



Ethnobotanical survey of plants used as traditional herbs and spices in north-eastern Namibia

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Research

Abstract

Background: Research on indigenous knowledge as an alternative key to unlock the power of health benefits associated with plant species has gained much interest recently. However, there is a lack of documented information about the use of indigenous plants as traditional herbs and spices and their contributions to health benefits in north-eastern Namibia. The aim of this study was to conduct an ethnobotanical survey of indigenous knowledge of plants used as culinary herbs and spices in north-eastern Namibia.

Methods: Using semi-structured interviews and closed-end questionnaires, ethnobotanical data was collected from random selected informants in the Kabbe North and Kabbe South constituencies between December 2018 and April 2019 without following a specific order. Plant parts and photographs of each species mentioned by at least three independent participants were collected and taken for further identification.

Results: Twenty-three (23) plant species belonging to 16 plant families were collected. Furthermore, the largest proportion of plants used as traditional herbs and spices documented belonged to the family Malvaceae. Leaves were the most used part in food preparations, mainly as leafy vegetables, seasoning, preservation, flavouring, and traditional medicines, followed by roots.

Conclusions: Our preliminary results will serve as a reference, which documents and preserves the indigenous knowledge of plants used as culinary herbs and spices in Kabbe constituencies, Zambezi region, Namibia. Further studies may be needed to determine the biological activities, chemical compounds, and toxicity to support the safe usage of these plants as food additives and natural preservatives for food safety applications.

Keywords: Ethnobotanical survey, herbs, indigenous knowledge, spices, Zambezi region.

Background

Herbs and spices have a long history of traditional usage for both culinary and medicinal purposes (Embuscado 2018, Karaköse 2022, Şen *et al.* 2022). Plants such as *Corchorus asplenifolius* Burch., *Commelina africana* L., *Gomphocarpus fruticosus* (L.) W.T.Aiton, *Sesamum triphyllum* Welw. ex Asch., and *Talinum arnotii* Hook.f. have been reported in Namibia as edible herbs as well as widely used as traditional medicines for pain, heart complaints, venereal diseases, snake bites, malaria, tuberculosis, gonorrhoea, coughs, and warts (SEPASAL Namibia Project Team, 2006). Culinary herbs and spices may still be tough to differentiate. This could be because both culinary herbs and spices are used in small amounts during food preparation and provide flavour to food dishes or drinks (Asowata-Ayodele *et al.* 2016). However, a study by Spencer (2017) provided a definite distinction between herbs and spices. This author defined herbs as plant parts, mostly the green and fresh leaves, flowers or stems of plants with flavour, delicious, tasty or aromatic properties; in contrast to spices, which are aromatic seed, fruit, root parts, bark, or even the stigma of a flower consumed to enhance sensory quality of foods such as flavour, colour, and aroma. The global trend of using herbs and spices to enhance palatability and the taste of food is widespread and emphasized in literature (Motti 2021, Ivanova *et al.* 2022, Ahirwar *et al.* 2024, Inta *et al.* 2025). Considering the importance of herbs and spices in traditional cuisine, such plant species are often planted in home gardens near houses so that the species are readily available when needed (Némethy *et al.* 2020, Pushpakumara *et al.* 2020, Pranskuniene *et al.* 2021).

According to Raghavan (2006), spices are the building blocks of flavour in food applications. As a matter of fact, several scientific studies are currently underway analysing, confirming, and documenting phytochemicals, bioactive compounds as well as health beneficial effects beyond taste and flavour in plants traditionally used as herbs and spices (Sachdeva *et al.* 2018, Khanal *et al.* 2021, Rani *et al.* 2023, Kaur *et al.* 2025). Traditional culinary herbs and spices have become an important research area in recent years (Witkowska *et al.* 2013, Joseph & Voeks 2021, Ahad *et al.* 2023, Manyaga *et al.* 2025). This is because they contain phytochemicals which play important roles in food and beverage preservation, seasoning, flavouring, and traditional medicines (Tassou *et al.* 2012, Dini 2018, Adnan *et al.* 2022). Significantly, the phytochemicals found in herbs and spices can be categorized into several groups, which include phenolics, terpenoids, carotenoids, phenolics, sterols, essential oils, alkaloids, as well as lectins and polypeptides (Srinivasan 2016, Herrera *et al.* 2025, Kaur *et al.* 2025). Recent studies have linked immune-modulatory effects and organoleptic properties found in edible herbs and spices such as fresh leaves, flowers, stems, dried seeds, fruits, roots, barks, or vegetable substances to the presence of these phytochemicals' groups (Raghavan 2006, Weerakkody *et al.* 2010). The purpose of this study was to investigate and document the indigenous knowledge of traditional culinary herbs and spices used in north-eastern Namibia. It is expected that this study will contribute to the indigenous ecological knowledge about the usage of traditional herbs and spices in north-eastern Namibia and their contributions toward improving human health.

Materials and Methods

Study area

This study was undertaken in Kabbe constituency of the Zambezi region, in north-eastern Namibia (Fig. 1). Kabbe constituency is divided into Kabbe North (A) and Kabbe South (B), see Figure 1 (Kabbe Constituency 2018), with a population of about 14,518 people in 2011 (NSA 2014). The ethnobotanical survey of indigenous knowledge of plants used as culinary herbs and spices was undertaken in six villages in Kabbe North and eight villages in Kabbe South constituencies. The Zambezi region has a moderate temperature throughout the year than the rest of Namibia (Baseline Report for the Zambezi Integrated Regional Land-use Plan 2015). The highest temperatures are experienced in the region between September and November, with the average daily maximum ranging between 32°C and 35°C. In the winter months, the region has an average minimum temperature of 5°C (Baseline Report for the Zambezi Integrated Regional Land-use Plan 2015). The average rainfall in the study area is 555 mm per annum (Chinsemu *et al.* 2014). The dominant vegetation type in the Zambezi region is savanna, typically dominated by *Colophospermum mopane* (J.Kirk ex Benth.) J.Kirk ex J.Léonard (Giess 1971) with degraded *Hyphaene petersiana* Klotzsch ex Mart. plains in some places (Strohbach 2000). Local people depend on agricultural activities, which include the rearing of cattle and goats, as well as growing maize (*Zea mays* L.), pearl millet (*Cenchrus americanus* (L.)). Morrone and sorghum (*Sorghum bicolor* (L.) Moench (Chinsemu *et al.* 2014). The poorest families in the study area depend on the natural environment for resources such as firewood, construction timber, and fencing materials, as well as traditional medicines, leafy vegetables, and wild edible fruits (Chinsemu *et al.* 2014).

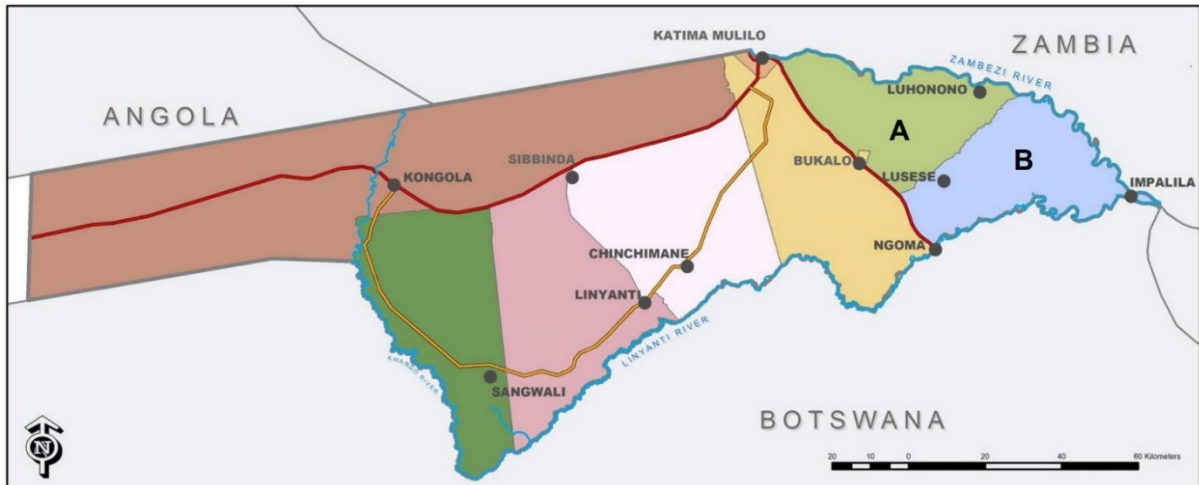


Figure 1. Map of the Zambezi region showing the location of Kabbe North (A) and Kabbe South (B) constituencies (adopted from Baseline Report for the Zambezi Integrated Regional Land-use Plan 2015)

Ethnobotanical data collection

The ethnobotanical survey was conducted in Bukalo, Mukungu, Saili, Kasheshe, Sikuzwe, and Mudaniko villages of Kabbe North constituency, and in Kandiyana, Kabula, Sinchembe, Kachepati, Muchenje, Libuyu, Lizauli, and Lifelo villages of Kabbe South constituency between December 2018 and April 2019. Sixty-eight randomly selected informants took part in this study. After explaining the objectives of the research and seeking their consent, the informants were individually engaged in semi-structured face-to-face interviews guided by a closed-ended questionnaire. The questionnaire was intended to document the socio-demographic aspects of the informants and the indigenous knowledge of traditional culinary herbs and spices used in the study area. Therefore, documented information included vernacular names of the species, their uses, parts used, preparation methods, and the therapeutic applications of the spices. All interviews were conducted in the local language, with the siLozi-English translator present during the conversations between the informants and the research team (Figure 2).



Figure 2. Photographs illustrating how interviews were conducted with informants (Photographer: A. Tomas)

Plant collection and identification

Parts of plant species used as herbs and/or spices mentioned by at least three informants were collected, and photographs of the species were also taken. Plant species used as herbs and/or spices were identified in the field, and the unknown plant species were collected, pressed, oven-dried, and identified by taxonomist at the National Herbarium of Namibia (WIND), Namibian Botanical Research Institute in Windhoek. All scientific names were confirmed through the Plants of the World Online database (<https://powo.science.kew.org>). The names were also updated by comparison with The World Flora Online (<https://www.worldfloraonline.org>), or the African Plant Database (<https://africanplantdatabase.ch>)

Data analysis

To determine the level of ethnobotanical knowledge about indigenous knowledge of plants used as culinary herbs and spices in north-eastern Namibia, we computed the ethnobiological indices such as use value (UV), frequency index (FI), informant consensus factor (ICF), and fidelity level (FL). The UV demonstrates the relative importance of plants known locally (Tardío & Pardo-De-Santayana 2008). It was calculated using the formula: $UV = \sum U_i / N$. Where U_i is the number of uses mentioned by each informant for a given species, and N is the total number of informants.

The FI was calculated for each plant species used as herb and/or spice collected to compare the relative importance of each plant species. The FI is a numerical expression of the percentage frequency of citation for a single plant species by informants (Mahwasane *et al.* 2013). The following formula was used to calculate FI.

$FI = FC/N \times 100$. Where FC is the number of informants who mentioned the use of the plant species, and N is the total number of informants. The FI was high when a particular plant was mentioned by many informants and low when it was mentioned by few.

The ICF was calculated according to the following formula (Sargin *et al.* 2013):

$$ICF = \frac{Nur - Nt}{Nur - 1}$$

Where Nur refers to the number of use citations in each category, and Nt to the number of the species used.

The ICF values of the culinary/therapeutic uses for plant species documented in this survey were conferred. The plant species that are presumed to be effective against different culinary/therapeutic use groups have higher ICF values. This method is used to check the homogeneity of the information (Sargin 2015, Güler *et al.* 2021, Karaköse 2022, Şen *et al.* 2022).

The FL, which is the percentage of informants claiming the use of a certain plant for the same major purpose, was calculated for the most frequently reported culinary/therapeutic uses as follows (Cheikhyoussef *et al.* 2011):

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

Where N_p is the number of informants that claim a use of a plant species as a culinary herb or spice, and N is the number of informants that use the plants for culinary/therapeutic purposes. Prior to the calculation of FL, reported uses were grouped into major culinary/therapeutic uses categories, which are leafy vegetables, seasoning, preservation, and traditional medicines.

Results and Discussion

Socio-demographic information

Sixty-eight informants in Kabbe North and Kabbe South constituencies between the ages of 23 and 89 participated in the study. Although most of the informants were in the range of 30-39 years age group, the number of knowledge holders gradually decreased in the higher age groups (40->80) in the study areas (Table 1). Therefore, it is important to document the indigenous knowledge in the elderly groups, so that it can be maintained and sustained for the next generations to learn from it. If not, these elderly knowledge holders will pass on, and the knowledge will be lost. This agrees with several studies, which also indicated that indigenous knowledge among the young generation is declining due to ignorance and disbelief in learning traditional and indigenous knowledge from the elderly (Negi *et al.* 2010, Wilder *et al.* 2016, Karaköse 2022, Negi *et al.* 2023).

Table 1. Overall number of informants by age group who participated in the ethnobotanical survey

	Age group (Years)					
	<30-39	40-49	50-59	60-69	70-79	>80
Female	15	7	3	10	4	5
Male	9	5	2	5	2	1
No. of plant species mentioned	98	33	12	56	12	20

On the other hand, male informants ($n = 24$; 35.3%) who participated in the ethnobotanical survey were fewer in comparison to female informants (Table 1). This could be because women, in general, are traditionally known to do most of the cooking and culinary activities in African families (Raidimi 2014, Gwandure & Lukhele-Olorunju 2023). Therefore, rural women have particular roles in traditional health care delivery, such as cooking and cultivating gardens than men in most families (Asowata-Ayodele *et al.* 2016). As a result, age and gender have significant effects with respect to indigenous knowledge of plants that are traditionally used as herbs and spices in Kabbe constituencies.

Two dominant ethnic groups were reported during the ethnobotanical survey living in Kabbe constituencies. The Masubia is the largest ethnic group with 74.4% of total informants participating in this study, followed by the Mafwe people with 17.9% and other ethnic groups, including the Mayeyi, Matotela, and the Mashi people, with 7.7% (Fig. 3). Although there was a lack of data about the distribution of these ethnic groups within the Zambezi region, this study noted that the Masubia people are dominant in Kabbe constituencies because their traditional authority (*kuta*) is based in Bukalo, a village in Kabbe North constituency. Furthermore, this study has recorded that the Masubia people are patrilineal, where their kinship and ethnic identity are dependent on their father. The Masubia people live off farming and gathering, hunting and fishing, where women are responsible for farming activities, while the men deal with the hunting and fishing.

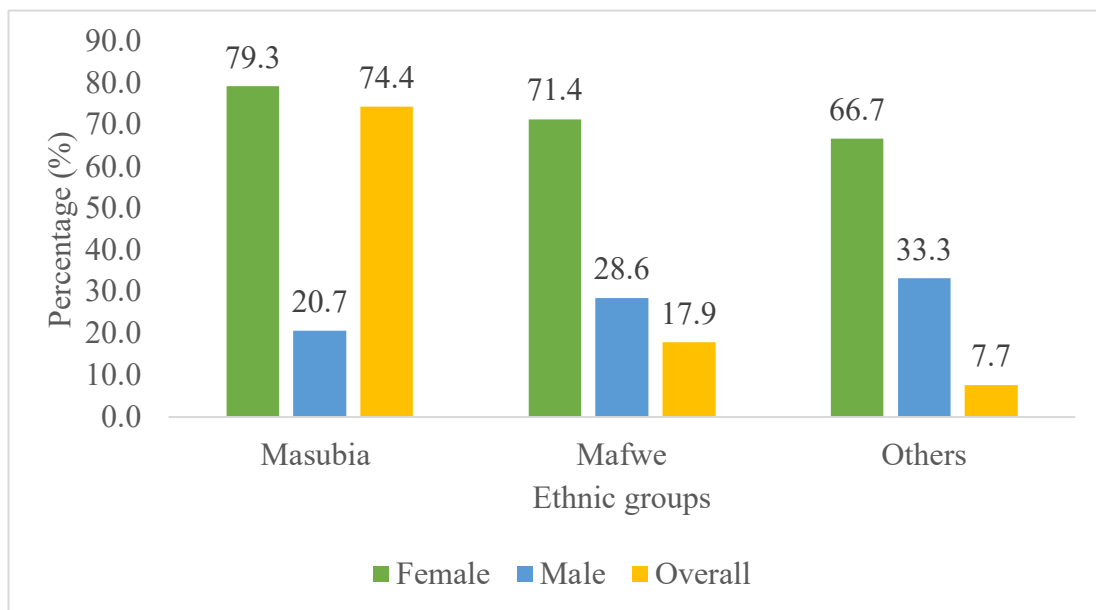


Figure 3. Ethnic groups that participated in the ethnobotanical survey of indigenous knowledge of plants used as culinary herbs and spices in north-eastern Namibia

Ethnobotanical uses of plants recorded in north-eastern Namibia

This study documented 23 plant taxa used as leafy vegetables, as seasoning, for preservation, and as traditional medicines (Table 2, Fig. 4). The majority of the species were used for preservation and seasoning purposes (30% each), followed by medicinal applications (24%) and as leafy vegetables (16%) (Fig. 5). The 23 species belong to 15 plant families (Fig. 6). The most significant proportion of documented species belongs to the family Malvaceae, and these species include *Adansonia digitata* L., *Corchorus tridens* L., *Hibiscus fuscus* Garcke, *H. mechowii* Garcke, *Hibiscus* spp. Other major families included Amaranthaceae, Cucurbitaceae, Fabaceae, and Moraceae, which were represented by two species each. The Malvaceae family consists of herbs or shrubs, even though some trees and lianas do exist (Bayer & Kubitzki 2003, Xu & Deng 2017), with potential in food and traditional medicine (Nikalje *et al.* 2025).

Table 2. Plant species traditionally used as herbs and spices in north-eastern Namibia

Family and scientific name	Habit	Voucher number	Vernacular	Parts used	UV	FI	Culinary and/or therapeutic uses
Amaranthaceae <i>Amaranthus hybridus</i> L. var. <i>hybridus</i>	Herb	T023	Lindowa	Leaves or roots	0.19	19.12	Leafy vegetable. Used to make green salad. Root decoction used against diarrhoea and to expel parasitic worms and other internal parasites
Amaranthaceae <i>Amaranthus thunbergii</i> Moq.	Herb	T020	Libowa or ihato	Leaves	0.79	79.41	Leafy vegetable. Help to expel parasitic worms and other internal parasites. Help increase production of urine. Used against kidney infections and TB sores
Annonaceae <i>Annona senegalensis</i> Pers.	Shrub	T016	Malolo	Fruits or roots	0.10	10.29	Flavouring and preservative. Fresh fruits used to make juice and salad. Root decoction used as herbal tea, to treat stomach-ache and malaria
Cleomaceae <i>Cleome gynandra</i> L.	Herb	T040	Sishungwa	Leaves	0.84	83.82	Leafy vegetable
Convolvulaceae <i>Ipomoea batatas</i> (L.) Lam.	Climber	T041	Ngulu (tubers), kalembula (leaves)	Leaves or tubers	0.40	39.71	Flavouring and preservative. Leafy vegetable. Tubers grounded to make flour. Leaf decoction helps to strengthen bones
Cucurbitaceae <i>Cucurbita maxima</i> (Duchesne) Poir.	Climber	T035	Nalumanga	Leaves	0.27	26.47	Leafy vegetable
Cucurbitaceae <i>Cucurbita</i> spp.	Climber	T027	Mangambwa	Leaves	0.77	76.47	Seasoning and preservative. Leafy vegetable. Leaf infusion used to treat joint pain, connective tissues and swelling
Euphorbiaceae <i>Manihot esculenta</i> Crantz	Shrub	T028	Mwanja	Leaves or roots	0.63	63.24	Flavouring and preservative. Leafy vegetable. Roots grounded to make flour
Fabaceae <i>Baphia massaiensis</i> Taub.	Shrub	T008	Muvunje	Roots	0.12	11.77	Flavouring and preservative. Roots used as herbal tea/coffee. Roots used as toothbrush.
Fabaceae <i>Vigna unguiculata</i> (L.) Walp.	Herb	T032	Nyangu or manawa	Fruits or leaves	0.56	55.88	Flavouring and preservative. Fruits and leaves used to make soup and relish
Malvaceae <i>Adansonia digitata</i> L.	Tree	T013	Mubuyu	Bark, leaves or roots	0.21	20.59	Flavouring and preservative. Bark or roots decoction or infusion used to boost appetite and general immune system. Leaf root decoction or infusion used to treat diarrhoea and malaria
Malvaceae <i>Corchorus tridens</i> L.	Herb	T024	Delele	Leaves	0.63	63.24	Leafy vegetable. Leaf infusion help boost appetite
Malvaceae <i>Hibiscus fuscus</i> Garcke	Shrub	T019	Sindambi	Leaves	0.32	32.35	Fresh/dry leaves used as vegetable. Leaf infusion used to treat diarrhoea, mouth and throat sores or boost low blood pressure

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Malvaceae <i>Hibiscus mechowii</i> Garcke	Herb	T042	Sindambi or mundambi	Leaves	0.78	77.94	Leafy vegetable. Leaf decoction or infusion used to treat diarrhoea, mouth and sore throat
Malvaceae <i>Hibiscus</i> spp.	Herb	T034	Mundambi	Leaves	0.37	36.77	Leafy vegetable.
Moraceae <i>Ficus exasperata</i> Vahl	Tree	T014	Mukwiyu or muchaba	Bark or leaves	0.35	35.29	Flavouring and preservative. Leaves used as herbal tea. Leaf decoction or infusion helps to boost low blood pressure and treat tuberculosis. Bark decoction or infusion improve appetite, treat diarrhea and malaria
Moraceae <i>Morus</i> spp.	Tree	T021	Murobeni	Leaves	0.16	16.18	Seasoning and preservative. Leafy vegetable. Boiled as herbal tea
Moringaceae <i>Moringa ovalifolia</i> Dinter & A. Berger	Tree	T022	Mulinga	Flowers, leaves, roots or seeds	0.25	25.00	Flavouring and preservative. Leaves and flowers used as relish. Leaves boiled as herbal tea. Seed or root decoction or infusion used to treat various infectious diseases such as diarrhoea
Myrtaceae <i>Eucalyptus</i> spp.	Tree	T005	Kapulanga	Bark or leaves	0.09	8.82	Seasoning and preservative. Bark is used as food supplement. Bark and leaves used as toothbrush. Leaf infusion used to treat symptoms of coughs, colds and congestion.
Nymphaeaceae <i>Nymphaea lotus</i> L.,	Herb	T025	Lisoto	Flowers, rhizomes or roots	0.31	30.88	Flavouring and preservative. Flowers used to make salad. Rhizomes or roots are grounded and mixed with maize (<i>Zea mays</i> L.) flour
Onagraceae <i>Ludwigia leptocarpa</i> (Nutt.) H.Hara	Herb	T043	Lifulanvunvu	Leaves	0.43	42.65	Seasoning and preservative. Leafy vegetable, source of salt and as dye
Solanaceae <i>Capsicum frutescens</i> L.	Shrub	T030	Mbili-mbili	Fruits or leaves	0.38	38.24	Seasoning and preservative. Fruits used as spice. Leaves used to make soup. Fruit or leaf decoction help to expel parasitic worms and other internal parasites, treat cough with mucus and sore throat
Talinaceae <i>Talinum arnotii</i> Hook.f.	Herb	T044	Nasilele	Leaves	0.29	29.41	Seasoning and preservative. Leafy vegetable



Figure 4. Photographs of some of the plant species traditionally used as herbs and/or spices in north-eastern Namibia: *Adansonia digitata* L. (T013), *Amaranthus thunbergii* Moq. (T020), *Annona senegalensis* Pers. (T016), *Baphia massaiensis* Taub. (T008), *Capsicum frutescens* L. (T030), *Cucurbita maxima* (Duchesne) Poir. (T035), *Eucalyptus* spp. (T005), *Hibiscus fuscus* Garcke (T019), *Hibiscus mechowii* Garcke (T042), *Ipomoea batatas* (L.) Lam. (T041), *Moringa ovalifolia* Dinter & A.Berger (T022), *Morus* spp. (T021) and *Vigna unguiculata* (L.) Walp. (T032)

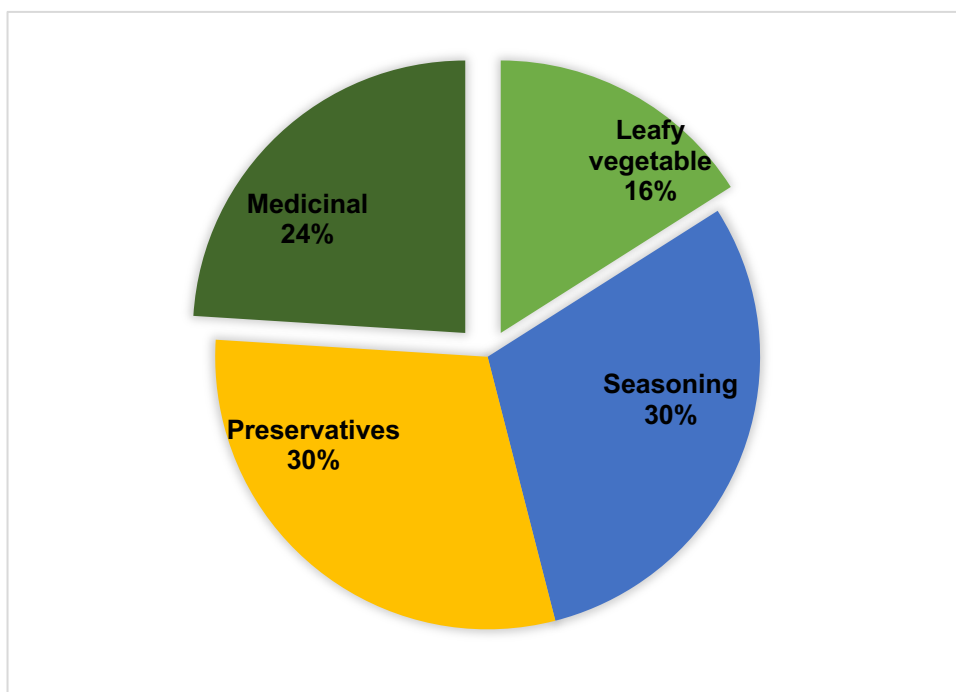


Figure 5. Major use categories of plant species recorded in north-eastern Namibia

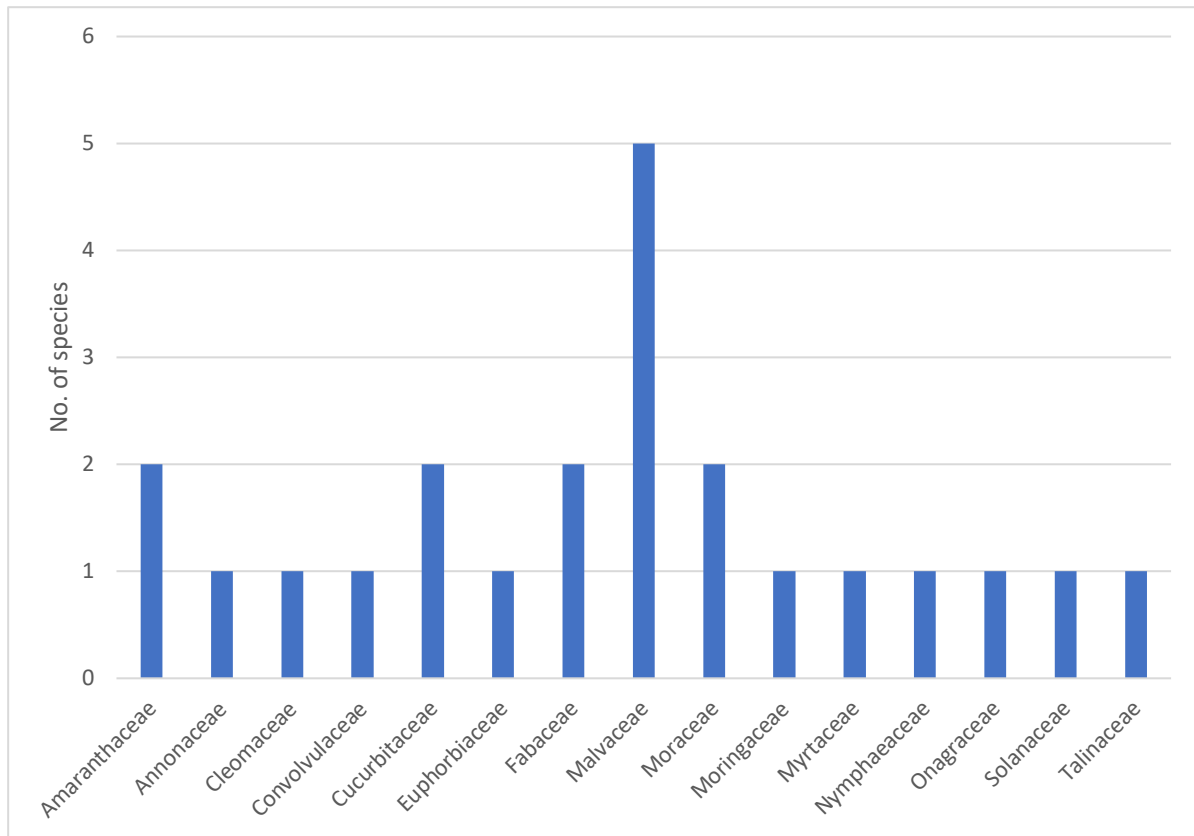


Figure 6. Families with the largest number of plants traditionally used as culinary herbs and spices in north-eastern Namibia

The leaves and barks of *Eucalyptus* spp. were reported to be added to food during cooking as a food supplement and as herbal medicine to treat symptoms of coughs, colds, and congestion. Similar ethnobotanical uses were reported in a study by Vecchio *et al.* (2016), where *Eucalyptus* spp. has been used as herbal medicine as well as seasoning for thousands of years due to essential oils found in leaves, fruits, buds, and bark of the species. However, this species has other ethnobotanical uses such as controlling algae proliferation in an aquatic milieu, and diverse pharmacological and medicinal properties such as antiperiodic, antiphlogistic, antiseptic, astringent, deodorant, anthelmintic, diaphoretic, expectorant, inhalant, insect repellent, rubefacient, sedative yet stimulant, suppurative, and vermifuge properties (Dixit *et al.* 2012, Zhao *et al.* 2019). The study by Ghisalberti (1996) also supports the traditional uses of *Eucalyptus* spp. as food preservatives and treatment of respiratory tract infections, and the species is characterized by several bioactive secondary metabolites such as terpenoids, tannins, flavonoids, and phloroglucinol derivatives, which have antiviral, antibacterial, antiseptic, antioxidant, anti-inflammatory, and anticancer activities.

The leaves of *Amaranthus hybridus* L. var. *hybridus* and *H. fuscus* Garcke were reported to be collected from the wild, cooked, and eaten as leafy vegetables. In agreement with this traditional use of *A. hybridus* var. *hybridus*, a study by Akubugwo *et al.* (2007) highlighted that this species is widely used to prepare soup, eaten as spinach or green vegetable, or sometimes boiled and mixed with groundnut sauce to make salad in most African countries. Furthermore, a study by Nana *et al.* (2012) is also in agreement with the traditional uses of *A. hybridus* var. *hybridus* to treat liver infections, knee pain, stomach aches, diarrhea and dysentery, and the species is also characterized by phytochemicals such as polyphenols, tannins, flavonoids, steroids, terpenoids, saponins and betalains. *Hibiscus fuscus* Garcke was documented in Kabbe constituencies as widely used to treat diarrhea, mouth and throat sores, in addition to being eaten as a leafy vegetable. Studies by Bunalema *et al.* (2014) and Gumisiriza *et al.* (2019) documented the uses of *H. fuscus* as traditional medicine for tuberculosis, splenomegaly, kidney disease, obstructed labor, febrile seizures, pleurisy, and fracture in Uganda. Moreover, this agreed with a study by Kakudidi (2004), which highlighted the ethnobotanical uses of *H. fuscus* Garcke during childbirth in western Uganda. Similarly, in Tamil Nadu, India, *H. fuscus* Garcke is known to boost low blood pressure, treat mental illness, as well as headache (Prabhu *et al.* 2014).

Moringa ovalifolia Dinter & A.Berger has exceptional medicinal and nutritional properties, and these include its uses as flavouring and preservative (Table 2). The leaves and flowers of *M. ovalifolia* Dinter & A.Berger are used as a relish or herbal

tea, with seed or root decoction or infusion used to treat various infectious diseases such as diarrhoea (Table 2). Similarly, the documented uses of *M. ovalifolia* Dinter & A.Berger were in agreement with the studies done by Ananias (2015) and Saini *et al.* (2016), which highlighted how the species is used to improve nutrition and health care needs of people due to the presence of functional bioactive compounds, such as alkaloids, carotenoids, tannins, anthraquinones, anthocyanins, proanthocyanidns, phenolic acids, flavonoids, phytosterols, natural sugars, vitamins, minerals, and organic acids. According to Singh *et al.* (2019), the phytochemicals found in the stems, leaves, flowers, pods, and seeds of *M. ovalifolia* Dinter & A.Berger provide several health benefits, including antiproliferation, hepatoprotective, anti-inflammatory, antinociceptive, antiatherosclerotic, oxidative DNA damage protective, antiperoxidative, cardioprotective, anti-aging, detoxifying agent against snake and scorpion bites, antimicrobial, and coagulant properties. Moreover, *M. ovalifolia* Dinter & A.Berger is rich in vitamin A, vitamin C, calcium, potassium, iron, as well as protein, and these essential nutrients help to prevent diseases (Ananias 2015, Ma *et al.* 2018). *Moringa ovalifolia* Dinter & A.Berger is also considered a multipurpose species, because it is also useful for water purification and biodiesel production (Jee & Jee 2018).

In the study area, *Capsicum frutescens* L., *Cucurbita* spp., and *Morus* spp. were reported to enhance taste, preserve food, and prevent infections and diseases (Table 2). To support the documented uses of *Morus* spp., literature studies show that the leaves, bark, root, and fruits of several *Morus* species are characterized by phytochemicals such as flavonoids, anthocyanins, and alkaloids, and these active ingredients play an important role in containing free radicals and pro-oxidants generated in the body due to metabolism and phagocytosis (Bhattacharjya *et al.* 2021). The *Cucurbita* spp. are generally considered rich in protein, fibres, minerals, polyunsaturated fatty acids, and phytosterols; therefore, they are regarded as valuable as nutraceuticals, in addition to their beneficial effects on blood glucose level, immunity, cholesterol, liver, prostate gland, bladder, depression, learning disabilities, and parasite inhibition (Patel 2013). The documented ethnobotanical uses of *C. frutescens* L. are in agreement with the study conducted by Alam *et al.* (2018), which discussed the agricultural and economic importance of the species in addition to its food flavour, colouring, nutritional, and medicinal values. Based on the study by Alam *et al.* (2018), *C. frutescens* L. is also rich in capsaicinoids, carotenoids, and phenolic compounds, which give the species a hot, spicy taste. Hence, these compounds help to protect the human body from free radicals due to their antioxidant activities (El-Massry *et al.* 2008).

The ethnobotanical uses of *Ludwigia leptocarpa* (Nutt.) H.Hara in north-eastern Namibia has been observed to be unique as no similar uses of the species were identified in the literature. The leaves of *L. leptocarpa* (Nutt.) H.Hara are used as seasoning, preservative, leafy vegetable, source of salt, and as a dye (Table 2). However, plant species in the *Ludwigia* genus are known for medicinal and ornamental purposes (Hernández & Walsh 2014). The *Ludwigia* species are characterized by phytochemical compounds such as saponins, tannins, polyphenols, alkaloids, linoleic acids, flavonoids, starch grains, and calcium oxalate crystals, which are responsible for numerous phytochemical properties associated with the species (Oyediji *et al.* 2011). Two studies by Tolken (1969) and SEPASAL Namibia Project Team (2006) reported the uses of *L. leptocarpa* (Nutt.) H.Hara as a leafy vegetable, eaten raw against thirst because it contains a lot of water, or as a green salad ingredient.

Growth forms and parts used

The major growth forms serving as primary sources of culinary herbs and spices in north-eastern Namibia are herbs (43%), followed by shrubs and trees (22% each) (Fig. 7A). Usage of shrubs and trees as culinary herbs and spices in north-eastern Namibia might be linked to their availability throughout the year, as they are relatively drought-resistant and are not affected by seasonal variations (Ref x). The plant parts used for the preparation of culinary herbs and spices were the bark, flowers, fruits, leaves, rhizomes, roots, seeds, and tubers. The leaves were the most frequently used (15 species), followed by roots (seven species), bark (three species), and fruits (two species) (Fig. 7B). Research by Chinsemu *et al.* (2014) showed that harvesting of leaves, unlike roots, is not labour-intensive and may not permanently damage the plants; therefore, most people prefer leaves compared to other plant parts.

Ethnobotanical indices of documented plant species

The UV and FI of documented species ranged from 0.09 to 0.84 and 8.82 to 83.82, respectively (Table 2). Species with UV values above 0.5 included *Vigna unguiculata* (L.) Walp. (0.56), *Manihot esculenta* Crantz (0.63), *Corchorus tridens* L. (0.63), *Cucurbita* spp. (0.77), *Hibiscus mechowii* Garcke (0.78), *Amaranthus thunbergii* Moq. (0.79) and *Cleome gynandra* L. (0.84). Species with FI values above 0.5 included *Vigna unguiculata* (L.) Walp. (55.88), *Corchorus tridens* L. (63.24), *Manihot esculenta* Crantz (63.24), *Cucurbita* spp. (76.47), *Hibiscus mechowii* Garcke (77.94), *Amaranthus thunbergii* Moq. (79.41) and *Cleome gynandra* L. (83.82) (Table 2). Therefore, species such as *Cucurbita* spp., *Hibiscus mechowii* Garcke, *Amaranthus thunbergii* Moq., and *Cleome gynandra*, which are characterized by UV and FI values, have potential as culinary herbs and as spices (Sargin 2015).

A sum of 243 use reports has been recorded in this research, which are categorized in 11 different culinary or therapeutic use groups (Table 3). The categories such as joint or connective tissue pain, kidney infections, and stomach-ache have the highest ICF values of 1.00 each, while the diarrhoeal category has the lowest ICF score of 0.62 (Table 3). The high occurrence of joint or connective tissue pain, kidney infections, and stomach-ache may be due to microbial infections, since the study area is situated in a tropical area characterized by high temperatures and rainfall, especially during the December-to-March rainy season. Such conditions and the terrain, which is mostly made up of swamps, floodplains, wetlands, and woodland, make it easier for microbial organisms to spread and cause microbial infections (Chinsembu *et al.* 2014). The ICF is used to determine the relative homogeneity of the informants' knowledge in terms of categories of diseases for which the plant species are traditionally used for (Asowata-Ayodele *et al.* 2016). Similarly, the FL values were calculated for plant species that have been cited by four or more informants for being used against a given culinary or therapeutic use category. The following species: *Adansonia digitata* L., *Amaranthus thunbergii* Moq., *Annona senegalensis* Pers., *Capsicum frutescens* L., *Corchorus tridens* L., *Cucurbita* spp., *Eucalyptus* spp., *Ficus exasperata* Vaha, and *Moringa ovalifolia* Dinter & A. Berger scored the highest FL values in excess of 70.0% (Table 4).

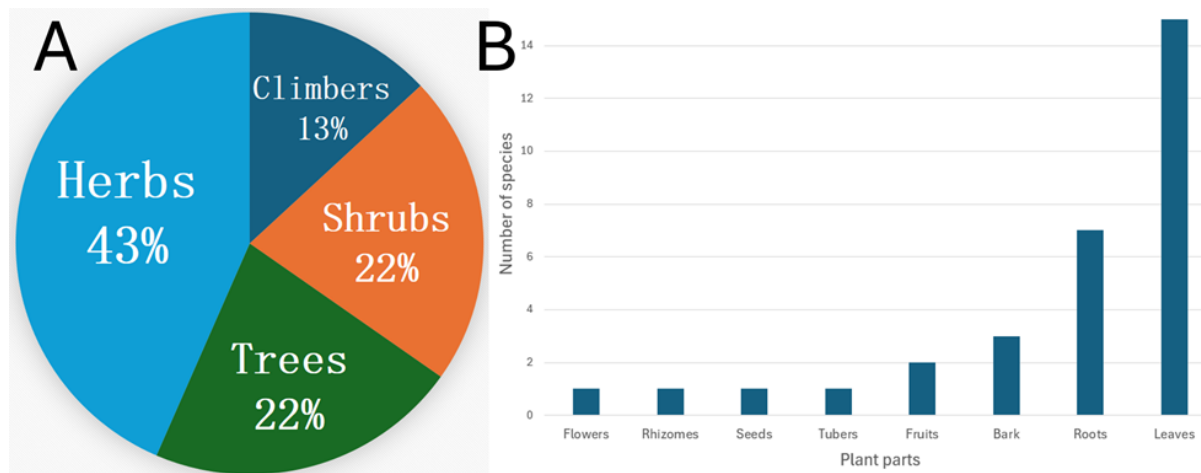


Figure 7. Characteristics of plants used as culinary herbs and spices in north-eastern Namibia. A: growth habit and B: plant parts used

Table 3. Informant consensus factor categories and values for culinary or therapeutic uses

Culinary or therapeutic use category	Citation number (Nur)	Number of taxa (Nt)	ICF value (Nur-Nt / Nur-1)
Appetite	33	3	0.94
Blood pressure	14	2	0.92
Coughs, colds or congestion	6	2	0.80
Diarrhoeal	14	6	0.62
Internal parasites	26	3	0.92
Joint pain or connective tissues	40	1	1.00
Kidney infections	46	1	1.00
Malaria	10	3	0.78
Mouth or throat sores	30	3	0.93
Stomach-ache	6	1	1.00
Tuberculosis sores	18	2	0.94

Table 4. Fidelity level (FL) values of plants used as herbs and spices cited by four or more informants for being used against a given culinary or therapeutic use category

Plant name	Culinary or therapeutic use category	Number of informants	Fidelity level value (%)
<i>Adansonia digitata</i> L.	Malaria	10	71.4
<i>Amaranthus thunbergii</i> Moq.	Kidney infections	46	85.2
<i>Annona senegalensis</i> Pers.	Stomach-ache	6	85.7
<i>Capsicum frutescens</i> L.	Internal parasites	26	100.0

<i>Corchorus tridens</i> L.	Appetite	33	76.7
<i>Cucurbita</i> spp.	Joint pain or connective tissues	40	76.9
<i>Eucalyptus</i> spp.	Coughs, colds or congestion	6	100.0
<i>Ficus exasperata</i> Vahl	Tuberculosis symptoms	18	75.0
<i>Hibiscus fuscus</i> Garcke	Blood pressure	14	63.6
<i>Hibiscus mechowii</i> Garcke	Mouth and throat sores	30	56.6
<i>Moringa ovalifolia</i> Dinter & A. Berger	Diarrheal	14	82.4

Conclusion

This study was undertaken to investigate the indigenous knowledge of plants traditionally used as culinary herbs and spices in Kabbe constituencies of the Zambezi region. Twenty-three plant species belonging to 16 plant families were documented. The most frequently cited plant family documented is the Malvaceae, which includes *Hibiscus fuscus* Garcke, *Corchorus tridens* L., and *Hibiscus mechowii* Garcke. Four plant species commonly used as herbs and spices with the highest frequency index above 60 are *Amaranthus thunbergii* Moq., *Corchorus tridens* L., *Cucurbita* spp., and *Manihot esculenta* Crantz. These plants are mostly used as herbs and spices for seasoning, leafy vegetables, preservatives, and traditional medicine.

Declarations

List of abbreviations: FC- Number of informants who mentioned the uses of a plant ; FI- Frequency index ; FIC- Fractional Inhibitory Concentration index; FL- Fidelity level; NBRI- National Botanical Research Institute; TB- Tuberculosis; TEK- Traditional ethnobotanical knowledge; UNAM- University of Namibia

Ethics approval and consent to participate: The purpose of the study was explained to the community members interviewed, and they were asked to sign an ethical confidentiality agreement form and a prior informed consent agreement. Moreover, the ethical clearance certificate and research permit were obtained from the local government authorities (Kabbe North Constituency Office and Kabbe South Constituency Office), University of Namibia Research Ethics Committee, National Commission on Research, Science and Technology (NCRST), and Ministry of Environment and Tourism (MET).

Consent for publication: Not applicable

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Author contributions: A.T. carried out fieldwork, data analysis and drafted the manuscript. A.C. and K.C.C. configured the research project, manuscript writing, data validation and supervised the work, A.M. validated the ethnobotanical information, data analysis and improved the manuscript.

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