Traditional medicinal plants used for gastrointestinal disorders by the Nyamwezi traditional health practitioners of Tabora region, Tanzania

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Research

Abstract

Background: Gastrointestinal disorders (GIDs) have a considerable effect on global morbidity and mortality. Nyamwezi people in Tanzania still use traditional medicinal plants (TMPs) as their first-aid medications against GIDs. The purpose of this study was to record the TMPs that Tanzania's Nyamwezi traditional health practitioners (THPs) employ to manage GIDs.

Methods: Ethnomedicinal data on TMPs were gathered from 108 THPs. Quantitative approaches were used to evaluate Family Use Value (FUV), Species Use Value (UV), Plant Part Value (PPV), Informant Consensus Factor (ICF) and Fidelity Level (FL).

Results: The study revealed that 64 TMPs belonging to 33 families were used to treat GIDs. The most prevalent family was Fabaceae (11 species). Root (PPV = 0.464) and decoction (51%) were the preferred plant part and preparation method, respectively. About 96.9% of the remedies were orally administered. The highest ICF value of 0.97 was recorded for constipation, diarrhoea and gastritis/worm infections, indicating excellent agreement among the THPs. The highest FL of 100% was recorded for *Euphorbia candelabrum*, *Sorghum bicolor* and *Cassia abbreviata*, indicating conformity of knowledge on the species with the best curative potential.

Conclusions: The study reveals that locals in the Tabora region use a wide diversity of TMPs to treat GDIs. The relatively high ICF advocates a substantial consensus among THPs on using the recorded TMPs. Though the ethnomedicinal data presented in this study serve as the baseline for further research for developing new drugs against GIDs, further research on the phytochemistry, safety, efficacy, and mechanisms of action of the recorded TMPs is recommended.

Keywords: Ethnobotanical, ethnomedicine, herbal medicine, indigenous, pharmacology, quantitative study

Background

Globally, traditional medicinal plants (TMPs) are indispensable sources of traditional medications against various ailments (Lawal *et al.* 2020, Maroyi 2013, 2023). Despite the development in modern health care, the use of TMPs is still a valuable resource, especially in remote areas of low- and middle-income countries, where access to modern health facilities is not feasible due to various factors such as high costs of the services and drugs, absence of access or existence of inadequate contemporary medical health facilities; thus, necessitating the use of TMPs for primary health care as they are plenty and simply accessible (Da Costa Ferreira *et al.* 2021). Moreover, other factors that involve the use of TMPs are sociocultural appeal, cultural beliefs or acceptability of the THPs and local pharmacopoeias, and the search for drugs without any side effects as allopathic ones (Kacholi & Amir 2022a).

Ethnobotany and ethnopharmacology are often used to investigate the exploration of new medications, as they demand low investment in terms of time and finance. While ethnobotany deals with analysing and documenting the associations between people and plants, ethnopharmacology is concerned with the appraisal of traditional preparations used to manage ailments in quest of efficacy (Faruque *et al.* 2018, Kayser 2018). In contrast to contemporary medicinal knowledge, indigenous knowledge is orally transmitted from generation to generation. This practice can cause the loss of ethnobotanical and ethnopharmacological information that is valuable to inform modern medical science (Boudjelal *et al.* 2013). Moreover, the loss of indigenous knowledge could be associated with the development of contemporary medicine as part and parcel of the globalisation process. Increasing disinterest in traditional medicine is either caused by the younger generations declining to learn the practice or the elder ones not transmitting it (Aswani *et al.* 2018, Kankara *et al.* 2018).

Gastrointestinal disorders (GIDs) refer to ailments that affect the gastrointestinal tract, from the mouth to the anus. Worldwide, the GIDs are prevalent causing considerable distress, and can be fatal. GIDs account for substantial healthcare utilization and spending, and most of the time, they affect patients' quality of life and productivity (Peery *et al.*, 2021). The burden of GIDs in low- and middle-income countries has been increasing, causing stern economic impact and substantial social cost. For instance, in Africa, the prevalence of GIDs ranges between 19.26% and 92% (Asombang & Kelly 2012), while in Tanzania, it ranges from 65% to 84% (Mbulaiteye 2009, Ngogo *et al.* 2020). Despite the efforts done by the government to improve the health facilities in the country, particularly in the Tabora region, GIDs remain among the top ten ailments that affect a huge number of rural citizens. For instance, diarrhoea is ranked fourth in the region for causing morbidity. The absence of access to clean and safe drinking water and inadequate sanitation and hygiene in most rural areas in the region contribute significantly to GIDs (Paul & Azage 2019, Kacholi & Amir 2022b, Kacholi 2024).

In Tanzania, over 80% of rural residents depend on TMPs for their primary healthcare due to insufficient modern health facilities, low income to pay for current health services and distance setting of the health facilities from the locals'' homes (Kacholi & Amir 2022a). On the other hand, traditional knowledge practices face numerous threats due to modernisation and lifestyle changes in rural societies. It is, therefore, imperative to increase ethnomedicinal studies to preserve this precious knowledge. Thus, the present study aimed to document TMPs used by the Nyamwezi THPs in treating GIDs in the Tabora region. The study commenced with the following questions. What is the number of TMPs known locally for treating GIDs? Which botanical family is dominant in treating GIDs? What is the source of TMPs? and What is the dominant life form? Which part of TMPs are mostly used, and how are they prepared for medicinal application? Which TMPs categories have the highest agreement for local use? Moreover, the study offers clues to conserve the ethnomedicinal knowledge for future phytochemical and pharmacological investigations and the development of new drugs.

Materials and Methods

Study area and climate

This study was conducted in the Tabora region, which is situated in the mid-western Tanzania. The region covers an area of about 76,150 km^2, which is approximately 8% of Tanzania's area. The Shinyanga region borders the region to the north, the Singida region to the east, Mbeya and Rukwa region to the South, and the Kigoma region to the west. The region has six administrative districts: Igunga, Kailua, Nzega, Sikonge, Urambo, Uyui district, and Tabora municipality. The ethnomedicinal survey was carried out in the Sikonge district (latitudes 05°15′ to 06° 45′S and Longitude 32° 15′ to 33° 45′E) and Urambo district (latitude 04° 41' to 05° 44′ S and longitudes 31°51′to 32°26 E) in the region (Figure 1), lying 1000 and 1800 meters above the mean sea level. The two districts cover approximately 43.7% of the area and 20% of the region's population, with an average annual population growth rate of 2.9%. The region's climate is bimodal; the rainy season lasts from November to April, and the dry season lasts from May to October. The mean annual rainfall of the area is 1370 mm, while the minimum and maximum temperatures are 17 ℃ and 29 ℃, respectively. The principal residents of the region are the Nyamwezi tribe, who depend exclusively on agriculture and livestock keeping for their livelihood.

Research clearance and ethical approval statement

Research certification and ethical approval to undertake this study was obtained from the office of the Vice Chancellor of the University of Dar es Salaam through a letter with Ref. No. AB3/12(B).

Ethnobotanical data collection

The ethnomedicinal data collection was conducted between February 2020 and March 2021 in Sikonge and Urambo Districts, Tabora region. A total of 108 traditional health practitioners (THPs) were involved in the study, 53 from Sikonge and 55 from Urambo district (Table 1). A snowballing technique was used to get the THPs in the region. Before the interview, the objective and importance of the study were communicated to all THPs and their consent to participate was requested. Only those who agreed to take part were interviewed. During the survey, information related to THPs profile (gender, age, education level, experience and residence) and TMPs (plant name, cured ailment, part used, preparation and administration methods) were collected through a semi-structured interview, focus group discussions, and field walk. All dialogues were done in the Swahili language. Identification of TMPs was done by experienced botanist, except for taxonomically challenging plants, which had to be collected and pressed for further identification in the College Herbarium. All scientific names were proven using the Plants of World Online database (https://powo.science.kew.org/).

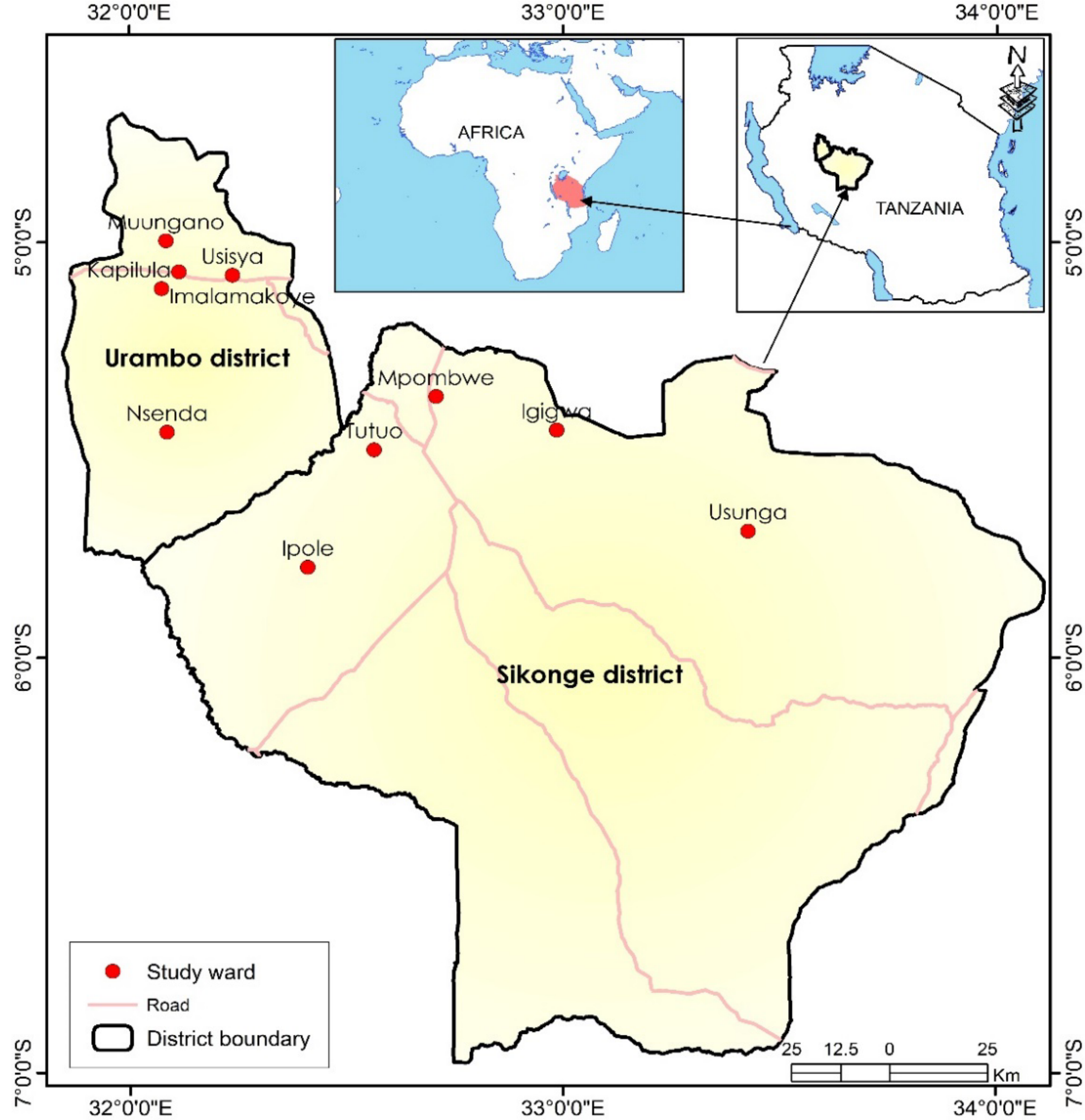

Figure 1. Map of Urambo and Sikonge districts and their settings in Tanzania

Informant sample size determination
The sample size of THPs was determined as per Cochran's formula (Bartlett et al. 2001), as indicated below.

$$n = \frac{N}{1 + N\,(e^2)}$$

Whereby n is the THPs sample size, N is the total number of THPs in the two districts, and e is the maximum margin of error (i.e., 5%). Hence, the required THPs size was 100.

$$n = \frac{148}{1 + 148\,(0.05^2)} = 108$$

Quantitative data analysis

Family use value (FUV)

The Family Use Value (FUV) index was used to identify the significance of MP families. It is an index of cultural importance used in ethnobotany to calculate the value of biological plant taxon (Afzal *et al.* 2021, Kacholi 2024). The index was calculated as per the formula given below;

$$FUV = \frac{UV_s}{N_s}$$

Where UV_s is the number of informants reporting the family, and N_s is the total number of MPs within each family.

Use value (UV)

The use value (UV) is a quantitative index demonstrating the relative importance of a given species known locally (Zenderland *et al.* 2019). The index was calculated as per the formula below;

$$UV = \frac{\sum UR}{N}$$

Where UR is the number of use reports cited by each informant for a given species, and N refers to the total number of informants interviewed for a given MP.

Plant part value (PPV)

To confirm the most utilized plant parts as medicinal bioresources in treating GIDs, the Plant Part Value (PPV) was used (Chaachouay et al. 2019, Kacholi 2024). The PPV was computed using the equation below.

$$PPV = \frac{RU_{plant\ part}}{RU}$$

Where RU is the sum of uses mentioned per part of a plant, and RU is the number of use reports of all plants. The TMP part with the highest index value is the most utilised by the locals.

Fidelity level (FL)

The fidelity level (FL) is the valuable index for recognising the most favoured TMPs used to manage a particular ailment by respondents (Gebreyes & Melesse 2016, Abebe & Chane Teferi 2021). High FL values refer to highly preferred TMPs, while low values reflect less preferred TMPs. The values are calculated in terms of the informant's percentage claiming the use of a definite plant species for the same ailment. FL values were computed using the formula below;

$$FL = \frac{I_p}{I_u}\ x\ 100$$

Where I_p is the number of use reports cited the importance of a given TMP for a particular use category, and I_u is the total number of use reports cited for a given TMP species.

Informant consensus factor ratio (ICF)

The Informant consensus factor (ICF) is the most preferred quantitative method for identifying the potentially effective TMPs in a specific ailment category for pharmacological and phytochemical studies (Faruque *et al.* 2018, Abebe & Chane Teferi 2021, Oryema *et al.* 2021). Before computing the ICF, all eleven ailments' categories were formed. The ICF values range between 0.00 - 1.00. A high ICF value for a plant implies the plant is more pharmacologically active than a low ICF value. The ICF was computed as per the formula shown below;

$$ICF = \frac{N_{ur} - N_t}{N_{ur} - 1}$$

Whereby N_{ur} is the number of use reports in each ailment category, and N_t is the total number of taxa used in each ailment category.

Results

Demographic profile of traditional health practitioners (THPs)

The overall demographic data revealed the domination of male THPs (85.2%) followed by female (14.8%). Most interviewed THPs (41.7%) were in the age range between 21 to 40 years old, followed by 40 to 60 years (37.0%) (Table 1). The majority of the THPs were primary education holders (75%), followed by illiterate (16.7%), and most THPs had 5 to 10 years of experience in traditional medicine, followed by those with > 15 years (27.8%) of experience (Table 1).

Table 1. Demographic profile of THPs in the study areas

Variable	Category	Number of THPs		
		Sikonge	Urambo	Overall
Gender	Male	47 (86.7)	45 (81.8)	92 (85.2)
	Female	6 (13.3)	10 (88.2)	16 (14.8)
Age groups (Y)	< 20	4 (7.6)	3 (5.5)	7 (6.5)
	21-40	19 (35.8)	26 (47.3)	45 (41.7)
	41-60	21 (39.6)	19 (34.5)	40 (37.0)
	> 60	9 (17.0)	7 (12.7)	16 (14.8)
Educational level	Illiterate	11 (20.8)	7 (12.7)	18 (16.7)
	Primary	37 (69.8)	44 (80)	81 (75.0)
	Secondary	5 (9.4)	3 (5.5)	8 (7.4)
	Tertiary	0 (0.0)	1 (1.8)	1 (0.9)
Experience (Y)	< 5	12 (22.6)	10 (18.2)	22 (20.4)
	5-10	13 (24.5)	22 (40.0)	35 (32.4)
	11-15	10 (18.9)	11 (20.0)	21 (19.4)
	> 15	18 (34.0)	12 (21.8)	30 (27.8)

Life forms and sources of medicinal plants

Among the recorded TMPs, tree (46.9%) was the dominant life form, followed by herb (29.7%) and shrub (23.4%). Most TMPs were collected exclusively from the wild (57.8) and cultivation (35.9%) areas, while 6.3% were from wild and cultivation environments (Figure 2).

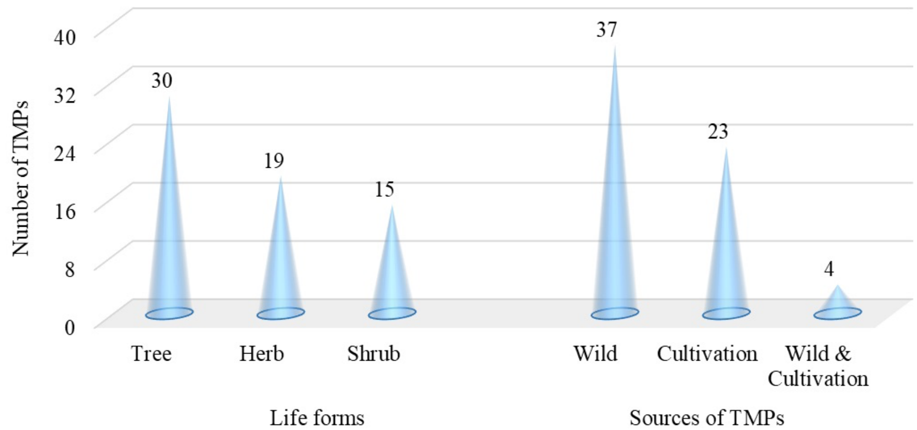

Figure 2. Life forms and sources of traditional medicinal plants in the study area

Table 2. Medicinal plants used by Nyamwezi THPs to treat digestive system disorders in the Tabora region

Family/ Taxonomic name/Voucher	Local name	Habit	Part used	Ailment cured	MoP and RoA	UR	UV	FUV
Alliaceae								1.016
Allium cepa L.	Kitunguu maji	H	Bu	Diarrhoea, Dysentery, Vomiting	Cooked with food and consumed orally or taken raw	37	0.34	
Allium sativum L.	Kitunguu swaumu	H	Bu	Haemorrhoid	Juice the bulb, mix with honey or sugar and ingest a half teaspoon a day	61	0.56	
Anacardiaceae								0.625
Lannea schimperi (Hochst. ex A Rich.) Engl.	Mugumbu	T	B	Stomachache	Chew and swallow the fluids	7	0.06	
Lannea stuhlmanii Dunkley (TBR024)	Mutinje	S	R	Diarrhoea	Decoction drunk	14	0.13	
Ozoroa insignis Del.	Mkalakala	S	R, L	Diarrhoea, haemorrhoid	Decoction drunk	33	0.31	
Sclerocarya birrea (A. Rich.) Hochst.	Mng'ongo	T	B	Constipation	Infusion drunk	28	0.26	
Annonaceae								1.031
Friesodielsia obovata (Benth.) Verdc.	Msalasi	S	R	Constipation	Decoction drunk	55	0.51	
Hexalobus monopetalus (A. Rich.) Engl. & Diels	Mkuwa	T	L	Gastric ulcer, constipation	Decoction drunk	9	0.08	
Xylopia antunensii L. (TBR023)	Msenene	T	L	Gastric ulcer, diarrhoea	Decoction drunk	10	0.09	
Apocynaceae								0.313
Strophanthus eminii Asch. ex. Pax (TBR0022)	Msungululu	S	R	Haemorrhoid	Decoction drunk	20	0.19	
Asphodelaceae								0.609
Aloe vera (L.) Burm. f.	Mlovera	H	Whp	Gastric ulcer, haemorrhoids	Decoction drunk for ulcer; massage the affected part in the anus using the peeled part to treat haemorrhoid	39	0.36	
Asteraceae								1.125
Bidens pilosa L.	Ndasa	H	Whp	Diarrhoea	Decoction drunk	59	0.55	
Launaea cornuta (Hochst. ex Oliv. & Hiern) (TBR0013)	Mchunga	H	L	Diarrhoea	Infusion drunk		0.24	
Caricaceae								0.797
Carica papaya L.	Mpapai	H	Fr	Constipation	Peel and eat the fruit	51	0.47	
Combretaceae								0.594
Combretum zeyheri F. Hoffm.	Musana	T	R, L	Diarrhoea, dysentery, Stomachache	Powder of the dried parts is mixed with tea or porridge, then taken orally	27	0.25	

Family/ Taxonomic name/Voucher	Local name	Habit	Part used	Ailment cured	MoP and RoA	UR	UV	FUV
Terminalia sericea Burch. ex DC.	Muzima	T	R	Gastric ulcer, stomachache,	Infusion drunk	32	0.30	
Cucurbitaceae								0.313
Cucumis maxima Duchesne	Msalyungu	H	Fr	Vomiting, diarrhoea	Decoction drunk	14	0.13	
Cucurbita pepo L.	Msusa	H	Se	Flatulence	Infusion drunk	6	0.06	
Cyperaceae								0.469
Cyperus articulates L. (TBR0019	Mndagondago	H	R	Stomachache	Decoction drunk	30	0.28	
Ebeneceae								0.234
Diospyros abyssinica Hiern.	Muningiwe	T	R	Constipation	Infusion drunk	15	0.14	
Euphorbiaceae								1.297
Jatropha gossypifolia L.	Mbono	S	B	Diarrhoea	Infusion drunk	27	0.25	
Phyllanthus engleri Pax. (TBR007)	Mng'olong'ondi	S	R	Diarrhoea	Decoction drunk	31	0.29	
Ricinus communis L.	Mnyonyo	S	Fr	Constipation	Chew and swallow the fluids	37	0.34	
Euphorbia candelabrum Kotyschy (TBR020)	Mulangali	T	Tw	Constipation	Decoction mixed with chicken meat taken orally	56	0.52	
Euphorbia hirta L. (TBR021)	Vakikulu	H	Whp	Constipation	Powder mixed with porridge taken orally	43	0.40	
Fabaceae								1.563
Archis hypogaea L. (TBR006)	Karanga	H	Se	Dysentery, gastric ulcer	Decoction drunk	13	0.12	
Branchystegia spiciformis Benth.	Mutunduru	T	R	Diarrhoea	Crushed then decocts	16	0.15	
Cajanus cajan (L.) Huth.	Mbaazi	S	L	Diarrhoea	Powder mixed with hot water or tea and drunk	25	0.23	
Cassia abbreviata Oliv.	Muzoka	T	L	Stomachache	Powder mixed with hot water and drunk	41	0.38	
Dalbergia melanoxlyon Guill. & Perr.	Mugembe	T	R	Stomachache	Infusion drunk	12	0.11	
Mundulea sericea (Willd.) A. Chev (TBR025)	Mutandala	T	R	Stomachache	Decoction drunk	36	0.33	
Pterocarpus angolensis DC.	Muninga	T	B	Dysentery	Decoction drunk	9	0.08	
Pterocarpus tinctorius Welw.	Mukulungu	T	R, B	Diarrhoea, heartburn, dysentery	Decoction drunk	18	0.17	
Senna siamea (Lam.) Irwin et Barneby	Mjohoro	T	R	Stomachache, diarrhoea	Decoction drunk	29	0.27	
Tamarindus indica L.	Mkwaju	T	Fr	Constipation, diarrhoea	Concoction	51	0.47	
Xeroderris stuhlmannii Dunn ex Baker f. (TBR015)	Mnyenye	T	R	Stomachache	Powder mixed with hot water or tea and drunk	36	0.33	
Flacourtiaceae								0.750
Flacourtia indica (Burm.f.) Merr.	Mupugaswa	T	R	Constipation	Decoction drunk	48	0.44	
Gutiferae								0.266
Psorospermum febrifugum Spanch (TBR005)	Msalunhunda	S	R	Worm infections	Powder mixed with hot water or tea and drunk	17	0.16	

Family/ Taxonomic name/Voucher	Local name	Habit	Part used	Ailment cured	MoP and RoA	UR	UV	FUV
Lamiaceae								1.391
Clerodendrum myricoides (Hochst.) Vatke.	Mpugambu	S	R, L	Dysentery, stomachache,	Decoction drunk	75	0.69	
Vitex mombassae L.	Mutalali	T	L	Dysentery	Decoction drunk	18	0.17	
Plectranthus barbatus L. (TBR018)	Mbelasigulu	H	R	Gastric ulcer, Flatulence	Infusion mixed with honey, then drunk	44	0.41	
Loganiaceae								0.750
Strychnos heterodoxa Gilg. (TBR0011)	Mugwegwe	H	B	Dysentery	Decoction drunk	24	0.22	
Strychnos innocua Del. (TBR003)	Mpundu	H	B	Gastric ulcer	Decoction drunk	15	0.14	
Strychnos nitida G. Don (TBR002)	Mwangajini	H	Whp	Constipation	Decoction drunk	33	0.31	
Lyrthaceae								1.219
Punica granatum L.	Mkomamanga	T	R	Gastric ulcer	Decoction drunk	78	0.72	
Malvaceae								0.792
Thespesia garckeana F. Hoffm. (TBR010)	Mtoho	T	L	Dysentery, diarrhoea	Decoction drunk	51	0.47	
Meliaceae								0.892
Azadirachta indica A. Juss.	Mwarobaini	T	R	Typhoid, stomachache	Decoction drunk	25	0.23	
Ekebergia benguelensis (Welw. ex C.DC.) (TBR001)	Mutunzya	T	R	Diarrhoea	Powder mixed with tea or porridge and drunk	32	0.30	
Moraceae								0.734
Entada abyssinica A. Rich. (TBR014)	Mufutwamyla	S	R	Gastritis	Powder mixed with tea or porridge and drunk	47	0.44	
Moringaceae								0.859
Moringa oleifera Lam.	Mulonge	T	Fr	Stomachache, gastric ulcer	Infusion drunk	55	0.51	
Musaceae								1.031
Musa sapientum L.	Mgomba	H	Fr	Heartburn, gastric ulcer	Peel the fruit, then eat it as food	66	0.61	
Myrtaceae								1.422
Psidium guajava L.	Mupera	T	L	Dysentery, diarrhoea, haemorrhoid	Decoction drunk	81	0.75	
Syzygium cumini (L.) Skeels	Musambarao	T	L	Gastric ulcer	Infusion drunk	34	0.31	
Olacaeae								0.453
Ximenia americana L. (TBR008)	Mtundwa	T	R	Diarrhoea	Infusion drunk	29	0.27	
Phyllanthaceae								0.750
Hymenocardia mollis Tul. (TBR017)	Mupala	S	R	Diarrhoea	Decoction drunk	48	0.44	
Poaceae								0.297
Sorghum bicolor (L.) Moench.	Mtama	H	L	Flatulence	Infusion drunk	19	0.18	

Family/ Taxonomic name/Voucher	Local name	Habit	Part used	Ailment cured	MoP and RoA	UR	UV	FUV
Polygonaceae								0.406
Securidaca longipendunculata Fresen. (TBR009)	Muteyu	S	R	Stomachache, gastric ulcer, constipation	Powder mixed with hot water and drunk	26	0.24	
Rhizophoraceae								0.875
Cassipourea mollis (R.E. Fries) Alston (TBR012)	Mlugala	T	R	Diarrhoea, stomachache and Gastric ulcer	Chew, then swallow the fluid	56	0.52	
Rutaceae								1.484
Citrus limon (L.) Burm. f.	Mdimu	T	R	Diarrhoea	Juicing roots, then mix with *Cordia africana* leaves and taken orally	18	0.17	
Harrisonia abysinica Oliv. (TBR016)	Musomwanjara	S	R	Stomachache	Decoction drunk	36	0.33	
Zanthoxylum chalybeum Engl. (TBR004)	Mlungulungu	S	R	Constipation, gastric ulcer, diarrhoea	Decoction drunk	77	0.71	
Sapotaceae								0.422
Chrysophyllum bangweolense R. E. Fries	Museveya	T	R	Constipation	Decoction drunk; enema	27	0.25	
Solanaceae								0.672
Solanum incanum L.	Ntalantu	H	Fr, R	Gastric ulcer, constipation	Decoction drunk	43	0.40	
Zingibaraceae								1.016
Zingiber officinale Roscoe.	Tangawizi	H	Rh	Diarrhoea	Chew, then swallow the fluid	65	0.60	

Note: MoP - Mode of Preparation, MoA - Mode of Administration, H - Herbs, S - Shrub, T - Tree, R - Root, L - Leaf, Bu - Bulb, Se - Seed, Fr - Fruit, Rh - Rhizome, Tw - Twigs, Whp - Whole plant, UR - Use Report, UV - Use Value and FUV - Family Use Value. TMPs with Voucher number represent existing Herbarium samples.

Plant part value (PPV), preparation and administration of remedies

In terms of plant part value (PPV), the root (0.464) was the most commonly used plant part, followed by the leaf (1.188) and fruit and bark (each with 0.101) (Figure 3). Most herbal remedies were prepared using the decoction technique (51%), followed by infusion (19%), powdering (14%), and Chewing (6%) (Table 4) and 96.9% of the remedies were administered orally, while 3.1% were applied through massaging or enema (Figure 4).

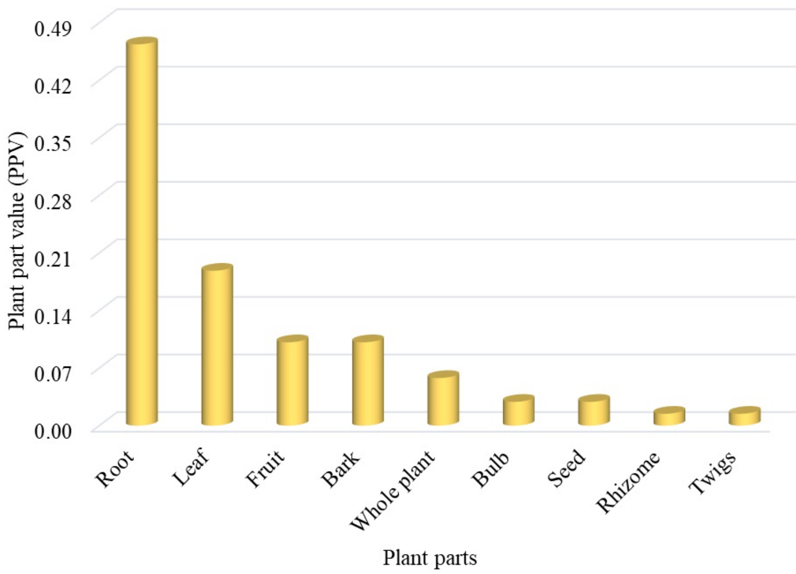

Figure 3. Plant part value (PPV) for each used plant part

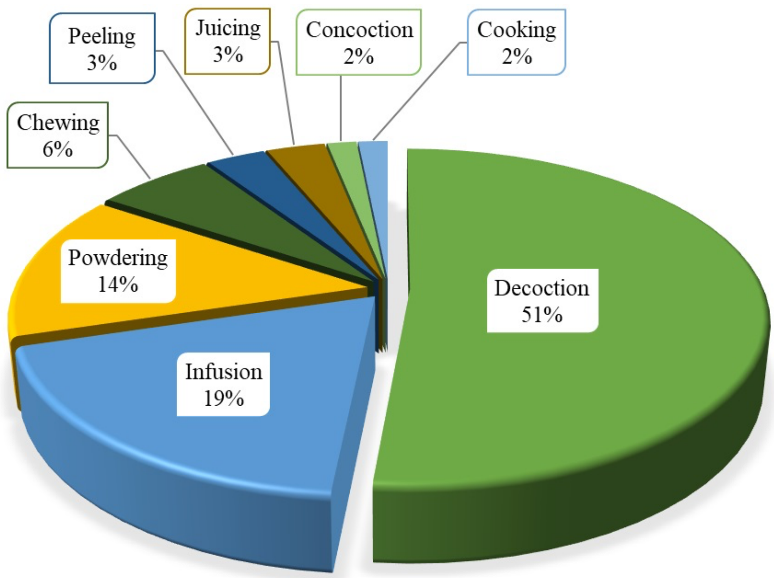

Figure 4. Modes of preparing herbal remedies

Use records of digestive system disorders

A total of 2,321 use reports were enumerated between the interviews with the THPs. These fit 11 diverse disorders (Table 3), whereby the most frequently reported disorder was diarrhoea, which contributed 30.2% of all use records, followed by constipation (23.5%), gastric ulcer (13.5%), stomachache (13.5%) and dysentery (8.6%).

Informant consensus factor (ICF) and fidelity levels (FL)

The informant's consensus factors (ICF) ranged between 0.93 and 0.97, with an average of 0.96 (Table 3). The highest degree of ICF was recorded for constipation, diarrhoea, and gastritis/worms' infection (0.97 each), followed by haemorrhoid and gastric ulcer (0.96 each), and dysentery, stomachache and vomiting (0.95 each). The highest fidelity level (FL) for the TMPs used by the Nyamwezi THPs was recorded for Euphorbia *candelabrum, Sorghum bicolor and Cassia abbreviata* (100% each), followed by *Punica granatum (96.3), Entada abyssinica* (95.7%), *Cucus maxima* (92.9%) and *Thespesia garckeana* (90.2%) (Table 4).

Table 3. Ailment categories and their Informant consensus factor (ICF)

Ailment category	List of plants and use reports	Nt	Nur	ICF
Constipation	*Hexalobus monopetalus* (5), *Sclerocarya birrea* (28), *Friesodielsia obovata* (55), *Plectranthus barbatus* (27), *Carica papaya* (51), *Ricinus communis* (37), *Euphorbia candelabrum* (56), *Euphorbia hirta* (43), *Flacourtia indica* (48), *Tamarindus indica* (27), *Strychnos nitida* (33), *Diospyros abyssinica* (15), *Securidaca longipendunculata* (7), *Zanthoxylum chalybeum* (48), *Chrysophyllum bangweolense* (27), and *Solanum incanum* (38)	16	545	0.97
Diarrhoea	*Allium cepa* (10), *Lannea stuhlmanii* (14), *Ozoroa insignis* (21), *Xylopia antunensii* (6), *Bidens pilosa* (59), *Launaea cornuta* (26), *Combretum zeyheri* (4), *Jatropha gossypifolia* (27), *Phyllanthus engleri* (31), *Pterocarpus tinctorius* (13), *Senna siamea* (17), *Tamarindus indica* (39), *Clerodendrum myricoides* (48), *Archis hypogaea* (6), *Ekebergia benguelensis* (32), *Psidium guajava* (70), *Ximenia americana* (29), *Hymenocardia mollis* (48), *Cassipourea mollis* (50), *Citrus limon* (18), *Zanthoxylum chalybeum* (68), *Zingiber officinale* (65), *Thespesia garckeana* (5), and *Cucumis maxima* (1)	24	707	0.97
Dysentery	*Allium cepa* (18), *Combretum zeyheri* (7), *Vitex mombassae* (18), *Pterocarpus angolensis* (9), *Pterocarpus tinctorius* (3), *Clerodendrum myricoides* (36), *Strychnos heterodoxa* (24), *Archis hypogaea* (6), *Thespesia garckeana* (46), and *Psidium guajava* (28)	10	200	0.95
Flatulence	Cucurbita pepo (6), Plectranthus barbatus (5), Sorghum bicolor (19)	3	30	0.93
Gastric ulcer	*Musa sapientum* (50), *Moringa oleifera* (22), *Hexalobus monopetalus* (4), *Xylopia antunensii* (4), *Aloe vera* (24), *Terminalia sericea* (19), *Archis hypogaea* (4), *Plectranthus barbatus* (17), *Strychnos innocua* (15), *Punica granatum* (78), *Syzygium cumini* (34), *Securidaca longipendunculata* (10), *Cassipourea mollis* (13), *Zanthoxylum chalybeum* (18), and *Solanum incanum* (5)	15	313	0.96
Gastritis, typhoid and worms' infection	*Azadirachta indica* (2) *Psorospermum febrifugum* (17), and *Entada abyssinica* (45)	3	64	0.97
Haemorrhoid	*Allium sativum* (38), *Ozoroa insignis* (12), *Strophanthus eminii* (20), *Aloe vera* (15), and *Psidium guajava* (30)	5	115	0.96
Heartburn	*Pterocarpus tinctorius* (2), and *Musa sapientum* (16)	2	18	0.94
Stomachache	*Azadirachta indica* (15), *Lannea schimperi* (7), *Combretum zeyheri* (15), *Terminalia sericea* (13), *Cyperus articulates* (30), *Cassia abbreviata* (41), *Dalbergia melanoxlyon* (12), *Mundulea sericea* (36), *Moringa oleifera* (26), *Senna siamea* (2), *Xeroderris stuhlmannii* (36), *Clerodendrum myricoides* (12), *Azadirachta indica* (22), *Securidaca longipendunculata* (6), *Cassipourea mollis* (11), and *Harrisonia abysinica* (36)	16	310	0.95
Vomiting	*Cucumis maxima* (13), *Allium cepa* (9)	2	22	0.95

Table 4. Fidelity levels of TMPs commonly preferred against a given ailment category

Ailment category	Medicinal herb	Ip	Iu	FL
Euphorbia candelabrum	Constipation	56	56	100.0
Sorghum bicolor	Flatulence	19	19	100.0
Cassia abbreviata	Stomach-ache	41	41	100.0
Punica granatum	Gastric ulcer	78	81	96.3
Entada abyssinica	Gastritis	45	47	95.7
Cucumis maxima	Vomiting	13	14	92.9
Thespesia garckeana	Dysentery	46	51	90.2
Zanthoxylum chalybeum	Diarrhoea	68	77	88.3
Allium sativum	Haemorrhoid	38	61	62.3

Discussion

Demographic profile of traditional health practitioners (THPs)

The findings revealed the domination of male THPs in the traditional healing practices, which is comparable to other ethnomedicinal studies from neighbouring countries, Kenya (Kamanja *et al.* 2015) and Uganda (Tabuti *et al.* 2023). The observed gender disproportionality is mainly because male THPs are more trusted in African traditional healing practices than females. Unlike other studies that reported that the young generation is not interested in traditional healing practices (Eshete & Molla 2021), the present results differ as over 48.2 % of the THPs involved are younger than 41 y old. Since most THPs are confirmed to inherit knowledge from their ancestors, they should uphold the practice for future generations, too.

Medicinal plant diversity, life form and sources

The Nyamwezi THPs mostly use TMPs belonging to the family Fabaceae, as the family has an exceptional place in household remedies, and most of its TMPs are customarily being used against various GIDs not only in Tanzania but also in South Africa (Olajuyigbe & Afolayan 2012), that may be due to the presence of potential phytochemicals. Other TMPs with high FUV, such as Rutaceae, Myrtaceae, Lamiaceae, Euphorbiaceae, Lyrthaceae and Asteraceae, are also reported in other ethnomedicinal studies to treat GIDs (Olajuyigbe & Afolayan 2012, Tangjitman *et al.* 2015). For instance, Asteraceae and Lamiaceae were reported to be commonly utilised families against GIDs in Spain (Calvo *et al.* 2013) and Morocco (Fatiha *et al.* 2018), respectively. These variations among the use of various families between diverse cultures can be allied with the dominant native flora of different areas or traditional beliefs.

Similar to this study, the tree was reported in South Africa as the common life form used to prepare remedies against GIDs (Olajuyigbe & Afolayan 2012). The prevalence of trees signifies that the THPs are well-informed about the use of higher plants in herbal remedies formulation, but it can also be because the life form is available throughout the year as it is not affected by seasonality. Most of the TMPs were obtained from the wild habitats, which are somehow highly depleted due to increased anthropogenic activities, resulting in a decline of TMPs growing in the habitats. This result aligns with the findings reported in Ethiopia (Eshete & Molla 2021), which explained that most TMPs grow well and are plenty in wild environments but are exceedingly affected due to overutilisation for various purposes.

Plant parts used, preparation and administration of remedies

Plant part value (PPV) helps identify the plant part used as a medicinal ingredient. Plant parts can accrue different and interesting active compounds because of their ability to act as factories that produce and offer vital pharmaceutical potential. In this study, the root was the most utilised plant part in preparing herbal remedies compared to other parts. Other ethnomedicinal studies conducted in Tanzania also displayed the dominance of the heart in the formulation of medications (Kacholi 2014, Mogha *et al.* 2022). Roots are favourite as they are conventionally perceived to possess more therapeutic potential than other parts, but their hit-or-miss exploitation can harm TMPs' survival (Chinsembu 2016). Therefore, using leaves as a substitute should be encouraged as a sustainable practice because, in most cases, harvesting reasonable leaves biomass does not interfere with the mother plant life, compared to roots, stem or whole plant, which may endanger the plant's existence.

In the present study, most herbal recipes were prepared using the decoction method and administered orally, which agreed with the results of other ethnomedicinal studies conducted in Thailand (Tangjitman *et al.* 2015). Moreover, most TMPs were singly or mono-herbal recipes utilised except for a few. The THPs in the studied areas used different vehicles like sugar, honey, and porridge during formulation and intake of the remedies for minimising the acrimonious taste of TMPs and subsequently evade vomiting or any other gastrointestinal discomfort.

Use value (UV), informant consensus factor (ICF) and fidelity level (FL)

The use value reveals the value of TMPs used by the THPs in the region. The study results exposed that the UV of the reported TMPs varied from 0.08 (*Hexalobus monopetalus*) to 0.75 (*P. guajava*) (Table 2). Other studies have demonstrated that *P. guajava* is frequently used against diarrhoea and is abundantly present in the region. In a clinical trial conducted in India, the administration of the decoction of *P. guajava* leaves thrice daily aided patients with acute infectious diarrhoea to regain normalcy in 72 hours (Birdi *et al.* 2020). Other TMPs like *P. granatum* and *Z. chalybeum* (0.71) are also known for their therapeutic potential in treating digestive system disorders (Mbinile *et al.* 2020, Qnais *et al.* 2007). High UV refers to extensive ethnomedicinal uses of the reported TMPs, while low UV refers to the minimum uses. Similar findings were also reported in Pakistan, where the highest UV represents the most exploited TMPs used to treat a particular ailment (Hussain *et al.* 2019).

The highest ICF values in the present study (Table 3) indicate the highest degree of consensus among the THPs in treating the GIDs in the region. The ailment categories with the highest agreement were constipation, diarrhoea, gastritis, typhoid, and worm infection. The TMPs with high ICF values against specific ailments are more likely to be biologically active than those with low ICF (Tangjitman *et al.* 2015). Hence, documenting them is indispensable in the search for bioactive ingredients.

Moreover, this study reported the highest FL values of four TMPs, namely *E. candelabrum, S. bicolor, and C. abbreviata*, which had FL values of 100%, in managing constipation, flatulence and stomachache, respectively (Table 4). Based on the literature, TMPs with a high FL are frequently utilised locally as bio-pharmacological resources and, therefore, should be prioritised for conservation, bioassays and phytochemical investigation to identify the bioactive ingredients responsible for the high therapeutic potential (Jadid *et al.* 2020). Possession of low FL can refer to a low abundance of TMPs in the region. Still, it can also indicate the presence of little data on its use among the informants. However, to preserve the traditional knowledge of the locals in treating various ailments, TMPs with low FL should be conserved for future generations to realise them.

Pharmacological relevance

Worldwide, humans have a long history of using TMPs for therapeutic purposes, and nowadays, the practice is actively promoted. The therapeutic implication of these TMPs can be verified through ethnomedicinal investigations. Few studies have approved the use of some TMPs reported in this study. The extracts of *P. guajava* leaf and *P. granatum* juice are known for their antidiarrheal activities (Gupta & Birdi 2015, Souli *et al.* 2015). The two TMPs have been reported to possess influential biological activities from tannins, flavonoids and alkaloids, which are responsible for antidiarrheal properties. Tannins are known for protein denaturation and the production of protein tannate, which lessens secretions from duodenal mucosa (Gutiérrez *et al.* 2008, Souli *et al.* 2015). Moreover, *Musa sapientum* (cooked green banana) has been reported to possess pectin, which helps reduce the duration of diarrhoea (Gunasekaran *et al.* 2020), and the plant contains monomeric flavonoid (leucocyanidin), an active compound with anti-ulcerogenic activity (Prakash Mishra *et al.* 2018). Other TMPs which have also been reported elsewhere to possess antidiarrheal activities are *B. pilosa* (Shandukani *et al.* 2018), *Tamarindus indica* (Kuru 2014), *Citrus lemon*, and *Cajanus cajan* (Ouachinou *et al.* 2019). Additionally, *Euphorbia hirta* possesses both antidiarrheal and laxative effects (Ali *et al.* 2020).

Similar to the present study findings, *T. indica* was reported to possess laxative properties due to malic acid, tartaric acid and potassium acid, which are significant players of laxative activity. Other TMPs with laxative activity include *Ricinus communis*, *C. cajan*, and *Z. officinale* (Ouachinou *et al.* 2019). Another phytochemical study revealed that extracts of *Entada abyssinica* and *Azadirachta indica* showed effective biological activities against *Helicobacter pyroli* (Fabry *et al.* 1996), hence, valuable TMPs in managing gastric ulcers. Other TMPs reported in the present study as anti-gastric ulcers and reported elsewhere against the challenge of *H. pyroli* include *Zanthoxylum chalybeum* (Mbinile *et al.* 2020), and *Arachis hypogaea* (Yang *et al.* 2011).

Generally, numerous TMPs exhibited effective pharmacological and biological activities against different GIDs. However, a review of the literature revealed that some TMPs such as *Euphorbia candelabrum*, *Hymenocardia mollis, Z. chalybeum, Lannea stuhlmanii, Pterocarpus angolensis, Phylanthus engleri, Sorghum bicolor, Cyperus articulates* and other TMPs used by the Nyamwezi THPs have scarce data on the GIDs. Therefore, it is of noteworthy interest to research their pharmacological and biological activities for treating GIDs that can lead to the discovery of novel agents with valuable properties and new drug formulations.

Conclusion

The GIDs have a high prevalence in terms of the morbidity rate among the locals in Tanzania. This is true for ethnic people with insufficient access to hygienic levels of sanitation, which may intensify the transmission of GIDs. Thus, this study offers findings that indicate the potential roles of 64 TMPs used by THPs to manage GIDs in the Tabora region. It has also characterised the cultural values of the locals in the studied districts. The UV, FUV, ICF, and FL presented can be used to support plant conservation and future pharmacological studies to discover new drugs. The highly cited TMPs warrant further phytochemical and pharmacological analyses to assess their bioactive ingredients. Moreover, the study suggests that in-vitro plant tissue culture could also be used as an alternative way to conserve documented TMPs.

Declarations

List of abbreviations: GIDs - Gastrointestinal disorders; TMPs - Traditional Medicinal Plants; THPs - Traditional Health Practitioners; FUV- Family Use Value; UV - Species Use Value; PPV - Plant Part Value; ICF - Informant Consensus Factor; FL - Fidelity Level.

Ethical approval and consent to participate: The study was approved by the University of Dar es Salaam Research and Ethics Committee and conducted in accordance with local legislation and institutional requirements. The participants provided their oral informed consent to participate in this study.

Availability of data and materials: The data of this work will be made available by the authors upon request.

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Author's contributions: DSK conceptualized and designed the study, organized, analyzed, and interpreted data, and wrote, read, and approved the manuscript for publication. HMA and AJI conducted fieldwork, organized, analyzed, and interpreted data, and wrote, read, and approved the manuscript for publication.

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