An ethnobotanical survey of plant species used for medicinal purposes in Amuru district, northern Uganda

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Ethnobotany Research and Applications 29:41 (2024) - http://dx.doi.org/10.32859/era.29.41.1-17
Manuscript received: 25/03/2024 – Revised manuscript received: 12/09/2024 - Published: 12/09/2024

Research

Abstract

Background: Medicinal plants provide health care to rural communities that have limited access to modern medicine in Uganda. Thus, documenting medicinal plants is important for their sustainable utilisation and conservation of medicinal plants and associated indigenous knowledge.

Methods: A cross-sectional ethnobotanical survey was conducted in August 2021 to assess the knowledge and use of medicinal plants in Lamogi Sub-County, Amuru district. We randomly sampled and interviewed 334 household heads using semi-structured questionnaires. Data was analysed using descriptive statistics, familiarity index (FI), fidelity level (FL) and informant consensus factor (ICF).

Results: Most of the respondents (90%) had knowledge of medicinal plants used for treating ailments in their community (high ICF values above 0.9). Plant with the highest FI value was *Gymnanthemum amygdalinum* (Delile) Sch.Bip. indicating its wide use in the community. Chi-square tests showed significant associations between the knowledge of medicinal plants and education level, occupation, age, marital status and monthly income of respondents ($p < 0.05$). Forty-nine medicinal plants from 30 families were documented, with Fabaceae and Asteraceae having the most species. Leaves were the most frequently used plant parts (65.4%), followed by roots (13.6%). Herbal remedies were mostly prepared by crushing and smearing on the body, infusion, decoction and administered orally.

Conclusion: The people of Amuru district have rich indigenous knowledge of diverse medicinal plants used for treating ailments. Most medicinal plants are harvested from the wild, threatening their survival and this requires putting in place practical conservation measures.

Keywords: Ethnobotanical, Ethnomedicine, Herbal remedies, Northern Uganda, Traditional use

Background

Medicinal plants provide primary health care needs to many people around the world. In Africa, about 80% of the rural populations use traditional medicines to treat their illness and this practice is deeply rooted in the continent (Mogha 2024, Maling *et al.* 2024; Ohemu *et al.* 2024). This is due to the growing disease burden, poor access to conventional medicine, inadequate medical personnel and poverty (Kidane *et al.* 2018, Owor *et al.* 2024). In 2000, the World Health Organization's regional committee for Africa recognized the use of herbal medicines in improving human health and urged member states to develop legislation governing their use. In this regard, the Uganda's parliament passed the Indigenous and Complementary Bill 2015 which culminated in the subsequent development of the Traditional and Complementary Medicine Act 2019.

Traditional healers are always the first health practitioners that rural populations seek for diagnoses and/or treatments of health complications (WHO 2013). Today, the Uganda government is promoting the use of traditional medicines with prospect of eventually integrating it into the national health system (Indigenous and Complementary Medicine Bill 2015). Most people in the country now have faith in traditional medicines and traditional healers who are found in practically every village (Philip *et al.* 2017, Asiimwe *et al.* 2021, Musoke *et al.* 2021, Nakaziba *et al.* 2021).

Northern Uganda's savannah grasslands comprise diverse plant species (Langlands 1974) that are poorly studied for their medicinal potential. The region experienced a protracted civil war between the Uganda People's Defense Forces and the Lord's Resistance Army Rebels which occurred from 1986 to 2008 (Van Acker 2004, Day 2017). The war crippled the health infrastructure, education system and created long lasting poverty in the region forcing people to heavily rely on herbal remedies as alternative treatment for diseases and any other health issues (Okot *et al.* 2018, Oryema *et al.* 2021, Nyero *et al.* 2021). The traditional medicine practice is also a source of income and livelihood for traditional healers and those involved in the business chain. However, the knowledge of medicinal plants is often passed orally to young people by elders, traditional healers and relatives (WH0 2013, Kidane *et al.* 2018; Akwongo *et al.* 2022). This method of vesting knowledge in human custodians can be compromised in the event of death, resulting in the loss of important information to future generations. Secondly, the country's current population pressure threatens the existence of some valuable medicinal plant species on earth (Anywar *et al.* 2020a) for example through widespread habitat destruction caused by human settlement, deforestation and agricultural expansion. Therefore, studies on medicinal plants are essential for conserving, sustainably using biological resources and documenting indigenous knowledge on medicinal plant use (Güneş *et al.* 2017, and references therein), hence the need to search and document the potential medicinal plants in northern Uganda. In Amuru district, most people currently rely on the use of herbal remedies to treat illnesses (Ikinyom *et al.* 2023) due to limited health infrastructure and poverty (UBOS 2022). In most cases, herbal medicines are always readily available and cheaper than modern medicines (Charwi *et al.* 2023). This study therefore assessed the plants used as medicines by the rural communities of Lamogi sub-county in Amuru district, northern Uganda.

Materials and Methods

Study area

The study was conducted in Lamogi sub-county in Amuru district (02°48' 49"N, 31° 56' 19"E) in northern Uganda (Figure 1). Lamogi sub-county covers 422.05 Km^2 of land and is situated 351.9 km North of Kampala, the capital city of Uganda and 14 km north-west of Gulu city in northern Uganda. Lamogi sub-county has only one Health centre (HC III) serving approximately 46,333 people in eight parishes and 55 villages (UBOS 2017). Amuru district has a total population of 186,696 of which 91,284 are males and 95,412 females (UBOS 2017). The Acholi ethnic group, South Sudanese and other Uganda's tribes, mostly inhabits the area. The Acholi tribe largely depend on subsistence agriculture for their livelihood (UBOS 2017). The area is mainly characterised by ferruginous sandy loam soil and savannah grasslands (Langland 1974). This area receives about 232.9 mm of precipitation and about 267 rainy days per year. The average temperature is 27.1°c (80.78°F), which is higher than the national average for Uganda (UBOS 2018). The grassland is characterized by dominant natural tree species like *Ficus natalensis* Hochst., *Vachellia hockii* (De Wild.) Seigler & Ebinger (Syn: *Acacia hockii* DeWild.), *Combretum apiculatum* Sond., *Borassus aethiopum* Mart., *Vitex doniana* Sweet, *Albizia gummifera* (J.F.Gmel.) C.A.Sm. The common grasses-*Imperata cylindrica* (L.) Raeusch., *Hyparrhenia rufa* (Nees) Stapf, *Megathyrsus maximus* (Jacq.) B.K.Simon & S.W.L.Jacobs (Syn: *Panicum maximum* Jacq.) and *Digitaria abyssinica* (Hochst. ex A.Rich.) Stapf; and herbs like *Bidens pilosa* L., *Ageratum conyzoides* L., *Amaranthus dubius* Mart. ex Thell., and *Lantana camara* L.

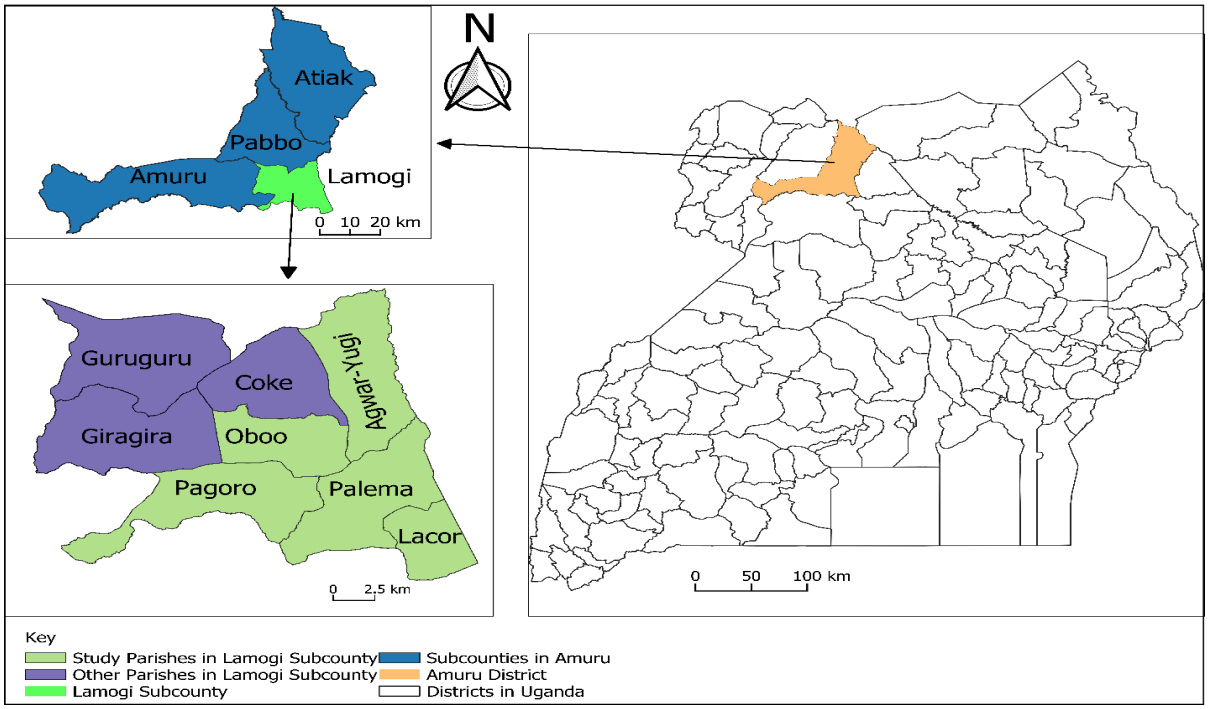


Figure 1. Location of Lamogi sub-county in Amuru district, northern Uganda. (Source: QGIS 3.2.1).

Data design and sample size determination

A cross-sectional survey was conducted in August 2021 in Lamogi sub-county, Amuru district in northern Uganda. Sample size determination table by Krejcie and Morgan (1970) was used to select 380 respondents from Lamogi sub-county (UBOS 2016). A multistage random sampling technique was used to select five parishes (Palema, Lacor, Agwaryugi, Pagoro and Oboo) followed by 10 villages (Keyo Trading Center, Pakiri, Pukure, Lwala-Kwar, Abyee, Jimo, Coorom, Kal, Oboo and Kaladima) from Lamogi sub-county. The participants were randomly selected from the 10 villages to obtain the opinions of community members on medicinal plant use. Traditional healers as key informants were identified using purposive sampling technique. Participants aged 15 years and above were included in the study because they are considered familiar with herbal medicines. The names of the participants were collected from the registers of respective local council chairpersons of the different villages.

Data collection procedure

Ethnobotanical data was collected from the local community members and key informants through semi-structured interviews (Anywar *et al.* 2020b, Tabuti *et al.* 2023). The questionnaires were translated into Acholi, the predominant local language spoken in the area. Field observation and guided field walks were undertaken with the respondents to locate the medicinal plants in their natural habitats, with the help of field assistants. The information collected included socio-demographic characteristics of the respondents, local names of plants, diseases treated, the plant parts used, habit, methods of preparation and modes of administration of the herbal remedies, and conservation status of medicinal plants for the management of various diseases in the community. The conservation status of different plant species was classified as 'wild and abundant, wild and rare, cultivated and abundant, cultivated and rare' following the procedures previously used by Ikinyom *et al.* (2023). Voucher specimens of all the plant species mentioned were collected and prepared following the standard procedures of Martin (1995). The plant species collected from the field were identified by a botanist from the Department of Biology, Gulu University, authenticated and deposited at the Herbarium of Makerere University, Uganda. The botanical names, families and species were cross-checked for accuracy by visiting plants of the world online database (https://powo.science.kew.org).

Data analyses

Descriptive statistics were used to summarize the data using frequencies, percentages and graphs. To identify priority medicinal plant species for healing different ailments and to ensure the level of consistency, three ethnobotanical indices were computed. Notably, the agreement among respondents on the use of potential medicinal plants for the various disease categories was tested by calculating Informant Consensus Factor (ICF) following the formula by Trotter and Logan

(1986). Accordingly, the ICF on medicinal uses of different plants species was calculated as the total number of use reports for each treatment cluster (Nur) minus the total number of plant species used in each disease category ('Ntaxa'), divided by the amount of use citations in each type minus one (Nakaziba *et al.* 2021). ICF values range from 0 to 1, with zero indicating no agreement and one being the highest agreement for the use of medicinal plants in the treatment of specific disease categories.

The familiarity index (FI) was used as a relative indicator of the popularity of a plant species (Friedman *et al.* 1986). Familiarity index was defined as the number of respondents that mentioned a medicinal plant species for a specific use, divided by the total number of respondents (Friedman *et al.* 1986). The value of FI varies between 0 and 1, whereby a value of 1 represents the highest familiarity of a medicinal plant in the area.

Fidelity level index (FL) indicate the key informants' most preferred plant species used for treating particular ailments (Friedman *et al.* 1986). $F_L = I_P/N \times 100$, where I_P is the number of informants who indicated use of a species for the same major ailment, N is the total number of informants who mentioned the plant for any other use. Fidelity level vary from 1 to 100%. Increasing values of FL for a species indicate its uniqueness to treat a particular ailment.

Chi-square test was used to assess the association between respondents' knowledge of medicinal plants and their gender, age, educational level, occupation, and religion and income level. All data were analyzed using SPSS version 25 (IBM Corporation, Armonk, NY, USA) at 95% confidence interval ($p < 0.05$).

Results

Socio-demographic characteristics of respondents

Most of the respondents interviewed were females (53.9%). The majority (30.5%) were aged between 36-45 years, had basic secondary level education (31.7%), peasant farmers (39.2%) and earned income between $2.64 - $26.31 (41.6%). By religion, majority were Anglicans (36.5%), followed by Catholics (30.2%), Pentecostals (24.3%) and Muslims (9.0%). By occupation, majority were peasant farmers (39.2%). About 90% of respondents had knowledge about medicinal plants (Table 1).

Traditional knowledge on medicinal plants

Knowledge of medicinal plants was significantly associated with occupation (χ^2 = 18.663, df =3, p = 0.001), level of education (χ^2 = 14.904, df = 3, p = 0.002), age (χ^2 = 10.786, df = 4, p = 0.029), marital status (χ^2 = 9.006, df = 2, p = 0.011) and monthly income of respondents (χ^2 = 15.245, df = 6, p = 0.018, Table 1). However, knowledge of medicinal plants was not significantly associated with gender (χ^2 = 3.39, df = 1, p = 0.066) and religion (χ^2 = 2.530, df = 3, p = 0.470, Table 1).

Table 1. The Chi-square tests of knowledge of medicinal plants and socio-demographic characteristics of the respondents

Characteristics	Numbers of respondents	Percentage	Knowledge of medicinal plants		χ^2	*P* value
			No	Yes		
Gender						
Male	154	46.1	11	143	χ^2 = 3.390, df = 1	p = 0.066
Female	180	53.9	24	156		
Age						
15-25	72	21.6	13	59	χ^2 = 10.786, df = 4	p= 0.029
26-35	72	21.6	08	64		
36-45	102	30.5	11	91		
46-55	35	10.5	03	32		
56-above	53	15.5	00	53		
Level of education						
Informal	105	31.4	03	102	χ^2 = 14.904, df = 3	p = 0.002
Primary	61	18.3	07	54		
Secondary	106	31.7	20	86		
Tertiary	62	18.6	05	57		
Religious affiliation						
Catholic	101	30.2	11	90	χ^2 = 2.530, df = 3	p = 0.470

Anglican	122	36.5	16	106		
Muslim	30	9.0	03	27		
Pentecostal	81	24.3	05	76		
Occupation						
Peasant farmer	131	39.2	08	123	$\chi^2 = 18.663$, df = 3	$p < 0.001$
Student	78	23.4	17	61		
civil servant	44	13.2	07	37		
Trader/self employed	81	24.3	03	78		
Marital status						
Single	100	29.9	18	82	$\chi^2 = 9.006$, df = 2	$p = 0.011$
Married	175	52.4	14	161		
Divorced	59	17.7	03	56		
Monthly income in UGX (USD)						
< 10,000 (2.6)	84	25.1	17	67	$\chi^2 = 15.245$, df = 6	$p = 0.018$
10,000 (2.6)- 100,000 (26.3)	139	41.6	07	132		
101,000 (26.6)- 200,000 (52.6)	60	18.0	05	55		
201,000 (52.9)- 300,000 (78.9)	18	5.4	03	15		
301,000 (79.2)- 400,000 (105.2)	15	4.5	01	14		
401,000 (105.5)- 500,000 (131.6)	14	4.2	01	13		
> 500,000 (131.6)	04	1.2	01	3		
Knowledge of medicinal plants						
No	35	10.5				
Yes	299	89.5				

Medicinal plants used for treating different diseases

A total of 49 medicinal plants (34 wild and 15 cultivated) in 30 families were used for medicinal purposes by the local communities of Lamogi sub-county (Figure 2, Table 2). The family Fabaceae (8 species) was most used followed by Asteraceae (5 species). *Gymnanthemum amygdalinum* (14.0 %) was the commonest species used for treating diseases followed by *Thunbergia alata* Bojer ex Sims (10.0%), *Vitex trifolia* L. (7.1%) and *Aloe vera* (L.) Burm.f. (6.2%).

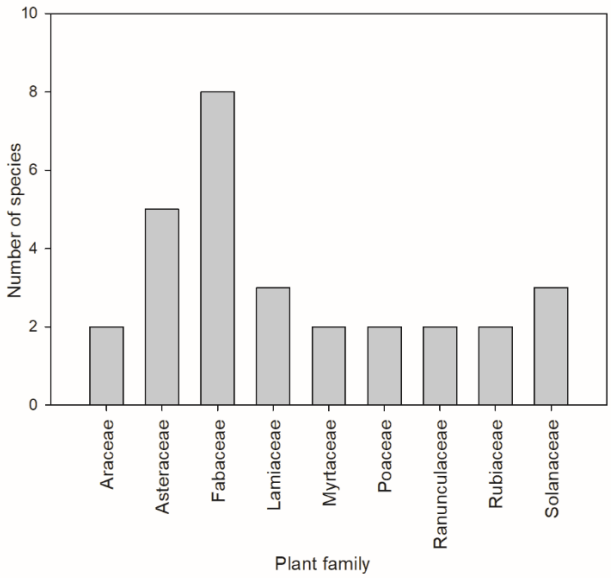


Figure 2. Common plant families recorded during the survey

Herbs (21 species) constituted the highest numbers of medicinal plants used, followed by trees (15 species), shrubs (8 species), bulbs (3 species) and grasses (2 species, Figure 3).

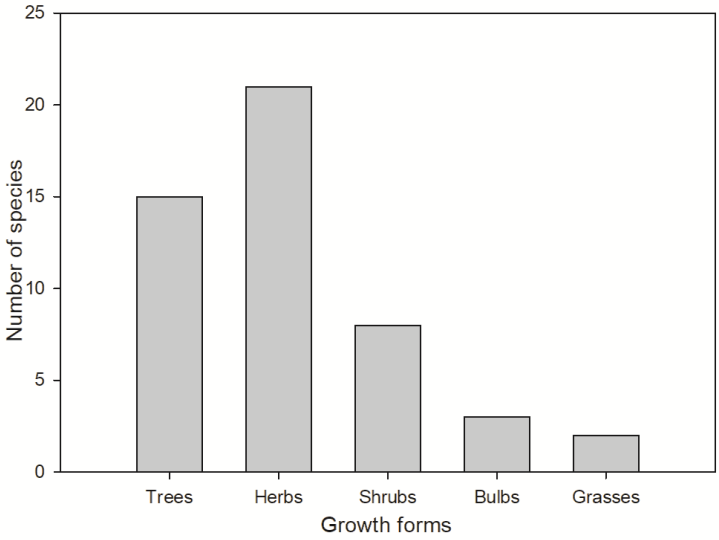


Figure 3. Growth forms of medicinal plants used for disease treament

Plant parts used, mode of preparation and administration of herbal remedies

Leaves were the most used plant parts (65.4%), followed by stems (5.3%), roots (13.6%) and leaves/ bark (4.9%). Other parts (leaves/fruits, roots/fruits, dry seeds/ bulbs, leaves/seeds) constituted (4.0%). Fresh plant parts were commonly harvested for preparation of herbal remedies (Figure 4).

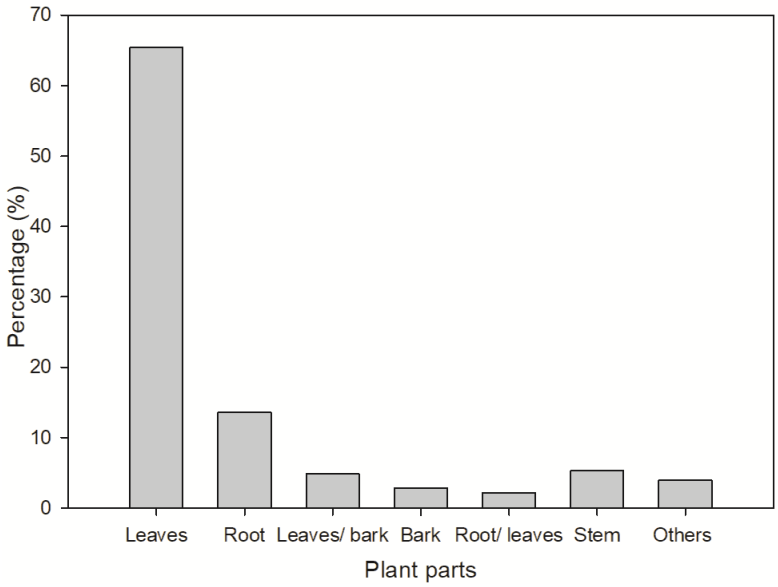
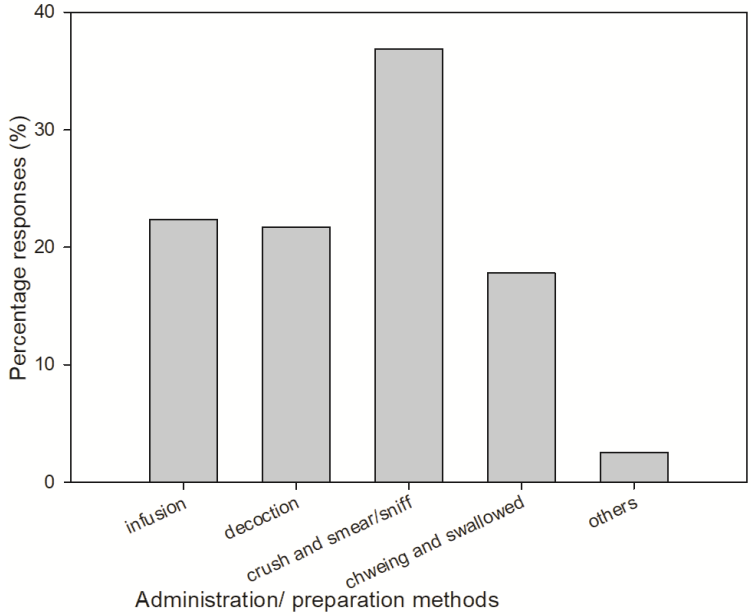


Figure 4. Different plant parts used for herbal remedies

The modes of preparation of herbal remedies included boiling in water, squeezing fresh leaves, crushing and pounding, and chewing. Cold or hot water was the main solvent for herbal preparations. The majority of the herbal medicines were prepared from single plant part (42 species, 91.3%). However, plant species like *Capsicum annuum* L., *Senna siamea* (Lam.) H.S.Irwin & Barneby, *Azadirachta indica* A. Juss., *Solanum incanum* L., *Caladium bicolor* (Aiton) Vent., and *P. americana* Mill. were prepared in mixtures. The most common method of preparation of herbal remedies was by crushing and smearing/sniffing (36.9%) followed by infusion (22.4%) and decoctions (21.7%). Other methods include peeling root epidermis and tying around the head, squeezing and sniffing the herbs and burning dry plant and inhaling the smoke (2.5%). In most cases, prepared remedies were administered orally (61.9%, Figure 5).



Gymnanthemum amygdalinum was the most preferred plants for treating malaria and fever (FI = 0.55, FLI = 0.16), followed by *T. alata* (for bone structure and sprain) (FI = 0.39, FLI = 0.11), *V. trifolia* (for cough) (FI = 0.28, FLI=0.08 and *A. vera* (for malaria, fever and Stomach ache) (FI = 0.25, FLI = 0.06, Table 2).

Table 2. Medicinal plant used in Lamogi sub-county in Amuru district, northern Uganda

Family	Scientific & local names in native Acholi dialect & Voucher Number)	Disease Treated	Plant part	Mode of preparation & administration	Habit	Conservation status	Frequency (%)	Familiarity index	Fidelity level
Acanthaceae	*Thunbergia alata* Bojer ex Sims Agwedeko pa oyo **BFG 031**	Bone fracture Sprain	Leaves	Pounded and smeared the paste on the fracture	Herb	W/A	9.95	0.392	0.111
Amaryllidaceae	*Allium vineale* L. Lenga **BFG 023**	Gastro-intestinal candida	Bulb	Sun dried, ground and smeared in body	Bulb	W/A	1.67	0.069	0.017
	Allium cepa L. Mutugulu **BFG 049**	Painful body swelling	Bulb	Crushed and smear on the swollen part	Bulb	Cu/R	0.23	0.009	0.002
Anacardiaceae	*Mangifera indica* L. Mayembe **BFG 004**	Fever, Diarrhoea	Leaves, Bark	Crushed, dissolved in water and drunk	Tree	Cu/A	4.79	0.189	0.050
Apiaceae	*Steganotaenia araliacea* Hochst. Olwiro **BFG 042**	Itchy throat, sore throat, painful throat	Root	Crushed, dissolved in water and drunk	Tree	W/R	0.08	0.003	0.001
Apocynaceae	*Mondia whitei* (Hook.f.) Skeels Lurono **BFG 026**	Lack of appetite low libido	Root	Chewed and swallowed	Herb	W/A	3.50	0.138	0.036

Araceae	*Colocasia esculenta* (L.) Schott Opello/yam **BFG 001**	Throat pain	Leaves	Chewed and swallowed	Bulb	Cu/R	0.46	0.018	0.005
	Caladium bicolor (Aiton) Vent. Ature opello **BFG 030**	Fever Throat sores	Root, Leaves	Sap squeezed and smeared	Herb	Cu/A	2.13	0.084	0.022
Asphodelaceae	*Aloe vera* (L.) Burm.f. Atakarac **BFG 008**	Malaria Fever Stomach ache	Leaves	Fresh leaves dipped in water, shaken and drunk	Herb	Cu/A	6.23	0.246	0.064
Asteraceae	*Gymnanthemum amygdalinum* (Delile) Sch.Bip. (Syn: *Vernonia amygdalina* Delile) Labwori **BFG 018**	Malaria Fever	Leaves	Boiled in water and drunk	Shrub	W/A	13.98	0.551	0.163
	Biden pilosa L. Labika **BFG 017**	Eye rush, Fresh wound	Leaves	Squeezed and dropped in eyes, crushed &smeared on wound	Herb	W/A	5.78	0.228	0.061
	Lactuca canadensis L. Taa lyec **BFG 033**	Bleeding during pregnancy	Root	Crushed and mixed with cold water and drunk	Herb	W/R	0.23	0.009	0.002
	Artemisia ludoviciana Nutt. Dingtong **BFG 037**	Sore throat	Leaves	Crushed, dissolved in cold water and drunk	Herb	W/R	0.08	0.003	0.001
	Lactuca tatarica (L.) C.A.Mey. Okangali **BFG 038**	Malaria	Root	Crushed, boiled and the extract drunk	Herb	W/R	0.46	0.018	0.005
Cleomaceae	*Cleome gynandra* L. Akeyo **BFG 013**	Vomiting, Cataract	Root	Crushed, dissolved in water and drunk	Herb	W/A	0.61	0.024	0.006
Commelinaceae	*Murdannia nudiflora* (L.) Brenan Lawume luuk **BFG 043**	Lack energy during pregnancy and labour	Root	Crushed and dissolved in water	Herb	W/R	0.08	0.003	0.001
Cucurbitaceae	*Momordica foetida* Schumach. Bomo **BFG 002**	Stomach ache	Root	Crushed and dissolved in water and drunk	Herb	W/A	1.14	0.045	0.012
Euphorbiaceae	*Acalypha villicaulis* Hochst. ex A.Rich. Ayilla **BFG 029**	Headache	Root	Root epidermis peeled and tied around the head	Herb	W/R	0.08	0.003	0.001
Fabaceae	*Albizia adianthifolia* (Schumach.) W.Wight Ayek yek **BFG 019**	Toothache	Root	Chewed and swallowed	Herb	W/R	0.53	0.021	0.005
	Piliostigma thonningii (Schumach.) Milne-Redh. Ogali	Cough	Leaves	Chewed and swallowed	Tree	W/A	0.46	0.018	0.005

	BFG 016								
	Crotalaria ochroleuca G.Don Lalar **BFG 014**	Malaria, Fever	Leaves	Crushed, dissolved in water and drunk	Herb	Cu/A	4.71	0.186	0.049
	Senna siamea (Lam.) H.S.Irwin & Barneby Cassia **BFG 009**	Malaria	Leaves & Bark	Crushed, boiled and drunk	Tree	Cu/A	0.08	0.003	0.001
	Indigofera arrecta Hochst. ex A.Rich. Laywee **BFG 007**	Sprain	Bark	Dried, crushed to make paste and smeared	Shrub	W/A	2.05	0.081	0.021
	Philenoptera laxiflora (Guill. & Perr.) Roberty (Syn: *Lonchocarpus laxiflorus* Gull. Perr.) Olwedo **BFG 011**	Toothache	Root	Dried, ground and smeared on the gum	Tree	W/A	4.10	0.162	0.043
	Cajanus cajan (L.) Huth Lapena **BFG 032**	Cough	Soft leaves	Boiled in warm water and drunk	Shrub	Cu/A	2.81	0.111	0.029
	Vachellia caven (Molina) Seigler &Ebinger Okutu oryang **BFG 035**	wounds, sores, haemorrhoid	Bark	Boiled in warm and smeared	Tree	W/A	0.08	0.003	0.001
Lamiaceae	*Clerodendrum trichotomum* Thunb. Woloo **BFG 040**	Syphilis	Root	Crushed, boiled and drunk	Shrub	W/A	0.08	0.003	0.001
	Vitex trifolia L. Ature cel **BFG 041**	Cough	Leaves	Chewed and swallowed	Shrub	Cu/A	7.14	0.281	0.077
	Ocimum x africanum Lour. Mida **BFG 045**	Flu Epilesy	Leaves	Squeezed/ sniffed Burnt and inhaled as smoke	Herb	W/R	1.22	0.048	0.012
Lauraceae	*Persea americana* Mill. Ovacado **BFG 039**	Fever	Leaves Seeds	Boiled in water and drunk Dry seed crushed and drunk as tea	Tree	Cu/A	0.23	0.009	0.002
Meliaceae	*Azadirachta indica* A. Juss. Neem **BFG 028**	Malaria Fever Stomach ache	Leaves	Boiled in warm water and drunk	Tree	Cu/A	0.91	0.036	0.009
Malvaceae	*Grewia mollis* Juss. Pobo **BFG 021**	Sprain	Bark	Crushed, added little water and smeared by massaging	Tree	W/A	0.68	0.027	0.007
Moraceae	*Ficus sycomorus* L. Olam **BFG 047**	Ring worm	Stem	Sap smeared on the body	Tree	W/ A	0.61	0.024	0.006

Musaceae	*Musa x paradisiaca* L. Labolo **BFG 027**	Fresh injury /cut	Sap from leaves	Fresh leaf stalk cut, sap extracted and smeared	Herb	Cu/A	1.60	0.063	0.016
Myrtaceae	*Eucalyptus globulus* Labill. Kalatuc **BFG 006**	Cough, Flu	Leaves	Boiled and drunk	Tree	Cu/A	0.53	0.021	0.005
	Psidium guajava L. Mapeera **BFG 025**	Stomach ache	Leaves	Boiled and drunk	Tree	Cu/A	0.38	0.015	0.004
Olacaceae	*Ximenia americana* L. Kwii/olelemo **BFG 010**	Snake bite	Dry seeds	Ground into paste and smeared on the wound	Herb	W/A	0.38	0.015	0.004
Phyllanthaceae	*Hymenocardia acida* Tul. Okango **BFG 005**	Cough	Leaves	Chewed and swallowed	Tree	W/A	0.99	0.039	0.010
Poaceae	*Alopecurus myosuroides* Huds. Aleno **BFG 034**	Fresh injury (cut)	Leaves	Crushed and smeared	Grass	W/A	1.06	0.042	0.011
	Imperata cylindrica (L.) Raeusch. Obiya **BFG 036**	Cough	Root	Crushed, boiled in warm water and drunk	Grass	W/A	1.29	0.051	0.013
Polygalaceae	*Securidaca longipedunculata* Fresen. Laliya **BFG 012**	Flu, Cough	Root	Dried, ground into powder and sniffed	Tree	W/A	0.23	0.009	0.002
Ranunculaceae	*Clematis vitalba* L. Omwom byer **BFG 046**	Sore throat	Stem	Chewed and swallowed	Herb	W/ R	4.71	0.186	0.049
Rubiaceae	*Mitracarpus hirtus* (L.) DC. Yat dog yoo **BFG 044**	Ring worms Fungal infection	Leaves	Crushed and sap smeared on affected part	Herb	W/R	6.31	0.248	0.067
	Nauclea latifolia Sm. (Syn: *Sarcocephalus latifolius* (Sm.) E.A Bruce) Oculup **BFG 048**	Ulcer Rectal prolase	Root	Crushed, mixed in warm water and drunk	Tree	W/A	0.15	0.006	0.002
Solanaceae	*Capsicum annuum* L. Kalara **BFG 024**	Malaria, Ulcer	Leaves, Fruits	Crushed, dissolved in water and drunk, whole dry fruit swallowed	Shrub	Cu/A	0.23	0.009	0.002
	Solanum nigrum L. Ocuga **BFG 003**	Cataract, Itching throat	Leaves	Chewed and swallowed, boiled with salt and drunk	Herb	W/R	0.84	0.033	0.008
	Solanum incanum L. Ocok **BFG 015**	Diarrhoea Painful swelling	Root, Fruits	Crushed, dissolved in water; cut fruit open and smear on wound	Shrub	W/A	1.22	0.048	0.012

Verbenaceae	*Lantana camara* L. Bel winyo **BFG 022**	Cough	Leaves	Crushed and dissolved in water and drunk	Shrub	W/A	1.98	0.078	0.020
Vitaceae	*Ampelocissus africana* (Lour.) Merr. Olok **BFG 020**	Joint pain	Root	Crushed and dissolve in water and drunk	Herb	W/A	0.99	0.039	0.010

Conservation status: W/A: wild and abundant, W/R: wild and rare, Cu/A: cultivated and abundant, Cu/R: cultivated and rare.

Informant consensus factor about the medicinal plants

All the different disease categories had ICF (0.97), indicating very high level of consensus among the respondents on medicinal plants used for treating these disease categories (Table 3). The participants had high agreement for treating digestive disorders, respiratory diseases, infectious and parasitic diseases, eye illness and musculo-skeletal diseases. The diseases were categorized following International Classification of Primary Care guidelines of 2015 (https://www.globalfamilydoctor.com/).

Table 3. Ailment categories treated by different medicinal plants

Ailment category	**Ailments**	**Number of use reports (*Nur*)**	***Number of species used (*N taxa*)**	**ICF**
Digestive disorders	Stomachache, vomiting, ulcer, throat pain, itching throat, sore throat, diahorrea, toothache, gastro-intestinal candida, throat rushes, throat pain, rectal prolapse	383	16	0.96
Respiratory diseases	Cough, flu	361	9	0.98
Infectious & parasitic diseases	Malaria, fever, syphilis, epilepsy,	812	13	0.99
Eye illness	Cataract, eye rashes	105	3	0.98
Musculo-skeletal diseases	Sprain, joint pain, painful swelling, fracture	330	6	0.99
Reproductive disorders	Low libido, blood loss during pregnancy, lack of energy during labour	50	3	0.96
Skin infection	Ringworm, fungal infection	174	2	0.99
Other ailments	Snake bite, fresh wound, sores, haemorrhoids, lack of appetite, headache	65	6	0.92

*A species may be listed in more than one category

Discussion

The local communities interviewed in this study had rich knowledge about medicinal plants used for treating various ailments. Unfortunately, knowledge of indigenous medicinal use is usually transmitted orally by herbalists, elders and relatives to children (Chekole 2017, Malinga *et al.* 2020, Akwongo *et al.* 2022), putting it at risk of being lost unless documented. Documenting the knowledge in Uganda is very crucial given that most elders live in chronic poverty especially those in rural areas (Atamanov *et al.* 2022), thus at risk of dying. In addition, the social assistance grant of UGX 25,000 (about 6.7 USD) given by the government to elderly persons is little and often inaccessible (Nzabona & Ntoli 2015, Wandera *et al.* 2017). Contrary to the conventional wisdom that traditional healing was reserved for the illiterates, the current study found that people with formal education were regular users of medicinal plants in Amuru district (68.6% were literates). This finding is consistent with findings of previous studies conducted in Katikekile Subcounty, Moroto District, Uganda (Logiel *et al.* 2021) and Borabu sub-county, Nyamira county, Kenya, where nearly all the educated people

either use or practice traditional medicines (Omwenga *et al.* 2015). In contrast, however, Chekole (2017) noted that among the Ethiopia's educated population, knowledge of medicinal plants was rapidly disappearing. Basic education may be necessary for traditional healers to better understand medical problems, including disease diagnosis, conservation issues of threatened and endangered species, and the need to manage and conserve natural resources. Nevertheless, overall, the use of traditional medicines is still a common practice among the illiterates and rural population in Africa (Asiimwe *et al.* 2013, d'Avigdor *et al.* 2014, Malinga *et al.* 2020, Ikinyom *et al.* 2023), driven by poverty and poorly-equipped health infrastructures.

The use of medicinal plants was more predominant amongst women than men possibly, because women are always more concern about the health conditions of their children and/ or family members and always search for herbal remedies to treat illnesses. This is in agreement with previous studies conducted in Dar es Salaam and Morogoro Regions, Tanzania (Mogha 2024) and Dakshina Kannada district, Karnataka, India (Anadka & Gulimane 2024). The majority of respondents with substantial knowledge of ethnomedicine were over 36 years of age, which indicates that the knowledge and experience in rendering traditional healing develops over time as people becomes older (Tugume *et al.* 2019, Kutal *et al.* 2021). In addition, marital status, occupation and monthly incomes of the participants determined the practice of traditional medicine in Amuru district, in agreement with the previous findings in Jimma Town, Southwest Ethiopia (Chali *et al.* 2021 and references therein). However, religion was not a factor influencing the use of traditional medicines in the study area. Similarly, Akwongo *et al.* (2022) observed no influence of religion including other factors like gender, age, education level, occupation and marital status on the use of herbal medicines in the neighbouring Pader district, in northern Uganda. Predominant use of medicinal plants among people with low incomes could be attributed to poverty, as people cannot afford to buy modern drugs. Hailu *et al.* (2020) attributed frequent use of herbal medicines by the local communities in Tole District, Oromia, Ethiopia to poverty. Despite the wide use of medicinal plants globally, surprisingly there are anecdotal reports that some Christians still consider the practice as evil. However, the fact that from biblical point of view, balm and fig trees were used to treat wounds and sores among the Jews (Jeremiah 8: 22, II Kings 20:7), underscore the need to recognize traditional medicines as divine gift to improve human health.

Plant species belonging to the family Fabaceae were most commonly used as medicines, followed by Asteraceae which was also reported among other local communities in Uganda (Akwongo *et al.* 2022) and elsewhere in other parts of the world such as in Dakshina kannada district, Karnataka, India (Anadka & Gulimane 2024). *Gymnanthemum amygdalinum* in the family Asteraceae have been shown to have high healing potential for various conditions including diarrhea, diabetes, wound healing, tonsillitis, inflammation, retained placenta, headache, eye disease, intestinal parasite, bloating, hepatitis, toothache, anthrax, malaria, urine retention, gastritis, stomach disorders, and snake bites and cancer (Akah 2024, Atolani *et al.* 2024, Degu *et al.* 2024). In addition, the leafy parts contribute to improved human nutrition and food security due to high amount of nutrients (Degu *et al.* 2024). The predominant use of plant species in the families Asteraceae and Fabaceae might be due to the fact that the plants contain phenols, flavonoids and saponins that cure diabetes, oxidative stress and gastrointestinal disorders, bacterial and fungal infections (Murugesan *et al.* 2019). In contrast, Kutal *et al.* (2021) reported little use of plant species in the family Fabaceae in Nepal, due to the limited access plants in hilly and mountainous areas. *Gymnanthemum amygdalinum* had the highest familiarity and fidelity level (FI = 0.55, FLI = 0.16). The high ICF value (0.97), fidelity level and familiarity indices obtained for most plants indicate a consensus on the effectiveness of known plant species in managing diseases in Amuru district. The practice of treating diseases with medicinal plants is common among the rural communities that live in poverty and have ill-equipped health facilities. The extensive use of traditional medicine in rural parts of Uganda could be due to limited access to medical facilities and low motivation among the medical professionals to render their services to patients (Gumisirisa *et al.* 2021, Anywar *et al.* 2020a). Also, it may due to the ease of accessing traditional medicines and the strong belief people attach to their healing properties. Currently, the country is short of trained health workers, with a doctor-patient and nurse-patient ratio of approximately 1:25000 and 1:11000, respectively (Ajari & Ojilong 2020), which is well below the World Health Organization guidelines for healthcare workers population ratio of 1:1000 (WHO 2006).

Leaves were widely used by the local communities than other plant parts and this could be attributed to the ease with which they can be harvested in large quantities within a short time to treat ailments. Furthermore, it could also be due to the high amounts of secondary metabolites in the leaves more than other plant parts (Ikinyom *et al.* 2023). These metabolites can be effective against various diseases or pathogens (Nagmoti *et al.* 2015, Murugesan *et al.* 2019). Leaf harvesting does not pose a threat to plant survival compared to other plant parts and should be encouraged among local communities as a practical measure to conserve valuable medicinal plants. Leaf shoots are also constantly produced making them abundant and accessible. Communities in Lamogi sub-county prepared herbal remedies mainly by infusion.

This is in line with documented literature of Mateus *et al.* (2023) who stated that infusion is the main method for preparation of herbal tea. Preparations by decoctions was the second common method of preparation. Oryema *et al.* (2021) and Ikinyom *et al.* (2023) also observed a similar practice in their studies in different local communities in the Acholi sub-region. Boiling is ideal for hard plant parts like the bark/roots to facilitate extraction of compounds that are deeply embedded within hard/tough plant tissues and its subsequent preservation for a relatively longer time (Tugume *et al.* 2016). Herbal remedies were mostly administered orally to the patients. Oral route drug administration is safe and convenient for increasing drug absorption across the small intestine (Murakami 2017) and patient compliance (Mundaca-Uribe *et al.* 2021).

Herbs and trees were the common medicinal plant life forms that were harvested for medicinal purposes. This agrees with the findings by Tolo *et al.* (2023) in the Rwenzori region of western Uganda where herbs followed by shrubs and trees were commonly used. The main use of herbs might be attributed to their availability all year round (Maud *et al.* 2019). Besides, herbs have been found to poses high amounts of phytophenols that are pharmacologically efficient against body disorders (Azeez *et al.* 2020). In addition, herbs can grow faster even in low rainfall conditions (Radhamoni *et al.* 2023) making them relatively abundant throughout the year.

Currently, most medicinal plants are still being used in secret with no legislation, although African traditional pharmacopoeia is strongly advocating for standardization and legislation on their use for the wellbeing of people, raising serious concern about poor quality control and safety (Ozioma & Chinwe 2019). This is no exception with plant species such as *G. amygdalinum*, *B. pilosa*, *A. conyzoides*, and *L. camara* that are widely used in Amuru district as well as other parts of Africa (Oguntibeju 2018). *Ageratum conyzoides* and *L. camara* are alien species (Chahal *et al.* 2021, Barahukwa *et al.* 2023) that should have clear specifications regarding their usage. Traditional medicines if regulated well, can help in treating malaria, allergy, hypertension, cancer, diabetes, inflammation, microbes and oxidant (Xuan & Khanh 2016). Specifically, *G. amygdalinum* is highly effective against malaria (Angupale *et al.* 2023) and African bovine trypansomiasis (Iwaka *et al.* 2022).

Most medicinal plants are still harvested from the wild, placing these plants at risk of depletion from unplanned human activities such as agricultural expansion, human settlement and deforestation (Nambejja *et al.* 2019). Conservation strategies such as agroforestry, rotational bush fallowing, crop rotation and bush fire control are necessary to preserve medicinal plants. Herbal remedies are currently widely used in most parts of Uganda for treatment of several diseases, including gynecological disorders, digestive disorders, skin infections, malaria, and respiratory tract infections (Anywar *et al.* 2016,Tumgume *et al.* 2016, Nakziba *et al.* 2021, Asiimwe *et al.* 2021, Walusansa *et al.* 2022, Gang *et al.* 2023, Tolo *et al.* 2023). Similarly, in Lamogi sub-county medicinal plants are being used for treating digestive disorders, malaria, musculo-skeletal infections and respiratory tract infections. Majority of the respondents had a high consensus for plants used in treating various diseases, demonstrating these plants have high healing potential. Therefore, further studies should investigate the bioactive compounds found in different medicinal plants reported in this study to inform future drug development.

Conclusion

The people of Amuru district have diverse knowledge of medicinal plants used for the treating various ailments. The communities have high consensus on plants used for treating various ailments. The dominant plant species used were *G. amygdalinum, T. alata, V. trifolia*, *M. hirtus*, *A. vera* and *B. pilosa*. Digestive disorders, infectious and parasitic diseases were the most common diseases treated using medicinal plants. The high informant consensus values and familiarity index values of the recorded medicinal plants indicate the need to identify and isolate the bioactive compounds contained in them to validate their toxicity and therapeutic properties for the development of affordable modern medicines. The study recommends that the National Forestry Authority, Uganda should regulate the utilisation of medicinal plants in Amuru district in Northern Uganda due to the use of unsustainable harvesting techniques such as uprooting whole plants or cutting roots, which threatens plant survival. The traditional methods of preparation, formulation and administration of herbal medicines lack safety and quality control; therefore, the Uganda National Drug Authority should ensure quality assurance during utilisation of medicinal plants.

Declarations

List abbreviations: Not applicable

Ethics and approval of the study: Ethical approval for this study was obtained from Gulu University Research Ethic Committee (GUREC-055-20). The local council chairpersons of different villages granted permission to conduct the study. We obtained informed consent for adults and assent for person below 18 years of age preceding the interviews.

Consent for publication: N/A.

Conflict of interests: The authors declare no conflict of interests.

Availability of data: N/A.

Funding: There was no funding for this research.

Authors' contributions: GBF and RO conceived and designed the study. GBF collected data and performed partial analysis of data. RO completed data analysis and wrote the first draft of the manuscript. RO, BA, BO, JBO, RO, MA, GA and GMM critically reviewed the manuscript. All authors read and approved the final manuscript.

Acknowledgements

We greatly appreciate the local authorities and people of Lamogi sub-county generally for allowing us to collect data. We also thank the herbal traditional healers and local people for willfully sharing their valuable information. Our special thanks also go to the staff of Makerere university herbarium for helping with identification of the plant species.

Literature cited

Ajari EE, Ojilong D. 2020. Assessment of the preparedness of the Ugandan health care system to tackle more COVID-19 cases. Journal of Global Health 10: 020305

Akah PA. 2024. *Vernonia amygdalina* Delile. (Bitter leaf) a traditional anti-diabetic gold mine-Mini Review. Journal of Ayurveda and Integrated Medical Sciences 9 (1): 170-175.

Akwongo B, Katuura E, Nsubuga AM, Tugume P, Andama M, Anywar G, Namaganda M, Asimwe S, Kakudidi, EK. 2022. Ethnobotanical study of medicinal plants utilized in the management of candidiasis in Northern Uganda. Tropical Medicine and Health 50: 78.

Alzweiri M, Al Sarhan A, Mansi K, Hudaib M, Aburjai T. 2011. Ethnopharmacological survey of medicinal herbs in Jordan, the Northern Badia region. Journal of Ethnopharmacology 137: 27-35.

Anadka Y, Gulimane K. 2024. Ethnobotanical investigation on herbal remedies for musculoskeletal disorders in Dakshina Kannada district, Karnataka, India. Ethnobotany Research and Applications 29: 1-48.

Anywar G, Byamukama R, vant Klooster CIEA, Wilcox M, Nalumansi P, de Jong J, Rwaburindori P, Kiremire BT. 2016. Medicinal plants used in the treatment and prevention of malaria in Cegere sub-county, Northern Uganda. Journal of Ethnobotany and Applied Research 14:505-516.

Anywar G, Kakudidi E, Byamukama R, Mukonzo J, Schubert A, Oryem-Origa, H. 2020a. Indigenous traditional knowledge of medicinal plants used by herbalists in treating opportunistic infections among people living with HIV/AIDS in Uganda. Journal of Ethnopharmacology 246: 112205.

Anywar G, Kakudidi E, Byamukama R, Mukonzo J, Schubert A, Oryem-Origa H. 2020b. Medicinal plants used by traditional medicine practitioners to boost the immune system in people living with HIV/AIDS in Uganda. European Journal of Integrative Medicine 101011.

Asiimwe S, Namukobe J, Byamukama R, Imalingat, B. 2021. Ethnobotanical survey of medicinal plant species used by communities around Mabira and Mpanga Central Forest Reserves, Uganda. Tropical Medicine and Health 49: 52.

Atamanov A, Chris NM, Vincent FS. 2022. Quantifying vulnerability to poverty in Uganda. World Bank.

Atolani O, Usman MA, Adejumo JO, Ayeni AE, Ibukun OJ, Kola-Mustapha AT, Njinga NS, Quadri LA, Ajani EO, Amusa TO. Bakare-Odunola MT. 2024. Isolation, characterization and anti-inflammatory activity of compounds from the *Vernonia amygdalina*. Heliyon 10 (8).

Azeez AA, Akeredolu OA, Igata DF, Akomolede LA, Ojokunle AM, Ogundoyin AA. 2020. A review on the phytochemistry and medicinal values of ten common herbs used in Nigeria. Journal of Research in Forestry, Wildlife and Environment 12: 115-121.

Barahukwa A, Chapman CA, Namaganda M, Eilu G, Omeja PA, Lawes MJ. 2023. The effects of the invasive species, Lantana camara, on regeneration of an African rainforest. African Journal of Ecology 61 (2): 451-460.

Chahal R, Nanda A, Akkol EK, Sobarzo-Sánchez E, Arya A, Kaushik D, Dutt R, Bhardwaj R, Rahman, MH, Mittal V. 2021. *Ageratum conyzoides* L. and its secondary metabolites in the management of different fungal pathogens. Molecules 26 (10): 2933.

Chali BU, Hasho A, Koricha NB. 2021. Preference and practice of traditional medicine and associated factors in Jimma Town, Southwest Ethiopia. Evidence-Based Complementary and Alternative Medicine 2021 (1): 9962892.

Charwi MZ, Mogha NG, Muluwa JK, Bostoen K. 2023. Indigenous knowledge and use of medicinal plants among the Kuria communities in the Tarime and Serengeti Districts of Mara Region, Tanzania. Journal of Herbs, Spices and Medicinal Plants 29 (06):1-20.

Chekole G. 2017. Ethnobotanical study of medicinal plants used against human ailments in Gubalafto District, Northern Ethiopia. Journal of Ethnobiology and Ethnomedicine 13: 1-29.

d'Avigdor E, Wohlmuth H, Asfaw Z, Awas T. 2014. The current status of knowledge of herbal medicine and medicinal plants in Fiche, Ethiopia. Journal of Ethnobiology and ethnomedicine 10: 1-33.

Christopher RD. 2017. "Survival Mode": Rebel Resilience and the Lord's Resistance Army, Terrorism and Political Violence. Terrorism and Political Violence 31 (5): 1-21.

Degu S, Meresa A, Animaw Z, Jegnie M, Asfaw A, Tegegn G. 2024. *Vernonia amygdalina*: a comprehensive review of the nutritional makeup, traditional medicinal use, and pharmacology of isolated phytochemicals and compounds. Frontiers in Natural Products 3: 1347855.

Friedman J, Yaniv Z, Dafni A, Palewitch D. 1986. A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev Desert, Israel. Journal of ethnopharmacology 16 (2-3), 275-287.

Gang R, Matsabisa M, Okello D, Kang Y. 2023. Ethnomedicine and ethnopharmacology of medicinal plants used in the treatment of diabetes mellitus in Uganda. Applied Biological Chemistry 66: 39.

Gumisiriza H, Sesaazi CD, Olet EA, Kembabazi O, Birungi G. 2021. Medicinal plants used to treat" African" diseases by the local communities of Bwambara sub-county in Rukungiri District, Western Uganda. Journal of ethnopharmacology 268: 113578.

Güneş S, Savran A, Paksoy, MY, Çakılcıoğlu U. 2018. Survey of wild food plants for human consumption in Karaisalı (Adana-Turkey). Indian Journal of Traditional Knowledge.17: 290-298.

Hailu F, Cherie A, Gebreyohannis T, Hailu R. 2020. Determinants of traditional medicine utilization for children: a parental level study in Tole District, Oromia, Ethiopia. BMC complementary medicine and therapies 20: 1-11.

Ikinyom N, Lamwaka AV, Malagala AT, Ndyomugyenyi EK. 2023. Ethnobotanical study of nutraceutical plants used to manage opportunistic infections associated with HIV/AIDS in Acholi sub-region, Northern Uganda. Tropical Medicine and Health 51: 50.

Iwaka C, Azando EVB, Hountondji FCC, Worogo HSS, Attakpa EY, Olounlade PA, Hounzangbe-Adote, MS. 2022. Medicinal plants of the African traditional pharmacopoeia in the management of bovine trypanosomosis: A review. Journal of Medicinal Plants Research 16 (6): 214-229.

Jäger S, Beffert M, Hoppe K, Nadberezny D, Frank B, Scheffler A. 2011. Preparation of herbal tea as infusion or by maceration at room temperature using mistletoe tea as an example. Scientia pharmaceutica 79: 145-156.

Kidane L, Gebremedhin G, Beyene T. 2018. Ethnobotanical study of medicinal plants in ganta afeshum district, eastern zone of Tigray, northern Ethiopia. Journal of ethnobiology and ethnomedicine 14: 1-19.

Kutal DH, Kunwar RM, Uprety Y, Adhikari YP, Bhattarai S, Adhikari B, Kunwar LM, Bhatt MD, Bussmann RW. 2021. Selection of medicinal plants for traditional medicines in Nepal. Journal of Ethnobiology and Ethnomedicine 17: 1-11.

Langlands BW. 1974. Atlas of Population Census 1969 for Uganda (No. 48). Department of Geography, Makerere University.

Malinga GM, Baana K, Rutaro K, Atube F, Opoke R, Opika-Opoka H, Oryema C. 2020. An ethnobotanical study of plants used for the treatment of malaria in Budondo sub-county, Eastern Uganda. Ethnobotany Research and Applications 19: 1-15.

Maling S, Kabakyenga J, Muchunguzi C, Olet EA, Namaganda M, Kahwa I, Alele PE. 2024. Medicinal plants used by traditional medicine practitioners in treatment of alcohol-related disorders in Bushenyi District, southwestern Uganda. Frontiers in Pharmacology 15: 1407104.

Mander M, Ntuli L, Diederichs N, Mavundla K. 2007. Economics of the traditional medicine trade in South Africa care delivery. South African health review 2007: 189-196.

Martin G. J. 2015. Ethnobotany: a methods manual. Chapman & Hall, London, U.K.

Mateus ARS, Crisafulli C, Vilhena M, Barros SC, Pena A, Sanches Silva A. 2023. The Bright and Dark Sides of Herbal Infusions: Assessment of Antioxidant Capacity and Determination of Tropane Alkaloids. Toxins 15 (4): 245.

Maud KM, Cissy N, Patience T, Clement N. 2019. Medicinal plant species used in the treatment of skin diseases in Katabi Sub-County, Wakiso District, Uganda.

Mogha NG. 2024. Ethnobotanical study of medicinal plants used in management of COVID-19 in Dar es Salaam and Morogoro Regions, Tanzania. Ethnobotany Research and Applications 29: 1-16.

Mundaca-Uribe R, Karshalev E, Esteban-Fernández de Ávila B, Wei X, Nguyen B, Litvan I, Fang RH, Zhang L, Wang J. 2021. A Microstirring Pill Enhances Bioavailability of Orally Administered Drugs. Advanced Science 8: 2100389.

Murakami T. 2017. Absorption sites of orally administered drugs in the small intestine. Expert opinion on drug discovery 12: 1219-1232.

Murugesan S, Lakshmanan DK, Arumugam V, Alexander RA. 2019. Nutritional and therapeutic benefits of medicinal plant *Pithecellobium dulce* (Fabaceae): A review. Journal of Applied Pharmaceutical Science 9: 130-139.

Musoke P, Okot J, Nanfuka V, Rwamafa P, Masajjage J, Kisuule I, Nantaayi B, Ssewante N, Bongomin F. 2021. A preliminary report on herbal medicine use among patients hospitalized at two-large COVID-19 treatment centers in Uganda. Risk Management and Healthcare Policy, 4609-4617.

Nagmoti DM, Kothavade PS, Bulani VD, Gawali NB, Juvekar AR. 2015. Antidiabetic and antihyperlipidemic activity of *Pithecellobium dulce* (Roxb.) Benth seeds extract in streptozotocin-induced diabetic rats. European Journal of Integrative Medicine 7: 263-273.

Nakaziba R, Anyolitho MK, Amanya SB, Sesaazi CD, Byarugaba F, Ogwal-Okeng J, Alele PE. 2021. Traditional medicinal vegetables in northern Uganda: An ethnobotanical survey. International Journal of Food Science 2021: 5588196

Nyero A, Achaye I, Odongo W, Anywar G, Malinga GM. 2021. Wild and semi-wild edible plants used by the communities of Acholi sub-region, Northern Uganda. Ethnobotany Research and Applications 21:1-12.

Nzabona A, Ntozi J. 2015. The role of older persons in Uganda: Assessing socio-demographic determinants of older persons' value. Africa Development 40: 113-135.

Oguntibeju OO. 2018. Medicinal plants with anti-inflammatory activities from selected countries and regions of Africa. Journal of inflammation research 11: 307-317.

Ohemu TL, Okwori VA, Azila JJ, Nwobodo CA. 2024. Ethnobotanical Survey of Medicinal Plants Used to Treat Male Infertility in Jos North Local Government Area of Plateau State, Nigeria. Journal of Herbal Medicine 43, 100825.

Okot DF, Anywar G, Namukobe J, Byamukama R. 2020. Medicinal plants species used by herbalists in the treatment of snakebite envenomation in Uganda. Tropical Medicine and Health 48: 1-14.

Omwenga EO, Hensel A, Shitandi A, Goycoolea FM. 2015. Ethnobotanical survey of traditionally used medicinal plants for infections of skin, gastrointestinal tract, urinary tract and the oral cavity in Borabu sub-county, Nyamira county, Kenya. Journal of Ethnopharmacology 176: 508-514.

Oryema C, Rutaro K, Oyet SW, Malinga GM. 2021. Ethnobotanical plants used in the management of symptoms of tuberculosis in rural Uganda. Tropical Medicine and Health 49: 1-10.

Owor RO, Kawuma C, Nantale G, Kiyimba K, Obakiro SB, Ouma S, Lulenzi J, Gavamukulya Y, Chebijira M, Lukwago TW, Egor M. 2024. Ethnobotanical survey and phytochemistry of medicinal plants used in the management of HIV/AIDS in Eastern Uganda. Heliyon 10 (11): 1-21.

Ozioma EOJ, Chinwe OAN. 2019. Herbal medicines in African traditional medicine. Herbal medicine 10: 191-214.

Philip K, Elizabeth MM, Cheplogoi PK, Samuel KT. 2017. Ethnobotanical survey of antimalarial medicinal plants used in Butebo County, Eastern Uganda. European Journal of Medicinal Plants. 21(4):1-22.

Radhamoni HVN, Queenborough SA, Arietta AA, Suresh HS, Dattaraja H.S, Kumar SS, Sukumar R, Comita LS. 2023. Local-and landscape-scale drivers of terrestrial herbaceous plant diversity along a tropical rainfall gradient in Western Ghats, India. Journal of Ecology 111 (5):1021-1036.

Ştef DS, Gergen I, Traşcă TI, Monica Hărmănescu ŞL, Ramona B, Hegheduş MG. 2009. Total antioxidant and radical scavenging capacities for different medicinal herbs. Romanian Biotechnological Letters 14: 4705-4710.

Tabuti JR, Obakiro SB, Nabatanzi A, Anywar G, Nambejja C, Mutyaba MR, Omara T, Waako P. 2023. Medicinal plants used for treatment of malaria by indigenous communities of Tororo District, Eastern Uganda. Tropical medicine and health 51: 34.

Tolo CU, Kahwa I, Nuwagira U, Weisheit A, Ikiriza H. 2023. Medicinal plants used in treatment of various diseases in the Rwenzori Region, Western Uganda. Ethnobotany Research and Applications 25: 1-16.

Trotter RT, Logan MH. 1986. Informant consensus: a new approach for identifying potentially effective medicinal plants. In Plants and Indigenous Medicine and Diet (pp. 91-112). Routledge.

Tugume P, Kakudidi EK, Buyinza M, Namaalwa J, Kamatenesi M, Mucunguzi P, Kalema J. 2016. Ethnobotanical survey of medicinal plant species used by communities around Mabira Central Forest Reserve, Uganda. Journal of ethnobiology and ethnomedicine 12: 1-28.

Uganda Bureau of Statistics. 2022. Multi-dimensional Poverty Index for Uganda. Kampala: UBOS.

Uganda Bureau of Statistics. 2018. Statistical abstract, Kampala Uganda.

Uganda Bureau of Statistics. 2017. The National Population and Housing Census 2014 – Area Specific Profile Series, Kampala, Uganda.

Uganda-Gazette. 2015. Indigineous and Complementary Medicine Bill, 2015, VIII: Bill No 2.

Van Acker F. 2004. Uganda and the Lord's Resistance Army: The new order no one ordered. African Affairs 103: 335-357.

Walusansa A, Asiimwe S, Ssenku JE, Anywar G, Namara M, Nakavuma JL, Kakudidi EK. 2022. Herbal medicine used for the treatment of diarrhea and cough in Kampala city, Uganda. Tropical Medicine and Health 50: 1-21.

Wandera, SO, Ddumba I, Akinyemi JO, Adedini SA, Odimegwu C. 2017. Living alone among older persons in Uganda: Prevalence and associated factors. Ageing international 42: 429-446.

World Health Organization 2006. The world health report: working together for health. World Health Organization. https://iris.who.int/handle/10665/43432.

World Health Organization. 2013. WHO traditional medicine strategy: 2014-2023. World Health Organization.

Xuan TD, Khanh TD. 2016. Chemistry and pharmacology of *Bidens pilosa*: an overview. Journal of Pharmaceutical Investigation 46: 91-132.