Ethnobotanical study of medicinal plants traditionally used against erectile dysfunction in Tabora region, Tanzania

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Research

Abstract

Background: Globally, erectile dysfunction (ED) is a public health concern that upsets men's psychosocial well-being. Despite using indigenous knowledge to manage various disorders in Tanzania, there is a lack of data on the medicinal plants (MPs) used to manage ED. Therefore, this study was aimed at documenting MPs traditionally used by traditional healers (THs) to manage ED in Tabora region, Tanzania.

Methods: An ethnobotanical survey was conducted from June to October 2020. A semi-structured questionnaire was used to collect information from 38 THs in 9 wards, explicitly asking about MPs used against ED, parts used, methods of preparation, and routes of administration. The collected information was analyzed by computing percentage frequencies and familiarity index.

Results: Thirty-four plant species belonging to 21 families and 32 genera were documented to be used to manage ED. Family Fabaceae (26%) dominated the species used in the treatments. *Abrus precatorius* L. (59%)*, Senegalia senegal* (L.) Wild., *Ricinus communis* L. (with 57% each)*, Coffea arabica* L.*,* and *Flueggea virosa* (Willd.) Voigt. (56% each) were the most cited MPs. Tree (52%) and root (60%) were the most utilized growth form and plant part, respectively. Decoction (34%) and oral (97%) were the most used methods of preparing and administering the remedies, respectively.

Conclusion: The findings indicate that the region has diverse MPs for treating ED. Most MPs used by THs to treat ED are yet to be tested; thus, further research is required to authenticate the efficacy of the herbal remedies and to formulate low-cost contemporary drugs.

Keywords: Ethnomedicine, herbal remedies, impotence, Traditional medicine, Tanzania

Background

Erectile dysfunction (ED), also known as impotence, refers to the inability to achieve and/or maintain an erection sufficient for satisfactory sexual intercourse (Pallangyo *et al.* 2016). The disease is a common public health concern in many families worldwide, affecting about 15% of men yearly (Johannes *et al.* 2000). The ED burden is increasing

considerably every year, and it is anticipated that by 2025, about 332 million men will develop some degree of ED (Ayta *et al.* 1999). The problem is well-linked with aging, affecting most men above 40 years (Mutagaywa *et al.* 2014). However, current evidence suggests an increasing prevalence of ED in men younger than 40 years (Nguyen *et al.* 2017). The causes of ED vary significantly among individuals. Most are associated with common non-communicable diseases such as diabetes mellitus, cardiovascular illnesses, dyslipidemia, trauma, coronary artery diseases, chronic renal diseases, and depression (Mutagaywa *et al.* 2014, Pallangyo *et al.* 2016). Moreover, ED is associated with unhealthy lifestyles, such as lack of exercise, obesity, and smoking (Birowo *et al.* 2019).

Worldwide, the prevalence of ED differs extensively among various countries. For instance, in the United States of America, the ED is estimated to be 18.4% in men aged ≥ 20 years (Selvin *et al.*, 2007), 49.4% in Canada (Grover *et al.* 2006), and 63.6% in Hong Kong (Siu *et al.* 2001). In Africa, 71.45% of diabetic people develop ED (Shiferaw *et al.* 2020). In Tanzania, nearly 55.1% of diabetic patients developed ED at various degrees of dysfunction (i.e. 12.8% had mild, 11.5% moderate, and 27.9% severe), and the severity correlates with age (Mutagaywa *et al.* 2014). Similarly, a study conducted in Moshi Municipal in Tanzania reported an ED prevalence of 33% among men, whereby age and hypertension were independent predictors of the disorder (Nyalile *et al.* 2020).

Medicinal plants have been used to treat various human and animal ailments since time immemorial. In many rural settings of African countries, including Tanzania, the treatment of ED involves using MPs as no adequate, up-to-date treatment is available for its management (Moshi *et al.* 2012, Semenya *et al.* 2013). This is because MPs are alleged to possess bioactive compounds responsible for managing different ailments (Zhao *et al.* 2015). The rural occupants in Tanzania depend solely on herbal remedies for their primary health care needs due to the absence or scarcity of modern health facilities, the inability to pay for modern health services (Kacholi & Amir 2022a, Moshi *et al.* 2012)), and the majority lack health insurance cover. On the other hand, rural societies decide to use MPs due to their cultural barriers and traditional beliefs, easy accessibility, affordability, and acceptability by a community (Chinsembu *et al.* 2019, Mathibela *et al.* 2019).

Regardless of the diverse usage of herbal remedies in managing various ailments in Tanzania, studies on MPs used to treat ED are limited. The knowledge of specific plant species used to treat ED is still scanty and poorly documented. Therefore, the study's overall goal was to fill the existing gap by documenting and compiling a list of MPs, growth forms, sources, parts used, preparation methods, and administration routes used by THs in managing the ED in the Tabora region, central western Tanzania. This study would be the first to document MPs used to treat ED in the region and Tanzania.

Material and Methods

Description of the Study area

The present study was conducted in the Tabora region located in central-western Tanzania. Sampling sites included nine wards: Ipole, Tutuo, Mpombwe, Igigwa, Usungwa, Nsenda, Imalamakoye, Usisya, and Muungano (Figure 1). Geographically, the region is within latitudes 03°53' to 06°59'S and longitudes 31°02' to 34°14' E at about 1200 m above sea level. It is boarded by the Singida region to the east, the Shinyanga region to the north, Songwe and Mbeya regions to the south, and Kigoma, Katavi, and Geita regions to the west. Tabora is the largest region in the country, covering 8% of the country's area. According to the 2012 Tanzania national census, the region has a population of 2.291,623, an average annual growth rate of 2.9%, and a population density of 30 people per km^2. The region's average household is six people, making it the third-highest in the country and the eleventh-largest economy contributing 3.7% of the national economy (URT 2012).

Agriculture is the major socio-economic activity in the region. Major cash crops grown in the region are groundnuts, cassava, beans, sunflower, and cotton, while the major food crop is rice. Cattle herding is part of the local's traditional lifestyle, done mainly on a small scale. The region is the home of the miombo woodlands, which contribute to household income for the majority of the locals (Njana *et al.* 2013). The region's climate is tropical savannah with two distinct seasons, the wet season from November to April and the dry season from May to October. The region's average annual rainfall and temperature are 1222 mm and 23℃, respectively (Kacholi & Amir 2022b).

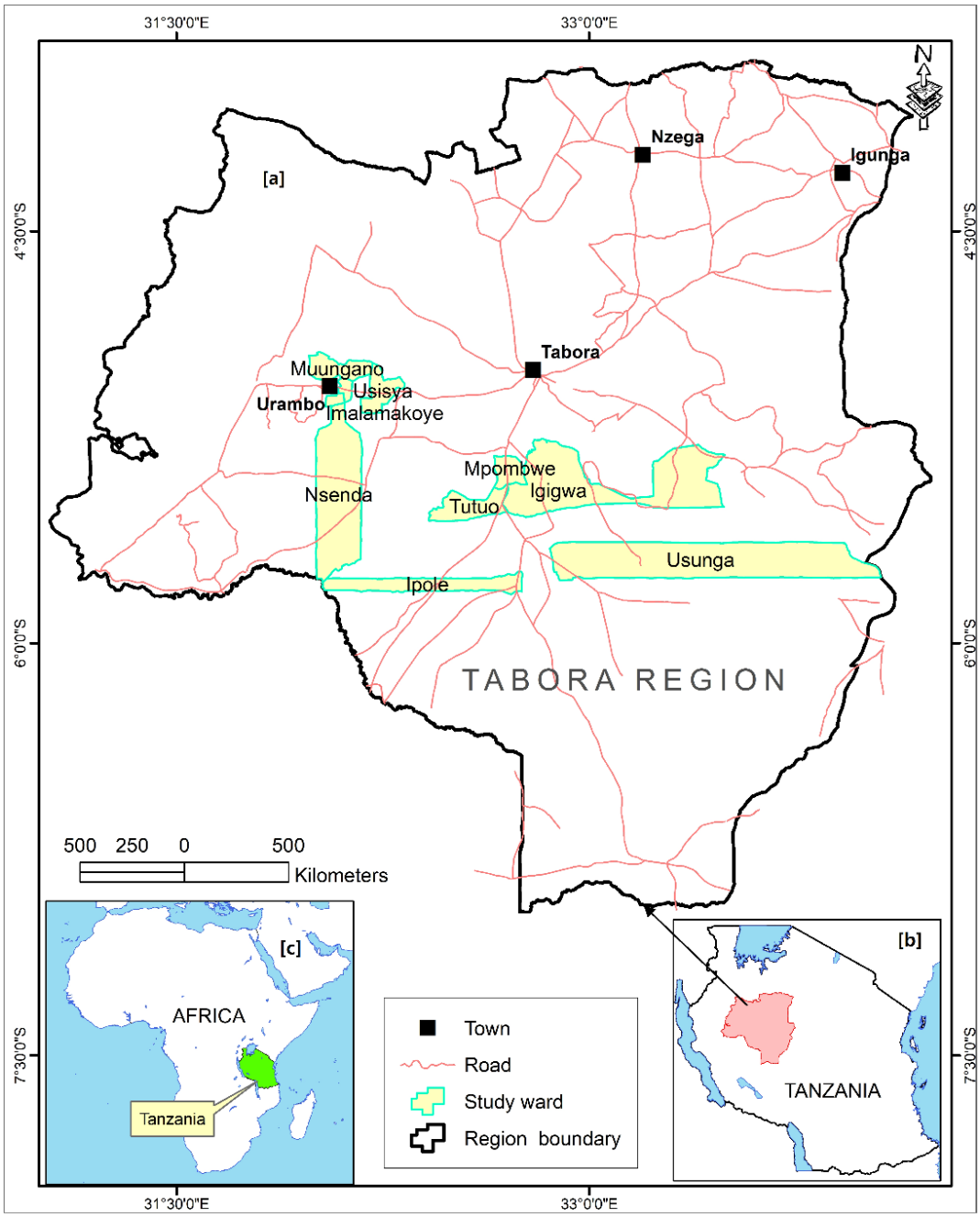

Figure 1. Map showing the location of; (a) study sites in Tabora region, (b) the region in Tanzania, and (c) Tanzania in Africa

Ethnobotanical survey and identification of specimens

The study was conducted between June and October 2020 in nine wards of Tabora region. A total of 38 THs with knowledge of the use of MPs, particularly aphrodisiacs/ED, were involved in the study (Table 1). A semi-structured questionnaire was used to gather information on the MPs used to treat ED, part(s) used, sources, preparation methods, and administration routes of the medicines. The interviews were conducted in the Swahili language and later translated into English. Identification and scientific naming of the plants were made according to (Weckerle *et al.* 2018) in terms of collecting specimens for herbarium vouchers, linking plants' names given during interviews to plants collected for herbarium preparation, as well as the collection of plant material and applying of visual aids for identification. Scientific names were verified using databases such as the Plant List Database (www.theplantlist.org) and the Tropicos (www.tropicos.org). The voucher specimens collected were deposited at the College herbarium (DUCE Herbarium).

Research clearance and Ethical consent

The office of the Vice Chancellor of the University provided the research clearance and ethical approval to undertake this study (DUCE-20030). The project's aim was communicated to all involved THs, and their verbal consent was requested before interviewing them.

Data analysis

The Microsoft Excel software version was used to analyze the collected ethnobotanical information for descriptive statistics, such as percentage frequencies of families, used plant parts, growth forms, as well as preparation and administration methods. Moreover, the familiarity index (F_i), an indicator of the popularity of a plant species as ethnomedicine was calculated as per the formula shown below. The higher the F_i value, the higher the familiarity of a plant species as ethnomedicine in the study area.

$$F_i = \frac{N_a}{N_b} \times 100$$

Whereas N_a is the frequency of a species cited as an ethnomedicine, and N_b is the total number of THs involved in the survey. Only MPs cited by at least three THs are included in the analysis.

Results and Discussion

Demographic profile of traditional healers

Thirty-eight THs from 9 wards participated in this study (Table 1). The majority of the THs were from Nsenda ward (21.1%), followed by Ipole ward (15.8%), Igigwa and Tutuo ward (with 13.1% each), Mpombwe (10.5), Usungwa and Imalamakoye (with 7.9%each), and Usisya and Muungano (with 5.3% each). Most interviewed THs were male (65.7%), while females were represented by 34.3%. A similar finding was also reported in Katsina State, Nigeria (Kankara *et al.* 2022) and Sesheke District, Zambia (Chinsembu 2016). The gender disproportion is because, in African culture, male THs are more easily accessible and trusted when discussing sexual-related issues than female THs, who face cultural limitations when talking about problems allied to sex (Kacholi & Amir 2022a).

The age of THs ranged from 22 to 71 years. The age group 46 - 55 (31.6%) was more represented, followed by 56 - 65 (23.7%) and 36 - 45 (21.1), and the remaining age groups were represented by less than five THs each. Most THs (63.2%) were of age above 50 years, indicating a wide gap between the older and younger generations. The finding agrees with an ethnobotanical study conducted in Kagera region, Tanzania (Kisangau *et al.* 2007) and Katsina, Nigeria (Kankara *et al.* 2022), which reported that 73% and 41% of the informants were aged above 50 years, respectively. Nevertheless, the enormous variation between elderly THs and young THs poses a severe threat to indigenous knowledge, as it may be lost after the demise of the older generation (Kacholi & Amir 2022a). The cultural modifications resulting from technological transformation have substantially contributed to undermining traditional healing practices by the younger generation (Kankara *et al.* 2022). The conventional healing experience of the interviewed THs ranged from 3 to 46 years, and the majority (50%) had practiced traditional healing using medicinal plants for 11 - 20 years at the survey time. The presence of 7.9% THs with more than 20 years of experience denotes a rapid eroding of indigenous knowledge with age.

Diversity of medicinal plants

A total of 34 MPs representing 32 genera and 21 families were documented as being used by THs to treat ED (Table 2). The dominant family was Fabaceae (9 species, 26% of all recorded species), followed by Euphorbiaceae, Annonaceae, and Rutaceae (each with 2 species, 6%). The remaining 17 families were represented by one species each. Similar to the present study, ethnomedicinal studies conducted in Ethiopia (Asmerom *et al.* 2021) and South Africa (Semenya & Potgieter 2013) reported Fabaceae as the frequently utilized family in treating ED. Species belonging to this family are commonly used as traditional herbal remedies for treating various ailments (Maroyi 2013, Mathibela *et al.* 2019). The preponderance of aphrodisiac plants in the Fabaceae is mainly due to their high species richness and extensive distribution across the ecosystems (Ajao *et al.* 2019). Moreover, the results advocate that screening the plant species belonging to this family can be vital for developing modern drugs for treating ED. The other families, such as Euphorbiaceae, Rutaceae, Malvaceae, Solanaceae, Zingiberaceae, and Tiliaceae, were also reported in Uganda (Kamatenesi-Mugisha & Oryem-Origa 2005) and Ethiopia (Asmerom *et al.* 2021) as helpful in treating ED.

The number of MPs recorded in this study is lower than those reported in Ethiopia (Asmerom *et al.* 2021) but higher than those reported in Uganda (Kamatenesi-Mugisha & Oryem-Origa 2005), DR Congo (Ipona *et al.* 2018) and South Africa (Semenya & Potgieter 2013). The finding informs us that the region is rich in MPs, and its people possess diverse ethnobotanical knowledge in managing ED. Among the recorded MPs in this study, 24 have been

reported in other countries (Table 2) being used to manage ED. Of these, two species, *Abrus precatorius* L. (Fabaceae) and *Zingiber officinale* Roscoe (Zingiberaceae) were cited to treat the ED in four other countries, as shown in Table 2. On the other side, seven plant species, namely, *Ozoroa insignis* Del. (Anacardiaceae), *Senegalia senegal* (L.) Wild. (Fabaceae), *Senegalia mellifera* (M. Vahl) Seigler & Ebinger (Fabaceae), *Aloe vera* (L.) Burm. f. (Asphodelaceae), *Oldfieldia dactylophylla* (Welw. ex Oliv.) J.Léonard (Picrodendraceae) (Ruffo 1991), *A. precatorius,* and *Dichrostachys cinerea* (L.) (Fabaceae) (Kokwaro 2009) were reported to treat ED in other regions within the country.

Table 1. Demographic information of informants and their background (n = 38)

	Group	No. of THs	%
Gender	Male	25	65.8
	Female	13	34.2
Age (years)	< 25	2	5.3
	25 - 35	4	10.5
	36 - 45	8	21.1
	46 - 55	12	31.6
	56 - 65	9	23.7
	> 65	3	7.9
Experience (years)	< 5	4	10.5
	5 - 10	12	31.6
	11 - 20	19	50.0
	> 20	3	7.9
Wards	Nsenda	8	21.1
	Ipole	6	15.8
	Igigwa	5	13.1
	Tutuo	5	13.1
	Mpombwe	4	10.5
	Usungwa	3	7.9
	Imalamakoye	3	7.9
	Usisya	2	5.3
	Muungano	2	5.3

Familiarity Index

The ten MPs with the highest familiarity index in treating ED were *A. precatorius* (59%), *S. Senegal* (57%), *R. communis* (57%), *C. arabica* (56%), *F. virosa* (56%), *Z. officinale* (55%), *S. mellifera* (54%), *Punica granatum* L. (Lythraceae) (52%), *Allium sativum* L. (Amaryllidaceae), and *D. cinerea* (each with 50%). The other 24 species had a familiarity index of less than 50%. Similar to the present study, *R. communis, and Z. officinale* were reported to have a higher familiarity index in Ethiopia (Asmerom *et al.* 2021), while *A. sativum* and *Z. officinale* had the highest index in Uganda (Kamatenesi-Mugisha & Oryem-Origa 2005). The use of *R. communis* is linked with saponin as a significant ingredient (Taur *et al.* 2011), which exhibits a substantial promotion of erection (Zhang *et al.* 2019). The current *in vivo* appraisals of *R. communis* leaves have established that saponin strengthens serum testosterone levels and several majors of erotic activity, supporting the existing orthodox claim (Asmerom *et al.* 2021). Also, *Mundulea sericea* (Willd.) A.Chev. (Fabaceae) roots are reported to boost libido and persuade penile erection in the Tabora region (Ruffo 1991), and the same plant species is also reported in South Africa (Abdillahi & Van Staden 2012). Therefore, the present study suggests that phytochemicals, toxicological and ethnopharmacological analysis of the documented MPs are essential in establishing their safety and efficacy and developing modern drugs.

Novelty

Of the recorded MPs, eight species, namely *Brachystegia speciformis* Benth. (Fabaceae), *Combretum obovatum* F. Hoffm. (Combretaceae), *Diospyros abyssinica* (Hiern) F.White (Ebenaceae), *Friesodielsia obovata* (Benth.) Verdc. (Annonaceae), *Harrisonia abyssinica* Oliv. (Rutaceae), *Strychnous potatorum* L.f (Loganiaceae), *Suregada zanzibariensis* Baill. (Euphorbiaceae), and *Zanthoxylum chalybeum* Engl. (Rutaceae) are reported in and outside Tanzania to be used against ED. These MPs had the lowest RFC values (Table 2), which signifies that they are least known for treating ED. Thus, further research is needed to discover the bioactivity potential of these MPs against ED problems.

Table 2. Medicinal plants used for the treatment of erectile dysfunction in the Tabora region

Scientific name (Voucher No.)	Family	Local Name	So	GF	PU	F_i	MoP & RoA	Countries with Similar usages
Abrus precatorius L. (TBR005)	Fabaceae	Kantyentye	W	Cl	R	59	Infusion; oral	Cameroon (Mondal *et al.* 2017), DR Congo (Ipona *et al.* 2018), and India (Jain *et al.* 2004)
Adansonia digitata L. (TBR013)	Malvaceae	Mbuyu	W	T	R	48	Crushing, then mix with honey; oral	Ethiopia (Asmerom *et al.* 2021) and Kenya (Kareru *et al.* 2006)
Allium sativum L. (TBR006)	Amaryllidaceae	Kitunguu swaumu	C	H	B, L	50	Chewing, cooking with food; oral	Uganda (Kamatenesi-Mugisha & Oryem-Origa 2005)
Aloe vera (L.) Burm. f. (TBR025)	Asphodelaceae	Itembwe, Lugaka	C	Su	La	32	Smearing penis with exudate; topical	Nigeria (Erhabor and Idu 2017)
Brachystegia speciformis Benth. (TBR051)	Fabaceae	Mtundusombweya	W	T	R	18	Decoction; oral	Not found
Cassia abreviata Oliv. (TBR021)	Fabaceae	Muzoka	W	T	R	43	Infusion; oral	Zimbabwe (Maroyi 2013)
Cassia singuena Del. (TBR038)	Fabaceae	Msambila	W	T	R	36	Infusion; oral	
Coffea arabica L. (TBR012)	Rubiaceae	Mkahawa	C	S	Se	56	Decoction, chewing dry seeds; oral	Uganda (Kamatenesi-Mugisha & Oryem-Origa 2005)
Combretum obovatum F. Hoffm. (TBR048)	Combretaceae	Mgoweko dume	W	T	R	14	Decoction; oral	Not found
Dichrostachys cinerea (L.) Wight & Arn. (TBR042)	Fabaceae	Mutunduli	W	S	B	50	Decoction; oral	DR Congo (Ipona *et al.* 2018)and Uganda (Kamatenesi-Mugisha & Oryem-Origa 2005)
Diospyros abyssinica (Hiern) F.White (TBR022)	Ebenaceae	Mlingiwe	W	T	R	14	Powdering, then mix with water; oral	Not found
Ekebergia benguelensis Welw. ex C.DC. (TBR014)	Meliaceae	Mtuzya	W	T	R, B	37	Decoction; oral	DR Congo (Valentin *et al.* 2020)
Flueggea virosa (Willd.) Voigt. (TBR010)	Phyllanthaceae	Mukwambe	W	S	L, R	56	Infusion; oral	Uganda (Kamatenesi-Mugisha & Oryem-Origa 2005)
Friesodielsia obovata (Benth.) Verdc. (TBR015)	Annonaceae	Msalasi	W	S	R	34	Infusion; oral	Not found
Grewia similis K. Schum. (TBR039)	Tiliaceae	Mkomabubu	W	S	L, B	27	Decoction; oral	Uganda (Kamatenesi-Mugisha & Oryem-Origa 2005)
Gymnosporia senegalensis (Lam.) Loes. (TBR018)	Celastraceae	Mwambangoma	W	T	B	37	Powdering, then cook mixed with meat; oral	Ethiopia (Asmerom *et al.* 2021)
Harrisonia abyssinica Oliv. (TBR033)	Rutaceae	Msomanjala	W	S	R	9	Powdering, then mix with milk; oral	Not found
Mundulea sericea (Willd.) A.Chev. (TBR043)	Fabaceae	Mtandala	W	T	R	20	Powdering, mix with tea or porridge; oral	South Africa ((Abdillahi & Van Staden 2012)
Myristica fragrans Houtt. (TBR019)	Myristicaceae	Kungumanga	C	T	F	47	Powdering, then use in beverages or food; oral	India (Malviya *et al.* 2011)

Scientific name (Voucher No.)	Family	Local Name	So	GF	PU	F_i	MoP & RoA	Countries with Similar usages
Oldfieldia dactylophylla (Welw. ex Oliv.) J.Léonard (TBR031)	Picrodendraceae	Muliwanfwengi	W	T	R	20	Decoction; oral	Tanzania (Ruffo 1991)
Ozoroa insignis Del. (TBR027)	Anacardiaceae	Mwembe pori	W	T	R	23	Decoction; oral	Tanzania (Ruffo 1991)
Punica granatum L. (TBR035)	Lythraceae	Mkomamanga	C	S	F	52	Make fresh juice; oral	Kenya (Kareru *et al.* 2006, Katana *et al.* 2020)
Ricinus communis L. (TBR001)	Euphorbiaceae	Mnyonyo	C	S	L, Se	57	Crush leaves and mix with porridge, tea or milk, powdering seeds, mix with *Aloe vera* in water, then drink before the sexual act; oral	Ethiopia (Asmerom *et al.* 2021)
Senegalia mellifera (M. Vahl) Seigler & Ebinger (TBR040)	Fabaceae	Mugongwa	W	S	R	54	Cooking mixed with meat; oral	Ethiopia (Asmerom *et al.* 2021)
Senegalia senegal (L.) Britton. (TBR008)	Fabaceae	Magwata	W	S	R	57	Infusion; oral	Ethiopia (Asmerom *et al.* 2021)
Solanum incanum L. (TBR002)	Solanaceae	Ntalantu	C	H	R	25	Decoction; oral,	Uganda (Tugume *et al.* 2016)
Strychonus potatorum L.f (TBR017)	Loganiaceae	Mpandepande	W	T	R	9	Decoction; oral	Not found
Suregada zanzibariensis Baill. (TBR024)	Euphorbiaceae	Mdimu pori	W	S	R	11	Decoction; oral,	Not found
Tamarindus indica L. (TBR016)	Fabaceae	Msisi	C	T	F	16	Slicing and eating fresh; oral	Ethiopia (Asmerom *et al.* 2021)
Ximenia caffra Sond. (TBR009)	Olacaceae	Munembwa	W	T	R	41	Decoction; Oral	Botswana (Motlhanka 2013) and Zimbabwe (Maroyi 2013)
Xylopia aethiopica (Dunn.) A. Rich. (TBR003)	Annonaceae	Mshenene	W	T	R	18	Powdering, mix in tea or porridge; oral	Nigeria (Erhabor *et al.* 2013)
Zanha africana (Radlk.) Exell (TBR030)	Sapindaceae	Mkalya	W	T	R	20	Decoction; oral	Zimbabwe (Gelfand 1985)
Zanthoxylum chalybeum Engl. (TBR020)	Rutaceae	Mlungulungu	W	T	R	11	Infusion; oral	Not found
Zingiber officinale Roscoe (TBR004)	Zingiberaceae	Tangawizi	C	H	Rh	55	Chew and swallow the exudate; oral	DR Congo (Ipona *et al.* 2018), Uganda (Kamatenesi-Mugisha & Oryem-Origa 2005, Tugume *et al.* 2016), and Ethiopia (Asmerom *et al.* 2021)

Note: So – Source, GF – Growth form, PU – Part(s) used, Fi – Familiarity index, MoP – Methods of preparation, RoA – Routes of administration, W – Wild, C – Cultivated, T – Tree, H – Herb, S – Shrub, Su – Succulent, Cl – Climber, R – Root, B – Bark, L – Leaf, Rh – Rhizome, Se – Seed, F – Fruit, La – Latex,

Growth forms, Sources, and Parts used

The growth forms of the documented MPs were Tree (52%), Shrub (33%), Herb (9%), and Succulent and climber (3% each) (Figure 2). A similar observation was also reported in ethnobotanical studies conducted in DR Congo (Ipona *et al.* 2018, Valentin *et al.* 2020). Trees and shrubs are used because of their availability and accessibility throughout the year, local knowledge of their medicinal use, and sociocultural beliefs and practices in managing ED (Mathibela *et al.* 2019, Tariq *et al.* 2017). The two forms are obtainable throughout the year; hence, warranty treatment ED.

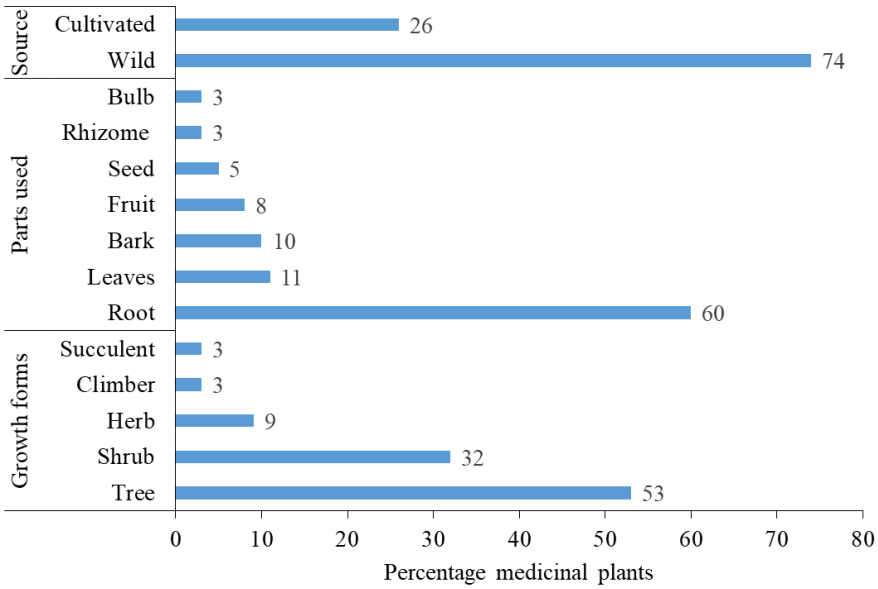

Figure 2: Growth forms, parts used, and source of the herbal remedies

The most utilized plant part was the root (60% of all species), followed by Leaves (11%) and Bark (10% each). (Figure 2). The finding agrees with other ethnobotanical studies that reported root as the predominant plant part used for treating ED (Asmerom *et al.* 2021, Ipona *et al.* 2018, Semenya & Potgieter 2013). The preference is due to the belief that superior healing power is confined in the roots than in other parts. Also, the effectiveness of the root in managing ED is due to the richness of metabolite (Adnan *et al.* 2014). Regardless of the dominance, endorsing the claimed plant part's biological and pharmacological activities is paramount, as most numerous bioactive compounds.

In the present study, THs accessed most plant materials (74%) from the wild (Figure 2). The locals rely on wild resources as they are free, and no permits are needed for gathering MPs. Therefore, from a conservation point of view, the study suggests that strategic protection and managing the wild environment are paramount for guaranteeing the sustainable supply of aphrodisiac plants. The establishment of home gardens should be prioritized as the practice is essential in safeguarding future access to the MPs and providing materials for discovering contemporary drugs through modern science.

Preparation and administration of the remedies

The most familiar preparation technique for the remedies was decoction (34%), followed by infusion and powdering (with 20% each), crushing and chewing (9% each), and smearing (3%). The oral route (97%) was the commonest mode of administration of remedies, followed by topical applications (3%) (Figure 3). The findings conform to the ethnobotanical studies conducted in DR Congo (Valentin *et al.* 2020), South Africa (Semenya & Potgieter 2013), and sub-Saharan Countries (Ajao *et al.* 2019)), whereby decoction and oral route were reported to be the most standard preparation and administration methods, respectively. The decoction method involves extracting active ingredients by boiling a plant part. The process has been reported as the most favoured technique in Zambia (Chinsembu *et al.* 2019) and Zimbabwe (Maroyi 2013) as it helps extract valuable active constituents from a plant part at a suitable concentration than other techniques.

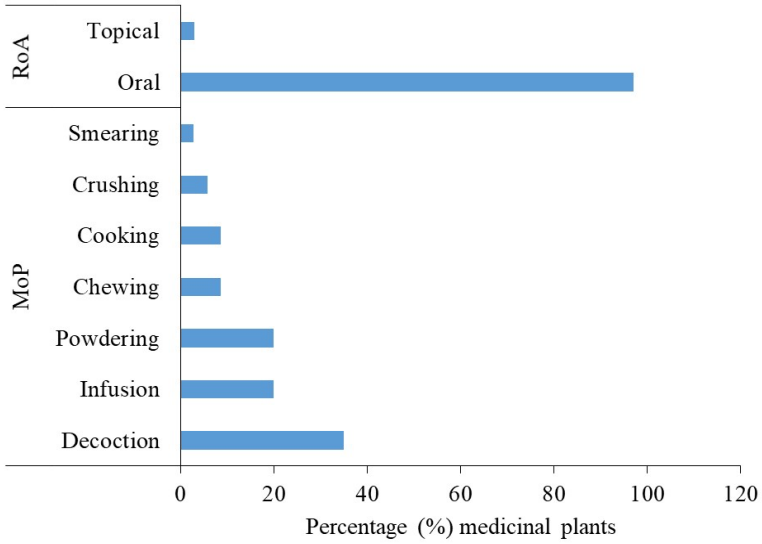

Figure 3. Methods of preparation (MoP) and Routes of administering (RoA) herbal remedies

On the other hand, the infusion technique involves using solvents by allowing the plant materials to remain suspended over time, helping to preserve the volatile substances in the plant materials that could have been lost by boiling (De Wet *et al.* 2012). This study advocates that the documented plants from the region could be a good source of developing contemporary drugs against ED. Therefore, the present findings serve as a reference source for a selection of plants in developing modern medications for the management of ED.

Conclusion

Documenting information about the use of MPs clears the way for future drug discovery research attempts based on ethnobotanical clues. Both researchers and policymakers have equally expressed concerns about losing traditional knowledge. The study contributes to conserving culturally and scientifically valuable medical understanding of the recorded MPs in Tabora region. Twenty-four recorded MPs have been reported elsewhere to treat ED, and ten are reported for the first time, which signifies a high level of medicinal use in the management of ED. Thus, this study recommends further pharmacological studies to investigate the recorded MPs' efficacy in enhancing confidence in herbal remedies and discovering contemporary drugs.

Declarations

List of abbreviations: MP - Medicinal plant; ED - erectile dysfunction; RFC - relative frequency citation; DR Congo - Democratic Republic of Congo; MoP - Methods of preparation; RoA - Routes of administration

Ethical approval and consent to participate*:* All the participants provided prior informed consent before the interviews.

Data and material availability: Voucher specimens have been deposited at the Department of Biological Sciences herbarium (DUCE Herbarium), Dar es Salaam University College of Education.

Disclosure statement: The authors declare that there is no competing interest.

Author's contributions: DSK conceptualized and designed the overall strategy of the study. HMA conducted fieldwork and collected plant materials for identification. DSK processed, interpreted the surveyed data, and drafted the manuscript. All authors read, reviewed, and approved the final manuscript.

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