Ethnobotanical study of medicinal plants utilized in the management of candidiasis in Northern Uganda

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Abstract

Background: The emergence of resistant Candida species to antifungal drugs has led to resurgence in herbal usage globally. However, little is known about anti-candida plants. This study explored ethnomedicinal plants as treatment option for candidiasis in Pader, Northern Uganda.

Methods: A cross-sectional survey of potential anti-candida plants was conducted using questionnaires, focus group discussions and field observations in March 2022. Sixty-three respondents were selected by snowball technique. The frequencies of respondents/responses were analyzed, associations of respondents’ socio-demographics with indigenous knowledge of herbal usage established by Chi-square (χ²) test using SPSS 27. Informant Consensus Factor was computed to establish level of agreement on herbal usage, and thematic analysis done for focus group discussions.

Results: Candidiasis is still common and troublesome in Pader. All herbalist had equal chances of receiving and treating candidiasis patients irrespective of herbalist’s gender, age, education level, occupation, marital status and religion (p > 0.05). About 39.7% of herbalists received candidiasis patients weekly (p < 0.01). All herbalists had knowledge on candidiasis. Death (56.8%) and discomfort (36.8%) were the major health risks of oropharyngeal candidiasis (OPC) and vulvovaginal candidiasis (VVC), respectively. A total of 32 potential anti-candida plant species in 18 families were identified. Families of Fabaceae (9 species) and Asteraceae (5 species) had most plant species. Trees (50.0%) and herbs (43.8%) were the dominant life forms. The commonest plants by frequency of mention were: Momordica foetida (26), Sansevieria dawei (20), Khaya anthotheca (15), Pilostigma thonningii (10), Clerodendrum umbellatum (7), Hallea rubrostipulata (5) and unidentified plant, ‘Agaba/daa layata’ in Acholi dialect (5). Plant parts mainly used were roots (56.3%) and stem barks (15.6%) harvested majorly by cutting (46.9%) and uprooting (12.5%). Most respondents (females, 95%) preferred herbal to western medication (p < 0.01) due to its perceived effectiveness. There was high consensus among herbalists on herbal remedies for OPC and VVC (FIC = 0.9).

Conclusions: Pader communities have diverse indigenous knowledge on candidiasis and prefer herbal medicines to orthodox treatment for candidiasis. However, the herbalists use unsustainable harvesting techniques like uprooting whole plants and cutting main roots. Hence, the need to document such indigenous knowledge before being lost for community usage and scientific validation.

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Introduction

The global incidence of fungal infections averaged one billion people with more than 1.6 million deaths associated with overall fungal infections [1]. Additionally, there were more than 1.5 million deaths from invasive fungal infections yearly [2]. Candida species are the most common cause of serious invasive fungal infections, and contribute significantly to global human morbidity and mortality [3]. Research showed that most fungal infections are caused by Candida, Aspergillus species and members of the order Mucorales [4]. In Africa, there is still limited data on fungal disease prevalence since the infections have been inextricably tied to and associated with tuberculosis and HIV [5, 6]. In Uganda, the situation is not any different since 2.5 million people (6.5% of the total population) get fungal infections and about 38,000 people die yearly, mainly from HIV-related fungal infections [7]. Most of these cases are from Eastern and Northern Uganda [8]. These two regions also have the highest burden of HIV-related opportunistic infections, especially oral candida [8].

According to Achkar and Fries [9], the most common infectious agent of candida species is Candida albicans. This commensal yeast colonizes the skin, mouth, gastrointestinal and the reproductive tracts. However, other Candida species such as C. glabrata, C. tropicalis, C. parapsilosis, C. krusei, and C. guilliermondii are also increasingly becoming more relevant, since they can also colonize human mucocutaneous surfaces [10]. Mucocutaneous candidiasis is divided into two: (i) non-genital disease with oropharyngeal candidiasis as the most common, and (ii) genitourinary disease frequently manifested as vulvovaginal candidiasis (VVC), which is also termed as vaginal yeast infection or vulvovaginitis in women, balanitis and balanoposthitis in men, and candiduria in both sexes [9]. Uganda registers 45,000 cases of HIV-related oral and oesophageal candidiasis annually. Conversely, non-HIV candida in expectant mothers affects 651,600 women yearly, out of which, 375,540 women experience recurrent episodes per year [7].

In Uganda, the main treatment for fungal infections is fluconazole, which is a broad spectrum anti-fungal drug [11]. However, there is a worrying concern of the emergence of resistant candida strains to this first-line drug [12]. Evolution of multidrug-resistant fungal organisms could lead to complicated human fungal diseases [13].

It is worth noting that an estimated 80% of the population in developing countries particularly in Africa use herbal remedies to treat various ailments including fungal infections [14]. Most rural Ugandans use herbal medication to meet their healthcare needs in a culturally appropriate manner [15]. Studies recently conducted in Uganda revealed that many plant species, for example, Erythrina abyssinica, Pentas longiflora, Albizia coriaria, are used to treat fungal skin infections [16–20].

In Pader district, the management of fungal infections is a big challenge due to inadequate technical and health infrastructural capacities. This problem unfortunately frustrates efforts to access fungal diagnostic and treatment services [21]. Similarly, the long political instability of 1986–2006 that arose from the conflict between the Lord’s Resistance Army (LRA) rebels of Northern Uganda, and the Uganda People’s Defense Forces (UPDF) greatly disrupted economic activities in the district [22]. This contributed to the negative shift in nutritional contents of the foods for the community leading to malnutrition; and coupled with increased stress, negatively alters people’s (fungal hosts) immune responses. These consequently favor candida species to overgrow and cause candidiasis [23]. Additionally, the war also resulted into serious shortages of healthcare workers, drugs and food supplements [22, 24]. Thus, patients often had to walk long distances in search of healthcare services [25]. This inaccessibility to the modern health care system makes people resort to the use of herbal medicine as an alternative treatment option [26]. Traditional Medical Practitioners (TMP) are custodians of a lot of valuable knowledge on medicinal plants for treatment of many diseases including fungal diseases. Unfortunately, some of this knowledge has not been documented.

As a result, there is increasing loss of indigenous knowledge on medicinal plants in Africa in general and Uganda in particular, due to their death [27]. This implies that the undocumented information may be permanently lost [28]. The situation is compounded by the fact that the custodians of Traditional Medicine (TM) are often secretive and accessing such valuable information may not be easy [27]. However, ethnobotanical studies on traditional medicinal plants usage for treatment of various ailments, for example candidiasis, are not comprehensive enough in several African countries such as Uganda where Pader district is located. As a result, there is need for more research in this area in order to fill the gaps [29]. It is hoped that when such studies are made, they will help in documenting and preserving this valuable knowledge for continued use by the community, as well as for future use in research activities such as testing for antifungal compounds. This will lead to attainment of...
Sustainable Development Goal, agenda 3, of good health and well-being by 2030.

This study therefore documented potential anti-candida plant species, plant parts used, life forms, as well as the indigenous knowledge of potential anti-candida herbal remedies in Pader district.

**Methods**

**Study area**
The research was conducted in Pader district in Northern Uganda in March 2022. The district lies between 32°45′E–33°00′E and 2°45′N–3°00′N. Pader district is characterized by gender inequality, high youth unemployment, low economic development and inaccessibility to basic services including education and health [30]. Overall, 31.6% of the households do not have access to health facilities [31]. Out of the 12 sub-counties (Angagura, Laguti, Acholibur, Latanya, Atanga, Lapul, Pajule, Ogom, Pader, Pader Trading Centre, Awere and Puranga) in Pader district, Ogom, Angagura, Lapul and Pajule were chosen for this study (Fig. 1). This is because Ogom and Angagura sub-counties have the poorest access to health facilities at 71.7% and 58.4%, respectively. These families are located more than 5 km away from the nearest health centers [31]. On the other hand, many communities in Pajule and Lapul sub-counties, can easily access Pajule Health Centre (HC IV) which is the biggest community hospital in Pader district. It is also important to note that Ogom and Angangura sub-counties have the highest and third highest number of food insecure households at 27.4% and 25.3% in the district [31]. The poor living conditions experienced by such communities predispose them to opportunistic diseases including fungal infections.

**Research design**
The study was a cross-sectional survey that involved collection of ethnobotanical information on utilization of medicinal plant species in the management of candidiasis in Pader district. Both qualitative and quantitative approaches (mixed methods) were used. Focus group discussions (FGD) and semi-structured interviews (survey and open-ended questions) were used to collect in-depth information on antifungal medicinal plant usage.
Data collection methods

Sampling strategies

The principle of saturation was followed during snowball sampling to select 63 key respondents (herbalists and knowledgeable persons) for key informant interviews. Selection of respondents was based on the recommendations of local authorities/community elders. Herbalists had to have at least 5 years experience [32] of treating candidiasis using potential anti-candida herbal remedies for them to be included in the study. Eight to ten pregnant women in antenatal visits at each of the health centers in the study sub-counties were randomly chosen for FGD using interview guides [33].

Field survey

Semi-structured interviews using questionnaire guides were carried out among the herbalists. The questionnaire covered a list of topics on potential anti-candida plant species. The initial respondent was selected randomly by flipping a coin [34]. Snowball sampling was used to identify the 63 subsequent herbalists in their networks [35]. Rapport was created with the herbalists by researchers through establishment of cordial interpersonal interactions on the intentions of the study [36]. Field excursions were undertaken with the help of the herbalists to locate the medicinal plants in their habitats. Questionnaire guides were administered via personal contact discussions [37]. In order to obtain all the relevant data on herbal remedies against VVC and OPC, data were collected until saturation of views of respondents was reached [38]. With permission from the respondents, the interviews were audi-taped in order to obtain accurate information [39]. Field guides familiar with the areas were used to identify the selected respondents. Data collection was done with the help of field assistants who were knowledgeable in the local language. Data for FGD were collected using interview guides. The researchers facilitated the discussions among the participants [40]. All the plants mentioned were collected following standard procedures described in Martin [34], voucher specimens were prepared and taken for identification and classification at the Makerere University Herbarium. Current taxonomic nomenclature was used based on the African Plant Database (APDB), Global Biodiversity Information Facility (GBIF) and Plants of the World (POWO). The voucher specimens were given voucher numbers and deposited at Makerere University Herbarium.

Data analysis

Data were analyzed using SPSS 27. Descriptive statistics such as frequencies were used to present respondents’ demographics, knowledge of candidiasis and potential anti-candida herbal remedies in tables, bar graphs and pie charts. Associations of respondents’ socio-demographics with knowledge of herbal usage were established using Chi-square ($\chi^2$) test at 5% level of significance. These statistics were used to identify the most useful plant species for treating OPC and VVC [41].

Informant Consensus Factor (FIC) was computed to establish the agreement among herbalists on potential anti-candida herbal usage. FIC values range from 0 to 1, with 1 indicating highest level of informant consensus/agreement and 0 for no agreement on use of medicinal plant species for particular ailments. FIC was calculated according to formula, $\text{FIC} = \frac{\text{Nur} - \text{Nt}}{\text{Nur}} - 1$ [42]

Where, $\text{Nur} =$ number of use reports from informants for a particular plant use category, $\text{Nt} =$ number of species that are used for that use category for all informants. Values of FIC above 0.7 were used to indicate high levels of agreement of traditional knowledge usage of medicinal plants [43].

FIC analysis was done by grouping medicinal plant species into three categories, that is, plants for treating OPC only, VVC only and both OPC and VVC conditions. The FGD responses were transcribed and thematic analysis as used by Omara and Akwongo [44] was used to generate themes and sub-themes from the discussions. Some of the key findings (verbatim) with illustrative experiences were incorporated into the discussion section [45] to give insights of candidiasis in the study area.

Results

Socio-demographic characteristics of respondents (herbalists)

The majority of the respondents were female (95.2%), in the age bracket of 36–55 years (39.7%), attained primary education (66.7%) and were crop farmers (88.9%). Furthermore, most respondents were Roman Catholics (68.3%) and married (85.7%) (Table 1).

Herbalists’ knowledge on candidiasis (signs and symptoms, and health risks) and herbal usage

Based on herbalists’ experiences from interactions with the community, and also from the direct/indirect exposure to the disease(s); all respondents had knowledge on candidiasis. Death (56.8%) and discomfort (36.8%) were reported as the main health risks for OPC and VVC, respectively (Fig. 2). The main reported signs and symptoms of OPC (Fig. 3a) were inflammation of the gut (29.7%), white coatings on the tongue (26.7%) and diarrhea (25.6%); while for VVC, the signs and symptoms indicated were; itching genitals that later become inflamed due to scratching (31.6%), burning/painful sensation when urinating (29.0%); lower abdominal pain/cramps (13.2%) and smelly discharge from the genitals (13.2%) (Fig. 3b).
Most herbalists collected the potential anti-candida plants at anytime (68.5% (Fig. 4a) citing patients’ availability (60.6% (Fig. 4b) as the main reason. This was followed by collecting the plants in the morning hours (17.3%), with the main reason being that the plants work better when picked at that time (10.2%).

### Burden of candidiasis in the study area

There was no association between herbal treatment frequencies of candidiasis with each of the demographic characteristics of the herbalists ($p > 0.05$). However, most herbalists ($p < 0.01$) received candidiasis patients weekly (25), followed by monthly (19) (Table 2).

### Treatment options for candidiasis

Treatment options for candidiasis was highly influenced by gender ($p < 0.01$) but not age, educational level, occupation, marital status or religious affiliation ($p > 0.05$). More females (59) preferred herbal medicine to western medication ($p < 0.01$) than males (2) (Table 3).

### Herbalists’ knowledge of herbal medicine

The source of knowledge on potential anti-candida plants is not associated with gender, age, education level, main occupation, marital status and religious affiliations ($p > 0.05$). However, the majority of the respondents ($p < 0.001$) inherited the knowledge from relatives (35), followed by fellow herbalists (19) (Table 4).

### Medicinal plants usage by herbalists for management of candidiasis in Pader district

#### Reasons for choice of herbal remedies

The majority of the respondents preferred herbal medication to conventional medicine mainly due to its effectiveness/failure of orthodox drugs from hospitals (87%) (Fig. 5 and Table 7).

#### Informant consensus factor for candidiasis treated by herbalists

FIC values for medicinal plants for treatment of only OPC or VVC were below 0.7, indicating low agreement among the herbalists on potential anti-candida plants for management of either of the infections, while FIC for medicinal plants used for treatment of both OPC and VVC, was greater than 0.7 (0.9), thus very strong agreement among the herbalists on usage of similar plants to manage both common forms of candidiasis (Table 5).

#### Medicinal plants for treatment of candidiasis

A total of 32 potential anti-candida plant species belonging to 18 families were identified. The majority of the plant species belonged to family Fabaceae (9 species, 50.0%) and Asteraceae (5 species, 27.8%). Half of all the plant species (16, 50.0%) were trees, followed by herbs (14 species, 43.8%). Roots (56.3%) were the most commonly used plant part followed by stem
barks (15.6%) and lastly leaves (3.1%). However for a similar plant, more than one plant part was also used i.e., barks/roots (9.4%), leaves/roots (9.4%), fruits/roots (3.1%) and stems/leaves (3.1%). The most commonly used plant species were *Momordica foetida* (26), *Sansevieria dawei* (20), *Khaya anthotheca* (15), *Piliostigma thonningii* (10), *Clerodendrum umbellatum* (7), *Hallea rubrostipulata* (5) and unidentified plant, ‘Agaba/daa layata’ in Acholi (5). Half of all the respondents, most of whom were herbalists (21), harvested the medicinal plants by cutting (46.9%) followed by uprooting (12.5%) and digging (12.5%). All the medicinal plants species were obtained from the wild, except *S. dawei* which was not only wild but also cultivated. Herbs were reported to be abundant during rainy season, while trees were available throughout the year (Table 6).

**Modes of preparation and administration**

The most commonly used methods of preparation were maceration (56.3%) and decoctions (12.5%). However for a similar plant, more than one method was also used to prepare the herbal remedies i.e., maceration/ decoction (28.1%) or maceration/ decoction/ infusion (3.1%). Water
Table 2  Frequency of herbal treatment of candidiasis in relation to herbalists’ socio-demographics

| Characteristics       | Categories | Daily | Once a week | Twice a week | Thrice a week | Monthly | Chi-square (χ²) | df | p-value |
|-----------------------|------------|-------|-------------|--------------|---------------|---------|----------------|----|---------|
| Gender                | Female     | 7     | 24          | 7            | 2             | 2       | 18             | 1.649 | 5       | 0.895   |
|                       | Male       | 1     | 1           | 0            | 0             | 0       | 1              |     |         |         |
| Age (years)           | 18–35      | 1     | 8           | 3            | 1             | 0       | 5              | 6.852 | 10      | 0.739   |
|                       | 36–55      | 2     | 10          | 3            | 1             | 1       | 8              |     |         |         |
|                       | > 55       | 5     | 7           | 1            | 0             | 1       | 6              |     |         |         |
| Education level       | None       | 2     | 4           | 2            | 0             | 0       | 7              | 7.292 | 10      | 0.698   |
|                       | Primary    | 6     | 17          | 5            | 2             | 2       | 10             |     |         |         |
|                       | Secondary  | 0     | 4           | 0            | 0             | 0       | 2              |     |         |         |
| Main occupation       | Crop farming| 7    | 21          | 6            | 2             | 2       | 18             | 1.85  | 5       | 0.869   |
|                       | Others     | 1     | 4           | 1            | 0             | 0       | 1              |     |         |         |
| Marital status        | Single     | 0     | 1           | 0            | 0             | 0       | 0              | 10.208 | 15      | 0.806   |
|                       | Divorced   | 0     | 0           | 0            | 0             | 0       | 1              |     |         |         |
|                       | Widowed    | 2     | 3           | 0            | 0             | 1       | 1              |     |         |         |
|                       | Married    | 6     | 21          | 7            | 2             | 1       | 17             |     |         |         |
| Religious affiliation | Roman catholic| 8 | 16 | 3 | 0 | 2 | 14 | 11.628 | 10 | 0.307   |
|                       | Anglican   | 0     | 4           | 2            | 1             | 0       | 2              |     |         |         |
|                       | Pentecostal| 0     | 5           | 2            | 1             | 0       | 3              |     |         |         |
| Overall frequency of  |            | 8     | 25          | 7            | 2             | 2       | 19             | 42.429 | 5      | 0.000   |

Table 3  Treatment options for candidiasis in relation with gender, age, educational status, occupation, marital status and religion

| Characteristics       | Categories | Western medication | Herbal remedies | Western and herbal | Chi-square (χ²) | df | p-value |
|-----------------------|------------|--------------------|-----------------|-------------------|----------------|----|---------|
| Gender                | Female     | 0                  | 59              | 1                 | 20.346         | 2  | 0.000   |
|                       | Male       | 1                  | 2               | 0                 |               |    |         |
| Age (years)           | 18–35      | 0                  | 18              | 0                 | 3.697          | 4  | 0.449   |
|                       | 36–55      | 0                  | 24              | 1                 |               |    |         |
|                       | > 55       | 1                  | 19              | 0                 |               |    |         |
| Education level       | None       | 0                  | 15              | 0                 | 1.033          | 4  | 0.905   |
|                       | Primary    | 1                  | 40              | 1                 |               |    |         |
|                       | Secondary  | 0                  | 6               | 0                 |               |    |         |
| Main occupation       | Crop farming| 1                | 54              | 1                 | 0.258          | 2  | 0.879   |
|                       | Others     | 0                  | 7               | 0                 |               |    |         |
| Marital status        | Single     | 0                  | 1               | 0                 | 0.344          | 6  | 0.999   |
|                       | Divorced   | 0                  | 1               | 0                 |               |    |         |
|                       | Widowed    | 0                  | 7               | 0                 |               |    |         |
|                       | Married    | 1                  | 52              | 1                 |               |    |         |
| Religious affiliation | Roman catholic| 1             | 42              | 0                 | 5.245          | 4  | 0.263   |
|                       | Anglican   | 0                  | 9               | 0                 |               |    |         |
|                       | Pentecostals| 0                | 10              | 1                 |               |    |         |
| Overall treatment options for candidiasis | 1 | 61 | 1 | 114.286 | 2 | 0.000 |
means of administration included, oral (43.8%) and anal/rectal routes (for bitter herbs) (3.1%) using disposable syringes. However more than one mode of administration for a similar plant were also used which included; oral/anal (25.0%), oral/massage (9.4%), oral/bath (6.3%), bath/smear (3.1%), oral/massage/tongue brush (3.1%), oral/anal/massage/bath (3.1%) and oral/anal/massage/ear drop (3.1%). Many respondents gave different and varying doses to children and adults (Table 6).

Community (non-herbalists) knowledge on candidiasis and their treatment options
The communities in Pader district have great knowledge on candidiasis, which they use to diagnose and offer anti-candida treatment options. They generally prefer herbal to orthodox medication, which herbal treatment they said was cheap and effective (Table 7).

Discussion
Knowledge of herbalists on candidiasis to justify prospective of potential anti-candida plants
All the herbalists had knowledge on candidiasis. In Acholi dialect, the herbalists referred to OPC as “two lango”, while VVC was referred to as “Odododo”. VVC can make you ashamed in public due to itching” (FGD, Ogom HCII). Nyirjesy et al. [46] reported pain resulting in discomfort as one of the signs of recurrent VVC that

was the only solvent used. In few cases, the tastes of the concoctions were made more palatable by adding sugar. The herbalists used varying measurements of plant materials and water for preparing their medicines. The
| Family and scientific names/voucher number | Local names | Hb | Part/s used | Life form | Season when abundant | Harvesting method | Freq | Disease treated | Mode of preparation (Prep.) and administration (Admn.) |
|------------------------------------------|-------------|----|-------------|------------|----------------------|-------------------|------|----------------|--------------------------------------------------|
| ANACARDIACEAE Sclerocarya birrea (A. Rich.) Hochst BA028 | Otitimo<sup>a</sup> | gd | Bark | Tree | Throughout the year | Cutting | 1 | OPC/WC | Prep. maceration: wash, remove outer epidermal layer, pound, add little water, sieve. Admn. orally: children; 3 tsp 3 times a day. Adults; any dose. Preparations: orally: children: 3 tsp 3 times daily. Anally: 4 full syringes (10 ml auto disable) twice a day & the child immediately passes green stool, medication continues green diarrhoea stops |
| APOCYNACEAE Carissa spinarum L BA027 | Acuga<sup>a</sup> | ah | Root/fruit | Shrub | Throughout the year | Cutting/hand picking | 1 | OPC | Prep. decoction: wash, pound, boil, cool; fruits: cook, sieve, filter, cooked with porridge. Admn. orally: children: 2 tsp thrice daily. Porridge to be drunk as much as desired. Anally: 4 full syringes (10 ml auto disable) twice a day & the child immediately passes green stool, medication continues green diarrhoea stops |
| ASTERACEAE Baccharoides adoensis (Sch. Bip.) H. Rob BA007 | Ludia<sup>a</sup> | bh | Root/leaves | Herb | Rainy season | Uproot / cut leaves | 2 | OPV/WC | Prep. maceration/decocation: wash, for roots, peel the bark, pound, mix with moderately cooled boiled water. For leaves, boil with moderate water covering it, sieve, add little sugar. Admn. orally: children < 2 years; ½ tsp 3 times daily; 1 tsp 2 or 3 times daily. Adults; 2 tsp twice a day for about 2 weeks. Anally: children < 2 years; 3-5 ml 3 times daily, 5-7 ml 3 times daily |
| Bidens pilosa L BA031 | Labika<sup>a</sup> | gd | Leaves | Herb | Rainy season | Hand picking | 1 | OPC | Prep. decoction: wash, boil until ready, cool, then sieve. Admn. orally: 2 tsp 3 times a day |
| Family and scientific names/voucher number | Local names | Hb | Part/s used | Life form | Season when abundant | Harvesting method | Freq | Disease treated | Mode of preparation ( Prep.) and administration ( Admn.) |
|------------------------------------------|-------------|----|-------------|-----------|---------------------|------------------|------|----------------|--------------------------------------------------|
| **Cyanthillium cineum** (L.) H. Rob. BA008 | Lacaka A    | gd | Stem/leaves | Herb      | Rainy season        | Uprooting        | 1    | VVC            |佩: maceration: wash, pound, mix with water and sieve  
Admn: bath/smear: pour filtrate in bathing water/ smear filtrate around vulva after bathing, 3 times a day |
| **Echinops sp. BA024** | Atyiita A   | gd/Bh | Leaves/ root | Herb | Rainy season | Uprooting / Hand picking | 3 | VVC |佩: maceration: wash, can pound and mix with little water  
Admn: orally: children; squeeze out few drops in the mouth, 3 times a day  
Adults: chew few/ drink any amount of filtrate once/ thrice daily. Bath: add filtrate in bathing water |
| **Solanecio mannii** (Hook. F.) C. Jeffrey. BA003 | Taa lyec A  | bh | Root | Herb | rainy season | dig out root | 2 | OPC/WC |佩: maceration: wash, pound, add little water & squeeze to get filtrate  
Admn: orally: orally: children 3 tsp twice a day; adults, ¼ mug cup once a day  
Bath: add little filtrate in bathing water |
| **FABACEAE Piliostigma thonningii** (Schumach.) Milne-Redh. BA009 | Ogali A    | Bh | Root/bark | Tree | Throughout the year | Cutting | 10 | OPC |佩: maceration: decoc- 
Admn: orally: 1 or 2 tsp/ 5/10/15 mls once/twice/ thrice a day. Can mix little filtrate with food; anally:  
3mls / 1 full syringe (10 ml auto disable) once a day |
| **CELASTRACEAE Mystroxylon aethiopicum** (Thunb) Loes. BA017 | Akekedo A | hc | Root | Tree | Throughout the year | Cutting | 1 | VVC |佩: maceration: pound, mix with moderate water,  
Admn: orally: adult, 1 nice cup once a day. Youths, ½ nice cup once a day |
| **COMBRETACEAE Combretum molle** R.Br. ex G.Don. BA022 | Olim A    | bh | Bark | Tree | Throughout the year | Cutting | 1 | OPC |佩: maceration: pound, mix with water,  
Admn: orally: 2 tsp twice daily |
| Family and scientific names/voucher number | Local names | Hb | Part/s used | Life form | Season when abundant | Harvesting method | Freq | Disease treated | Mode of preparation (Prep.) and administration (Admn.) |
|------------------------------------------|-------------|----|-------------|-----------|---------------------|------------------|------|----------------|------------------------------------------------|
| CONVOLVULACEAE                            | Astripomoea malvacea (Klotzsch) A. Meeuse. BA006 | Agila^1 / Temony^4 | bush | Root | Herb | Rainy season | Uprooting | 3 | OPC | Prep. maceration/decocation: wash, can remove epidermal layer, peel bark, pound them, mix with little cold water/ boil and cool, sieve. Admin: orally: children; ½ or 1 tsp twice/thrice a day, for one week. Adults; any dose any time. Anally: 1 full syringe (10 ml auto disable) twice a day |
|                                           | Unidentified BA029 | Agaba/daa layata^4 | bh/ gd | Root | creeping herb | rainy season | uprooting/ digging out/ cutting | 5 | OPC/WC | Prep. maceration: wash, remove epidermal skin by peeling, pound, mix with little/moderate water, sieve. Admin: orally: children: 1 or 2 or 3 tsp twice/thrice a day. Adults: 2 tsp/ 50 ml/ ¼ cup once/twice a day for 1 week/any dose. Massage affected area. Brushing off fungal coating with residue |
| CUCURBITACEAE                             | Momordica foetida Schumach BA005 | Bomo^4 | bh | Root | Climbing herb | Rainy season | Uprooting/ cutting roots | 26 | OPC/WC | Prep. maceration/decocation: wash, can remove outer epidermal layer, pound, mix with cold water or boil, cool then sieve. Admin: orally: children: 1 or 2 or 3 tsp 2 or 3 times a day. Adults: engulf filtrate full in the mouth and swallow it, twice a day. Anally: children 3 or 5 or 10 ml/s or 1 or 2 or 3 full syringes (10 ml auto disable) twice/thrice a day for a week/10 days/until recovery. Massage: massage stomach with residue. Bath: add filtrate in bathing water |
| Family and scientific names/voucher number | Local names | Hb | Part/s used | Life form | Season when abundant | Harvesting method | Freq | Disease treated | Mode of preparation (Prep.) and administration (Admn.) |
|------------------------------------------|-------------|----|-------------|-----------|----------------------|-------------------|------|----------------|--------------------------------------------------------|
| DRACAENACEAE Sansevieria dawei Stapf BA002 | Twooro bye / gwok⁴ | ah | Root | Herb | Throughout the year | Uprooting/ cutting or digging out (roots unsustainably removed that cause the plant to dry out) | 20 | OPC/WC | Pep: maceration/ decoction: Wash, can remove epidermal layer; pound mix with little cold water; boil until turns yellow, cool, sieve (can also be mixed with Momordica foetida, Hallea rubrostipulata) Admn: orally: children; 1 or 2 tsp 1 or 2 or 3 or 4 times a day for 2 weeks/ until symptoms disappear. Adults; 2 tsp twice a day/ any amount, thrice a day. Anally: 5/10/30 mls / 2 full syringes (10 ml auto disable) once / twice/thrice a day. Massage: residue massaged on the stomach Smear: filtrate smeared around reddened anal area/ Pour some filtrate in bathing water Ear drop: add 2 or 3 drops in the ears once a day |
| EUPHORBIACEAE Acalypha crenata Hochst. ex A. Rich. BA001 | Ayila⁴ | cg | Root | Herb | Rainy season | Uprooting (the whole plant removed) | 3 | OPC/WC | Pep: maceration/ decoction: cut, wash, remove epidermal skin, pound fresh/dried, power, mix with little cool boiled water/ boil, cool, & sieve Admn: oral route: adults; 1 or 4 nice cup once a day; Children; 1 or 2 tsp twice a day |
| | Croton macrostachyus Hochst. ex Delile BA032 | bh | Root | Tree | Throughout the year | Cutting | 1 | OPC | Pep: decocotion: wash the root, pound, boil, cool Admn: anally: 3 full syringes (10 ml auto disable) times a day. Complete one day treatment done on weekly basis until recovery |
| Family and scientific names/voucher number | Local names          | Hb | Part/s used | Life form | Season when abundant | Harvesting method | Freq | Disease treated | Mode of preparation (Prep.) and administration (Admn.) |
|------------------------------------------|----------------------|----|-------------|-----------|----------------------|-------------------|------|----------------|-------------------------------------------------|
| **FABACEAE**                             |                      |    |             |           |                      |                   |      |                |                                                 |
| Albizia malacophylla var. ugandensis Baker f. BA011 | Ayeyek²               | bh | Root        | Tree      | Throughout the year  | Cutting           | 1    | OPC            | Prep: maceration; remove epidermal layer; wash, pound, mix with cold water, sievel Admn: orally; two tsp thrice a day for one week. Massage the head with residue |
| Erythrina abyssinica Lam. ex DC BA020 | Kicoro/Lacoro²       | gd | Bark        | Tree      | Throughout the year  | Cutting           | 2    | OPC            | Prep: maceration; remove the epidermal layer; wash, pound, mix with little water Admn: orally: children: 1 tsp twice a day. Adult: 2 tsp twice a day for about one week Bath: pour filtrate in bathing water. Can also put few drops in the mouth 3 times a day |
| Indigofera arrecta Hochst. ex A. Rich BA021 | Laywe madongo²       | gd/bh | Root       | Herb     | Rainy season        | Digging out / cutting | 3    | OPC            | Prep: maceration / decoction; remove the epidermal layer; wash, pound, mix with little water / boil and cool, sieve Admn: orally: 1 tsp twice/thrice a day. Anally: one full syringe (10 ml auto disable) twice a day |
| Indigofera spicata Forssk BA012 | Lakemtu²             | afp | Root        | Herb     | Rainy season        | Uprooting          | 3    | OPC            | Prep: maceration; wash, remove epidermal layer, pound the bark, mix with moderate cooled boiled water Admn: orally: children: 1 tsp once/twice a day. Adults: 4 tsp twice a day Massage all over the body with more emphasis on the mouth and anal areas |

*Table 6 (continued)*
| Family and scientific names/voucher number | Local names                  | Hb  | Part/s used | Life form | Season when abundant | Harvesting method | Freq | Disease treated | Mode of preparation (Prep.) and administration (Admn.) |
|------------------------------------------|------------------------------|-----|-------------|-----------|----------------------|-------------------|------|----------------|----------------------------------------------------------|
| Philenoptera laxiflora (Guill. & Perr.) Roberty. BA018 | Olwedo A                      | hc  | Root        | Tree      | Throughout the year  | Cutting           | 1    | VVC           | Pep. maceration: wash, pound, mix with water, sieve      |
|                                           |                              |     |             |           |                      |                   |      |               | Admn. orally: adults and youths: 1 mini mug once a day |
| Senna siamea (Lam.) H.S.Irwin & Barneby. BA015 | Gasia A                      | hc  | Root        | Tree      | Throughout the year  | Cutting           | 1    | OPC           | Pep. maceration: remove epidermal layer of bark, pound, and mix with little water Admn. orally: 2 tsp twice a day for about 4 days or a week |
| Unidentified BA023 | Amumuru A                    | gd  | Root        | Tree      | Throughout the year  | Dig out           | 2    | OPC           | Pep. maceration: wash, pound, mix with little water, sieve, can also mix with Piliostigma thonningii Admn. orally: 1 tsp thrice a day; Anal.: 1 full syringe (10 ml auto disable) twice daily |
|                             | Tido A                      | fs/tp/gd/as | Bark/root | Tree      | Throughout the year  | Cutting           | 15   | OPC/WC        | Pep. maceration/decoc- tion/ infusion: remove epidermal layer, pound, mix with little cold/warm water/ boil & cool, sieve Admn. orally: children: 1 or 2 tsp/3mls for 2 or 3 times a day for about 3 days/ until recovery. Adults: any dose; Anal.: 1 or 3 full syringe(s) (10 ml auto disable) / 3mls for 2 or 3 times a day. Can also add a drop in the mouth, 3 times a day |
| FABACEAE Acacia persiciflora Pax BA014 | Itooko/ladiku A              | hc  | Bark        | Tree      | Throughout the year  | Cutting           | 1    | OPC           | Pep. maceration: remove epidermal layer, pound and mix with moderate water Admn. orally: 2 tsp twice a day for 1 week |
| Family and scientific names/voucher number | Local names       | Hb | Part/s used | Life form | Season when abundant | Harvesting method | Freq | Disease treated | Mode of preparation (Prep.) and administration (Admn.) |
|------------------------------------------|-------------------|----|-------------|-----------|----------------------|-------------------|------|-----------------|-------------------------------------------------|
| MORACEAE Ficus glumosa Delile BA016       | Kworo*             | hc | Root        | Tree      | Throughout the year  | Cutting           | 1 OPC| 1 OPC          | Pesp maceration; pound, mix with very cold water. Admn: orally: children; 2 full bottle tops of filtrate, twice a day. Adults: 4 bottle tops of filtrate twice a day. |
| RHAMNACEAE Ziziphus abyssinica Hochst. ex A.Rich BA010 | Okutu lango*       | gd | Root        | Tree      | Throughout the year  | Cutting           | 1 OPC| 1 OPC          | Pesp decoction: remove epidermal layer, wash, pound, boil in water until soft, cool and sieve. Residue mix with boiled cooking oil. Admn: orally: children: 1 tsp of filtrate 3 times a day; Massage the stomach with prepared residue. |
| RUBIACEAE Hallea rubrostipulata (K Schum) Leroy BA019 | Oculu*             | gd | Root/bark   | Tree      | Throughout the year  | Cutting           | 5 OPC/WC| 5 OPC/WC      | Pesp maceration/ decoction: remove epidermal layer, wash, pound, mix with little water/ boil, cool, sieve, can mix with Saus-aia dawe. Admn: orally: 3mls / any amount 2 or 3 times a day; Anally: 3mls three times a day. |
| SAPOTACEAE Vitellaria paradoxa C.F. Gaertn. BA026 | Yaa (Shea butter tree)* | gd | Bark        | Tree      | Throughout the year  | Cutting           | 1 OPC| 1 OPC          | Pesp maceration: remove epidermal layer, pound, add little water, sieve. Admn: orally: 1 tsp of filtrate twice daily. Can also add filtrate in food. |
| SIMAROUBACEAE Harrisonia abyssinica Oliv. BA025 | Pedo*              | ah | Root        | Shrub     | Throughout the year  | Dig out            | 1 OPC| 1 OPC          | Pesp maceration: remove epidermal layer from the root, wash, pound, add little water, sieve. Admn: orally: 1 teaspoon twice a day, can also add filtrate in food. |
### Table 6 (continued)

| Family and scientific names/voucher number | Local names | Hb | Part/s used | Life form | Season when abundant | Harvesting method | Freq | Disease treated | Mode of preparation (Prep.) and administration (Admn.) |
|-------------------------------------------|-------------|----|-------------|-----------|----------------------|-------------------|------|----------------|-----------------------------------------------|
| LAMIACEAE Clerodendrum umbellatum Poir. BA004 | Acilo / Lacer A | gd | Leaves/ root | Herb | Throughout the year | Uprooting/ hand picking | 7 | OPC | Prep: maceration/ decoction, wash, can remove epidermal layer, pound, mix with moderate cooled boiled water/ boil until green & cool. Admn: orally: Children; 5 mls a day or 1 or 2 tsp 2 or 3 times a day; Adults; 2 tsp 2 or 3 times a day |
| VITACEAE Cyphostemma adenocaula (Steud. ex A. Rich.) Desc. ex Wild & R.B. Drumm. BA030 | Anunu A | gd | Root | Herb | Rainy season | Digging out | 1 | OPC | Prep: maceration; wash, pound, add little water, sieve. Admn: orally: 1 tsp 3 times a day |

Key: local names: Acholi A, Langi B
Habitats (Hb): Bush: bh; garden: gd; crop garden: cg; anthill: ah; forest: ft; home compound: cp; rocky places: rp; along stream: as; along foot path: afp

Mode of administration: Tea spoon: tsp; OPC; Oropharyngeal candidiasis, VVC; Vulvovaginal candidiasis; Freq. Frequency of mention
creates a very poor self-image that affect the patients psychologically. According to Benzie and Wachtel-Galor [47], herbalists use their knowledge of the diseases to help them diagnose and offer treatment to the patients based on their holistic views and symptoms presented.

Burden of candidiasis and urgency to use medicinal plants for treatment
Candidiasis disease is still prevalent in Pader district and is one of the causes of death. This finding is in agreement with findings of the research carried out by Ministry of Health (MOH) Uganda and WHO [48] in Pader district, which indicated that OPC was the second leading cause of death among children under five years in internally displaced persons’ camps in Pader district, next to malaria. Furthermore, data from Pader district local government (2022) records (unpublished work), showed an annual general increase in other oral conditions, including OPC in the last 5 years, i.e., 2017–2021. For instance, the year 2020–2021 registered an increase in other oral conditions from 1930 to 2913 cases. The disease burden in the area could be attributed to anti-candida drug resistance, few available anti-candida drugs on the market, and their misuse [49]. Besides, high poverty levels and poor sanitation due to the impact of the 1980s–2008 war [50] predispose the community to opportunistic infections like candidiasis. Thematic analysis of FGD also showed that OPC is still a problem in Pader as reflected in the following quotes: “...OPC is still very rampant” (FGD, Angagura HCII). It’s now 4 years, the disease has been recurring on my child and not responding to orthodox medication, I don’t know what to do” (FGD, Pajule HCIV).

The community generally prefers herbal to orthodox candidiasis medication because the herbs were cheap and effective. The effectiveness of the potential anti-candida plants could be due to the diversity of biochemical compounds they contain [51]. For instance, a study by Kakudidi et al. [19, 52] in southwestern Uganda showed that plants like Tetradenia riparia had high antifungal activity against C. albicans. This was attributed to various biochemical compounds like steroidal glycosides, coumarins and tannins it contained. Also, a study by Kamatenesi-Mugisha et al. [53] in and around Queen Elizabeth Biosphere Reserve, in western Uganda reported Allium sativum to be fungicidal to oral candidiasis. Solenostemon latifolius (Hochst. Ex. Benth) JK Morton, Hoslundia opposita Vahl, Azadirachta indica A Juss. and Rumex usambarensis Dammer are documented as potential anti-candida plants in Njeru sub-county, Buikwe district, central Uganda [54]. Additionally, a study conducted in Uganda by Anywar et al. [16] documented Chamaecrista absus (L.) H.S. Irwin & Barneby as a potential anti-candida plant.

Besides, these ethnomedicinal plants are cheap and easily available [55]. Therefore, plants documented in this study could potentially reduce the candidiasis burden in Pader district since the community can readily access them.

The herbalists had equal chances of treating candidiasis patients regardless of their gender, age, education level, occupation, marital status and religion. However, the information on herbal medicine was still secretive, mostly inherited or shared among herbalists. This was also cited by Ozioma and Chinwe [56] who stated that herbalists pass information to few trusted relatives and associates; thus, documentation will increase information access and usage by the community. Intellectual knowledge of herbalists must be acknowledged [57].

Medicinal plants as treatment options for candidiasis
The herbalists’ preference of herbal to western medication for treatment of candidiasis is corroborated by the results of FGDs (non-herbalists). “With herbal medicine, the child recovers in just one week, so everyone who wishes quick recovery of their children goes for herbal treatment option” (FGD, Ogom HCII). This could be due to limited access to health care services. Around 31.6% population of Pader district can hardly access health services [31]. A report from MOH [58] indicated that the biggest community Health Centre in Pader district is Pajule Health Centre (HC) IV. The others are at the level of HCs III and II.

Findings showed that females preferred herbal to western medication possibly because genitourinary candidiasis is more prevalent in females than men. About 50% of women, mostly in the reproductive age bracket get multiple infection episodes of VVC [59] and thus, the great demand for herbal remedies. Vaginal infections like VVC affect female private parts [60]. Culturally, this makes it difficult for the females to consult especially male medical doctors, they opt for herbal treatment. Furthermore, field observations showed that females are more responsible for nursing the sick members of their families, especially those with compromised immunity like HIV/AIDS patients. They frequently suffer from opportunistic diseases like OPC [61]. Kachmar et al. [62] attributed females’ preference of herbal to western medication to their nature of work of being in charge of obtaining and preparation of medicinal plants remedies, for the health care of the family members. Additionally, Purba and Febriani [63] noted that women have larger social networks that are used to get information. For instance, Welz et al. [64], showed that dissatisfaction with conventional treatment was the most important reason for use
of herbal remedies. There are many reported cases of conventional drug failures due to drug resistance [12, 65]. Of late, a lot of scientific investigations have been carried out on herbal medicine confirming their efficacy in certain conditions hence the several phyto-pharmaceutical products on the market [56].

**Harvesting time of medicinal plants**

Harvesting time has an impact on drug potency. A study by Black et al. [66] showed that harvesting time of *R. tomentosum* impacted on its phenolic content and bioactivity. Although some scholars have stated that harvesting time of plants for medicinal purpose is species specific [67, 68], others like Papadopoulos et al. [69] suggested that, generally it should be done early mornings immediately the dew on the plants dries off, when the concentration of the bioactive molecules in plants are at their peak. This is because high moisture contents of the plants can stimulate microbial fermentation and growth of molds that may make the herbs become harmful [70, 71]. The choice of harvesting in the morning by some of the herbalists can thus be supported by scientific evidence.

**Source of knowledge for potential anti-candida herbal medicine**

Knowledge on potential anti-candida herbal medicine in Pader district is orally passed from generation to generation, thus such knowledge is at the risk of being lost due to lack of documentation [72]. Transmission of indigenous knowledge in Pader district on potential anti-candida plants could be attributed to disease burden in the area. Besides, there is high dependency of these rural populations on herbal medicine for primary health care needs due to inaccessible health care services. Many homes are located 5 km and beyond from the nearest health centers [31]. Although there is a good practice of knowledge transfer by herbalists, the information still remains oral and secretive. It is done within families and among fellow herbalists, and not open to the general public, including research institutions [73].

**Medicinal plants usage for management of common fungal infections**

**Informant consensus factor (FIC)**

There was high consensus among herbalists on herbal remedies for both OPC and VVC (FIC = 0.9) (Table 5). Furthermore, there was consensus from the FGD held in Pajule HCIV that all these herbal remedies are good. This shows that there is agreement among the herbalists and the community on the medicinal plants for the management and treatment of candidiasis. OPC and VVC are caused by *Candida* spp [74, 75], thus similar plants are used in their management and treatment. Chekole [76] pointed out that values of FIC indicate the magnitude of shared knowledge of the most important herbal plant species for treating diseases that are prevalent in the community. Similarly, Mengistu et al. [43], stated that high values of FIC above 0.7 indicate high levels of agreement of traditional knowledge usage of medicinal plants.

**Medicinal plants for treatment of candidiasis and their effectiveness**

Although some of the widely used potential anti-candida plants in this study have not been reported in literature for their anti-candida potentials, different studies

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**Table 7** Focus group discussion to ascertain community (non-herbalists) knowledge on candidiasis and treatment options

| SN | Themes | Sub-themes |
|----|--------|------------|
| 1  | Burden of candidiasis | Every home experienced candidiasis Sometimes recurrent |
| 2  | Signs and symptoms of candidiasis | OPC: slippery diarrhoea, pus in stool; reddened anal and genital areas, white coating on tongue, rough feeling of stomach VVC: itching genitals that leads to inflammation, white discharge, painful urination, pus in urine |
| 3  | Health risks of candidiasis | OPC: transmissible, death, recurrent VVC: discomfort due to itching; Can become chronic due to poor treatment |
| 4  | a) Candidiasis treatment options (orthodox vs herbal medication) | Its trial and error Community in deep villages: heavily use herbal medication Community near health centers (urban and semi urban): use both orthodox and herbal medicine |
|    | b) Preferred anti-candida treatment option | Herbal Reasons: cheap, effective, orthodox drug failure, Side effects of orthodox medication |
| 5  | Potential anti-candida plants | *Khaya anthotheca, Sansevieria dawei, Momordica foetida, Clerodendrum umbellatum, Hallea rubrostipulata, Harrisonia abyssinica* However, VVC is mostly treated using orthodox medication |
| 6  | Anti-candida knowledge source | Inherited, elders, herbalists |
| 7  | Herbal toxicity | Vomiting, inflammation of the month |
revealed that they contain several specific bioactive compounds that makes them potential therapeutic plants. The three most frequently used potential anti-candida plant species in Pader district were Momordica foetida, Sansevieria dawei and Khaya anthotheca. A systematic review by Muronga et al. [77] indicated that Momordica foetida contains various curative compounds like phenolic glycosides and alkaloids which exhibited diverse medicinal values against various diseases. For instance, Kamatenesi-Mugisha et al. [53] documented Momordica foetida as one of the potential anti-fungal plants in and around Queen Elizabeth Biosphere Reserve in western Uganda. Namukobe et al. [78] and Omar et al. [79] documented Sansevieria dawei as a plant with medicinal purposes due to various phytocompounds like saponins, terpenoids and flavonoids. Sansevieria hyacinthoides demonstrated antifungal activity against Candida albicans [80, 81]. It was also reported that Khaya anthotheca contains various limonoids that demonstrate an extensive range of biological activities that promote health in living organisms. Hamza et al. [82] reported antifungal activity of methanol Khaya anthotheca extract against Candida krusei. Khaya ivorenensis exhibited significant antifungal activity against the plant pathogenic fungus (Botrytis cinerea Pers.) [83]. Also, Solanecio mannii in this study exhibited anti-candida activity [52] from southwestern Uganda. Thus, for some of the documented plant species whose anti-candida activities are not yet reported, bioactivity studies based on their FIC should be carried out for their validation as potential anti-candida therapies.

In this study, roots and barks of the plants were commonly used possibly because they are sites with more bioactive compounds. Szwajkowska-Michalek et al. [84] stated that most of the secondary metabolites containing the bioactive compounds are located in vacuoles and cell walls of peripheral tissues. Wei et al. [85] discovered various phytochemicals from root barks of Morus species, with variety of antimicrobial potentials. Similarly, Lezoul et al. [86] compared the total bioactive compounds in organs of three medicinal plants, viz. Passiflora caerulea, Physalis peruviana and Solanum muricatum. Their leaves and roots contained higher concentrations of bioactive compounds than other organs.

**Sustainable utilization of medicinal plant species**

Uprooting whole plants and cutting the plant parts of interest, like the main roots (Table 6), are inappropriate harvesting methods that threatens the existence of these plants [87], thus, need for sustainable utilization of these plants [88]. Khumalo et al. [67] advised herbalists to use plant parts, for instance lateral roots, which must be dug out at distance of about 30 cm from the main root/ stem. Ring barking must be avoided to avoid death of the plants. Instead, small sections of the barks could be removed. Plants obtained from the wild can easily be lost due to lack of monitoring and maintenance [89]. This therefore calls for conservation measures for seasonal medicinal plants to increase on their availability for use by the community.

**Modes of preparation and administration of potential anti-candida plants**

Decoction and maceration were commonly used (Table 6) because heat produced during decoction increases the solubility of herbal compounds, and hence their easy transfer from plant materials to the solvent. Decoctions are suited for extraction of thermal stable compounds. Maceration is one of the simplest and widely used methods. It operates on the principle of diffusion. However, it requires a lot of time to allow the molecules to diffuse from the plant materials to the solvent [90]. The use of polar solvents such as water is common practice in extraction of compounds from medicinal plants [91]. Sansevieria dawei, Momordica foetida and Hallea rubrostipulata were mixed together to increase their synergy [92]. The herbalists are knowledgeable on herbal medicinal properties, including steps that can extract the curative compounds [56]. This gives high degree of authenticity to the research findings of potential anti-candida plants.

Oral and anal routes of herbal administration being preferred to orthodox medicine could be related to the nature of bioactive compounds in those plants. For instance, alkaloids are easily absorbed when orally taken [93]. Different portions of the small intestine (duodenum, jejunum and ileum) play particular roles in drug assimilation and with special absorptive capabilities [94]. However, the biggest challenge with medicinal plants usage is lack of standardization that jeopardizes quality control and safety. Furthermore, the disposable syringes may be shared and are not sterilized, hence high chances of disease transmission. The integration of herbal medicine into the health care system, will promote use of safe, cheap and easily accessible health care service provision. Thus, this trend will result in increased economic potential and poverty reduction among the communities [56].

**Limitations of the study**

The major limitation of this study was failure to collect fertile plant specimens of a few plants species that were not in flowering/fruiting stage. These plants could not be identified and so local names were used.
Conclusion
The community of Pader district has rich indigenous knowledge on candidiasis which is troublesome in the area, and they prefer herbal remedies to manage the infections compared to orthodox treatment. This has made people to transfer the knowledge from generation to generation, though the practice is still secretive among relatives and herbalists. The herbalists mostly use unsustainable harvesting techniques like uprooting whole plants and cutting of roots. Therefore, there is need for community sensitization on candidiasis herbal remedies and sustainable harvesting of the plants. This study recommends that the use of herbal medicine as alternative treatment option for candidiasis should be supported by the government of Uganda through standardizing herbal remedies to improve on their quality; this will provide cheaper health care option and also widen the knowledge base among the locals to meet their primary health care needs. This is in line with Sustainable Development Goal, agenda 3, of ensuring healthy lives and promoting well-being for all by 2030. The study further recommends putting in place practical conservation measures to conserve medicinal plants in Pader district. Further studies should be conducted on the mentioned plant species to verify their anti-candida potentials and safety.

Declarations

Ethics approval and consent to participate
This study was approved by School of Veterinary Medicine and Animal Resources (SVAR), Institutional Animal Care and Use Committee (IACUC), Reference number #SVAR_IACUC/100/2022. Consent was got from the study participants before data collection. Principle of Access and Benefit Sharing (ABS) was followed by the researchers as they acquired the knowledge from the traditional knowledge custodians (95).

Consent for publication
All the collected data were anonymized, and therefore, consent for publication was not applicable.

Competing interests
The authors declare that they have no conflicting interests.

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