Natural Resources for Human Health

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Original Research

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Received 02 July 2024
Revised 04 August 2024
Accepted 04 September 2024
Available online 05 December 2024

Edited by Manoj G Kulkarni

KEYWORDS:
Ethnomedicinal study
Kimalalu community
Flora
Songo Municipality
Angola

Natr Resour Human Health 2025; 5 (1): 40-69
https://doi.org/10.53365/nrfhh/192950
eISSN: 2583-1194

Medicinal plants traditionally used by the rural Kimalalu people in the municipality of Songo (Uíge province), Northern Angola

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ABSTRACT: Herbal medicine is an important age-old tradition in Angola and forms part of the socio-cultural heritage of both the rural and urban population. In Kimalalu (northern Angola), phytotherapy continues to be used in the treatment of human illnesses, because of its low cost, accessibility, availability and acceptability. The aim of this study was to document the medicinal plants used to treat human illnesses in Kimalalu. Data were collected randomly from informants through semi-structured interviews and field observations. Ethnobotanical indices such as the relative frequency of citations were calculated. A total of 72 medicinal plant species belonging to 35 botanical families used for the treatment of 59 human diseases have been documented. The most abundant taxa were from the Fabaceae family, with 8 species (11.3%), and treated 17 human diseases. The leaves (62.5%) are the main plant organs used in the galinic preparation. Shrubs (31%) are the greatest life forms of documented plants. Decoction (50%) and oral intake (56.21) are the dominant used methods of preparation and administration, respectively. The most frequently cited illnesses were low haemoglobin (anaemia), followed by yellow fever, stomach ache, cough, typhoid fever, diarrhoea and malaria. Kimalalu is home to a wide variety of medicinal plants. It is therefore necessary to put in place policies and practices to conserve medicinal plants and the traditional knowledge associated with them. Local communities must be involved in the conservation and management of plant resources and their indigenous knowledge.

1. INTRODUCTION

Since ancient times, people have collected medicinal plants to treat various ailments (Pei et al., 2020). Traditional knowledge developed over time is influenced by elements of ancestral heritage, intercultural links and interaction with the natural environment (Saslis-Lagoudakis et al., 2014). The use of plant species to treat diseases stems from ancient knowledge, originating from different generations, which incorporates new uses and practices over the years. It is worth noting that some traditional communities have a vast ethnobotanical field, using plants as raw materials to treat many diseases, in a safe and sustainable way, in balance with environmental conservation (Modro et al., 2015).

It is estimated that around 80% of the human population and 90% of livestock depend on traditional medicine, most of which comes from plants (Aragaw et al., 2020; Mengistu et al., 2019), due to the inadequacy or absence of modern health services (WHO, 2002).

Indigenous knowledge of medicinal plants has been passed down from generation to generation through oral conversation (Shinwari & Gilani, 2003). This oral conversation

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promotes the transmission of indigenous knowledge about medicinal plants, but it also deteriorates over time as it is passed from one person to another (Balick & Cox, 1996). Through ethnobotanical surveys, the indigenous knowledge of medicinal plants is compiled and documented to describe the plants that can be a source of medicines to cure diseases (Sarwat & Ahmad, 2012). A number of ethnobotanical and ethnomedicinal studies have been carried out in the province of Uíge, including those by Jendras et al. (2020); Lautenschläger et al. (2020, 2018); Mawunu, and Manuel SP, et al. (2022); Mawunu, António, et al. (2023); Mawunu, Kiangala, et al. (2023); Mawunu, Panzo, et al. (2022). Despite the accumulation of rich popular ethnomedicinal knowledge gained through practice and experience in their long struggle with disease, there have never been ethnobotanical studies to document it. Also, traditional medicinal knowledge is under threat due to the lack of written records. It is therefore imperative to document medicinal plants and the indigenous knowledge associated with them in order to safeguard this rich cultural heritage.

Herbal medicine is an important age-old tradition in Angola and forms part of the socio-cultural heritage of both the rural and urban population. It is passed down orally from one generation to the next. Moreover, information on the use of medicinal plants in the treatment of human illnesses in Kimalalu is scarce. The principal aim of this study is therefore to document ethnobotanical knowledge of the medicinal plants used by the inhabitants of Kimalalu (Angola), whose flora is renowned for its biological richness, and to highlight the relevance of ethnobotanical findings for a more rational use of plants and for the creation of a traditional Angolan pharmacopoeia.

The specific objectives of this study were: (1) to typify the sociodemographic profile of the informants; (2) to list the plant species and plant organs used by the Kimalalu community; (3) to highlight the diversity of uses; and finally (4) characterize the traditional usages of medicinal plants: modes of preparation and administration and diseases treated.

2. METHODS AND MATERIALS

2.1. Study area

Kimalalu is a rural area forming part of the municipality of Songo in the province of Uíge, in the north of Angola (Figure 1) and is located between 7°,489012 South latitude and between 14°,920251 East longitude.

The inhabitants of Kimalalu are largely of Bantu origin and belong to the Bakongo ethnolinguistic group. Kikongo and Portuguese are the most widely spoken languages in the region. Subsistence bush farming is the community's main source of income, food and employment. The predominant climate in Kimalalu is humid subtropical, with a long, well-defined rainy season from September or October to May. The months of April and November are characterised by heavier rainfall, with annual rainfall of between 1,300 and 1,600 mm/year, with an annual average of 1,450 mm. Clearly, there is much less

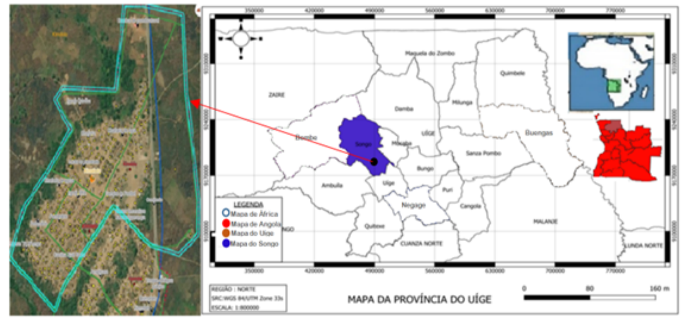

Figure 1. Location map ofUíge province (northern Angola), with the municipality of Songo in purple, while the black dot indicates Kimalalu, which is the study area.

rainfall in the dry season than in the wet season. High levels of relative humidity fluctuate around 95%, and the average annual temperature varies between 20 and 22°C (Diniz, 2006; Monizi et al., 2019, 2018).

2.2. Material

In the current research, all the plants documented constitute our biological material. These are plant parts (roots, stems, leaves, inflorescences, stem barks, seeds, fruits, root barks) or the whole plant used to treat human diseases.

2.3. Methods

2.3.1 Socio-demographic and ethnobotanical surveys

The survey was conducted between May and August 2022. A total of 250 randomly selected informants were interviewed, including 152 female (62.02%) and 98 (37.98%) men, all residents of the study area, and at least 18 years of age. The informants were chosen at random, in order to give everyone the same chance, without favouritism. The interviews were oral, but there were also written forms. These informants were approached using semi-structured interviews that were conducted in the Portuguese language. Semi-structured interviews and direct field observations were used to collect ethnobotanical data (Lautenschläger et al., 2018; Mawunu, and Manuel SP, et al., 2022; Mawunu, António, et al., 2023; Mawunu, Kiangala, et al., 2023), and based on the open-ended interview guide, which avoids influencing the informant's response (Martin, 2004).

2.3.2 Questionnaire

The questionnaire was divided into two sections: (1) attributes of the personal informant (including, gender, age, education level, and source of income); and (2) ethnomedicines data (including, local names of medicinal plants, habitat, life forms, and the status of medicinal plants used, plant organs used, ailments treated, and in each case the methods of preparation and administration were also recorded (Mawunu, and Manuel SP, et al., 2022). During the fieldwork, plant samples were collected, and photographs were taken for later identification. The individual anthropological interviews were conducted in the local languages Kikongo and Portuguese, the languages spoken by the informants. It should be noted that some of the informants interviewed spoke all three languages, while others spoke only one. For this reason, during the interview, the informant was questioned in the language he or she spoke best. Besides, the selection criteria of the surveyed people were based on the age of informants (aged 18 years old and over) who had knowledge of the utilization of medicinal plants under investigation anwd uses of those plants in the management of human diseases, and who were available at the time of the survey. At last, direct observations and the semi-structured questionnaire were submitted orally to the different informants (18-80 years old).

2.3.3 Identification, classification and ecological characterization of the plants studied

Scientific names have been updated in accordance with the Plants of the World Online database (POWO, 2023). This database originates from the Royal Botanic Gardens (Kew) and all taxonomic data incorporated reflect the latest peer-reviewed studies on accepted scientific names and synonyms of plant families. In addition, the life forms of the species listed have been classified using Raunkiar's life form classification method (Raunkiaer, 1934). The inventoried plant species are classified into different morphological types based on the Raunkiaer system (Raunkiaer, 1934), as adopted by Lejoly et al. (1988), and Pisco et al. (2024). These types include trees (over 15 m in height), shrubs (under 7 m), small shrubs (under 2 m), lianas (climbing plants), and annual herbs (plants whose aerial and underground parts die each year). Biological types are also classified using the Raunkiaer system, extended to tropical areas. These types are geophytes (plants with buds and young leaves in the soil), therophytes (plants that persist as seeds during unfavorable seasons), caephytes (plants with small vegetative devices and persistent leaves), and phanerophytes (plants with aerial sleeping buds over 50 cm above the soil). Phanerophytes include mesophanerophytes (10-30 m tall), microphanerophytes (2-10 m tall), nanophanerophytes (0.4-2 m tall), and lynephanerophytes (woody, climbing plants). The biotope types are determined from existing floras and include primary forests, secondary forests, savannahs, ruderal areas, and cultivated species. The phytogeographical distribution is determined using the classification of Mawunu et al. (2024) , based on criteria such as widely distributed species (e.g., cosmopolitan, pantropical, afro-neotropical, palaeotropical), widely distributed African species (e.g., Afro-tropical continental, Afro-Malagasy), and regional species (e.g., Sudanese, Guinean-Congolese, Zambezi).

2.3.4 Data processing and analysis

Data processing and analysis uses Microsoft Excel 2010, IBM SPSS Statistics 20 and Origin. Briefly, the data collected was first in put into Microsoft Excel and analysed using IBM SPSS statistics. A single-variable analysis of categorical variables (socio-demographic and ethnobotanical variables) was conducted to obtain descriptive statistics including relative frequencies. The Kolmogorov-Smirnov test is used to verify the normal distribution of quantitative variables. Multivariate analysis, in particular multi-correspondence analysis, is carried out to investigate the relationship between dependente variables (ethnological parameters) and independent variables (socio-demographic parameters). Additionally, it should be noted that the Kolmogorov-Smirnov test was used to validate the hypotheses concerning the distribution of data on the age of the respondents, while Multivariate analysis was used to analyse and visualise the relationships between qualitative variables, thus enriching the analysis of ethnobotanical practices and knowledge.

Three types of frequencies were determined in order to provide analytical support for the taxa inventoried during the survey work: Relative frequency of Citation (RFC), citation index (CI), and medicinal capability index (MCI):

(1) Relative frequency of Citation (RFC), this index presents the number of informants who mention the use of the species (FC) in the number of informants participating in the survey (N) (Shuaib et al., 2021), and the Relative frequency of citation (RFC) index shows the local importance of each species;

The following Formula 2 calculates the index: RFC= FC/ N. The RFC index varies from 0 to 1. An RFC index of 0, means that nobody refers to the plant as useful, but an RFC index 1 indicates that all informants in the survey agreed that this plant is useful. FC: Citation frequency is the number of informants who mentioned a particular species and N: Total number of informants. As well, the relative frequency of citation index in percentage (FRC%) was calculated as follows number of reports of use (number of times a particular species was mentioned) / (Total number of times all species were mentioned) $\times$ 100 (FRC%) and was used as a quantitative index. Moreover, in ethnobotanical study, RFC indicates the native significance of plants species present within a region (Umair et al., 2017) .

(2) Confirmation Index or Informant Consensus (CI or ICs), IC = NP/NT. In this formula, NP is the number of informants who cited a species; while NT is the total number of informants. The ICs varies between [0 - 1]. A low value, close to 0, indicates that the informants disagree on the proposed uses. When this value is close to 1, it indicates high agreement around the use of the plant. ICs: the Informant consensus of use (ICs) was calculated to assess the agreements of informants on the use of plants for therapeutic uses (Byg & Balslev, 2001). Besides, this index makes it possible to evaluate the local cultural importance of a medicinal plant cited by different surveys in a given territory. For example, in this study the CI allows us to determine the number of times a plant has been cited in the management of hemorrhoids in the region, and consequently to identify the level of consensus within the population on the curative use of a given species in the management of hemorrhoids.

(3) The medicinal capability índex (MCI), was calcuted by the formula MCI= Number of taxa cited to manage a give pathology/Total number of taxa inventoried during the study. Besides, the MCI enables us to measure the potential of a given community to manage a well-dened pathology (Valentin et al.,

2024).

3. RESULTS AND DISCUSSION

3.1. Data on socio-demographic characteristics of respondentes

A total of 250 informants from the Kimalalu agreed to take part in the study, including 152 women (62.02%) and 98 men (37.98%). The distribution of informants by age, sex, experience of phytomedicine use, sources of income and level of education is shown in Table 1.

A total of 250 informants were randomly interviewed in the Kimalalu groupement (Table 1). However, 198 women (62.02%) were predominantly female, compared with 98 men (37.98%) (Table 1). Farming (67.4%) is the main source of food, employment and income for the respondents. Similarly, phytomedicine is used by all age groups, with 45% of respondents aged $\leq$ 45, followed by those aged [46-64], and $\geq$ 65 with a percentage of 34.5%, and 28.3% respectively (Table 1). Also, most of the informants were married (48.7%) and young (37.2%), with an average age of 43.86 years. The descriptive statistics indicate that the mean age of the participants is 49.75 years with a standard error of 0.977. The 95% confidence interval for the mean is between 47.83 and 51.68 years. The 5% trimmed mean is 49.90 years, and the median is 50.50 years. The variance is 307.282 and the standard deviation is 17.529. Ages range from 16 to 86 years, with a range of 70 years and an interquartile range of 31 years. The skewness is -0.199 with a standard error of 0.136, and the kurtosis is -1.013 with a standard error of 0.271. The normality tests show that the age of the participants does not follow a normal distribution. The Kolmogorov-Smirnov test has a statistic of 0.090 with a degree of freedom (df) of 322 and a significance of 0.000. Similarly, the Shapiro-Wilk test has a statistic of 0.961 with a df of 322 and a significance of 0.000. These results, with significance values less than 0.05, indicate that the age distribution significantly deviates from normality.

Additionally, the results of the ethnobotanical survey revealed that the main part of informants (64.31%) had more than ten years' experience of using medicinal plants. The descriptive statistics for years of experience show a mean of 17.91 years, with a 95% confidence interval ranging from 16.55 to 19.26 years. The 5% trimmed mean is 17.25 years, while the median is 16 years, indicating that half of the individuals have less than 16 years of experience and the other half have more. The variance is 152.128 and the standard deviation is 12.334 years, reflecting a significant dispersion of values around the mean. The years of experience range from 1 to 50 years, with a range of 49 years and an interquartile range of 18 years. The skewness of 0.622 indicates a slight rightward tendency of the values, while the kurtosis of -0.533 suggests a slightly flattened distribution compared to a normal distribution. The normality tests for years of experience show significant results for the Kolmogorov-Smirnov test (statistic = 0.125, df = 322, significance = 0.000) and the Shapiro-Wilk test (statistic = 0.934, df = 322, significance = 0.000), indicating that the distribution of years of experience deviates significantly from normality. Experience accumulated with age is the primary source of local information on the use of medicinal plants, particularly among women.

Besides, women are important sources of traditional knowledge because they are well informed about the value of plants, particularly local medicinal and food plants, due to their role in Bakongo families as the people responsible for the family's health and diet. Besides, women are more involved in the maternal and family health system (Abba & Dogara, 2021; Abouri et al., 2012; Monizi et al., 2019). In agreement with Monizi et al. (2019) in Angola, Voeks (2007) and Vasconcelos et al. (2001) in Brazil, the predominance of women is justified by the fact that women know more medicinal plants than men and that in various societies, women have been given responsibility for domestic chores, raising children and primary care in their households. Ultimatily, Olanipekun (2023) in Nigeria, women are closer to the well-being of family members than men. Schunko et al. (2016) in Austria, women were more familiar with medicinal plants because they were responsible for food and medicine.

Furthermore, the high number of female respondents may be linked to their availability during the survey. It should be noted that this gender imbalance could be due to men's reticence towards researchers, even if they have proven knowledge of medicinal plants.

It should be noted that in the study area, married people tended to use traditional medicine, particularly medicinal plants, for their health care in order to minimise the expansive costs required by modern medicine. Finally, according to the level of education of the informants, 16.4% were illiterate. People with primary and secondary education had a significant percentage of use (25.3% and 18.1%, respectively). These results are similar to those of other studies such as Barkaoui et al. (2022) and Ouhaddou et al. (2015).

3.2. Data on medicinal floral diversity studied

The floral diversity of medicinal plants belonging to different families, local names, parts used, voucher numbers, ailments, remedies and methods of administration are shown in Table 2. Overall, 72 taxa belonging to 68 genera and 35 botanical families were explored on the study site. All species were identified and their ethnobotanical information interpreted (Table 2). All the taxa documented are listed in alphabetical order, with vernacular names (if known to the local people), life forms, ecological characteristics, nativity status, parts used, preparation methods, and ethnobotanical methods of use reported by the informants are presented in Table 2. Among the plant taxa reported, the Fabaceae (Leguminosae) occupy first place with 8 species (11.3%), followed by the Asteraceae/Compositae (5 species, i.e. 7.0%), Rubiaceae (5 species, i.e. 7.0%), Anacardiaceae (4 species, i.e. 5.6%), Euphorbiaceae (4 species, i.e. 5.6%), Lamiaceae, Malvaceae, Poaceae and Solanaceae with 3 species each, i.e. 4.2%. Also, seven botanical families documented in this study are composed of only two (2.8%) species each: Acanthaceae,

Table 1
Socio-demographic characteristics of informants in the study area.

Variables		Percentage
Sex	Female	62.02
	Male	37.98
Education level	Illiterate	16.4
	Adult	4.9
	Primary	25.3
	Secundary	18.1
	University	4.5
Age group	≤45	37.2
	[46-64]	34.5
	≥ 65	28.3
Occupation	Agriculture	67.4
	Liberal jobs	15.7
	Civil service	8.0
	Pupil and student	1.5
	Trading	7.4
Experience on used phytoterapy	≤ 5	18.46
	[6-10]	17.23
	>10	64.31

Apocynaceae, Cucurbitaceae, Moraceae, Myrtaceae, Solanaceae and Urticaceae. In addition, each of the nineteen (19) botanical families has only one species (1.4%), namely Amaranthaceae, Amaryllidaceae, Apiaceae, Asphodelaceae, Burseraceae, Caricaceae, Clusiaceae, Combretaceae, Convovulaceae, Costaceae, Crussulaceae, Hypericaceae, Lauraceae, Meliaceae, Ochnaceae, Phyllanthaceae, Polygalaceae, Rutaceae, and Zingiberaceae. In terms of generic richness, the richest families are the Fabaceae with 8 genera, followed by the Asteraceae (5 genera), Anacardiaceae (4 genera), Rubiaceae (4 genera), Lamiaceae (3 genera), Malvaceae (3 genera), Solanaceae (3 genera) and Poaceae with 2 genera. The other 27 botanical families listed have only one genus per family. Ultimately, the genera with the largest number of species represented in the present study are Annona (4 species) and Cymbopogon (2 species). The higher number of species represented in the Fabaceae family could be attributed to the species diversity, wider distribution, abundance of this family and associated knowledge of the Kimalalu flora and/or richness in medicinally active constituents. In agreement with Van Wyk (2020), the traditional African medicinal flora is dominated by the Fabaceae. The other dominant botanical families are Rubiaceae, Asteraceae, Malvaceae, Euphorbiaceae, Apocynaceae, Lamiaceae and Acanthaceae. The predominance of taxa from the Fabaceae family also corroborates the work of Ribeiro et al. (2010) in Mozambique, Mawunu et al. (2022b), Jandras et al. (2020) and Lautenschläger et al. (2018) in Angola, Djoza et al. (2021) in the Democratic Republic of Congo (DRC), Teshome et al. (2023) Teshome et al. (2023) in Ethiopia and Todou et al. (2023) in Cameroon.The medicinal use of the taxa in this family is probably explained by the bioactive elements they contain, in particular tannins, alkaloids, coumarins, steroids, saponosides, phenolic acids, lectins, carotenoids, flavonoids and isoflavonoids (Mekkiou, 2005; Usman et al., 2022).

3.2.1 Life forms, status of origin and habitats of the plants studied

Figure 2 shows the morphological shape of plants documented in the Kimalalu.

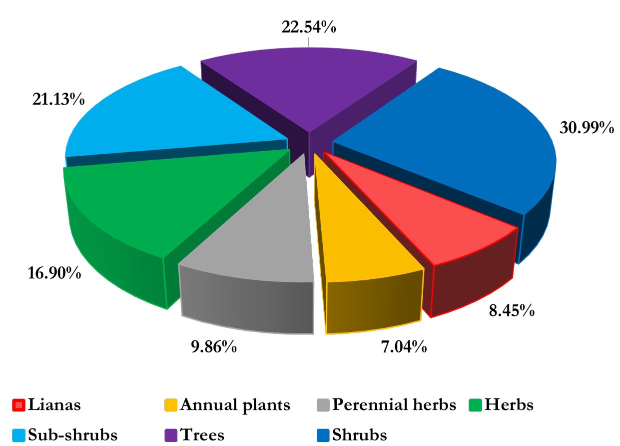

Figure 2. Growth forms of the plants studied (%).

The study showed that the most frequently cited life form was shrubs with 22 species (30.99%), followed by trees (16 species, i.e. 22.54%), sub-shrubs (15 species, i.e. 21.13%) and herbs with 12 species (16.90%), including 7 species of perennial herbs (9.86%), 5 species of annual plants (7.04%) and 6 species of lianas with 8.45% (Figure 2). Shrubs are the most commonly used plant species in the study area. This could be due to their abundance and accessibility in the region and the abundance of associated knowledge within the community. This study relates wiith Mawunu, and Manuel SP, et al. (2022), where dominance of shrubs in the medicinal flora of the Songo, Angola.

Table 2
List of medicinal plant species cited, parts used, methods of preparation and administration, symptoms and diseases treated and other details.

Plant species	Vernaculares Name	BT	PD	Leaf size types	Diaspores types	Growth lifes	Parts used	Ailments and symptoms	Preparation modes	Administration modes
Acanthaceae										
Brillantaisia owariensis P.Beauv.	Malemba lemba (Kik.)	Chd	GC	Meso	Ballo	Subshrub	Leaf	Measles, headache	Grinding	Dermal, bind on head
Dianthera secunda (Lam.) Griseb.	Makaya ma menga (Kik.), folha de Jeova (Port.)	Chd	GC	Meso	Ballo	Subshrub	Leaf	Anemia	Decoction	Oral intake, dermal
Amaranthaceae										
Dysphania ambrosioides (L.) Mosyakin & Clemants	Kinsidi nsimba (Kik.), Santa Maria (Port.)	Thd	Cosm	Nano	Sclero	Perennial herb	Leaf, whole plant	Fever, malaria, bronquitis, cold	Decoction	Bath, stem bath, inhilation, enema
Amaryllidaceae										
Allium sativum L.	Alho (Kik.)	Gb	Pan	Micro	Sclero	Annual herb	Bulb	Typhoid, Tuberculosis	Maceration, decoction	Oral intake
Anacariaceae										
Anacardium occidentale L.	Nkaziwa (Kik.), Cajueiro (Port.)	MsPh	Pan	Meso	Sarco	Tree	Leaf, stem, stem bark	Diabetes, toothache	Maceration	Oral intake, mouth wash
Mangifera indica L.	Manga (Kik), Mangueira (Port.)	MsPh	Pan	Meso	Sarco	Tree	Stem bark	Diarrhoea, Mastitis, breast milk infection	Maceration	Oral intake
Pistacia terebinthus L.	Terebintina (Port.)	McPh	Pal	Micro	Sarco	Shrub	Fruit, root	Typhoid, belly ache	Grinding, Maceration	Enema, oral intae
Spondias mombin L.	Mungiengie (Kik), Gajageira (Port.)	MsPh	Pan	Meso	Sarco	Tree	Leaf	Asthma, lordosis, bronchitis, mastitis, breast milk infection	Decoction, grinding	Oral intake

Continued on next page

Table 2 continued

Annonaceae										
Annona stenophylla subsp. cuneata (Oliv.) N.Robson	Lolua lolua, lololkiambulu (Kik.)	NPh	AT	Meso	Sarco	Subshrub	Leaf	Anemia/low haemoglobin, cold, fatigue	Maceration	Oral intake
Annona senegalensis Pers.	Lomboloka (Kik.)	NPh	AT	Meso	Sarco	Subshrub	Leaf	Anemia, diarrhea, fatigue	Decoction	Oral intake
Annona muricata L.	Sapi sapi (Port.)	McPh	Pan	Meso	Sarco	Shrub	Leaf, fruit	Stomachache, yellow fever	Decoction	Oral intake
Apiaceae										
Steganotaenia araliacea Hochst	Nkula mvumbi, munkula mvumbi (Kik.)	McPh	AT	Meso	Ptero	Shrub	Leaf	Back ache, stom-achache, body pain, cold	Decoction, Macera-tion	Oral intake, bath
Apocynaceae										
Catharanthus roseus (L.) G. Don	Beija mulato (Port.)	Nph	Pan	Micro	Sarco	Subshrub	Leaf	Diabetes, Amoeba	Decoction, Macera-tion	Oral intake
Mondia whitei (Hook.f.) Skeels	Nlondo londo, Kimbiolongua (Kik.)	LPh	GC	Macro	Ballo	Climbing	Root	Impotence	Chewing	Eating, oral intake
Asphodelaceae										
Aloe buettneri A.Berger	Ba dia nseke, aloe (Kik.)	Grh	GCSZ	Meso	Sarco	Perennial herb	Leaf	Snakebite, lordosis, Hep-atomegaly	Grinding, decoc-tion	Dermal, enema
Asteraceae										
Aspilia kotschyi (Sch.Bip. ex Hochst.) Oliv.	Lubini lua mbua (Kik.	Thd	AT	Nano	Pogo	Annual herb	Leaf, inflo-res-cence, stem	Cough, fever, fatigue	Grinding	Wound drops
Chromolaena odorata (L.) R.M.King & H. Rob	Kongo ya sika (Ling.)	Chd	Pan	Meso	Pogo	Perennial herb	Leaf	Wounds	Maceration	Oral intake

Continued on next page

Table 2 continued

Gymnanthemum amygdalinum (Delile) Sch.Bip.	Malulu, malulua, nlulu (Kik.)	Grh	AT	Meso	Pogo	Tree	Leaf	Skin infections, Abdominal bloating, Belly ache	Decoction	Oral intake
Helichrysum mechowianum Klatt	Lumpakuludi (Kik.)	Thd	AT	Micro	Pogo	Perennial herb	Leaf	Anemia	Grinding, macera-tion	Dermal, enema
Pleiotaxis rugosa O.Hoffm.	Ntelema katesa, Telema katesi (Kik.)	Chd	GC-Z	Micro	Sclero	Subshrub	Leaf, inflo-res-cence, stem	Anemia, diarrhea, diabetes, typhoid	Maceration	Oral intake
Burseraceae										
Pachylobus edulis G.Don	Nsafu (Kik.), Safueiro (Port.)	MsPh	BGC	Meso	Sarco	Tree	Leaf, stem bark	Canididiasis, toothache	Decoction	Dermal, Mouth Wash, oral intake
Caricaceae										
Carica papaya L.	Mamoeiro (Port.), Kikila (Kik.)	MsPh	Pan	Marco	Sarco	Tree	Fruit, root	Belly bloating, toothache, abdominal bloating	Chewing, dococ-tion, chewing	Eating, mouth wash
Clusiaceae										
Garcinia kola Heckel	Ngadiadia (Kik.)	MsPh	GC	Meso	Sarco	Tree	Seeds	Typhoid	Maceration, chewing	Oral intake, eating
Combretaceae										
Combretum racemosum P. Beauv.	Mussubiala, Nsumbi (Kik.)	LPh	GC	Micro	Ptero	Liana	Leaf	Diarrhoea	Grinding	Oral intak
Convolvulaceae										
Ipomoea batatas L.	Ramas de batata (Port.), Mbala nzenzo (Kik.)	Gt	Pan	Meso	Sarco	Creeping	Leaf	Anemia	Cooking	Eating
Costaceae										
Costus afer Ker Gawl.	Nsangalavu (Kik.)	Grh	AT	Meso	Sarco	Perennial herb	Culm, leaf	Hypertension, lordosis	Chewing, macera-tion	Oral intake
Crussulaceae										

Continued on next page

Table 2 continued

Kalanchoe crenata (Andrews) Haw.	Luyuki yuki (Kik.)	Nph	AT	Meso	Sclero	Subarbusto	Leaf	Earache	Heating	Ear Drops
Cucurbitaceae										
Momordica balsamina L.	Lumbuzu, mambuzu (Kik.)	Thgr	Pan	Micro	Sarco	Climbing	Leaf	Hernia, cryp-torchidism	Maceration, roast	Dermal, oral intake
Cucurbita pepo L.	Malengue (Kik.), abobora (Port.)	Thgr	Pan	Meso	Sarco	Creeping	Fruit pulp, seed	Stomachache	Decoction	Eating
Euphorbiaceae										
Alchornea cordifolia (Schumach. & Thonn.) Müll.Arg.	Gunze, muwunze, wunze (Kik.)	McPh	AT	Meso	Sarco	Shrub	Leaf	Vaginal canal dilatation	Maceration	Vaginal bath
Jatropha curcas L.	Mpuluka (Kik.)	MsPh	Pan	Meso	Ballo	Shrub,	Leaf, sap	Lordosis, ringworm, toothache	Decoction	Eye Drops
Manihot esculenta Crantz	Madioko (Kik.), Mandioqueira (Port.)	McPh	Pan	Meso	Ballo	Shrub	Tuber, leaf	Eye inflam-mation, eye parasites	Pressing	Oral intake, dermal, mouth wash
Maprounea africana Müll.Arg.	Nsiele nsiele (Kik.)	MsPh	AT	Micro	Ballo	Shrub	Root, stem bark	Chronic wounds, stom-achache, toothache	Grinding, decoc-tion, macera-tion	Apply to wound, eating, oral intake
Fabaceae										
Cajunus cajan L.	Wandu (Kik.)	Nph	Pal	Micro	Ballo	Shrub	Leaf	Vertigo, eye worms	Maceration, pressing	Face wath, eye drops
Dichrostachys cinerea subsp. Africana Brenan & Brummitt	Mvanga, nsende za mvanga (Kik.)	McPh	Pal	Lepto	Ballo	Shrub	Root	Inflammation	Grinding	Dermal
Entada abyssinica Steud. ex A.Rich.	Nsofi, Lusofi (Kik.)	McPh	AT	Micro	Ballo	Shrub	Root, leaf, stem, stem bark	Yellow fever, toothache, inflamma-tion, grinding	Decoction	Dermal, oral intake, mouth wash

Continued on next page

Table 2 continued

Erythrina abyssinica DC.	Mungominina, mungoma ngoma (Kik.)	MsPh	GC	Meso	Ballo	Shrub	Stem bark	Fatigue, yellow fever, typhoid, back pain, anemia	Decoction, maceration	Oral intake
Indigofera paracapitata J.B.Gillett	Mbaya ya londe,Diamba dia nseke (Kik.)	Thd	GC	Nano	Pogo	Subshrub	Leaf, inflorescences	Anemia, fatigue	Decoction, maceration	Oral intake
Millettia versicolor Welw. ex Baker	Mbota (Kik), Pau ferro (Port.)	MsPh	BGC	Meso	Ballo	Shrub	Leaf, stem bark	Hernia, inflammation, body ache	Decoction, peeling	Dermal, oral intake, tie
Senna occidentalis (L.) Link	Manioka nioka, Dinioka nioka (Kik.)	Nph	Pan	Micro	Ballo	Subshrub	Leaf, root	Diarrhea, blood diarrhoea, belly ache, diabetes, typhoid	Decoction, grinding, maceration	Oral intake, enema
Vigna unguiculata L.	Mbuengue (Kik.)	Thgr	Pan	Meso	Ballo	Creeping	Leaf	Abdominal varices	Grinding	Dermal
Hypericaceae										
Harungana madagascariensis Lam: Ex Poir	Ntunu, muntunu (Kik.)	MsPh	AM	Meso	Sarco	Tree	Stem bark	Hepatitis, yellow fever	Decoction	Oral intak
Lamiaceae										
Ocimum gratissimum L.	Mansusu nsusu, dinsu nsu (Kik.)	Chd	Pal	Meso	Sclero	Shrub	Leaf	Cough, asthma, lordosis, eaeache	Pressing, decoction, maceration, grinding	Oral intake, steam bath, eye drops, dermal
Mesosphaerum suaveolens (L.) Kuntze	Nkama nsongo (Kik.)	Thd	AA	Micro	Desm	Subshrub	Leaf, inflorescence, stem	Cough, fever, cold, malaria	Maceration	Eating, oral intake

Continued on next page

Table 2 continued

Vitex madiensis Oliv.	Mfilu, mufilu (Kik.)	Nph	AT	Nano	Sarco	Shrub	Leaf, stem bark	Diarrhoea, candidiasis, anemia, fatigue, low haemoglobin	Chewing, dococ- tion, macera- tion	Steam bath, inhalation
Lauraceae										
Persea americana Mill.	Abacateiro (Port.), Mvoka (kik.)	MsPh	Pan	Meso	Sarco	Tree	Leaf, seed	Hypertension, Anemia, Low haemoglobin, Stom- achache, Measles	Decoction, Grind- ing	Oral intake, dermal
Malvaceae										
Gossypium barbadense L.	Algodão (Port.), Mavusu (Kik.)	McPh	Pan	Nano	Pogo	Shrub	Leaf	Candidiasis, vomiting	Decoction, Grind- ing	Oral intake
Hibiscus acetosella Welw. ex Hiern	Ngai ngai Ling.), Usse (Port.)	Nph	Pal	Meso	Desm	Subshrub	Leaf	Low haemoglobin/anemia	Grinding	Dermal
Sida acuta Burm.f.	Mimvumvu. Mumvumvu (Kik.)	Nph	Pan	Micro	Ballo	Subshrub	Leaf	Panaris, headache	Cooking	Eating
Meliaceae										
Azadirachta indica A. Juss	Cura tudo (Port.)	MsPh	Pan	Micro	Sarco	Tree	Leaf	Malaria, cold, fever	Decoction	Enema
Moraceae										
Dorstenia psilurus Welw.	Mikombo, Kintamba (Kik.)	Chrh	GC	Meso	Ballo	Subshrub	Root	Belly ache	Decoction, grind- ing, macera- tion	Enema
Ficus sycomorus L.	Nkuzu, kienga (Kik.), Pau mulado (Port.)	MsPh	GS- Z	Meso	Sarco	Tree	Leaf	Anemia/low haemoglobin	Decoction	Oral intake
Myrtaceae										
Corymbia citriodora (Hook.) K.D.Hill & L.A.S.Johnson	Eucalipto (Port.)	MsPh	Pan	Meso	Sarco	Tree	Leaf	Cough, asthma	Decoction	Oral intake
Psidium guajava L.	Ngavua, mfuluta (Kik.)	MsPh	Pan	Meso	Baro	Shrub	Leaf	Diarrhoea	Chewing	Mouth Wash
Ochnaceae										

Continued on next page

Table 2 continued

Ochna afzelii subsp. Mechowiana (O.Hoffm.) N. Robson	Nkosi nti, Ngo nti (Kik.)	MsPh	GC	Meso	Ballo	Tree	Stem bark	Anemia	Decoction	Oral intake
Phyllanthaceae										
Bridelia ferruginea Benth.	Mwindu, nkangati (Kik.)	McPh	Pan	Meso	Sarco	Tree	Stem bark	Eye pain, chronic wounds	Grinding	Apply to wound, Eye Drops
Poaceae										
Cymbopogon citratus stapt	Sinde dia mputu (Kik.), Chá cachinda (Port.)	Hce	Pan	Micro	Scl	Perennial herb	Leaf	Yellow fever	Decoction	Oral intake
Cymbopogon densiflorus (Steud.) Stapf	Sangu sangu, Lusangu sangu (Kik.)	Hce	GC	Micro	Sclero	Perennial herb	Leaf, inflo-res-cence	Cough, fever, asthma	Maceration	Oral intake
Saccharum officinarum L.	Mukuku, Muinse (Kik.), Cana de açúcar (Port.)	Hce	Pan	Meso	Sclero	Perennial herb	Culm	Yellow fever, body weakness, vomiting	Chewing, decoc-tion	Oral intake, dermal
Polygalaceae										
Securidaca longepedunculata Fresen.	Nsunda, usunda, nsunda nsunda (Kik.)	McPh	AT	Micro	Ptero	Shrub	Root	Inflammation, body ache, cold, con-stipation, lordosis, Gonor-rhoea, thrombosis	Grinding, macera-tion	Dermal, enema, inhalation, oral intake
Rubiaceae										
Crossopteryx febrifuga (Afzel. ex G.Don) Benth	Mvala (Kik)	McPh	AT	Micro	Sarco	Shrub	Root	Toothache	Decoction	Mouth Wash, oral intake
Gardenia ternifolia subsp. jovis-tonantis (Welw.) Verdc.	Nlemba nzau (Kik.)	McPh	AT	Meso	Sarco	Shrub	Root, fruit	Inflammation, belly ache, diarhoea, toothahe	Grinding, decoc-tion	Dermal, mouth wash, oral intake
Morinda lucida Benth	Nsiki, musiki (Kik.)	MsPh	GC	Meso	Sarco	Shrub	Leaf	Belly ache, diarrhoea	Decoction	Oral intake

Continued on next page

Table 2 continued

Nauclea latifolia Sm.	Lolo, Nlolo (Kik.)	McPh	AT	Meso	Sarco	Shrub	Root, stem bark	Impotence, hernia, typhoid, anemia	Chewing	Eating, oral intake, dermal
Nauclea pobeguinii (Hua ex Pobég.) Merr.	Nganzi, Muzelenga, Nzelenge (Kik.)	MsPh	GC	Meso	Sarco	Tree	Stem bark, root bark	Bladder pain, diabetes, typhoid, malaria	Maceratio, decoc-tion	Oral intake
Rutaceae										
Citrus sinensis (L.) Osbeck	Laranjeira (Port.)	MsPh	Pan	Micro	Sarco	Shrub	Root, leaf	Urinary tract infections, cough	Decoction	Oral intake,
Solaceae										
Capsicum frutescens L.	Ndungu za fioti (Kik.)	Thd	Pan	Micro	Sarco	Subshrub	Leaf	Lordosis	Decoction	Oral intake
Nicotiana tabacum L.	Tumbaku, Mfomo (Kik.)	Thd	Pan	Macro	Sarco	Annual herb	Leaf	Hemorrhoid, Cryp-torchidism	Heating, pressing	Nose drops, put on nose
Solanum lycopersicum L.	Tomateiro (Port) Lumatu (Kik)	Thpr	Pan	Micro	Sarco	Subshrub	Leaf	Headache	Roast	Dermal
Urticaceae										
Laportea aestuans (L.) Chew	Vidi, mansiensie (Kik)	Thd	Pan	Meso	Sclero	Annual herb	Leaf	Anemia, asthma, cough	Decoction	Oral intake
Musanga cecropioides R.Br. ex Tedlie	Nsenga, nsega nsenga, Musenga (Kik.)	MsPh	GC	Macro	Sarco	Tree	Root	Dehydration, diarrhoea	Incision	Oral intake
Zingiberaceae										
Aframomum melegueta K.Schum.	Ndungu za nzo (Kik.)	Grh	AM	Meso	Sarco	Annual herb	Seeds	Angina	Chewing	Oral intake

In contrast, Lautenschläger et al. (2018) in their first large-scale ethnobotanical study in the province of Uíge, northern Angola, reported that trees were in the majority compared to other life forms. Additionally, with regard to the status of origin of the medicinal plants recorded in this study, the majority were indigenous species (41 species, i.e. 57.75%) while the remainder (30 species, i.e. 40.25%) were of exotic or introduced (allochthonous) origin. Lastly, of all the medicinal plants (72 species) collected and identified in the study area, the majority (29.9%) came from allotments in the vicinity of dwellings. The other medicinal plant harvesting sites were savannah (21%), fallow land (18.6%), forest (16.8%) and cultivated fields (13.6%). (Mawunu, and Manuel SP, et al., 2022) who studied the medicinal flora of the small town of Songo reported that the greater part (67.4%) of medicinal plants were of exotic origin. With regard to habitat, Lautenschläger et al. (2018) also reported that the majority of medicinal plants grew in savannahs and forests.

3.2.2 Parts of plants used in the preparation of phytoremedes

Figure 3 shows the different parts of plants used to treat human diseases in the study area.

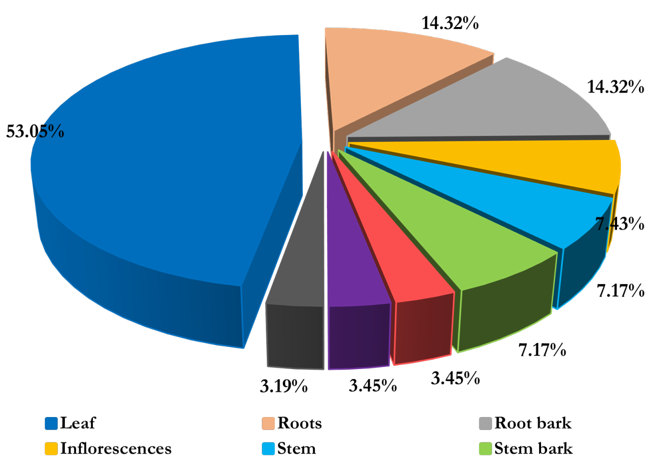

Figure 3. Parts of medicinal plants used in the Kimalalu flora (%).

Medicinal preparations were made from a single part of the plant or a combination of several plant parts. Figure 3 shows that the leaf was the part of the plant most commonly used to make phytomedicines in Kimalalu (53.05%), followed by roots and root bark (14.32%), inflorescences (7.43%), stem and stem bark (7.17%), seeds (2.65%), fruit and fruit pulp (3.45%), tubers (0.27%) and sap with 0.27% (Figure 3). The use of leaves as compared to roots is considered less destructive especially to trees and shrubs. It is important to note that, in some species, more than one part was used in the preparation of phytomedicines. Leaves were the dominant plant parts employed in remedy preparations for the treatment of human in the study area, which could be attributed to their perceived efficacy, accessibility, ease of harvesting, and simplicity of preparation. Our results are in line with the conclusions of similar studies carried out in Angola and elsewhere in the world (Abadi et al., 2023; Camacho-Hernández et al., 2022; Djoza et al., 2021; Lautenschläger et al., 2018; Liyongo et al., 2023; Mawunu, and Manuel SP, et al., 2022; Mobale et al., 2023; Pisco et al., 2024) in which the most widely used part of the plant was also the leaves, used to treat various human ailments.

Also, the preference for leaves for medicinal production is a positive result for the conservation of plant resources. Collecting leaves in moderation neither harms nor affects the health, reproduction or development of the plant. This practice is linked to the abundance and convenience of using leaves compared to other parts of the plant, as well as to confidence in the effectiveness of its use (Santos et al., 2008). Lastly, harvesting leaves has been reported to have much less damaging effects on the mother plant as compared to other parts such as roots and barks, the gathering of which could seriously affect the existence of individual plants (Teka et al., 2020).

3.3. Ecological characteristics of the flora studied

3.3.1 Biological types

Data on the biological types of the flowering plant studied are shown in Figure 4 .

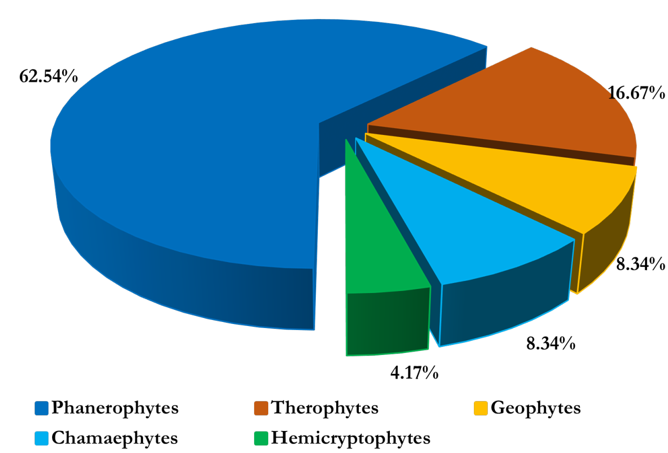

Figure 4. Biological types of documented plants (%).

The biological types show a predominance (Figure 4) of Phanerophytes with 45 species, i.e. 62.54% of the flora inventoried; followed by Therophytes with 12 species, i.e. 16.67%; Geophytes with 6 species, i.e. 8.34%; Chamaephytes with 6 species, i.e. 8.34% and Hemicryptophytes with 3 species, i.e. 4.17% of the flora studied. This predominance of Phanerophytes gives a forest-like appearance to the flora studied. Among the Phanerophytes, mesophanerophytes (MsPh) are the most preponderant with 21 species, i.e. 29.17% of the flora, followed by microphanerophytes (McPh) with 13 species, i.e. 18.06%; nanophanerophytes (NPh) with 9 species, i.e. 12.50%; and creeping phanerophytes (CPh) with 2 species, i.e. 2.78% of the flora. Cryptophytes include rhizomatous geophytes (Grh) with 4 species (5.56%) and tuberous geophytes (Gt) with 1 species (1.39%). Within the Therophytes, there are erect therophytes (The) with 8 species, i.e. 11.11%, climbing therophytes (Thc) with 3 species, i.e. 4.17% and prostrate therophytes (Thpr) with 1 species, i.e. 1.391%. In the Chamaephytes, we distinguish the erect chamaephytes (Che) with 5 species, i.e. 6.94% and the rhizomatous chamaephytes (Chrh) with 1 species, i.e. 1.39% of the flora studied. Lastly, there are the Hemicryptophytes (Hce), with only 3 species, or 4.17% of the flora inventoried. The abundance of phanerophytes proves the forested nature of the study site. The present results are in agreement with previous studies carried out in the same region by (Mawunu, Kiangala, et al., 2023), who reported that the dominance of phanerophytes (52.2%) in the ethnobotanical survey of herbal teas consumed in the province of Uíge (Angola) reflects the state of vegetation in the tropics. These results corroborate those of research carried out on the flora of the Wamba valley in the DRC (Théophane et al., 2022).

3.3.2 Phytogeographical distribution of documented plants

Table 3 shows the phytogeographical distribution of the flora studied in the Kimalalu community in the Uíge province.

Table 3 shows that the proportion of species with a very wide distribution (51.39%) and African species with a wide distribution (41.67%) are the most important in the flora studied. The largest of the medicinal flora studied is made up of tropical species with 68.05% (Table 3), including 29 pantropical species representing 40.28% of the total and 15 Afro-tropical species, i.e. 20.83%. Paleotropical species followed (5/72, i.e. 6.94%), Lower-Guineo-Congolese (2/72, i.e. 2.78%), and Afro-Malagasy (2/72, i.e. 2.78%). Also, the Afro-American, Cosmopolitan, Guineo-Congolese-Zambezian, Guineo-Congolese-Sudanese and Guineo-Congolese-Sudanese-Zambezian species each have 1 species with 1.39% (1/72). The present results are in agreement with the previous study carried out in northern Angola by (Mawunu, Kiangala, et al., 2023). These results corroborate research carried out in the DRC by Théophane et al. (2022), Masengo et al. (2024).

3.3.3 Types of foliar dimensions

The overall analysis of the types of leaf dimensions of all the species inventoried in the Kimalalu is illustrated in Figure 5.

Figure 5 shows that mesophyll species are more numerous; they make up 41 species, or 56.94% of the total number of plants in the flowering bed. Microphylls accounted for 21 species (29.17%), nanophylls for 5 species (6.94%), macrophylls for 4 species (5.56%) and leptophylls for 1 species (1.39%). Similar results were also reported by Théophane et al. (2022), and Pisco et al. (2024) in the DRC.

3.3.4 Types of diaspora

Analysis of diaspora types produced the results shown in Figure 6.

Analysis of the spectra of diaspores highlights the clear dominance (Figure 6) of Zoochores with 35 species, i.e. 48.61% of the florule inventoried. These types of diaspores are spread

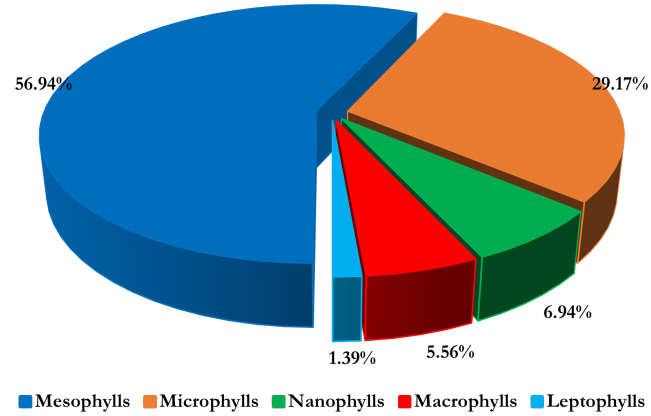

Figure 5. Types of foliar dimensions of the flora studied (%).

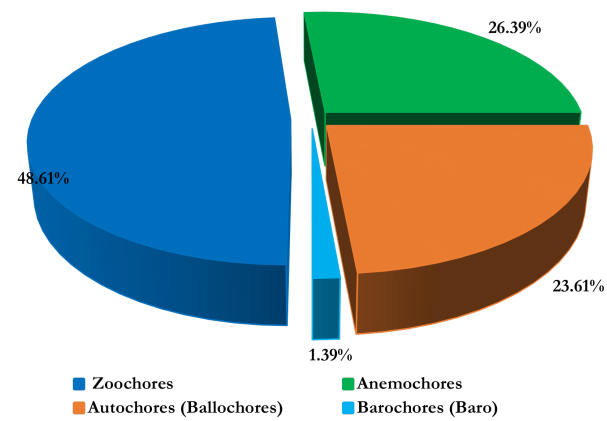

Figure 6. Types of diaspores in the flora studied (%).

by animals (Zoochory). Anemochores followed with 19 species (26.39%); Autochores (Ballochores) with 17 species (23.61%); and Barochores (Baro) with 1 species (1.39%). Among the Zoochores, the Sarcochores (Sarco) are the most dominant with 33 species, i.e. 45.83% of the florule studied and 94.29% of all the Zoochores in the florule inventoried; then come the Desmochores (Desm) with 2 species, i.e. 2.78% of the florule inventoried and 5.71% of all the Zoochores in the florule studied. Among the Anemochores, we find Sclerochores with 10 species, i.e. 13.89% of the flora inventoried and 52.63% of all the Anemochores in the flora studied; Pterochores with 3 species, i.e. 4.17% of the florule inventoried and 15.79% of all the Anemochores and Pogonochores with 6 species, i.e. 8.33% and 31.58% of all the Anemochores in the florule inventoried. Similar results were reported by Théophane et al. (2022) in their study of the flora of the Wamba valley in the DRC.

3.4. Ethnomedicinal data on the flora plant studied

3.4.1 Solvents and methods used in the preparation of phytomedicaments

It should be noted that the informants used several solvents when preparing the phytomedicines, in particular water (96.6%), palm wine (2.4%) and honey (1.2%). Furthermore, some remedies were prepared without the additional solvents

Table 3
Phytogeographical distribution of the flora studied

Phytogeographical distribution	Species number	Percent
I. Species with largest distribution	**37**	**51.39**
Afro-Americans (AA)	2	2.78
Cosmopolites (Cosm)	1	1.39
Paleotropical (Pal)	5	6.94
Pantropical (Pan)	29	40.28
II. African species with largest distribution	**30**	**41.67**
Afro-malagasy (AM)	2	2.78
Afro-tropical (AT)	15	20.83
Guineo-Congolese (GC)	13	18.06
Guineo-congolo-sudanese-zambezian (GCSZ)	1	1.39
Guinean-Congolian-Sudanese (GCS)	1	1.39
Guineo-Congolese-Zambezians (GCZ)	1	1.39
III. Guinean-Congolian regional species	**2**	**2.78**
Lower Guinean-Congolese (LGC)	2	2.78
General total	**72**	**100**

mentioned above.

3.4.2 Methods of preparing phytoremedias

Figure 7 shows the different methods of preparing phytoremedias used by the Kimalalu communities.

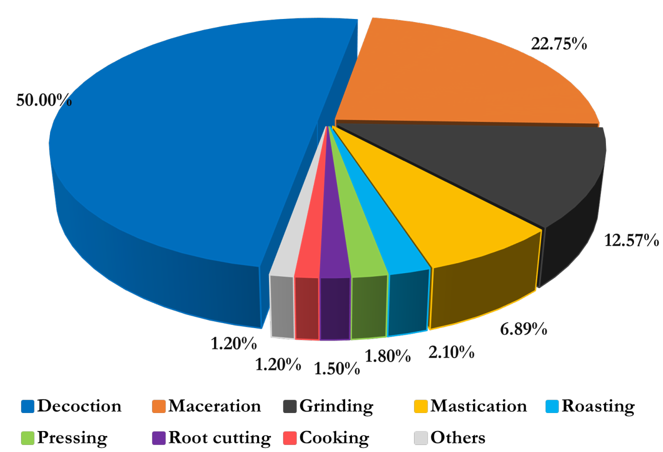

Figure 7. Preparation methods for medicinal plants used to treat human ailment (%).

Various traditional methods of preparing phytomedicines were used in the study area (Figure 7). The preparation method most commonly used to treat human diseases was decoction (50.00%). The other preparation methods used to make phytomedicines were maceration (22.75%), grinding (12.57%), mastication (6.89%), cooking (2.78%), pressing (1.80%), root cutting (1.50%), roasting (2.10%), cooking (1.20%), heating (0.60%), peeling (0.30%) and incision (0.30%) (Figure 7). The common practice of decoction as a method of preparing medicinal plants can be explained by the fact that it is an easy way to collect the main medicinally active compounds (active ingredients) and to attenuate or eliminate toxic substances present in some medicinal plants (Lazli et al., 2019). Also, Li et al. (2024), reported that decoction is generally considered the most common method of herbal medicine preparation because it can easily and effectively extract the active ingredients from the plant materials. Similar results have been reported by authors such as Lautenschläger et al. (2018) and Mawunu, and Manuel SP, et al. (2022) in Angola, Ngbolua et al. (2021) in DRC, and Moncayo and Diago (2022) in Colombia that decoction is the main preparation method in traditional therapeutic recipes. Furthermore, the study by Canga et al. (2022) showed that the use of maceration to prepare a remedy was the most frequently used preparation method.

3.4.3 Phytoremediation routes

With respect to the routes of remedy administration, the local community recommends different routes depending on the type of disease treated. Figure 8 shows the different methods of administration used by the Kimalalu communities.

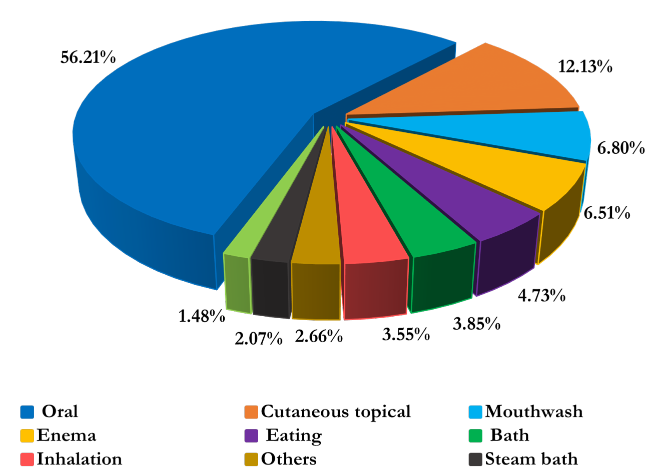

Figure 8. Phytoremediation methods (%).

There are different ways of administering the traditional medicinal products prepared by the local community of Kimalalu. Seventeen (17) methods of administering herbal treatments are used by the Kimalalu communities in northern Angola (Figure 8). The most frequently used route of administration is oral (56.21%), followed by cutaneous topical (12.13%), mouthwash (6.8%), enema (6.51%), inhalation (3.55%), eating (4.73%), bath (3.85%), steam bath (2.07%) and eyewash with 1.48% (Figure 8). Other methods of administering phytomedicines (tying on the head, ear drops, face wash, nasal drops, etc.) accounted for 2.66%. Oral was the most popular route of remedy administration which could be due to the reason that it creates favorable environmental condition for quick physiological reaction of the preparation against the pathogens and by so doing boosts its healing power. Oral administration has an additional advantage in that it allows the traditional medicine practitioners to reverse complication that might happen on the clients during treatment using antidotes. The results of this study are in agreement with other studies such as Mawunu, and Manuel SP, et al. (2022); Pisco et al. (2024), and Lautenschläger et al. (2018) who reported that the oral route of administration (per os) is the most commonly used in Northern Angola.

The frequent use of oral absorption as a route of administration for medicinal plants may be related to the fact that it is rapid and provides a large effective surface area for absorption of the active drug components (Hillery et al., 2001). Oral administration has an additional advantage in that it allows the traditional medicine practitioners to reverse complication that might happen on the clients during treatment using antidotes. Once absorbed, the drug passes through the intestinal wall and liver before being transported to target sites via the bloodstream (Kwon, 2005).

3.4.4 Diseases and symptoms treated by phytotherapy

The study identified 59 human symptoms and illnesses treated with phytomedicines by the inhabitants of Kimalalu. Figure 9 shows the diseases and symptoms treated with medicinal plants, highlighting the sixteen main illnesses documented in the study area.

According to the data in Figure 9, the condition that most affected Kimalalu residents during the ethnobotanical surveys was low haemoglobin (12.53%) - commonly known as anaemia. This was followed by yellow fever (6.04%), abdominal pain (5.59%), toothache (5.37%), cough (4.70%), typhoid fever (4.25%), fever (4.25%), malaise (4, 25%) and diarrhoea (4.25%), malaria (3.36%), lordosis (2.91%), diabetes (2.91%), colds (2.91%), asthma (2.91%), inflammation (2.46%) and gastritis (2.24%). Studies by Mawunu, and Manuel SP, et al. (2022) reported that in the small town of Songo, medicinal plants were used more for the treatment of coughs, anaemia, malaria and diarrhoea. Besides, Canga et al. (2022) reported the dominance of infectious and parasitic diseases, notably malaria, leprosy and cholera. Further, Pathy et al. (2021) in the city of Mbanza Ngungu in the DRC reported that haemorrhoids,

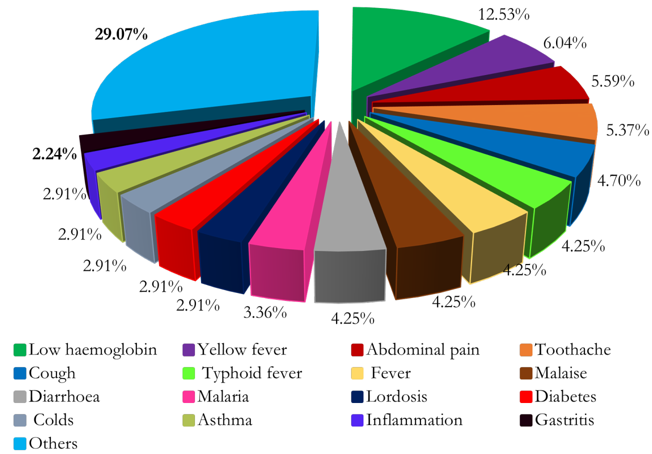

Figure 9. Main diseases and symptoms documented at Kimalalu (%).

hernia and sexual impotence were the most prevalent diseases.

3.5. Relationships between botanical families and conditions treated

Table 4 shows the relationships between botanical families and the ailments treated with medicinal plants in Kimalalu.

The data in Table 4 show that medicinal plants in the Fabaceae family treat more (17) of the diseases and symptoms of all 35 botanical families documented in this study. Next come the Rubiaceae families with 13 ailments; Asteraceae (11 ailments); Lamiaceae (11 ailments); Anacardiaceae (9 ailments); Euphorbiaceae (9 ailments): Polygalaceae (8 ailments); Annonaceae (6 ailments); Amaranthaceae, Malvaceae, Myrtaceae, Poaceae, Solanaceae, and Urticaceae each treat 5 ailments; Apiaceae and Lauraceae treat 4 ailments; Acanthaceae, Apocynaceae, Asphodelaceae, Caricaceae, Clusiaceae, Cucurbitaceae, Hypericaceae and Meliaceae each treat three conditions; Amaryllidaceae, Moraceae and Phyllanthaceae each treat two conditions. As well, the botanical families that treat just one ailment are the Burseraceae, Combretaceae, Convolvulaceae, Crussulaceae and Zingiberaceae. In the same province, Mawunu, Panzo, et al. (2022) reported that the Solanaceae family is the most used in traditional medicine in the small city of Songo with 15 different therapeutic uses, followed by Caricaceae (13 medicinal uses), Lamiaceae (12 medicinal uses), Asteraceae (12 medicinal uses), Anacardiaceae (11 medicinal uses), Poaceae (10 medicinal uses), Malvaceae (10 medicinal uses), Fabaceae (10 medicinal uses), Euphorbiaceae (10 medicinal uses), Lauraceae (7 medicinal uses), Annonaceae (7 medicinal uses), Acanthaceae (7 medicinal uses), Amaranthaceae (5 medicinal uses), Burseraceae (5 medicinal uses), and Rubiaceae (5 medicinal uses).

3.6. Relationships between human diseases and medicinal plants in Kimalalu

Table 5 shows the relationships between human diseases and the medicinal plants used by theKimalalu population.

Table 4
Relations entre familles botaniques et affections médicales.

Botanical family	Ailments and symptoms	Number of ailments
Acanthaceae	Headache, measles, low haemoglobin	3
Amaranthaceae	Fever, malaria, bronquitis, cold, belly ache	5
Amaryllidaceae	Tuberculosis, typhoid	2
Anacardiaceae	Mastitis, lordosis, bronchitis, asthm, belly ache, typoid, breast milk infection, diabetes, toothache	9
Annonaceae	Diarrhoea, cold, fatigue, low haemoglobin, stomachache, yellow fever	6
Apiaceae	Backache, body pain, cold, stomachache	4
Apocynaceae	Diabetes, amoeba, impotence	3
Asphodelaceae	Lordosis, snakebite, hepatomegaly	3
Asteraceae	Belly ache, skin infections, abdominal bloating, diarrhoea, typhoid, diabetes, low haemoglobin, cough, fever, fatigue, wounds	11
Burseraceae	Toothache	1
Caricaceae	Belly bloating, toothache, abdominal bloating	3
Clusiaceae	Typhoid, belly ache, stomachache	3
Combretaceae	Diarrhoea	1
Convolvulaceae	Anemia	1
Crussulaceae	Earache	1
Cucurbitaceae	Hernia, cryptorchidism, stomachache	3
Euphorbiaceae	Chronic wounds, stomachache, toothache, vaginal canal dilatation, eye inflammation, eye worms, lordosis, rigworm, toothache	9
Fabaceae	Belly ache, blood diarrhoea, diarrhoea, diabetes, typhoid, low haemoglobin, fatigue, hernia, inflammation, body ache, abdominal varices, yellow fever, back pain, vertigo, eye worms, kwashiorkor, toothache	17
Hypericaceae	Hepatitis, yellow fever	3
Lamiaceae	Cough, asthma, lordosis, earache, diarrhoea, candidiasis, low haemoglobin, fatigue, fever, cold, malaria	11
Lauraceae	Hypertension, measles, stomachache, low haemoglobin	4
Malvaceae	Candidiasis, vomiting, low haemoglobin, panaris, headache	5
Meliaceae	Malaria, cold, fever	3
Moraceae	Belly ache, low haemoglobin	2
Myrtaceae	Cough, asthma, diarrhoea, diabetes, typhoid	5
Ochnaceae	Low haemoglobin	1
Phyllanthaceae	Eye pain, chronic wounds	2
Poaceae	Asthma, bronchitis, yellow fever, body weakness, vominting	5
Polygalaceae	Body ache, bronchitis, cold, constipation, gonorrhoea, inflammation, lordosis, thrombosis	8
Rubiacece	Inflammation, typoid, malaria, bladder pain, diabetes, belly ache, diarrhoea, toothache, urinary tract infections, impotence, hernia, typhoid, low haemoglobin	13
Solanaceae	Headache, lordosis, hemorrhoid, cryptorchidism	5
Urticaceae	Low haemoglobin, asthma, cough, diarrhoea, dehydration	5
Zingiberaceae	Angina	1

Table 5
Main ailments treated with phytomedicines in Kimalalu.

Ailments	Medicinal plants used	Number of plants mentioned
Asthma	*Corymbia citriodora* *Cymbopogon densiflorus* *Laportea aestuans* *Ocimum gratissimum* *Spondias mombin*	5
Belly ache	*Crossopteryx febrifuga* *Dorstenia psilurus* *Dysphania ambroisioides* *Entada abyssinica* *Garcinia kola* *Gardenia ternifolia* subsp. jovis-tonantis *Gymnanthemum amygdalinum* *Morinda lucida* *Pistacia terebinthus* *Senna occidentalis*	10
Cold	*Annona stenophylla* subsp. cuneata *Azadirachta indica* *Dysphania ambroisioides* *Mesosphaerum suaveolens* *Securidaca longepeduncula* *Steganotaenia araliacea*	6
Cough	*Aspilia kotschyi* *Corymbia citriodora* *Laportea aestuans* *Ocimum gratissimum* *Mesosphaerum suaveolens*	5
Diabetes	*Anacardium occidentale* *Catharanthus roseus* *Nauclea pobeguinii* *Pleiotaxis rugosa* *Psidium guajava* *Senna occidentalis*	6
	Annona senegalensis *Combretum racemosum* *Gardenia ternifolia* subsp. jovis-tonantis	

Continued on next page

Table 5 continued

Ailments	Medicinal plants used	Number of plants mentioned
Diarrhoea	*Morinda lucida*	9
	Musanga cecropioides	
	Pleiotaxis rugosa	
	Psidium guajava	
	Senna occidentalis	
	Vitex madiensis	
Fatigue	*Annona senegalensis*	6
	Annona stenophylla subsp. cuneata	
	Aspilia kotschyi	
	Erythrina abyssinica	
	Indigofera paracapitata	
	Vitex mandiensis	
Inflammation	*Entada abyssinica*	5
	Dichrostachys cinerea subsp. Africana	
	Gardenia ternifolia subsp. jovis-tonantis	
	Millettia versicolor	
	Securidaca longepeduncula	
Lordosis	*Aloe buettneri*	6
	Capsicum frutescens	
	Jatropha curcas	
	Ocimum gratissimum	
	Securidaca longepeduncula	
	Spondias mombin	
Low haemoglobin	*Annona stenophylla* subsp. cuneata	16
	Hibiscus acetosella	
	Persea americana	
	Vitex mandiensis	
	Annona senegalensis	
	Annona stenophylla subsp. cuneata	
	Dianthera secunda	
	Erythrina abyssinica	
	Ficus sycomorus	
	Helichrysum mechowianum	
	Indigofera paracapitata	
	Ipomoea batatas	
	Laportea aestuans	
	Sarcocephalus latifolius (*Nauclea latifolia*)	
	Ochna afzelii subsp. mechowiana	
	Pleiotaxis rugosa	

Continued on next page

Table 5 continued

Ailments	Medicinal plants used	Number of plants mentioned
Stomachache	*Annona muricata* *Cucurbita pepo* *Garcinia kola* *Maprounea africana* *Persea americana* *Steganotaenia araliacea*	6
Toothache	*Anacardium occidentale* *Carica papaya* *Crossopteryx febrifuga* *Entada abyssinica* *Gardenia ternifolia* subsp. jovis-tonantis *Jatropha curcas* *Maprounea africana* *Pachylobus edulis*	8
Typhoid	*Allium sativum* *Erythrina abyssinica* *Garcinia kola* *Sarcocephalus latifolius* (*Nauclea latifolia*) *Nauclea pobeguinii* *Pistacia terebinthus* *Pleiotaxis rugosa* *Psidium guajava* *Senna occidentalis*	9
Yellow fever	*Cymbopogon citratus* *Entada abyssinica* *Erythrina abyssinica* *Harungana madagascariensis* *Saccharum officinarum* *Annona muricata*	6

Of the 59 illnesses and symptoms documented in this study, the greatest number of medicinal plants were used to treat low haemoglobin levels, with 16 species with 22.54% (Table 5). Next came stomach ache with 10 species (14.08%), diarrhoea (9 species, i.e. 12.68%), typhoid (9 species, i.e. 12.68%), toothache (8 species, i.e. 11.27%), diabetes (7 species, i.e. 9.86%), colds (6 species, i.e. 8.45%), fatigue (6 species, i.e. 8.45%), lordosis (6 species, i.e. 8.45%), stomach ache (6 species, i.e. 8.45%), yellow fever (6 species, i.e. 8.45%), cough (5 species, i.e. 7.04%), and inflammation with 5 species (7.04%) of medicinal plants. Furthermore, the other diseases are treated by less than 5 medicinal plant species. Table 5 shows the thirteen main illnesses treated with phytomedicines in Kimalalu. According to (Mawunu, and Manuel SP, et al., 2022) cough is the main illness treated with the highest number of medicinal plants in the small town of Songo (in northern Angola), with 17 species in total, followed by anaemia (14 species), stomach ache (8 species), yellow fever (8 species.), malaria (8 species), diarrhoea (7 species), fever (6 species), hypertension (6 species), malaria (6 species), typhoid (6 species), hepatitis (5 species), worms (5 species), asthma (4 species), skin infection (4 species), stomach infection (4 species) and toothache (4 species).

3.7. Relationship between medicinal plants and ailments treated at Kimalalu

The results of this study reveal that the most versatile medicinal plant in the study area is Securidaca longepedunculata, which treats eight (8) human ailments: body pain, bronchitis, colds, constipation, gonorrhoea, inflammation, lordosis, thrombosis). In addition, the other medicinal plants most frequently used in the treatment of human illnesses are: *Spondias mombin* (mastitis, lordosis, bronchitis, asthma, breast milk infection); *Senna occidentalis* (stomach ache, bloody diarrhoea, diarrhoea, diabetes, typhoid); *Saccharum officinarum* (yellow fever, body weakness, vomiting); Pleiotaxis rugosa (low haemoglobin, diabetes, diarrhoea, typhoid); *Persea americana* (hypertension, measles, stomach ache, low haemoglobin). Also, *Sarcocephalus latifolius* (*Nauclea latifolia*) (impotence, hernia, typhoid, anaemia); *Nauclea pobeguinii* (typhoid, malaria, bladder pain, diabetes); *Mesosphaerum suaveolens* (cough, fever, cold, malaria); *Entada abyssinica* (stomachache, inflammation, yellow fever, toothache); *Steganotaenia araliacea* (backache, body aches, cold, stomachache); and *Vitex mandiensis* (diarrhoea, candidiasis, low haemoglobin, fatigue). All in all, the other medicinal plants have only been used to treat one to three human ailments. Mawunu, and Manuel SP, et al. (2022) reported that Carica papaya was the most used herbal plant in traditional medicine treating 13 different symptoms and diseases commonly documented in the small town of Songo, followed by *Gymnathemum amygdalinum* with 8 medicinal uses, *Annona muricata* (7 medicinal uses), *Solanum lycopersicum* (6 medicinal uses), *Persea americana* (6 medicinal uses), *Brillantaisia owariensis* (6 medicinal uses), *Abelmoschus esculentus* (6 medicinal uses), *Pachylobus edulis* (5 medicinal uses), *Manihot esculenta* (5 medicinal uses), *Mangifera indica* (6 medicinal uses), *Dysphania ambrosioides* (5 medicinal uses), and *Anacardium occidentale* (5 medicinal uses).

3.8. Quantitative ethnobotanical indexes

3.8.1 Frenquency of citation

The current study is the first report on medicinal plants used in traditional medicine in Kimalalu, northern of Angola. Table 6 shows the different citation frequencies of the medicinal plant species in the current study, i.e. frequency of citation (FC), relative frequency of citation (RFC), relative frequency of citation in percent (RFC%) and CI is used to determine the number of times a plant has been cited in the management of diseases in the study area.

According to the results in Table 6, the highest relative frequency of citation (RFC) was observed in *Persea americana* with RFC=0.04, followed by *Harungana madagascariensis* (RFC=0.037), *Spondias mombin* (RFC=0.037), *Dysphania ambrosioides* (RFC=0.034), *Senna occidentalis* (RFC=0.031), *Securidaca longepedunculata* (RFC=0.028), *Entada abyssinica* (RFC=0.025), *Pachylobus edulis* (0.028), *Securidaca longepedunculata* (RFC=0.028), *Ficus sycomorus* (RFC=0.025), *Mondia whitei* (RFC=0.025), *Cymbopogon densiflorus* (RFC=0.022), *Indigofera paracapitata* (RFC=0.022), *Ocimum gratissimum* (RFC=0.022), *Pleiotaxis rugosa* (RFC=0.019), *Costus afer* (RFC=0.019), *Gymnanthemum amygdalinum* (RFC=0.019), *Jatropha curcas* (RFC=0.019), *Morinda lucida* (RFC=0.025), *Nauclea latifólia* (RFC=0.019), *Nicotiana tabacum* (RFC=0.019), *Saccharum officinarum* (RFC=0.019), *Anacardium occidentale* (RFC=0.016), *Annona stenophylla* subsp.cuneata (RFC=0.016), *Carica papaya* (RFC=0.016), *Dianthera secunda* (0.016), *Dorstenia psilurus* (RFC=0.016), *Gardenia ternifolia* subsp. jovis-tonantis (RFC=0.016), *Laportea aestuans* (RFC=0.016), *Mesosphaerum suaveolens* (RFC=0.016), *Millettia versicolor* (RFC=0.016), *Musanga cecropioides* (RFC=0.016), *Vitex madiensis* (RFC=0.012), *Aloe buettneri* (RFC=0.012), *Annona muricata* (RFC=0.012), *Aspilia kotschyi* (RFC=0.016), *Cymbopogon citratus* (RFC=0.012), *Aloe buettneri* (0.012), *Annona muricata* (RFC=0.012), *Aspilia kotschyi* (RFC=0.012), *Cymbopogon citratus* (RFC=0.012), *Psidium guajava* (RFC=0.012), *Sida acuta* (RFC=0.012), *Steganotaenia aralidcea* with RFC=0.012. Ethnomedicinal plant species with high RFC values indicate that they are widely used and known by local communities. The above shows that Persea amaerina was the most frequently cited plant for medicinal use, making it the plant species most widely used in local pharmacopoeia. Masengo et al. (2024), in their study based on Inventory and ethnobotanical study of edible fruit plants in Uíge city, Northern Angola reported that the most commonly used medicinal plant species were Mangifera indica and Persea americana.

Table 6
Some ethnobotanical indices calculated in this study.

N0	Medicinal plant species	Ethnobotanical indices			
		FC	RFC	RFC%	CI
1	Persea americana	13	0.040	4.0	0.052
2	*Spondias mombin*	12	0.037	3.7	0.048
3	*Harungana madagascariensis*	12	0.037	3.7	0.048
4	*Dysphania ambrosioides*	11	0.034	3.4	0.044
5	*Senna occidentalis*	10	0.031	3.1	0.040
6	*Securidaca longepedunculata*	9	0.028	2.8	0.036
7	*Pachylobus edulis*	9	0.028	2.8	0.036
8	*Entada abyssinica*	9	0.028	2.8	0.036
9	*Ficus sycomorus*	8	0.025	2.5	0.032
10	*Mondia whitei*	8	0.025	2.5	0.032
11	*Erythrina abyssinica*	8	0.025	2.5	0.032
12	*Pleiotaxis rugosa*	7	0.022	2.2	0.028
13	*Ocimum gratissimum*	7	0.022	2.2	0.028
14	*Indigofera paracapitata*	7	0.022	2.2	0.028
15	*Cymbopogon densiflorus*	7	0.022	2.2	0.028
16	*Saccharum officinarum*	6	0.019	1.9	0.024
17	*Nicotiana tabacum*	6	0.019	1.9	0.024
18	*Nauclea latifolia* Sm	6	0.019	1.9	0.024
19	*Morinda lucida* Benth	6	0.019	1.9	0.024
20	*Jatropha curcas*	6	0.019	1.9	0.024
21	*Gymnanthemum amygdalinum*	6	0.019	1.9	0.024
22	*Costus afer*	6	0.019	1.9	0.024
23	*Vitex madiensis*	5	0.016	1.6	0.020
24	*Musanga cecropioides*	5	0.016	1.6	0.020
25	*Millettia versicolor*	5	0.016	1.6	0.020
26	*Mesosphaerum suaveolens*	5	0.016	1.6	0.020
27	*Laportea aestuans*	5	0.016	1.6	0.020
28	*Dorstenia psilurus*	5	0.016	1.6	0.020
29	*Dianthera secunda*	5	0.016	1.6	0.020
30	*Carica papaya*	5	0.016	1.6	0.020
31	*Annona stenophylla* subsp. cuneata	5	0.016	1.6	0.020
32	*Anacardium occidentale*	5	0.016	1.6	0.020
33	*Gardenia ternifolia* subsp. jovis-tonantis	5	0.016	1.6	0.020
34	*Steganotaenia araliacea*	4	0.012	1.2	0.016
35	*Sida acuta*	4	0.012	1.2	0.016
36	*Psidium guajava*	4	0.012	1.2	0.016
37	*Cymbopogon citratus*	4	0.012	1.2	0.016
38	*Aspilia kotschyi*	4	0.012	1.2	0.016
39	*Annona muricata*	4	0.012	1.2	0.016
40	*Aloe buettneri*	4	0.012	1.2	0.016

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Table 6 continued

N0	Medicinal plant species	Ethnobotanical indices			
		FC	RFC	RFC%	CI
41	*Ochna afzelii* subsp. Mechowiana	3	0.009	0.9	0.012
42	*Momordica balsamina*	3	0.009	0.9	0.012
43	*Maprounea africana*	3	0.009	0.9	0.012
44	*Gossypium barbadense*	3	0.009	0.9	0.012
45	*Garcinia kola*	3	0.009	0.9	0.012
46	*Crossopteryx febrifuga*	3	0.009	0.9	0.012
47	*Catharanthus roseus*	3	0.009	0.9	0.012
48	*Vigna unguiculata*	2	0.006	0.6	0.008
49	*Solanum lycopersicum*	2	0.006	0.6	0.008
50	*Pistacia terebinthus*	2	0.006	0.6	0.008
51	*Nauclea pobeguinii*	2	0.006	0.6	0.008
52	*Manihot esculenta*	2	0.006	0.6	0.008
53	*Mangifera indica*	2	0.006	0.6	0.008
54	*Hibiscus acetosella*	2	0.006	0.6	0.008
55	*Cucurbita pepo* L.	2	0.006	0.6	0.008
56	*Corymbia citriodora*	2	0.006	0.6	0.008
57	*Cajunus cajan*	2	0.006	0.6	0.008
58	*Brillantaisia owariensis*	2	0.006	0.6	0.008
59	*Bridelia ferruginea*	2	0.006	0.6	0.008
60	*Allium sativum*	2	0.006	0.6	0.008
61	*Alchornea cordifolia*	2	0.006	0.6	0.008
62	*Kalanchoe crenata*	1	0.003	0.3	0.004
63	*Ipomoea batatas*	1	0.003	0.3	0.004
64	*Helichrysum mechowianum*	1	0.003	0.3	0.004
65	*Dichrostachys cinerea* subsp. Africana	1	0.003	0.3	0.004
66	*Combretum racemosum*	1	0.003	0.3	0.004
67	*Citrus sinensis*	1	0.003	0.3	0.004
68	*Chromolaena odorata*	1	0.003	0.3	0.004
69	*Capsicum frutescens*	1	0.003	0.3	0.004
70	*Azadirachta indica*	1	0.003	0.3	0.004
71	*Annona senegalensis*	1	0.003	0.3	0.004
72	*Aframomum melegueta*	1	0.003	0.3	0.004

According to Mawunu, and Manuel SP, et al. (2022) the most frequently used medicinal plant species in the small town of Songo (northern Angola) were *Carica papaya* (Caricaceae) with a relative frequency of RFC=0.07 (37 citations), followed by *Mangifera indica* (RFC=0.06, 29 citations), *Persea americana* (RFC=0.05, 27 citations), *Pachylobus edulis* (RFC=0.05, 24 citations) and Annona muricata (RFC=0.04, 23 citations). To end, Lautenschläger et al. (2018) reported in their ethnobotanical study of plants from the province of Uige (Angola) that *Annona stenophylla* subsp. Cuneata (RFC=0.371) *Hymenocardia acida* (RFC=0.355), Vitex madiensis (RFC=0.323), *Psorospermum febrifugum* (RFC=0.306), *Raphia matombe* (RFC=0.306), and *Chromolaena odorata* (RFC=0.274) were the species with the highest relative frequency of citation.

As for the Confirmation Index (CI), i.e. the number of times a plant was cited in the management of human diseases in the study area, the results in Table 6 reveal that the taxa most frequently cited individually by resource persons were *Persea americana* (CI=0.052), *Spondias mombin* (CI=0.048), *Harungana madagascariensis* (CI=0.048), *Dysphania ambrosioides* (CI=0.044), *Senna occidentalis* (CI=0.040), *Securidaca longepedunculata* (CI=0.036), *Pachylobus edulis* (CI=0.036), and *Entada abyssinica* (CI=0.036). Also, the remaining species had a Confirmation Index of less than 0.036 (Table 6). Besides, the consensus index (CI=0.052) obtained for *Persea americana* indicates that there is high agreement around its dietary and therapeutic use. This can be explained by the cultural proximity of the respondents. According to Heinrich et al. (1998), the informant's consensus can help to select plant species for further pharmaceutical analyses. Lautenschläger et al. (2018), in their ethnobotanical study in northern Angola, reported that the diseases with the highest informant consensus values were malaise, diarrhoea, anaemia, skeletal deformities and stomach ache.

3.8.2 Medicinal capability index (MCI)

With regard to the measurement of the potential of the community studied to treat well-defined diseases, i.e. the medicinal capacity index (MCI), the results obtained after the calculations reveal that the main diseases treated with more plants out of the 72 plants documented were low haemoglobin (MCI=0.222), diarrhoea (MCI=0.125), typhoid (MCI=0.125), toochache (MCI=0.111), cough (MCI=0.097), cold (MCI=0.083), diabetes (MCI=0.083), fatigue (MCI=0.083), lordosis (MCI=0.083), stomachache (MCI=0.083), yellow fever (MCI=0.083), and inflammation (MCI=0.069), belly ache (MCI=0.069) and asthma (MCI=0.069). Valentin et al. (2024) Valentin et al. (2024) in the Democratic Republic of Congo reported in their study that the diseases with the highest MIC were gastrointestinal disorders (MCI=0.31), sexual infections (MCI=0.14), malaria (MCI=0.13), wounds (MCI=0.11), fever (MCI=0.09), sexual dysfunction (MCI=0.09), rheumatism (MCI=0.08), and tooth decay with MCI=0.06.

3.9. The Correlation between the variables studied and the dimensions of the principal component analysis

Figure 10 shows the correlation between the variables studied and the dimensions of the principal component analysis.

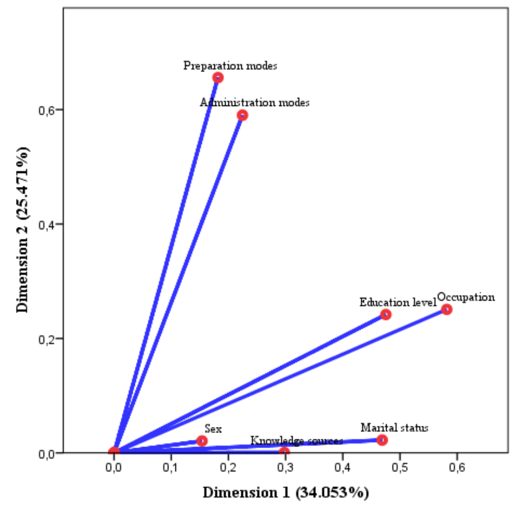

Figure 10. The correlation between the variables studied and the dimensions of the principal component analysis.

The multiple component analysis revealed that the preparation modes showed a correlation of 0.445 with the administration modes, followed by a correlation of 0.147 between the administration modes and the knowledge sources. The weakest correlations were observed between sex and preparation modes (0.019), as well as between sex and marital status (0.086). The first dimension, with an eigenvalue of 2.384, explained the variance significantly, followed by the second dimension at 1.271, and so on, indicating that the first dimension had a greater influence on the data than the subsequent dimensions. The correlation coefficients between the variables studied (preparation modes, administration modes, knowledge sources, sex, marital status, education level, and occupation) and the dimensions of the principal component analysis are given in the figure 10. It can be noted that in the first dimension, occupation has the highest coefficient (0.582), followed by education level (0.475) and marital status (0.469), indicating that these variables are strongly related to this dimension. However, in the second dimension, preparation modes (0.656) and administration modes (0.590) have the highest coefficients, indicating that they are most closely related to this dimension. Knowledge sources have a low coefficient in the first dimension (0.298) and a coefficient close to zero in the second dimension (0.001), suggesting that they have little impact on the differentiation of individuals in these dimensions.

3.10. Ways of acquiring and transmitting traditional medical knowledge

The results of this survey show that herbal medicine is an important age-old tradition in Angola, particularly in the Kimalalu comunity. The one and only (100%) way of transmitting ethnobotanical knowledge used by local people in Kimalalu was through oral tradition. In addition, the vast majority of informants (88%) stated that they had passed on their knowledge to other people (in particular, family members, children, nieces, nephews, grandchildren and biological brothers and sisters; unrelated people living in the same community), while 12% of the surveys preferred to keep it secret. In addition, the vast majority of informants (88%) stated that they had passed on their knowledge to other people (in particular, family members, children, nieces, nephews, grandchildren and biological brothers and sisters; unrelated people living in the same community), while 12% of the surveys preferred to keep it secret. Also, the holders of indigenous herbal knowledge in the study area also passed on their knowledge to other members of the community in order to ensure its continuity.In addition, traditional knowledge comes from various people in the community, including relatives (66.4%), in particular mothers, fathers, uncles, grandfathers and grandmothers.Other members of the community were the elderly (18%), friends and acquaintances (15.2%) and local neighbours (0.4%). Our results are consistent with those of authors Mawunu, and Manuel SP, et al. (2022) in Angola and Teshome et al. (2023) and Yohannis et al. (2018) in Ethiopia, who indicated that most sources of traditional knowledge about medicinal plants are transmitted orally and by relatives.

3.11. Other uses of medicinal plants documented, threats and conservation Practices

According to the data from this study, informants told us that, with population growth, medicinal plants are being used for a variety of purposes, including bioenergy (charcoal, firewood), housing construction and the manufacture of household implements. Residents of the study area still believe in the medicinal properties of the plants, and are familiar with their habitats (biotopes) and harvesting techniques. Several medicinal plants were found in home gardens in the study area (Table 2). Most of the medicinal plants grown in allotments are of exotic origin. However, wild medicinal plants are rarely grown in the study area.

As shown in Figure 11, in the study area most of the non-medicinal uses are also used for other non-medicinal purposes. The majority of plants are used for herbal teas (25.69%), followed by bioenergy (22.02%) including charcoal and firewood, food (16.51%), ornamentation (9.17%), construction materials (7.34%), hedges (4.59%), shade (2.75%), spices (2.75%), stimulant (1.83%), windbreak (1.83%), aphrodisiac (0.92%), brooms (0.92%), timber (0.92%), traditional alcoholic beverage (0.92%), lightning rod (0.92%) and pestle with 0.92%. The results of this study are partly consistent with those reported by Mawunu, and Manuel SP, et al. (2022) in the small town of Songo in northern Angola.

According to threats to medicinal plants and conservation practices, local people in the study area indicated that medicinal

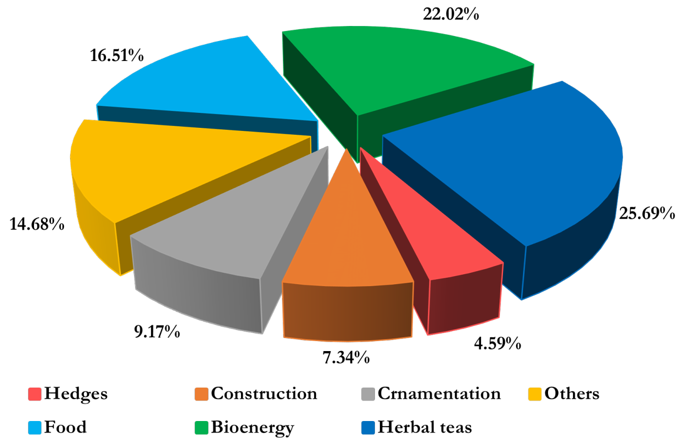

Figure 11. Non-medicinal uses of plants studied at Kimalalu.

plants were most threatened by the expansion of slash-and-burn agriculture or shifting cultivation and deforestation (71.6%). Other threats (28.4%) to medicinal plants were timber, woods for Leathering bricks, charcoal, construction materials, mechanised agriculture firewood, and building materials, road construction, village expansion and bush fires. Our results are in agreement with those of Gonfa et al. (2020) in Ethiopia who reported that the main threats to medicinal plants in the study area were agricultural expansion (41.6%), charcoal production (16.6%), firewood (28.3%) and construction (13.3%). Research carried out elsewhere in the country also revealed that agricultural expansion and deforestation are main threats to medicinal plants reported that medicinal plants were threatened by agricultural expansion, charcoal production, firewood and overexploitation of ecosystems (Bogale et al., 2023; Mekuanent et al., 2015; Monizi et al., 2019).

The results of this study into the medicinal plants traditionally used by the rural populations of Kimalalu, in the municipality of Songo (Uíge province), highlight the crucial importance of conserving and preserving traditional knowledge. This ancestral knowledge represents an invaluable cultural and scientific heritage that can contribute to the discovery of new medicines. For practical applications, it is essential to promote programmes to document and disseminate this knowledge to future generations and healthcare practitioners. Politically, it is recommended that legal frameworks be put in place to protect the rights of local communities to their traditional knowledge and to facilitate equitable access to the benefits derived from the use of these plants. Moreover, policies to conserve biodiversity, support ethnobotanical research and develop collaboration between researchers and traditional healers should be put in place to maximise the socio-economic and medical benefits.

4. CONCLUSIONS AND PERSPECTIVES

This study presents the first exploration of indigenous ethnomedical knowledge in the rural territory of Kimalalu in the province of Uíge, Angola. This area is home to a great diversity of wild and cultivated medicinal plants, as well as a reservoir of traditional knowledge that plays an important role in the treatment of various human ailments. Most of the medicinal plants listed in this study are of indigenous origin. Local communities are generally unaware of the importance of conserving medicinal plants. Documenting indigenous knowledge is essential for its preservation, the sharing of information in the civil service, the invention of new medicines and the future conservation management of threatened flora. In the course of this study, very important information was gathered on many medicinal plants. The 72 medicinal plants reported are used by indigenous people to treat more than 59 illnesses, including low haemoglobin or anaemia, yellow fever, stomach ache, toothache, cough, typhoid fever, fatigue, diarrhoea and malaria. The medicinal plants most frequently cited by the inhabitants of Kimalalu were Dysphania ambroisioides, Persea americana, Spondias mombin, and Senna occidentalis. Most people ignore conservation strategies, leading to the extinction of many species. Based on the results of the current survey, urgent attention is required for the conservation and documentation of traditional plant knowledge and the conservation of medicinal plants. Securidaca longepedunculata, was the ethnomedicinal species most commonly used in the record-breaking treatment of eight human ailments: body aches, bronchitis, colds, constipation, gonorrhoea, inflammation, lordosis and thrombosis. Slash-and-burn agriculture is the main source of jobs, income and food, and is also responsible for the degradation of plant biodiversity. Oral tradition is the only way of passing on ethnobotanical knowledge. The local medicinal flora is dominated by phanerophytes of tropical origin.

Despite the significant contributions of this study, certain limitations should be highlighted, including the limited sample size, variability in ethnolinguistic groups, ecological areas, seasons, and traditional practices that may not be representative of the entire province. For future research, it is suggested that the sample be expanded to include other quantitative methods to assess the effectiveness of the identified medicinal plants within the community. In addition, longitudinal and comparative studies between different communities could provide more comprehensive insights into the use and preservation of traditional knowledge in Angola and beyond. Mereover, it is therefore important to put in place interventions that involve and inform local users of medicinal plants in order to halt and reverse the negative impact they have caused on these natural resources. One such intervention strategy could be the domestication of these species in situ or ex-situ botanical gardens. These would encourage the conservation of these precious genetic resources, serve as open spaces for research and act as education centres to promote a greater appreciation of their use among younger generations, and provide local traditional healers and pharmaceutical industries with access to medicinal plants harvested sustainably in a single location.

ABBREVIATIONS

BT: Biological distribution; PD: Phytogeographical distribution; Afro-american (AA); Afro-tropical continental (AT); Low Guinean-Congolese (LGC); Guineo-congolese (GC); Paleotropics (Pal); Pantropical (Pan); Cameroonian-Guinean-Congolese (CGC); Cosmopolytes (Cos); Fr.= French; Kik.= Kikongo; Ling.= Lingala; Port.= Portuguese; Phanerophytes (Ph); Therophytes (Th) Geophytes (G) %; Mesophanerophytes (MsPh); Microphanerophytes (McPh); Nanophanerophytes (NPh) liana phanerophytes (LPh); Rhizomatous geophytes (Grh); tuberous geophytes (Gt); erect therophytes (Thd); climbing therophytes (Thgr); prostrate therophytes (Thpr); erect chamaephytes (Chd); rhizomatous chamaephytes (Chrh); Hemicryptophytes (Hce); Zoochores (Zoo); ballochores (Ballo); Barochores (Baro); Sarcochores (Sarco); Desmochores (Desm); pterochores (Ptero); and pogonochores (Pogo).

CONFLICTS OF INTEREST

Authors declare that there is no conflict of interest.

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ETHICAL APPROVAL

Ethical approval for the study was obtained from the Life Sciences Department, Faculty of Science and Technology (University of Kinshasa), under protocol number 022/CDB/MSV/FST/UNIKIN.

This study has been conducted under the provisions of the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization of the Convention on Biological Diversity. Oral Prior consent was obtained from each participant. This study does not contain any experimente (s) on humans and animals. This study has been conducted under the provisions of the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity. During the ethnobotanical data collection from informants a prior oral consent was taken. Consent for publication: Not applicable-this manuscript has no personal data from the authors. Availability of data and materials: The original data is presented in the article. There is no supplementary data. The raw data without the names of informants can be provided by authors.

AUTHOR CONTRIBUTIONS

MM conceived and designed the study. ADM, LCA and MM carried out data collection, integrated the inventory, and performed the analysis, as well as contributed to manuscript writing. MM, LL, ADM, LCA, KNN, and LN identified the plants, reviewed, and edited the manuscript. All authors have read and approved the final published version.

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