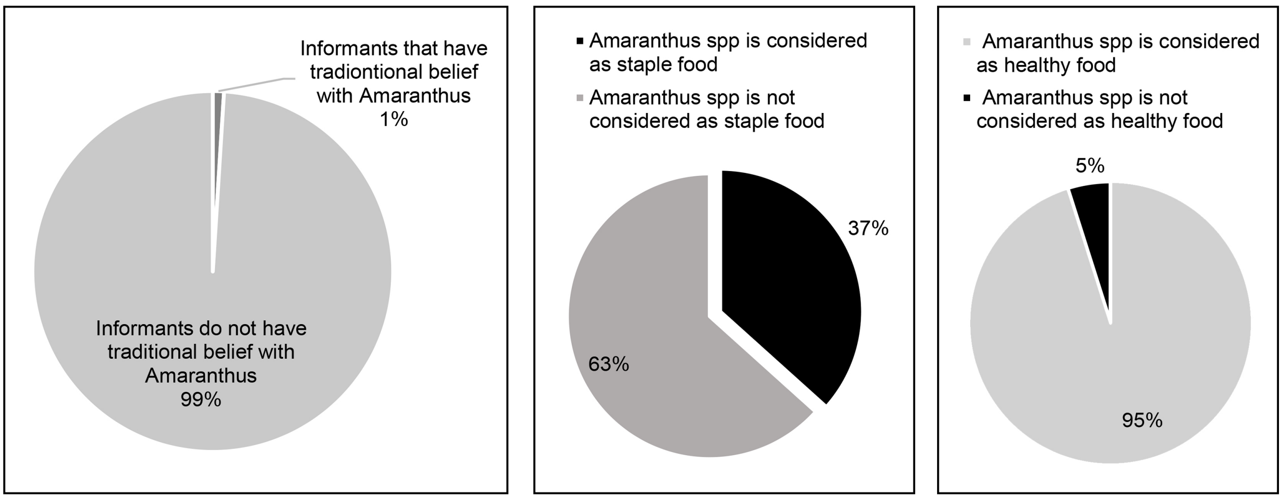
Figure 5. General use of Amaranth in percentage: (a) Main use of Amaranth in Malawi; (b) Mode of preparation of Amaranth; (c) Dishes of which Amaranth is eaten in Malawi.

3.6. Perceptions and Beliefs Linked with Amaranth

3.6.1. Cultural or Traditional Beliefs about Amaranth in Malawi

The results of our investigation showed that 99% of the investigated population did not associate any cultural or traditional beliefs with Amaranth in Malawi, while 1% did (Figure 6(a)).

While 95% of the informants (Figure 6(c)) considered Amaranth as healthy food in Malawi, 63% of them did not consider it as a staple food (Figure 6(b)). From the informants who consider *Amaranthus* spp. as healthy food, 50% said that they are highly nutritive, while 33%, 12%, and 5% of them said Amaranth can increase blood cell production, provide vitamins to the body, and reinforce the immune system (Figure 7).



(a) (b) (c)

Figure 6. (a) Proposition of informants who have or do not have traditional beliefs to Amaranth; (b) Proportion of informants who consider or do not consider Amaranth as staple food; (c) Proportion of Informants who consider or do not consider Amaranth as healthy food.

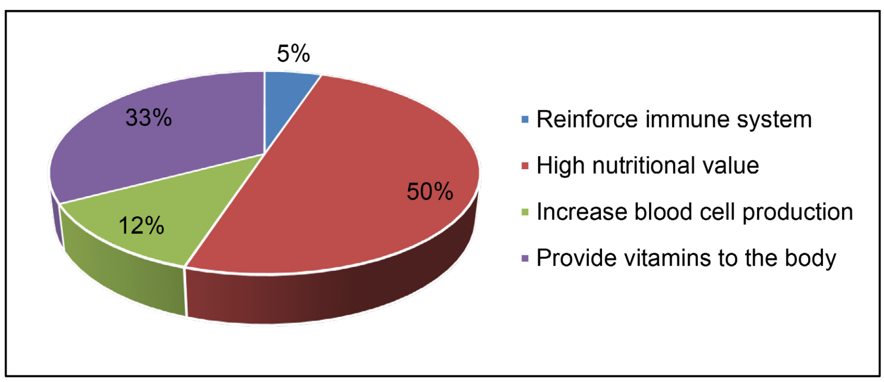


Figure 7. Benefits of *Amaranthus* spp. to human body.

3.6.2. Medical Use of Amaranth

About 21% of the total number of people investigated used some of the Amaranth species for medicinal purposes (Figure 8).

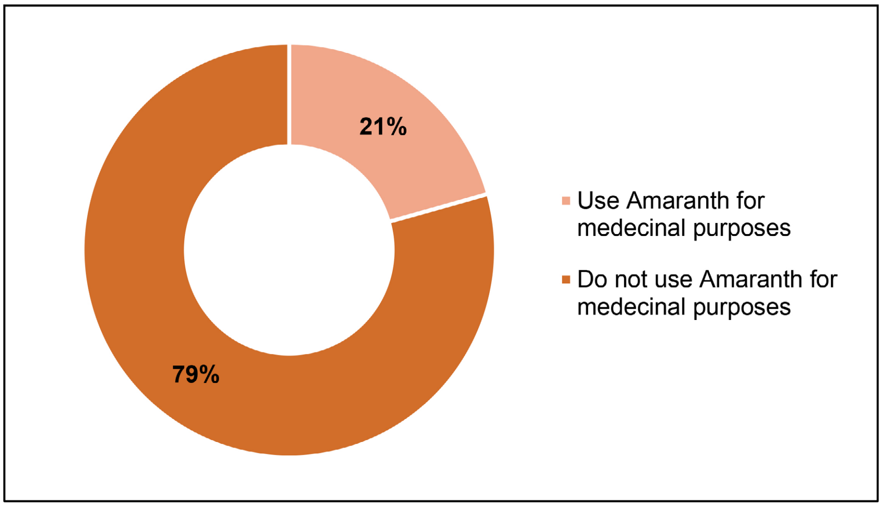


Figure 8. *Amaranthus* spp. used as medicine purpose.

3.7. Cultivation and Conservation

3.7.1. Frequency of Citations (Fc) of Amaranth Species for Medicinal Purposes

Table 9 shows the Fc of Amaranth species used for medicinal purposes. *A. hypochondriacus* L. and *A. hybridus* L. are the most used species for medicinal purposes with 13.67% and 10.16%, respectively.

Table 9. Citation frequencies of *Amaranthus* spp. for medicine purpose.

Species	Frequency of citation (Fc), %
A. hybridus L.	10.16
A. hypochondriacus L.	13.67
A. dubius Mart. Ex Thell	0.83
A. spinosus L.	0.83
A. thunbergii Moq.	0.83
A. cruentus L.	0.17

3.7.2. Factor of Informant Consensus (FIC)

The FIC among informants about *Amaranthus* species for a particular remedy is presented in Table 10.

There is strong agreement among all the informants that *A. hypochondriacus* L. is used for blood pressure regulation, while the agreement is moderate for *A. hypochondriacus* L. and *A. hybridus* L. for digestive problems treatment.

3.7.3. Fidelity Level (FL)

The percentage of informants claiming the use of Amaranth species for blood pressure regulation is presented in Table 11.

The FL of *A. hypochondriacus* L., *A. hybridus* L., *A. spinosus* L., as well as *A. dubius* Mart. Ex Tell. are < 100%. This means that all those species of *Amaranthus* are used for multiple purposes, suggesting they have a broader range of applications or less specific association with a single use.

Table 10. Factor of informant consensus of *Amaranthus* spp.

Species	FIC			
	Digestive problems	Malaria treat	Skin condition treat	Blood pressure regulation
A. hybridus L.	0.67	-	-	-
A. hypochondriacus L.	0.67	0.56	0.6	0.97

Table 11. Fidelity level of informants claimed the use of *Amaranthus* spp. species for blood pressure regulation.

Species	Fidelity level (FL), %
A. hybridus L.	80.33
A. hypochondriacus L.	86.75
A. dubius Mart. Ex Thell	40
A. spinosus L.	80

3.7.4. Use Value (UV)

The UV of the Amaranth species assessed across the district is presented in **Table 12**.

Table 12. UV of *Amaranthus* spp. species across the district.

Species	UV by district					Kruskal-Wallis significance
	Mzimba	Lilongwe	Dedza	Machinga	Zomba	
A. hybridus L.	0.68	0.3	0.4	0.6	0.3	0.032*
A. dubius Mart. Ex Thell			0.1		0.09	0.155
A. spinosus L.	0.07	0.037		0.06		0.895
A. thunbergii Moq.	0.07	0.037		0.06		0.488
A. hypochondriacus L.	0.5	0.74	0.95	0.35	0.5	0.003*
A. cruentus L.		0.037				1

*p < 0.05.

A. hypochondriacus L. as well as *A. hybridus* L. have the highest across the district. Their UVs are statistically significant, $p < 0.05$, indicating they are widely recognized and used for various purposes within the Malawi community.

For the use of Amaranths in traditional medicine, 95.2% of users use them as a decoction, while 3.2% use them after drying and pounding or mixing with other trees, like ntuvituvi and ntutumuko, and fumigated to the infected person (1.6%). At the same time, 95.2% of the informants who used them for medicinal purposes declared using them for the whole family, while 2.4% of them used them to treat children or adults.

3.8. Challenge with Amaranth Cultivation in Malawi and Conservation

In Malawi, Amaranth species may be found in several areas, such as wild habitats, home gardens, and cultivation fields. Those used for food purposes may be found in marketplaces. This represents 44% of the answers given by the informants (Figure 9), followed by 30% (cultivation fields), 17% (wild habitats), and 9% for home gardens. Despite their beneficial effects on humans, there are some challenges to their cultivation. Among the investigated population, less than 50% accepted the existence of this (Figure 10). The most cited challenge by the informants is climate change (55.15%), followed by lack of seeds and planting materials (29.39%), pests and diseases (9.39%), and poor soil quality (5.45%) (Figure 11).

Regarding their conservation, 87.31% of informants gave their agreement, while 54.73% think that Amaranth can play a role in improving food security (Figure 12 and Figure 13).

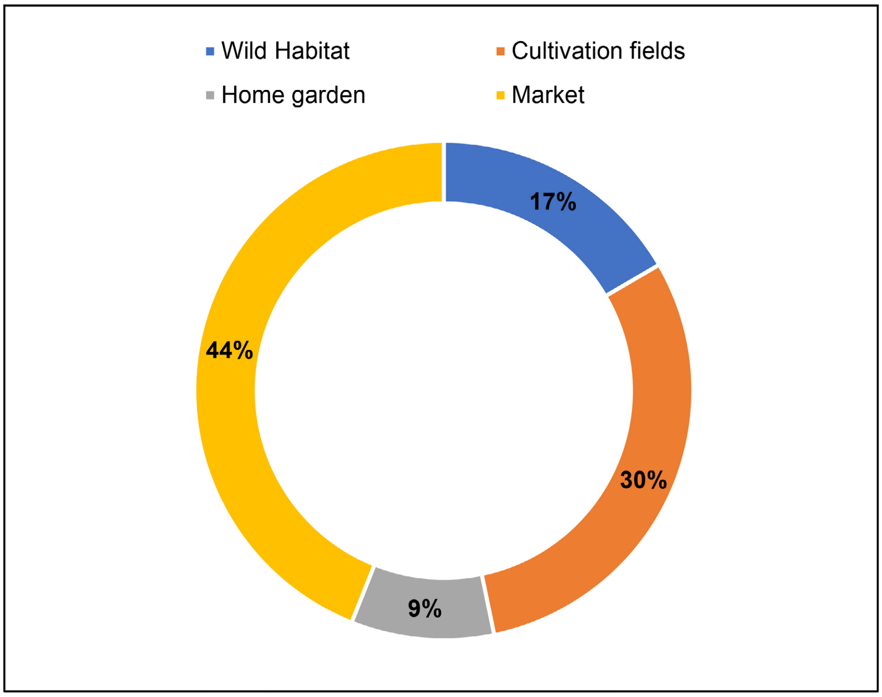
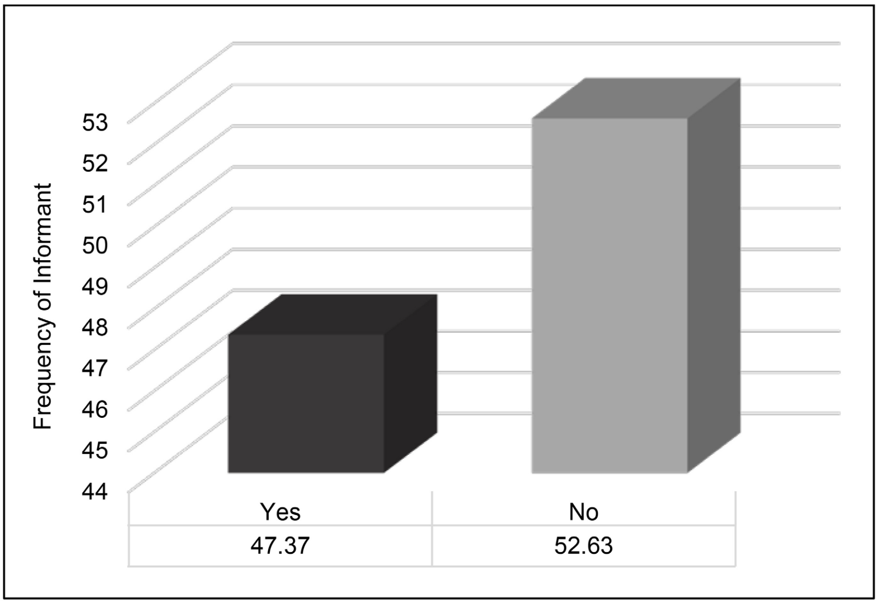


Figure 9. Place where *Amaranthus* spp. is found by the population.



NB: Yes: Informants accepting existence of challenges for *Amaranthus* spp. cultivation in Malawi; No: Informants do not accept existence of challenges for *Amaranthus* spp. cultivation in Malawi.

Figure 10. Accepting the challenges for cultivating Amaranth in percentage.

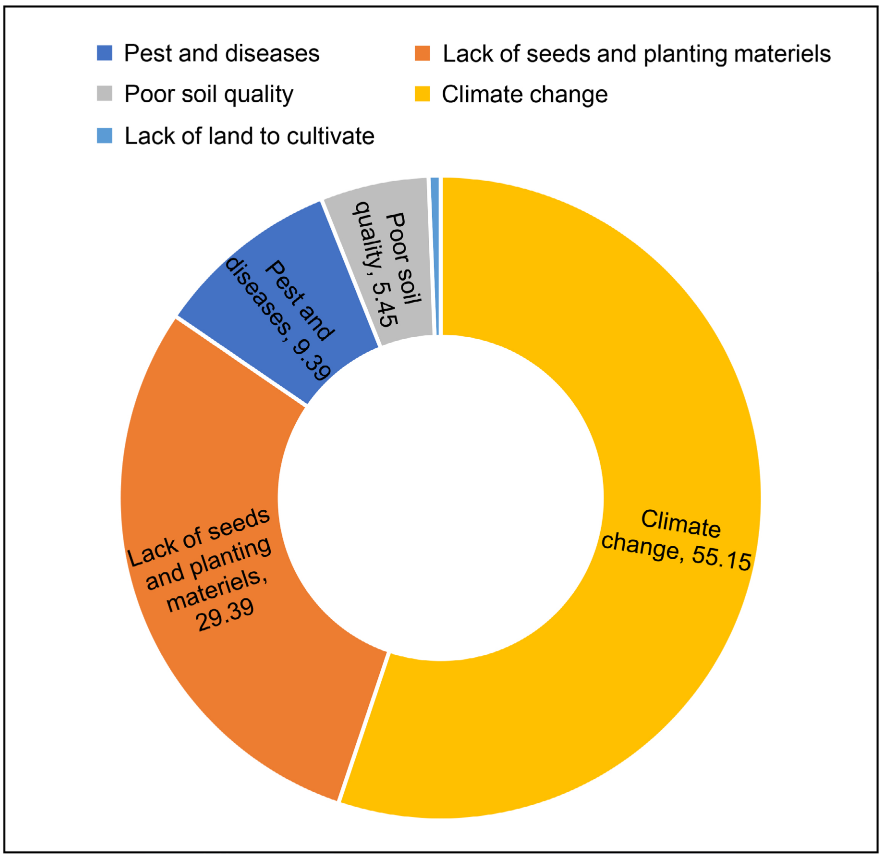


Figure 11. Type of challenge that population face for cultivating or finding *Amaranthus* spp.

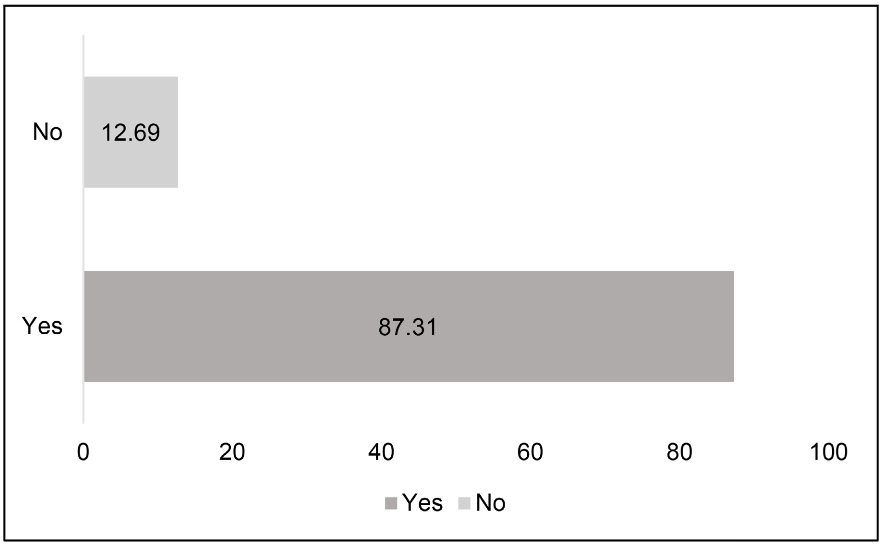


Figure 12. Informants in percentage who are interested in the promotion and conservation of *Amaranthus* spp.

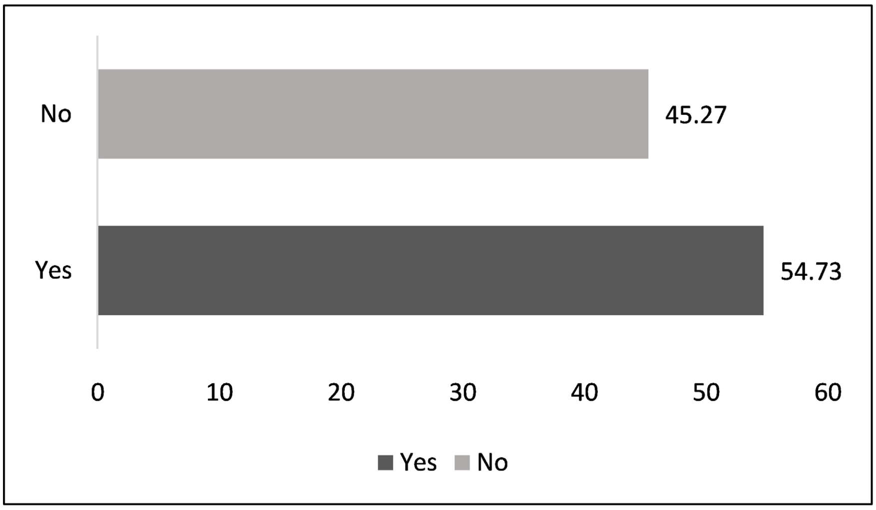
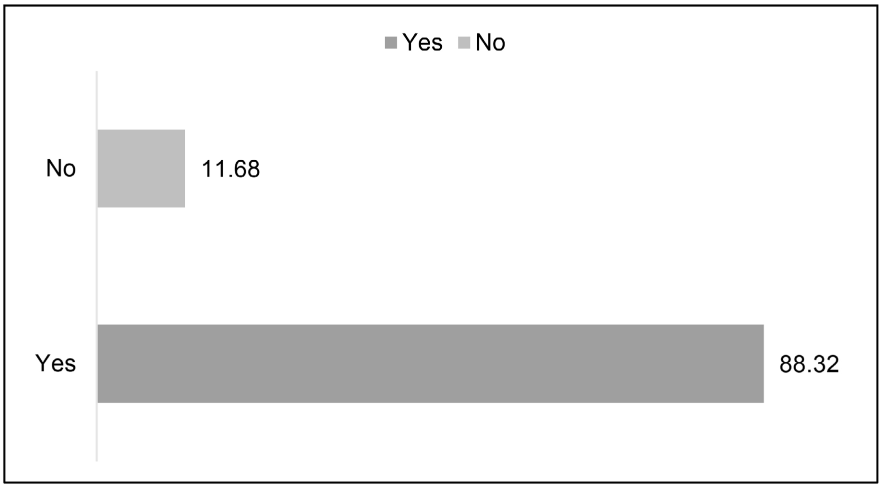


Figure 13. Informants in percentage who thought that *Amaranthus* spp. can improve food security.

3.9. Nutritional Knowledge

The main reason the Malawian population uses Amaranth is due to its perceived high nutritional value, particularly its rich vitamin content. The majority of informants (88.32%) recognize Amaranth's good nutritional value, with many specifically noting the high vitamin content (65%), while 30% consider its positive impact on children's growth. Only 5% considered it a rich source of protein (Figure 14 and Figure 15). Furthermore, a significant portion (91.05%) of those aware of its nutritional benefits incorporate Amaranth into their children's diets, and 95.94% are interested to learn more about its nutritional value (Figure 16(a), (Figure 16(b)), while *A. hybridus* L. is the *Amaranthus* species used in children's diets in Malawi.



NB: Yes: Informants in percentage who are aware for nutritional value of *Amaranthus* spp.; No: Informants in percentage who are not aware for nutritional value of *Amaranthus* spp.

Figure 14. Informants aware for nutritional value of *Amaranthus* spp.

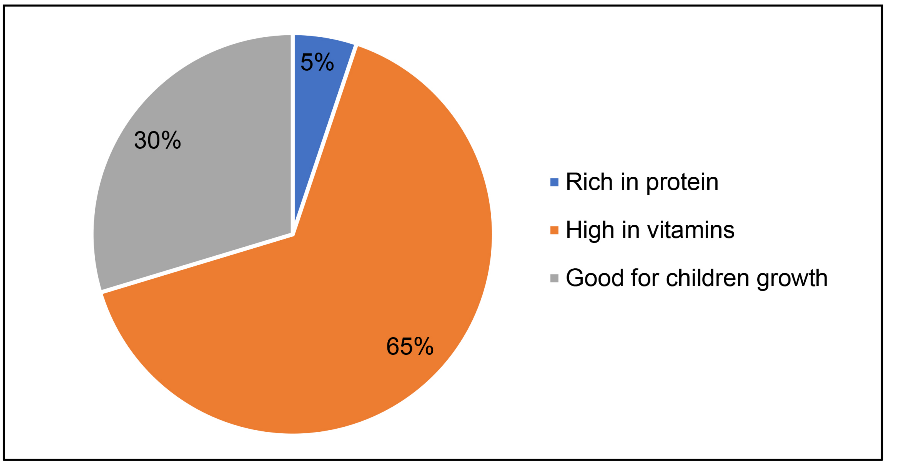
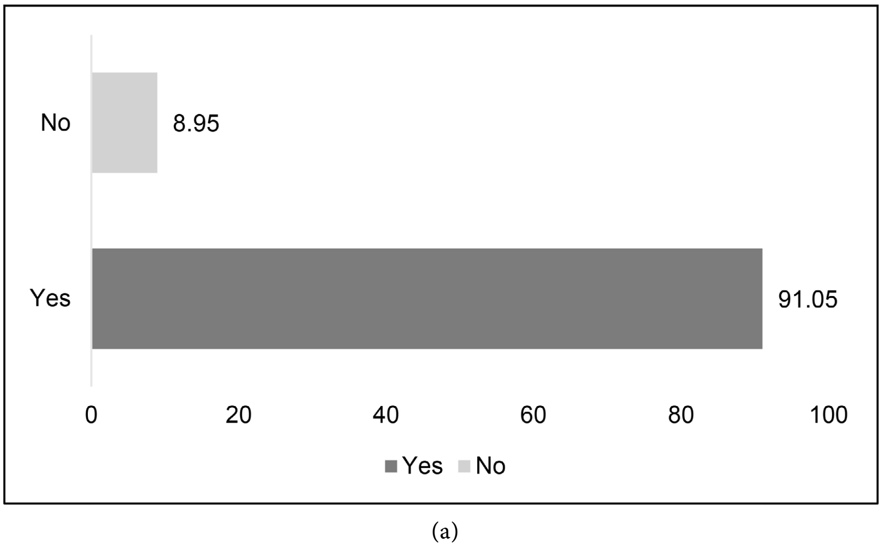
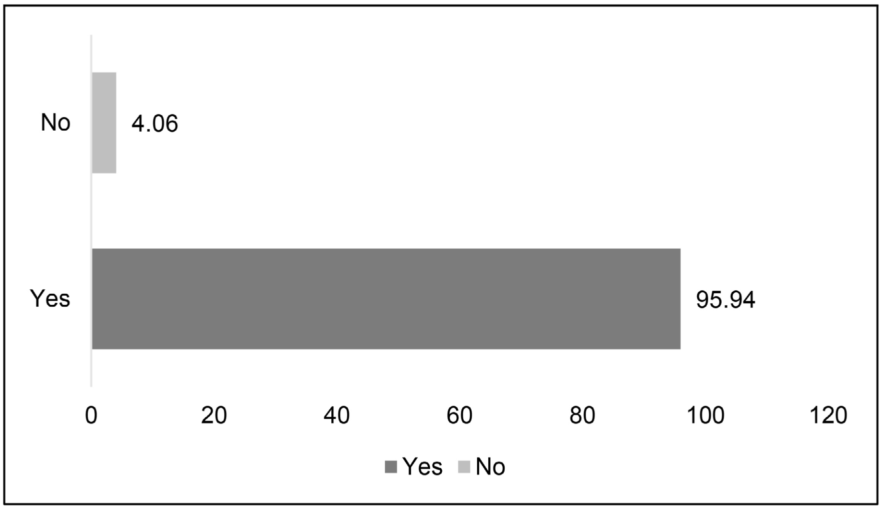


Figure 15. Nutritional benefits of *Amaranthus* spp.



(a)



(b)

Figure 16. (a) Informant in percentage who use *Amaranthus* spp. for children's diets; (b) Informants in percentage who are interested to learn more about the *Amaranthus* spp. nutritional value.

4. Discussion

In a phytogeographical study, data accessed from the Zomba Herbarium in Malawi identified the presence of various *Amaranthus* species in 18 districts. *A. dubius* Mart. Ex Thell. was found in Nkhata Bay, Rumphi, Dedza, and Mulanje districts. *A. spinosus* L. was reported in Nkhata Bay, Dedza, Mulanje, Chikwawa, Lilongwe, Blantyre, Zomba, Kasungu, Salima, Mangochi, Mzimba, Nsanje, Karonga, and Machinga. *A. thunbergii* Moq. was found in Nkhata Bay, Dedza, Mulanje, Zomba, Kasungu, Thyolo, Salima, Mangochi, and Mzimba. *A. hybridus* L. appeared in Dedza, Lilongwe, Blantyre, Zomba, Kasungu, Thyolo, Salima, Mangochi, Ntcheu, Dowa, and Mzimba. *A. graecizans* (A. Gray) was only identified in Chikwawa, while *A. lividus* L. was found in Blantyre, Zomba, and Mzimba. These species were documented between 1933 and 1991.

However, recent fieldwork showed additional distributions not previously recorded. For instance, *A. hybridus* L. was also identified in Nkhata Bay; *A. cruentus* L., *A. hypochondriacus* L., and *A. australis* (A. Gray) were observed in Mzimba, Dedza, and Lilongwe. Further exploration identified *A. thunbergii* Moq., *A. dubius* Mart. Ex Thell., and *A. graecizans* L. in Nsanje, and *A. australis* (A. Gray), *A. hybridus* L., and *A. graecizans* L. in Mulanje. *A. spinosus* L. was newly recorded in Thyolo.

This data indicates that the existing herbarium database is outdated and requires revision. Except for *A. thunbergii* Moq., which is native to Central, East, and Southern Africa (including Malawi), the other species have origins outside Africa [36] (https://prota.prota4u.org/). For example, *A. dubius* originates from Mexico to Tropical America, *A. graecizans* spans Macaronesia to the Indian Subcontinent, *A. hybridus* L. comes from the eastern USA, and *A. lividus* L. (also known as *A. blitum* L.) is tropical in origin [37]-[43]. *A. spinosus* L. likely hails from lowland tropical South and Central America, *A. hypochondriacus* L. from Tropical America, *A. cruentus* L. from southern Mexico and Guatemala, and *A. australis* (A. Gray) from southeastern USA to Mexico [41]-[45].

Their successful establishment in Malawi demonstrates their adaptability to diverse climates and environments [10] [46]. These species tolerate temperature extremes, variable soils, and drought, and respond to photoperiod changes due to their C4 photosynthetic pathway, which supports resilience in dry conditions [47]-[50].

In neighboring countries like Ethiopia, *A. hybridus* L., *A. cruentus* L., *A. spinosus* L., *A. thunbergii* Moq., *A. graecizans* L., and *A. dubius* L. that we observed during our study have been reported, while species like *A. tricolor* L., *A. caudatus* L., and *A. palmeri* L. were not observed [51]. In South Africa, *A. hybridus* L., *A. thunbergii* Moq., *A. spinosus* L., *A. defletus* L., *A. hypochondriacus* L., *A. viridis*, and *A. graecizans* L. are common in agriculture [52].

In Egypt, naturally growing species include *A. graecizans* L., *A. lividus* L., and *A. viridis* L., while in Benin City, Nigeria, *A. cruentus* L. and *A. hybridus* L. are cultivated. While *A. cruentus* L. and *A. hypochondriacus* L. are seed crops in the Americas and South Africa, in Malawi, they often grow wild [53] [54].

The average age of participants in the survey was approximately 35 years, with 75% being female. Over half had a low education level. Major ethnic groups included Chewa, Lomwe, Yao, Ngoni, Tumbuka, and Sena. In African contexts, women predominantly manage food, especially for children under five [55] [56]. Studies indicate that low education among parents correlates with child malnutrition due to inadequate nutritional knowledge, poor feeding practices, and limited healthcare access [57]-[59]. Additional factors like poverty and climate-related challenges further exacerbate child malnutrition in Malawi [60]-[63].

The majority of participants were familiar with *Amaranthus* species, except for a minority in Dedza. Most learned about the plant from family members. Not only farmers, but also herbalists, vegetable vendors, and general consumers grow Amaranth, suggesting its adaptability and wide interest across different population segments. *A. dubius*, *A. graecizans*, *A. hybridus*, and *A. australis* are typically cultivated, while *A. spinosus*, *A. thunbergii*, *A. hypochondriacus*, and *A. cruentus* grow wild.

Leaves are the most commonly used part, followed by seeds, and they are primarily consumed as leafy vegetables. In West Africa, such as Nigeria, Amaranth is a common side dish for various starchy foods. It's also believed to improve red blood cell count [27] [64]. Popular species include *A. cruentus* L., *A. dubius* Mart. Ex Thell., *A. blitum* L., and *A. tricolor* L. They have been cultivated both as vegetable, fodder, medicine, and grain depending on the market of the producer [27]. In Malawi, leaves are often boiled and cooked with onions, tomatoes, oil, and served with staple foods like *nsima* or rice. Though maize remains Malawi's primary staple, cassava, rice, sweet potato, and legumes are also important [65] [66].

Approximately 20% of respondents use Amaranth for medicinal purposes. *A.*

hypochondriacus L. and *A. hybridus* L. were the most frequently cited for medical use, particularly for managing blood pressure and digestive ailments. These species demonstrated a strong preference in medicinal use, whereas *A. dubius* Mart. Ex Thell., *A. spinosus* L., *A. thunbergii* Moq., and *A. cruentus* L. were cited less often. Traditional applications encompass burning for potash in Benin, root decoctions in Senegal for infant laxatives, macerated plant water for pain relief in Ghana, and ash for wound care in Sudan and Gabon [67] [68]. The leaves are acknowledged for treating various ailments and promoting health in young children, nursing mothers, and patients with anemia or kidney issues [27].

Nutritionally, informants considered Amaranth leaves healthy due to their associations with blood cell production and immune support. They are rich in proteins, iron, zinc, calcium, magnesium, phosphorus, folic acid, potassium, and vitamins A, B, and C, while being low in carbohydrates. Their antioxidant properties further enhance health [69]-[71].

Despite Africa's deep-rooted cultural practices, 99% of the participants had no traditional or cultural knowledge tied to Amaranth. Some individuals avoid it due to spiritual beliefs, while others use it in rituals [72]-[75]. *A. hybridus* L. and *A. australis* (A. Gray) are more often cultivated and even sold in local markets, unlike *A. spinosus* L., *A. thunbergii* Moq., *A. hypochondriacus* L., and *A. cruentus* L., which grow in the wild.

Challenges identified include climate change, limited access to seeds, pest and disease attacks, and poor soil conditions. Pest issues such as leaf miners, cutworms, aphids, and armyworms severely affect yield [46]. Studies have identified key pests like *Hymenia recurvalis*, *Psara* sp., and *Liriomyza* sp. [53]. Defoliators are the main pests, with grain attackers such as *Cletus* sp. and *Aspavia armigera*. Natural enemies include parasitoids like *Aphidius colemani* and coccinellid beetles [56].

Additionally, the perception of Amaranth as a "poor man's crop" and its classification as a wild vegetable contribute to its underutilization and conservation neglect [46].

Given the widespread belief (by over 50% of participants) in Amaranth's role in food security and the 87% in favor of its conservation, further research, especially for genetic improvement, is crucial. The motivation behind its use lies in the belief that its nutrient-dense leaves support healthy child development. About 91% already include Amaranth in their children's diet, and 95% expressed willingness to learn more about its nutritional benefits. A detailed study of the nutritional profile of each cultivated *Amaranthus* seed type in Malawi is therefore warranted.

5. Conclusions

During our study, we identified 8 *Amaranthus* species (*A. dubius* Mart. Ex Thell., *A. spinosus* L., *A. thumbergii* Moq., *A. hybridus* L., *A. graecizans* L., *A. cruentus L., A. hypochondriacus* L. and *A. australis* (A. Gray)) in 5 districts (Mzimba, Lilongwe, Dedza, Machinga, and Zomba) of Malawi. All of the species were found in Mzimba district, while three species (*A. spinosus* L., *A. thumbergii* Moq., *A. hybridus* L.) were found in Machinga district.

Concerning the demographic information, the average informants' age belongs to young people, and most of them are female with a low education level. According to our findings, all the target population grows *Amaranthus*. *Amaranthus* leaves are mostly used as a relish taken with nsima and rice (staple foods in Malawi), while for medicinal purposes, *A. hypochondriacus* L. and *A. hybridus* L. are the most important *Amaranthus* spp. *A. hypochondriacus* L. is used for blood pressure regulation. 95% of the informants consider *Amaranthus* as healthy food, while 99% of them do not use it for any traditional practice.

In Malawi, *A. hybridus* L. and *A. australis* (A. Gray) are the main *Amaranthus* species that are grown for their leaves, which are sold in the market as a leaf vegetable. The informants agree to their conservation because of their potential to improve food security. Further work is needed to study the nutrient content of the leaves and seeds of the *Amaranthus* species.

6. Study Limitation

This study is limited by the bias associated with the absence of verification of all the information provided by the informants. The absence of some districts that could be agro-ecological districts of *Amaranthus* spp., as well as the lack of chemical validation, is also a limitation.

Acknowledgements

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Authors' Contributions

P. Agnandji, G. Tanzito, M. Allavo, and G. Alunga designed the study. P. Agnandji conducted the investigation, collected the data, and wrote the original draft of the manuscript. B. K. Kokouvi, N. Ndong, I. Baldé, and P. Agnandji analyzed the data. A. Mukisa, P.A. Kiwango, J.K. Mutazindwa, J. Nababi and K. Masamba reviewed the manuscript. M.K. Chiipanthenga and M. Tembo supervised the work.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix: Supporting Information

Supplementary data associated with this article can be found in the following table.

Country	District	Specific locality	LAT	NS	LONG	*Amaranthus dubius*	*Amaranthus spinosus*	*Amaranthus thunbergii*	*Amaranthus hybridus*	*Amaranthus graecizans*	*Amaranthus lividus*	Year
Malawi	**Nkhata Bay**	6 Miles South of Chintheche	11.8167	S	0	x						1978
		Makulawe on L. Malawi in Likoma Island	12.0333	S	34.7167		x					1989
		Mzenga Estate	0	S	0			x				1987
	Rumphi	On Livingstonia Road near South Rukuru River	0	S	0	x						1980
	Dedza	Golomoti along Livulezi River	14.35	S	34.6	x						1980
		Chongoni Forest Reserve	14.2	S	34.2				x			1986
		Dedza Mountain	14.3333	S	34.3333				x			1987
		Chongoni Forest Reserve, near Mr. Mjuweni House	14.2	S	34.2				x			1968
		Masasa Controlled Area	14.4333	S	36.4167				x			1989
		Dzenza Hills	14.15	S	34.1333				x			1990
		Nsituwalengwe Forest, Chiwamba No. 2 village, T.A. Kasumbu	0	S	0				x			1985
		Chongoni Forest Reserve. Growing on Waste Places as Weeds							x			1968
		Chongoni Forest Reserve	14.2	S	34.2		x					1968
		Tsanya Forest	14.3	S	34.6		x					1990
		Golomoti-Monkey Bay Road	0	S	0		x					1990
		Golomoti-Monkey Bay Road	0	S	0			x				1990
		Masasa Controlled Area	15.0167	S	35.1167			x				1990
	Mulanje	Maombwe Stream, Nambazo	0	S	0	x						1984
		Mphwisi Hill in Chinani Village	15.5667	S	34.8167		x					1987
		Lumbuli Estate	16.05	S	35.5667			x				1985
	Chikwawa	West Bank of Shire River at Kasisi, 6 km North of Chikwawa	0	S	0					x		1970
		West Bank of Shire River at Kasisi, 6 km North of Chikwawa	15.9333	S	34.75		x					1970
		Near Nchalo on Nchalo-Chikwawa Road	0	S	0		x					1985
		Makungwa Village on the Marsh along River Basin	0	S	0		x					1991
	Lilongwe	Near Bunda	0	S	0				x			1972
		Nature Sanctuary Forest Zone A. Lingazi River Bank	13.9833	S	33.7667				x			1985
		Nature Sanctuary. Forest Zone A. North Trail. Lingazi River Bank	13.9833	S	33.7667				x			1987
		Chitedze Agricultural Research Station	13.9667	S	33.5833		x					1967
		Nature Sanctuary Forest Zone C. Lingadzi River Bank	13.9833	S	33.7667		x					1985
		Chitedze Agriculture Research Station	0	S	0		x					1956

Continued

Blantyre	Matenje Road, 1 - 2 km North of Limbe	0	S	0			x			1970
	Sunnyside	15.7833	S	34.9833			x			1971
	Below Sunset Cornes	0	S	0					x	1971
	Shire Highlands Hotel	15.8167	S	35.0667	x					1966
	Bvumbwe	15.9167	S	35.0167	x					1967
	Nyambadwe	15.7667	S	35.0167	x					0
	Maone, 2 km North East of Limbe	15.7833	S	35.0667	x					1970
	Sanjika-Hill	14.8	S	34.5833	x					1971
	Sunnyside	15.7833	S	34.9833	x					1975
	Michiru Mountain Forest	15.7333	S	34.95	x					1989
Zomba	Nandolo	0	S	0			x			1978
	Chancellor College, around Lawn Tennis Field	0	S	0			x			1977
	Kalimbuka Housing Area, behind House No. 11	0	S	0			x			1983
	Mpita Tobacco Estate, Thondwe	15.45	S	35.2167			x			1984
	Mpita Estate, Thondwe	15.45	S	35.2167			x			1986
	Mpita Estate, Thondwe.	15.45	S	35.2167			x			1986
	Herbarium Grounds. Ash Terrace in Herbarium Garden	0	S	0			x			1987
	Near Namitembo Mission. Namitembo Stream Bank	15.8333	S	33.3833			x			
	Makoka Vge, Chisi Island, Lake Chilwa	15.3167	S	35.7167			x			
	Zomba Mountain Slopes	15.3167	S	35.3					x	1988
	Chancellor College behind Kanjedza Hall	15.4	S	35.3333	x					1977
	5 Miles West of Lake Chilwa	15.3833	S	35.7167	x					1977
	Near Nasawa	0	S	0	x					1981
	2km West of Chancellor College	15.3833	S	35.2667	x					1984
	Mpita Tobacco Estate, Thondwe	15.45	S	35.2167	x					1984
	Chuka villageon Chisi Island. Lake Chilwa	15.3833	S	35.7167	x					1986
	Maela stream in Mthitha Village, T.A. Mulumbe	0	S	0	x					1987
	Chingale. Along Linthipe Stream	15.4	S	35.1833	x					1990
	Mkotamo Village at Chisi Island on Lake Chilwa	15.3167	S	35.7167	x					1990
	Herbarium Grounds	15.3833	S	35.3167		x				1987
Kasungu	Mtunthama School	0	S	0			x			1979
	Mtunthama School	13.0167	S	33.6667	x					1979
	Kamuzu Academy	0	S	0		x				1979
	Mtunthama School	13.0167	S	33.6667		x				1979

Continued

Thyolo	Bvumbwe	15.9167	S	35.0667			**x**			1985
	Mpeni Tea Estate	15.9667	S	35.0833		**x**				1986
Salima	Lifidzi Breeding Centre	13.9167	S	34.4667			**x**			1985
	Lifidzi Goat Breeding Centre. Near the office	13.9167	S	34.4667	**x**					1985
	Khola No. 3 Goat Breeding Centre	13.9	S	34.45		**x**				1985
Mangochi	Kamuzu Bridge at Mangochi Boma	0	S	0			**x**			1986
	Chiwalo Village. T.A. Nankumba. Lukululu Stream	14.3667	S	34.8333			**x**			1986
	Namwera, Sr. Martha Hospital	14.3667	S	35.5	**x**					1976
	Phirirlongwe Forest Reserve	14.55	S	34.9167	**x**					1986
	Monkey Bay	14.0667	S	34.9167	**x**					1988
	South West of Maldeco Road Path to Senjere Village	0	S	0	**x**					1989
	Maldeco Road to Nkopola Lodge	14.3167	S	35.15		**x**				1989
	Chipalamawamba Village	14.5	S	35.25		**x**				
Ntcheu	Mwavi Forest Reserve	14.85	S	34.6			**x**			1986
Dowa	10 km west of Dowa Boma	13.65	S	33.9333			**x**			1987
Mzimba	Lunyangwa in Mzuzu	11.45	S	34.0167			**x**			1986
	Lunyangwa in Mzuzu	11.45	S	34.0333			**x**			1986
	Lunyangwa in Mzuzu	11.4167	S	34.0167			**x**			1986
	Lunyangwa Botanic Site, Mzuzu	11.4	S	34.0333			**x**			1991
	Marymount in Mzuzu	11.4667	S	34.0333					**x**	1970
	Lunyangwa Agricultural Forest, Mzuzu	11.4	S	34.0167	**x**					1991
	2.75 miles South West of Chikangawa	11.8667	S	33.7667		**x**				1978
Nsanje	Port Herald Hills on Shire Plains	16.9167	S	35.2667	**x**					1933
Karonga	St. Anne's, 2 mi. N. of Chilumba	10.4	S	34.2333	**x**					1969
Machinga	Ukasi compound, Chindusi Hills, Liwonde Forest Reserve	15.0667	S	35.5	**x**					1984
	Liwawazi River, Liwonde-Balaka Road	0	S	0	**x**					1986
	Kankolanje harbour, Lake Chiuta	14.7833	S	35.8667	**x**					1988

NB: **x**: Presence of *Amaranthus* spp. in Malawi.