Ethno-medicinal study on medicinal plants species: the reality of practice and traditional knowledge in Omdurman locality major markets, Sudan

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Research

Abstract

Background: Traditional medicinal knowledge in Sudan is primarily transmitted orally and remains insufficiently documented despite its importance in primary healthcare. Medicinal plants constitute a major component of traditional medicine practiced by herbalists. This study aimed to document the ethno-medicinal knowledge of herbalists in Omdurman locality, Khartoum State, Sudan; with emphasis on the medicinal uses of medicinal plants traded in Omdurman markets.

Methods: An ethnobotanical survey was conducted through semi-structured interviews with 20 herbalists practicing in Omdurman markets. Information was collected on medicinal plant species, vernacular names, plant parts used, methods of preparation, and routes of administration. Plant specimens were taxonomically identified, and descriptive statistics together with quantitative ethnobotanical indices, including use value (UV) and informant consensus factor (ICF), were applied to evaluate the recorded knowledge.

Results: Forty-eight medicinally plant species belonging to 45 genera and 25 families were documented, with Fabaceae representing the dominant family. Trees accounted for the highest proportion of growth forms (41.67%). The recorded species were used to treat 17 disease categories, and bark was the most frequently utilized plant part (33.33%). Oral administration was the principal route (83.3%), followed by external application (16.7%). *Waltheria indica*, *Tribulus terrestris*, and *Citrullus colocynthis* exhibited the highest use values, indicating their prominent role in local traditional medicine.

Conclusions: Omdurman herbalists preserve extensive ethno-medicinal knowledge regarding medicinal plants. Documenting this knowledge contributes to safeguarding traditional practices and provides a scientific foundation for future phytochemical, pharmacological, and conservation studies targeting the most culturally important medicinal species.

Keywords: Ethnobotany, Ethno-medicine, Medicinal plants, Herbalists, Traditional healers, Traditional medicine, Omdurman.

Background

Medicinal plants, from the early history, have been used as therapeutic resources across generations with knowledge of their preparations and applications being transmitted within various local communities. Traditional plant-based medicine remains an important component of healthcare in many regions, such as India and China, and including Sudan, where diverse plant resources are incorporated into local therapeutic and traditional practices. The continued use of these resources reflects the accumulation of indigenous knowledge concerning plant identification, preparation, and perceived medicinal applications (Ullah *et al.* 2021; Hamad 2021). Sudan's diverse ecological conditions and cultural heritage have contributed to a rich tradition of medicinal plant use and provide an important basis for ethnobotanical investigations (Ahmad *et al.* 2019).

Traditional medicine is cheaper and more accessible to most of the rural population and could become the potential source of new drugs. It was reported that 60-85% of the population in developing countries relies on traditional, alternative, or complementary medicine (Agize *et al.* 2013). The diversity of climates in Sudan results in a rich variety of flora species, corresponding to the wide range of ecological habitats and vegetation zones. Thus, the intersection of cultures and the unique geographical position of Sudan potentiate research in many fields, the most important of which is research in the field of medicinal and aromatic plants (Ahmad *et al.* 2019).

Ethnobotany plays an important role in understanding the dynamic relationship between biological diversity and social and cultural systems (Ahmad *et al.* 2012). Studying local knowledge is useful in documenting, analyzing and disseminating the knowledge on the interaction between biodiversity and human society, and how it is valued in different societies, and how it is influenced by various human activities. Therefore, the conservation of ethnobotanical knowledge as part of living culture, knowledge and practices between communities and the environment is essential for biodiversity conservation (Adam 2014). Generally, ethnobotany is the scientific investigation of plants as used in indigenous cultures in food, medicine, rituals, building, household utensils and implements, musical instruments, firewood collection, pesticide, clothing, shelter and other purposes (Seyoum *et al.* 2015). Ethnobotany is also useful to define local community plant resource needs, utilization and management (Havva & Necattin 2019). It is important to identify promising plants used in traditional medicinal system to develop new therapeutic candidates, ethno-medicinal studies remain very important in the discovery of new drugs and in the development of improved herbal preparations for use by local people (Esqivel-Garcia *et al.* 2018).

Generally, the knowledge on medicinal plants uses is still passing orally. Previous studies indicated that a rich tradition, employing hundreds of plant species is in danger of disappearing. Both, the knowledge of the use of medicinal plants, as well as many of the plants themselves, may be threatened. Ethnobotanical documentation, as general, provides a means of locally recognized records of plant resources, accompanied with the knowledge associated with their medicinal uses. Information on vernacular names, botanical identity, plant parts utilized, preparation methods, and therapeutic applications can support subsequent botanical, phytochemical, pharmacological, and conservation research (Wanjohi *et al.* 2020; Singh *et al.* 2020). Systematic documentation is particularly relevant because traditional knowledge is largely transmitted through local practitioners and may be affected by environmental changes, resource depletion, and changes in patterns of traditional practice (Tugume *et al.* 2016). Therefore, particularly in Sudan, recording this knowledge can therefore contribute to both the preservation of cultural heritage and the sustainable management of medicinal plant resources (El-Kamali 2009; Hamad 2021).

Despite the considerable ethnobotanical literature available from different regions of Sudan, previous investigations have largely focused on rural communities, natural forests, or markets outside the Omdurman, and Khartoum state area. Consequently, the trade of medicinal plants, associated with the traditional knowledge maintained by herbalists in Omdurman markets, remain comparatively under-documented. This present survey study was designed to record this knowledge specifically within Omdurman markets and to characterize the diversity of medicinal plants, plant parts utilized, preparation methods, routes of administration, and patterns of informant consensus. By focusing on the market-based knowledge of local herbalists and traditional healers, the survey study provides a localized baseline that can complement previous ethnobotanical surveys from other regions of Sudan and help identify culturally important species and plant-use patterns requiring further scientific and conservation attention.

Materials and Methods

Study area

The investigation was conducted in Omdurman locality, in Khartoum State, Sudan. Khartoum State comprises three major urban areas—Khartoum, Omdurman, and Khartoum North "Bahri"—which together form the principal metropolitan region of the whole state. Omdurman is situated on the western side of the Nile River and represents a major urban and commercial center. Its markets provide important points of contact between medicinal-plant vendors, traditional practitioners, and consumers and were therefore selected as the setting for this market-based ethnobotanical investigation. (Fig. 1).

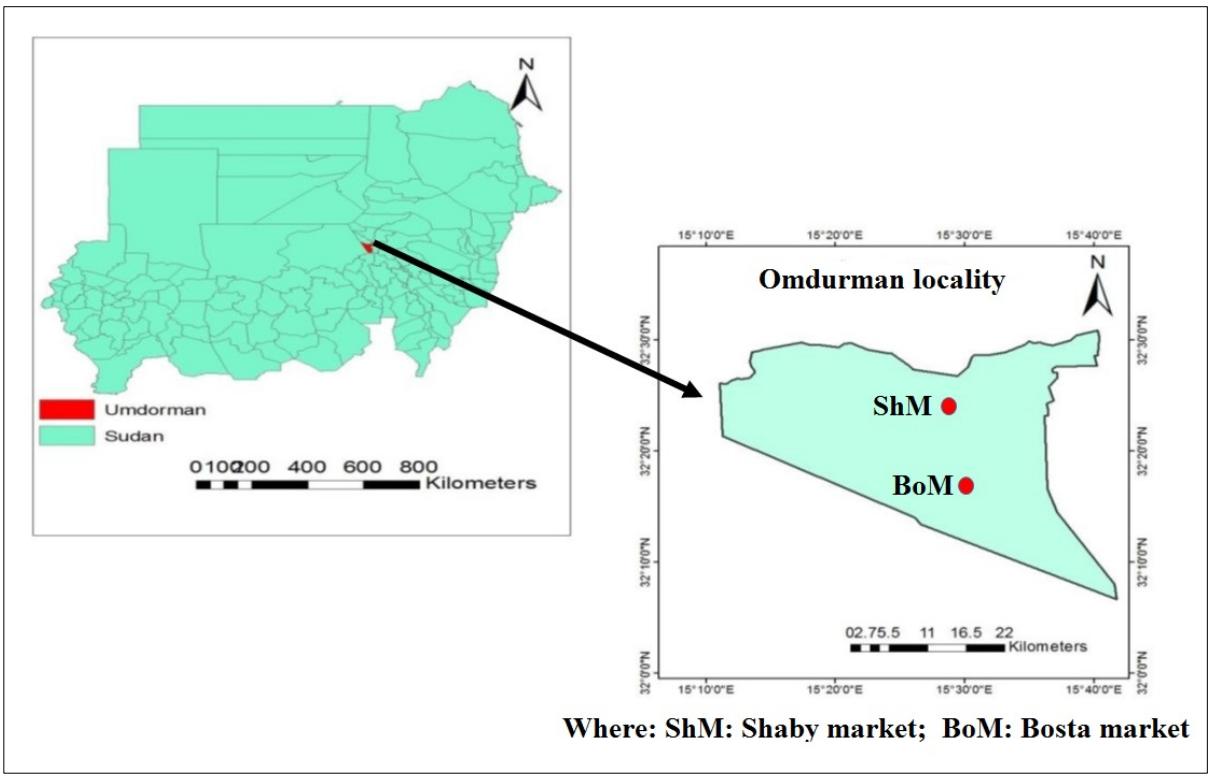


Figure 1. The map shows Sudan country and Omdurman locality with their local markets.

Omdurman occupies an area of 740 square kilometers. The population is about 2,395,159 (2008) people distributing in 11 local administrative units: namely, Wad Noubaui Unit, Hay Al-Arab Unit, The Grand Market Unit, Central Market Unit, Popular Market Unit, Industries Unit, Supply Unit, Abu Anja Unit, Abu Sea'd Unit, Karari Unit, and Rural Unit.

Topography, geological characteristics and soil

Surface and terrain

The topography of Sudan is generally characterized by relatively uniform terrain across extensive areas. In Omdurman, the landscape is predominantly characterized by gently sloping (incline) and relatively level terrain, with the elevation gradually increasing toward the northwestern part of the locality; the highest elevations are associated with the Jebel Karrari (Karrari Mountains). Some of the valleys and pits where rainwater is collected during the fall season are then carried out in the flat land and descend towards the Nile, the most important of which is "Khor Abuanja", "Shambat", and "Wadi Sidna" (Adam 2018).

Geological composition

Omdurman's geological composition consists of the following:

i. The basic rocks: There are in the northern and western parts and includes a group of nests, granite and schist; and there are post-pyrotechnic formations of granite and volcanic formations that formed the water falls.
ii. Nubian sandstone formation: This is covering a large part of the area of Omdurman, and may be at the beginning of the second geological time due to vertical movements; they are horizontal layers with a slight slope over basal rocks formed from basalt and the thickness of this rock ranges from a few meters to any more than 500 meters.

iii. Modern sedimentary formations: These are the muddy formations which are located near the Nile River and are fertilized by flooding and thin deposits from the Blue Nile; This is an arable land for Omdurman, which is located on the banks of the Nile in the western part of the Northern and Southern countryside, where most of the vegetables and fruit trees that are marketed in the national capital markets are grown. In addition, from modern sedimentary formations, gravel and sand washed away by the sand, which are located in the north of the city.

Soil

The importance of the soil and its impact on its chemical and mechanical composition is important in determining the most suitable locations for different types of activities. It is also the most important natural resource for economic production. The composition of the soil in Omdurman is very much related to its geological components. By flooding the Nile and changing sectors with sedimentary deposits and this type is located in the lands located along the Nile from the west. There is a shallow green soil with gravel, sand and stone and it is far away on the Nile and part of it is found in the western and southwestern regions. Desert soil is dry soil with few organic materials and is found in the western parts of the local area.

Climate and vegetation characteristics

Climate

Omdurman has a predominantly hot and dry climate characteristics of the semi-desert zones of central Sudan and other similar zones in the world. Rainfall is concentrated mainly during the summer months, particularly from July to September, while the remainder of the year is generally characterized by prolonged dry and semi-dry conditions. Although the nighttime temperature decline considerably during the cooler season (winter), the temperatures are high for much of the year (summer season). These climatic conditions influence the distribution and availability of naturally occurring and cultivated plant resources within and around the locality (Adam 2018).

Vegetation

According to the differentiation of Sudan into plant regions, the location of Omdurman is within the desert and semi-desert region, so that the natural plants that cover the vegetation are limited to 70% annual plants and 30% old plants. The cover is mostly composed of *Acacia tortilis* subsp. *tortilis* (locally known as seyal), *Ziziphus spina-christi* (locally known as sidr), and others. In addition to grasses, the daisy, as well as shade trees which are used for decoration purposes by livings and villages.

Ethnobotanical surveys and data collection

Reconnaissance studies

Reconnaissance studies is the first step to get information from the study area before the ethnobotanical surveys, it was conducted during October to November 2021 in Omdurman local markets to obtain an impression about the local markets in term of the availability of herbalists, traditional healers, and the sellers of medicinal plants. In addition, to have a general view about the respondents to be selected for the study and build teams for the market surveys of data collection. The market-based approach was selected because local medicinal plant markets represent important points of interaction between plant resources, herbalists, traditional healers, and consumers. These settings provide an opportunity to record, not only the identity of medicinal plants, but also the plant parts traded, preparation practices, routes of administration, and locally recognized therapeutic uses. The reconnaissance survey was, therefore, used to identify markets with active medicinal plants trade and practitioners with relevant knowledge before the main data collection. The two markets were chosen due to their established significance and ease of access as well-known sites for the trade of medicinal plants in Omdurman; these markets are widely recognized by local residents as places where herbalists and traditional healers can be readily encountered and where the public can access medicinal plant materials and traditional therapeutic knowledge. Accordingly, the two markets were considered appropriate settings for documenting market-based ethno-medicinal knowledge in Omdurman. It is noted that no official census or governmental registry was available to provide a reliable estimate of the total population of herbalists and traditional healers operating in Omdurman. Consequently, a population-based sample size could not be calculated from an established sampling frame. A total of 20 informants, comprising 10 practitioners from each of the two selected markets, were therefore included in the survey to obtain information from both major market settings. Given the absence of an official sampling frame and the localized market-based design, the findings and the quantitative indices were interpreted as descriptive of the participating informants and should not be generalized to represent all herbalists, traditional healers, or residents of Omdurman.

Collection of primary data

The field information was obtained from 20 herbalists and traditional healers working in Al-Bosta Market (BoM) and Al-Shaby Market (ShM), with 10 participants recruited from each location. Data collection combined semi-structured interviews,

guided observations during market visits, and group discussions. The questionnaire recorded the local and scientific identification of plants, reported ailments, plant parts utilized, condition of the material, preparation procedures, and routes of administration. Prior informed consent was obtained from all participants, and the information was recorded without including any personal identifiers.

Collection of secondary data

Literature review (Books, web sites, and libraries) was used as a secondary data source.

Data analysis

Data of informant's backgrounds on the usage of plants for medical purposes in Omdurman local markets, was organized by Excel spreadsheet for statistical analysis, by using descriptive statistical methods (Musa *et al.* 2011). The information of the respondents about the medicinal plants, as common names of plants, habits, parts used, local preparation methods, and administration, were utilized in construction of taxonomic checklist with updated families (Angiosperm Phylogeny Group 2009 & 2016, Haston *et al.* 2009); and the botanical names of all recorded plants species (Darbyshire *et al.* 2015, Gibreel 2008, Hamad 2021). The data was analyzed using simple descriptive statistics (percentage and frequency) methods and quantitative analytical tools for ethnobotanical methods were employed to identify the number and percentages of medicinal and wild edible plants species, genera and families, their growth forms, and percentage of commonly utilized plants parts; these included the following:

I- Use value (UV): It was calculated from the following equation:

$$UV = (\Sigma U) / N$$

Where, "UV" is the use value of a plant species, "ΣU" is the total number of use-reports recorded for that species across all informants, and "N" is the total number of informants participating in the survey. The UV, therefore, represents the average number of reported uses of a species per informant, and was used to identify species that were relatively prominent within the documented medicinal knowledge.

II- Informant consensus factor (ICF): It is used to estimate the consistency of informants and the extent that the informants agree on the use of certain plant species for the treatment of a given illness or illness category; it was calculated for testing homogeneity in informant responses (Hamad 2021, Li *et al.* 2015, Musa *et al.* 2011) by using the following formula:

$$ICF = (Nur - Nt) / (Nur - 1) \quad (0 < ICF < 1)$$

Where, "Nur" is the number of individual plant use reports for each ailment category; "Nt" is the total number of species used by all informants for this ailment category.

Because the survey involved a relatively small number of participating herbalists, the quantitative indices were used to characterize patterns within the documented datasets rather than to infer population-wide levels of medicinal plant use. In particular, UV values were interpreted as indicators of the relative prominence of individual species among the participating informants, whereas ICF values were interpreted in conjunction with the number of use-reports and taxa represented in each ailment category. This approach was adopted to avoid over-interpreting numerical indices in relation to the broader Omdurman population.

Results

Taxonomic characteristics and diversity

The present survey recorded 48 medicinal plant species distributed among 45 genera and 25 families (Table 1). Fabaceae showed the greatest representation, comprising eight genera and eleven species. Rubiaceae and Malvaceae each contributed four genera and four species, whereas Combretaceae, Euphorbiaceae, and Zygophyllaceae were represented by three genera and three species each. Meliaceae accounted for two genera and two species, while each of the remaining represented families contributed a single genus. These findings obviously demonstrate a considerable taxonomic diversity among the medicinal plant resources documented in the two major Omdurman markets. Trees constituted the largest growth-form category, accounting for 41.67% of the recorded species, followed by shrubs at 29.17%. Herbs represented 22.92%, whereas grasses and climbers accounted for 4.17% and 2.08%, respectively (Table 3). The distribution indicates that both woody species and understory plants contribute to the medicinal plant resources traded in the surveyed markets.

Table 1. Taxonomic checklist of plants used in traditional medicine in Omdurman, showing their habits, parts used, methods of preparation, and ethnobotanical indices (value index).

Species (Family) and "Vernacular (Local) name"	Habit	Part used	Ailment treatment	Preparation	Mode of application	Number of Uses cited	UV*
Adansonia digitata L. (Malvaceae) "***al-tabaldi***"	Tree	Fruits/ leaves	Diabetes	Juice	Oral	16	**0.8**
Aristolochia bracteolata Lam. (Aristolochiaceae) "***umm galagl***"	Herb	Whole plant	Swellings/ Malaria	-	Oral	13	**0.65**
Azadirachta indica A. Juss. (Meliaceae) "***neem***"	Tree	Leaves	Malaria & Fevers	Decoction	Oral	14	**0.7**
Balanites aegyptiaca (L.) Delile (Zygophyllacea) "***al-heglleeg***"	Tree	Fruits	Reduces blood pressure	Maceration	Oral	7	**0.35**
Blepharis linariifolia Pers. (Acanthaceae) "***begheil***"	Herb	Bark	Renal problems	Maceration	Oral	12	**0.6**
Boscia senegalensis (Pers.) Lam. ex Poir. (Capparaceae) "***mukhait -kursan***"	Shrub	Bark	Toothache	Fresh direct applied	Oral	7	**0.35**
Boswellia papyrifera (Delile) Hochst. (Burseraceae) "***umm tragtrag - gafal tragtrag***"	Tree	Gum	Respiratory infection	Infusion with water	Oral	3	**0.15**
Carissa spinarum L. (Apocynaceae) "***allali***"	Shrub	Roots	Cough	Infusion with water & Smoke	Oral	15	**0.75**
Cassia arereh Delile (Fabaceae) "***gaga***"	Tree	Bark/ Seeds	Jaundice	Maceration	Oral	9	**0.45**
Catunaregam nilotica (Stapf) Tirveng. (Rubiaceae) "***shagarat el-marfaaein***"	Tree	Roots	Swellings	Decoction	External	8	**0.4**
Chrozophora plicata (Vahl) A. Juss. ex Spreng. (Euphorbiaceae) "***argassi - al-troub***"	Herb	Roots	Stomachache	Maceration	Oral	12	**0.6**
Cissampelos pareira L. (Menispermaceae) "***irg el-kil***"	Herb	Roots	Malaria	Infusion	Oral	7	**0.35**
Citrullus colocynthis (L.) Schrad. (Cucurbitaceae) ***"al-hundal"***	Climber	Fruits	Rheumatism	Grind and mixed with water	External (paste)	19	**0.95**
Combretum glutinosum Perr. ex DC. (Combretaceae) "***habil***"	Tree	Root/ leaves	Rheumatism	Smoking	External	7	**0.35**
Cymbopogon schoenanthus L. Spreng. (Poaceae) ***"maharib"***	Grass	Whole plant	Renal problems	Decoction	Oral	18	**0.9**
Detarium senegalense J. F. Gmel. (Fabaceae) "***abuleila***"	Tree	Wood	Rheumatism	Smoking	External	17	**0.85**
Dichrostachys cinerea (L.) Wight & Arn. (Fabaceae) "***kadad***"	Shrub	Bark	Wounds	Fresh, direct applied	External	4	**0.2**
Diospyros mespiliformis Hochst. ex A. DC. (Ebenaceae) "***goghan***"	Tree	Root/ Bark	Diarrhea	Decoction	Oral	12	**0.6**

Erythrina abyssinica Lam. ex DC. (Fabaceae) "***hab alarous***"	Tree	Bark	Jaundice	Decoction	Oral	7	**0.35**
Ficus sycomorus L. (Moraceae) "***al-gumaiz***"	Tree	Bark	Abdominal problem	Decoction	Oral	4	**0.2**
Gardenia ternifolia Schumach. & Thonn. (Rubiaceae) "***abu gawi - gardinia***"	Shrub	Roots	Jaundice	Decoction	Oral	5	**0.25**
Geigeria alata (Hochst. & Steud.) Benth. & Hook. f. ex Oliv. & Hiern (Asteraceae) "***gudgad***"	Herb	Leaves	Diabetes	Maceration	Oral	17	**0.85**
Grewia tenax (Forssk.) Fiori (Malvaceae) "***gudaim***"	Shrub	Fruits	Anemia	Juice	Oral	9	**0.45**
Guiera senegalensis J. F. Gmel. (Combretaceae) "***al-ghubeish***"	Shrub	Whole plant	Diabetes	Maceration	Oral	18	**0.9**
Hyphaene thebaica (L.) Mart. (Arecaceae) "***dom***"	Tree	Fruits	Reduce blood pressure	Juice	Oral	7	**0.35**
Jatropha curcas L. (Euphorbiaceae) "***jatrupha - habat elmuluk***"	Shrub	Leaves	Jaundice	Decoction	Oral	4	**0.2**
Khaya senegalensis (Desr.) A. Juss. (Meliaceae) "***mahogany***"	Tree	Bark	Stomachache/ Malaria	Maceration	Oral	13	**0.65**
Kigelia Africana (Lam.) Benth. (Bignoniaceae) "***umm shitour***"	Tree	Fruits	Breast tumor	Paste	External	10	**0.5**
Moringa oleifera Lam. (Moringaceae) "***moringa - al-rawag***"	Tree	Leaves	Stomachache	Decoction	Oral	15	**0.75**
Nauclea latifolia Sm. (Rubiaceae) "***karmadoda***"	Shrub	Bark	Dysentery	Infusion	Oral	18	**0.9**
Ocimum basilicum L. (Lamiaceae) "***al-rehan***"	Herb	Leaves	Urine system	Decoction	Oral	4	**0.2**
Piliostigma reticulatum (DC.) Hochst. (Fabaceae) "***garob - kharob - abu khameira***"	Shrub	Fruits	Reduce blood pressure & diabetes	Juice	Oral	13	**0.65**
Ricinus communis L. (Euphorbiaceae) "***khirui - khrwaiae***"	Shrub	Seeds	Sexual disability	Powder mixed with water	Oral	3	**0.15**
Sclerocarya birrea (A. Rich.) Hochst. (Anacardiaceae) "***humeid - al-humeid***"	Tree	Bark/ seed	Stomachache	Grind mixed with yoghurt	Oral	7	**0.35**
Senegalia polyacantha (Willd.) Seigler & Ebinger (Fabaceae) "***kakamoat***"	Tree	Bark	Dysentery	Infusion with water	Oral	4	**0.2**
Senegalia senegal (L.) Britton (Fabaceae) "***al-hashab***"	Shrub	Gum	renal problems	Maceration	Oral	16	**0.8**
Senna alexandrina Mill. (Fabaceae) "***Senna Senna - al-senamakka***"	Herb	Fruits	Abdominal problems	Maceration	Oral	15	**0.75**
Senna tora (L.) Roxb. (Fabaceae) "***el-kawal***"	Herb	Seeds	Jaundice	Powder mixed with yoghurt	Oral	17	**0.85**
Sterculia setigera Delile (Malvaceae) "***tartar***"	Tree	Bark	Reduces blood pressure	Maceration	Oral	10	**0.5**
Striga hermonthica (Delile) Benth. (Orobanchaceae) "***bouda***"	Herb	Whole plant	Diabetes	Decoction	Oral	7	**0.35**

Terminalia leiocarpa (DC.) Baill. (Combretaceae) "***sahab - silak***"	Tree	Bark	Jaundice	Decoction	Oral	16	**0.8**
Tribulus terrestris L. (Zygophyllacea) "***al-dereisa***"	Herb	Seeds	Renal problems	Decoction	Oral	19	**0.95**
Vachellia nilotica (L.) P. J. H. Hurter & Mabb. (Fabaceae) "***al-garad - sunt abu arida - abu gaffa***"	Tree	Fruits	Cough	Maceration	Oral	15	**0.9**
Vachellia seyal (Delile) P. J. H. Hurter var. *seyal* (Fabaceae) "***al-talih - talih ahmer***"	Shrub	Bark	Diarrhea	Maceration	Oral	16	**0.8**
Vangueria madagascariensis J. F. Gmel. (Rubiaceae) "***kirkir***"	Shrub	Fruits	Reduces blood pressure, Diabetes	Maceration	Oral	8	**0.4**
Waltheria indica L. (Malvaceae) "***irg el-nar***"	Herb	Root	Jaundice	Grind & direct application	External (paste)	19	**0.95**
Ziziphus spina-christi (L.) Desf. (Rhamnaceae) "***nabag - al-siddir***"	Shrub	Bark	Fever	Smoking	External	14	**0.7**
Zygophyllum creticum (L.) Christenh. & Byng (Zygophyllaceae) "***um shweika***"	Grass	Whole plant	Renal problems	Decoction	Oral	10	**0.5**

Where, UV is Use value index.

Table 2. Distribution of identified medicinal plant species and genera among plant families in Omdurman's local markets.

Family	Number of genera	Number of species
Acanthaceae	1	1
Anacardiaceae	1	1
Apocynaceae	1	1
Arecaceae	1	1
Aristolochiaceae	1	1
Asteraceae	1	1
Bignoniaceae	1	1
Burseraceae	1	1
Capparaceae	1	1
Combretaceae	3	3
Cucurbitaceae	1	1
Ebenaceae	1	1
Euphorbiaceae	3	3
Fabaceae	8	11
Lamiaceae	1	1
Malvaceae	4	4
Meliaceae	2	2
Menispermiaceae	1	1
Moraceae	1	1
Moringaceae	1	1
Orobanchaceae	1	1
Poaceae	1	1
Rhamnaceae	1	1
Rubiaceae	4	4
Zygophyllaceae	3	3
Total	**45**	**48**

Table 3. Distribution of the documented medicinal plant species by growth form in the local markets of Omdurman.

Plant habit	No. of species	Percentage (%)
Tree	20	41.67
Shrub	14	29.17
Herb	11	22.92
Grass	2	4.17
Climber	1	2.08
Total	**48**	**100.01**

Ethnobotanical indices

The Use-Value analysis (UV) showed substantial variation among the forty-eight documented species (Table 1). The highest UV was recorded for *Waltheria indica* L. "Locally known as **irg el-nar**", *Tribulus terrestris* L. "Locally known as **al-dereisa**", and *Citrullus colocynthis* L. Schrad. "Locally known as **al-hundal**" each with a value of 0.95. Seven species recorded comparatively high values, including *Cymbopogon schoenanthus* L. Spreng. "Locally known as **al-maharib**", *Nauclea latifolia* Sm. "Locally known as **al-karmadoda**", *Vachellia nilotica* (L.) P. J. H. Hurter & Mabb. "Locally known as **al-garad**", and *Guiera senegalensis* J. F. Gmel. "Locally known as **al-ghubeish**", each with a UV of 0.90; *Adansonia digitata* L. "Locally known as **al-tabaldi**" also showed a relatively high value of 0.80. These values show variations in the variety and frequency of reported uses among the informants who took part.

Furthermore, the plants were found to treat 19 various ailment categories (Table 4). To assess the homogeneity of knowledge, the informant consensus factor, abbreviated as ICF, was computed for each category of illness (Hamad 2021, Musa *et al.* 2011, Trotter & Logan 1986). ICF had reached (1) for some ailment categories, such as breast tumor (10 use-reports, 1 plant), sexual disability (3 use-reports, 1 plant), wounds (4 use-reports, 1 plant), toothache (7 use-reports, 1 plant), anemia (9 use-reports, 1 plant), urine system (4 use-reports, 1 plant), and respiratory infections (3 use-reports, 1 plant); followed by diarrhea and cough which showed (ICF = 0.97 each) (Table 4). In addition, rheumatism showed (0.96), dysentery, diabetes, and swellings showed ICF = 0.95, with variation in use-reports and number of plants used to treat the ailment.

Furthermore, renal problems had showed (0.94) same as abdominal problems. The fevers and malaria showed (0.93) same as jaundice. These results indicate that, the common uses of the most reported medicinal plants, in local markets, is against jaundice, renal problems and diabetes. The ICF values should be interpreted in relation to both the number of use-reports and the number of species recorded for each ailment category; categories represented by only one plant species produced an ICF value of (1.00), because all recorded use-reports were associated with a single taxon; therefore, these values should not be interpreted as evidence of strong inter-specific consensus. Greater interpretive value can be assigned to relatively high ICF values in categories involving several plant species and multiple use-reports, such as renal problems, diabetes, stomachache, and jaundice, where the index reflects agreement among informants despite the use of more than one species.

Table 4. Distribution of medicinal plants species, use citations, plant parts used, and Informant Consensus Factor (ICF) across different ailment categories.

Ailment category	No. of species	No. of use-cited	Part used								ICF
			Fruits	Seeds	Wood	Whole plant	Leaves	Gum	Roots	Bark	
Renal problems	5	75	0	1	0	2	0	1	0	1	0.94
Stomachache	5	54	0	1	0	0	1	0	1	2	0.92
Cough	2	30	1	0	0	0	0	0	1	0	0.97
Rheumatism	3	50	1	0	1	0	1	0	1	0	0.96
Diabetes	6	95	3	0	0	2	2	0	0	0	0.95
Toothache	1	7	0	0	0	0	0	0	0	1	1
Jaundice	7	86	0	2	0	0	1	0	2	3	0.93
Swellings	2	21	0	0	0	1	0	0	1	0	0.95
Blood pressure	5	45	4	0	0	0	0	0	0	1	0.91
Fevers and malaria	5	61	0	0	0	1	1	0	1	2	0.93
Wounds	1	4	0	0	0	0	0	0	0	1	1
Dysentery	2	22	0	0	0	0	0	0	0	2	0.95
Anemia	1	9	1	0	0	0	0	0	0	0	1
Abdominal problems	2	19	1	0	0	0	0	0	0	1	0.94
Diarrhea	2	40	0	0	0	0	0	0	1	2	0.97
Breast tumor	1	10	1	0	0	0	0	0	0	0	1
Sexual debility	1	3	0	1	0	0	0	0	0	0	1
Urine system	1	4	0	0	0	0	1	0	0	0	1
Respiratory infections	1	3	0	0	0	0	0	1	0	0	1

The plant parts used in traditional medicine

The percentages were calculated as the ratio between the numbers of plants in which a certain part is used and the total number of plants. The respondents were found to use different parts of medicinal plants, bark was the most frequently reported plant part (33.33%), followed by fruits (20.83%), roots (16.67%), seeds (12.5%), leaves (10.42%), whole plants (10.42%), gums (4.17%), and wood (2.08%) (Fig. 2). There are some instances where different parts of the same plant had been used for different medicinal purposes. There are also some cases where more than one plant is used to treat a particular aliment, for example, jaundice was treated with 7 different species; stomachache and diabetes were treated with 6 different species, while renal problems was treated with 5 species (Table 1). In addition, different parts of the identified plants were found to be used differently as medicine, as in *Adansonia digitata* L. "Locally known as **al-tabldi** or **gongolaiz**", where the fruits pulp is a traditional juice and have multiple medicinal values, while the young leaves are used as vegetable and edible either fresh or cooked as a meal "commonly known as **afoos**".

Mode of preparation of different plant's parts and routes of administration

The methods of plant's parts preparation and their routes of administration are vary between the identified medicinal plants, according to the plant's part used and the ailment treated (Fig. 3). The percentages of the mode of preparations were calculated as the ratio between plants used in a certain mode of preparation and the total number of recorded plants. Therefore, maceration was the common mode of preparation (33%; 16 plants) followed by decoction (29.1%; 14 plants), infusion (10.4%; 5 plants), smoking, direct application and powder (8.3%; 4 plants each). The least percentage of the mode of preparation was observed with the paste (2.8%; 1 plant). For fresh and dried collected plant parts, most of the preparations involved boiling the leaves and then drinking the infusion. Water is mostly used to dilute the remedies. Most remedies "preparations, medicine" of medicinal plants used are taken orally (83.3%; 40 plants), while others have an external application (Topically on the skin) (16.7%; 8 plants) (Fig. 4). To improve the acceptability of certain oral remedies, additives are frequently used (Table 1); for example, the remedy prepared from crushed seeds of *Cassia tora* (L.) Roxb. "Locally known as **al-kawal**" and seeds/barks of *Sclerocarya birrea* (A. Rich.) Hochst. "Locally known as **al-humeid**" are usually taken with yoghurt to reduce their bitterness.

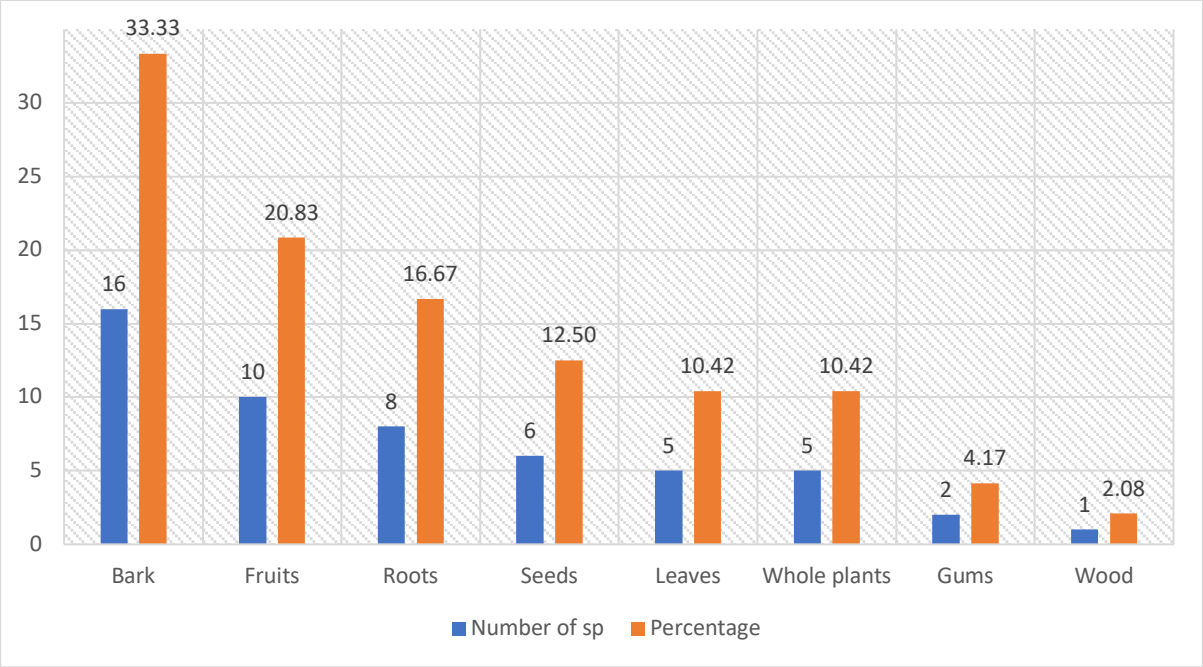


Figure 2. Parts of medicinal plants and under-story (grasses, herbs and climbers) used by different preparations to treat different diseases in local Omdurman's market.

Discussion

Medicinal plant resources contribute to traditional healthcare as well as to local livelihoods and plant-based trade (Ballal *et al.* 2014, Hamad 2021, Salih & Ali 2014). In the present survey study, the participating herbalists and traditional healers reported 48 medicinal species belonging to 25 families and 45 genera. The number of species recorded in Omdurman can be compared with findings from other Sudanese ethnobotanical investigations. For example, 59 medicinal species were reported from 25 families and 52 genera in West Kordofan (Hamad 2021), whereas 49 medicinal plants were reported in the same region (Doka & Yagi 2009). These differences may reflect variation in geographical setting, available flora, practitioner knowledge, and the characteristics of the surveyed markets. Other ethnobotanical studies in North Kordofan, Western Sudan, indicated the use of 48 plants (El Kamali 2009), and 59 plants (El-Ghazali *et al.* 1994), respectively. The relatively high UV values recorded for *Waltheria indica*, *Tribulus terrestris*, and *Citrullus colocynthis* indicate that these species were repeatedly cited and/or associated with several reported uses by the participating informants. Importantly, a high UV should be interpreted as an indicator of cultural and use prominence rather than as evidence of pharmacological efficacy. The frequent reporting of these species nevertheless identifies them as priority taxa for subsequent phytochemical, pharmacological, toxicological, and ethno-pharmacological investigation.

Although several patterns observed in this survey study are consistent with previous Sudanese ethnobotanical investigations, such agreement should not be regarded as the principal contribution of the study; the main contribution lies in documenting these practices within the specific commercial context of Omdurman markets, where medicinal plant knowledge is

maintained by herbalists and linked directly to the trade of plant materials. The present dateset, therefore, provides a geographically and socially localized record that complements previous studies, particularly those from West and North Kordofan and other Sudanese regions. Differences in the number of recorded species, plant parts, preparation methods, and ailment categories may also reflect variation in local flora, cultural knowledge, practitioner specialization, market availability, and patterns of plant trade.

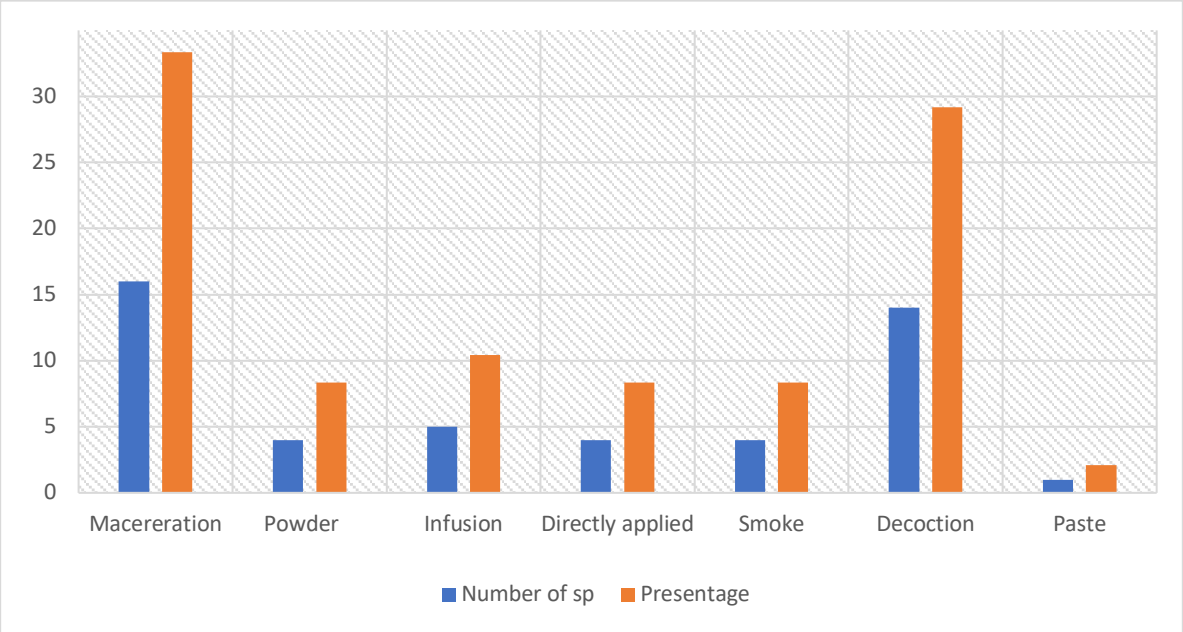


Figure 3. Mode of preparations (%) of ethno-medicinal plants reported from the market's surveys within Omdurman locality.

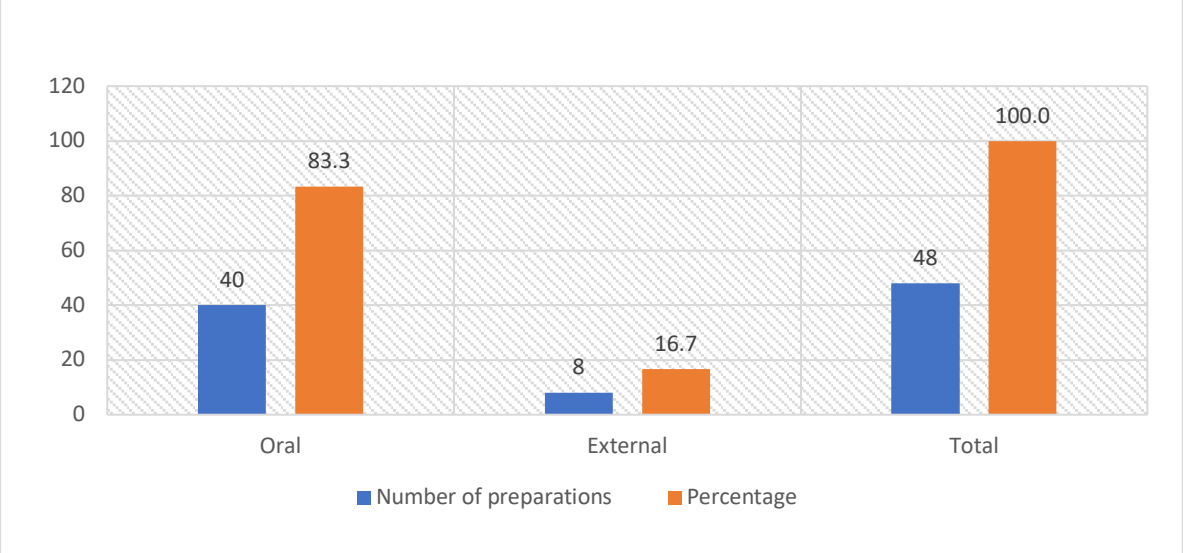


Figure 4. The route of administration of plant preparations used by local people in the local Omdurman markets as source of medicine.

Fabaceae was the most represented botanical family in the present dataset, with eight genera and eleven medicinal species. Hamad (2021) similarly identified Fabaceae as the leading family in medicinal plant markets and field surveys in West Kordofan, where nine genera and thirteen species were recorded. Previous Sudanese studies have also reported a substantial contribution of Fabaceae to medicinal plant diversity (El Amin 1990; Gibreel 2008; Isaa *et al.* 2018; Ismail 2020). Furthermore, Fabaceae was reported as the second-largest family, with 11 species used as medicinal and magic plants in the markets of La Paz and El Alto, Bolivia (Macia *et al.* 2004). The representation of this family in the present survey may be related to the abundance and accessibility of its woody members and the diversity of plant resources used by local practitioners. Nevertheless, family-level representation in an ethnobotanical dataset reflects patterns of availability and reported use and

should not be taken as an indication of superior medicinal efficacy. The prominence of Fabaceae in the present survey may reflect both the botanical representation of the family within Sudanese vegetation and the wide range of plant resources represented by its members. The family includes numerous trees and shrubs that are readily available as locally recognized resources and provide different plant parts used in traditional preparations. However, the predominance of Fabaceae in the present dataset should be interpreted as a pattern of documented market use rather than direct evidence that the family has greater medicinal efficacy than other botanical families.

The plants were the most commercialized in Omdurman markets as sources of medicine and were represented by a high percentage of trees (41.67%) and shrubs (29.17%) compared to understory plants, such as herbs (22.92%), grasses (4.17%) and climbers (2.08%). Similarly, in the markets of West Kordofan State, Sudan, the most commercialized medicinal plant species were trees (38.98%), followed by shrubs (33.90%), with lower percentages recorded for herbs (20.34%), grasses (1.69%), and climbers (5.08%) (Hamad 2021).

Different plant organs were represented in the medicinal preparations reported by the participants. Bark was the most frequently reported plant part (33.33%), followed by fruits (20.83%), roots (16.67%), seeds (12.50%), leaves (10.42%), whole plants (10.42%), gums (4.17%), and wood (2.08%). The relatively frequent use of bark and roots is consistent with observations from other ethnobotanical studies, including the findings of Hamad (2021), Musa (2011), and Idu *et al.* (2010). From a conservation perspective, repeated removal of bark or roots may cause greater damage to individual plants than harvesting renewable organs such as leaves or fruits. The substantial representation of bark and root use in the present dataset, therefore, supports the need for further assessment of harvesting intensity and consideration of less destructive collection practices where appropriate (Idu *et al.* 2010, Musa 2011). In the present survey study, bark represents 33.33% of the reported plant parts, and roots represent 16.67%, indicating that a substantial proportion of the documented medicinal plant use involves potentially destructive harvesting practices. In a commercial market context, repeated harvesting of bark and roots may increase pressure on slow-growing or heavily traded woody species. These findings, therefore, highlight the need for species-specific assessment of harvesting intensity and the promotion of less destructive collection practices where biologically feasible.

The interviewed herbalists and healers in Omdurman markets have ethnobotanical knowledge, as they reported different ways of preparing herbal medicines. Among these, maceration was the most common mode of preparation (16 plants; 33.33%), followed by decoction (14 plants; 29.17%), infusion (5 plants; 10.42%), smoking, direct application as powder (4 plants; 8.33% each), while the least common mode of preparation was paste (1 plant; 2.08%). In similar ethnobotanical surveys, decoction was the major preparation remedy (25%), followed by maceration (24%), smoking (12%), and direct application (8%) (Hamad 2021). Musa (2011) reported decoction as one of the dominant methods of remedy preparation in ethno-medicinal inventory of other socio-cultural groups in Sudan. The frequent use of decoctions and other aqueous preparations may reflect their practical suitability for extracting plant materials and their familiarity within the local traditional medical system. However, the present ethnobotanical data document traditional practices and do not establish the pharmacological efficacy, clinical effectiveness, or safety of the reported preparations (Hamad 2021, Musa 2011). In other studies, infusion (36%) and maceration (32%) were reported as the most commonly used methods for preparing medicinal plants (Issa *et al.* 2018).

The interviewed herbalists and healers in major Omdurman markets reported that most remedies (preparations or medicines) derived from medicinal plants were administered orally (83.3%; 40 plants), while others were administered externally by applying the remedies topically to the skin (16.7%; 8 plants). This finding agrees with Hamad (2021), who reported the same modes of administration of medicinal plants in Western Kordofan State, Sudan. The predominance of oral administration in this survey indicates that the majority of medicinal preparations were intended for systemic or internal use according to the practitioners' traditional knowledge. This pattern may also be related to the frequent preparation of plant materials as macerations, decoctions, infusions, juices, and powders that can readily be administered orally. Nevertheless, the documented routes of administration represent traditional practices reported by the participating informants and do not indicate clinical efficacy or safety.

According to Macia *et al.* (2005), the fact that such a high number of species are used to treat many different medical problems and have so many therapeutic applications can be explained by the possibility that rural and peasant people living in these cities may consider treatment with medicinal plants to be closer to or within their own traditional culture (Abebe & Teferi 2021, Macia *et al.* 2005).

Several limitations should be considered when interpreting these findings. First, the survey included 20 herbalists from two major markets in Omdurman; therefore, the recorded knowledge should not be assumed to represent all traditional practitioners or communities in Khartoum State, especially in Omdurman area. Second, the study was conducted in market settings and consequently reflects the knowledge and practices associated with medicinal plant trade rather than the complete ethno-medicinal practices of the wider community. Third, the field investigation represented a defined sampling period, and seasonal variation in plant availability, trade, and medicinal plant use may not have been fully captured. Accordingly, the reported quantitative indices should be interpreted as descriptive measures of the documented dataset rather than as estimates of the prevalence of medicinal plant use throughout Omdurman.

Based on the findings of this survey in Omdurman, Sudan, and in agreement with the outcomes of Erinoso and Aworinde (2018), we recommend establishing formal national policies to accredit traditional healers, standardize vendor practices regarding medicinal plants, and enforce strict quality control protocols to ensure the safety of the remedies. Also, indigenous botanical knowledge from the local community should be integrated into national biodiversity strategies to protect native medicinal plants from over exploitation, urban encroachment, and climate pressures (Erinoso & Aworinde 2018). Finally, we recommend incorporating ethnobotany as a distinct subject into academic curricula, as this will assist in preserving Sudan's rich biocultural heritage and effectively guiding future pharmacological research.

Conclusion

This market-based survey documented the medicinal plant knowledge reported by herbalists and traditional healers in two major Omdurman markets. Forty-eight medicinal plant species representing 45 genera and 25 families were recorded, with differences observed in the plant parts used, preparation techniques, administration routes, and reported therapeutic applications. Fabaceae was the most represented family, while trees formed the largest growth category. The use-value analysis identified *Waltheria indica*, *Tribulus terrestris*, and *Citrullus colocynthis* as species with the highest reported use values among the participating informants. Also, the findings provide a localized record of medicinal plant use associated with Omdurman markets and complement previous ethnobotanical studies conducted in other parts of Sudan. Because the investigation involved a limited number of practitioners and was restricted to two major market settings, the findings should be interpreted as descriptive of the surveyed participants rather than representative of the wider Omdurman population. Further investigations integrating ethnobotanical documentation with phytochemical, pharmacological, toxicological, and conservation studies would be valuable, particularly for species that were frequently reported by the participating practitioners. Continued documentation of local knowledge may also contribute to its preservation and to the development of sustainable approaches to medicinal plant use.

Declarations

List of abbreviations: BoM - Bosta (or Al-Bosta) Market; ICF - Informant Consensus Factor; ShM - Shaby (or Al-Shaby) Market; UV - Use Value index.

Ethics approval and consent to participate: This study was conducted in accordance with the ethical and legal principles governing research involving traditional knowledge. Participation of the herbalists and traditional healers was entirely voluntary and was based on their written informed consent. Prior to data collection, all participants were informed about the objectives of the study, the nature of their participation, and the confidentiality of the demographic information they provided.

Consent for publication: Not applicable.

Availability of data and materials: The data supporting this study are available from the corresponding author upon reasonable request.

Competing interests: The authors declare that they have no competing interest.

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Author contributions: Conceptualization: W.O., H.H.G.; Design: W.O., H.H.G., A.A.; Literature search: H.H.G., R.M.Y.D.; Data curation: H.H.G., R.M.Y.D.; Data analysis: A.E.S., M.M.; Methodology: W.O., H.H.G.; Project management: W.O.; Resources: H.A.W., A.E.S.; Supervision: H.H.G., A.A.; Validation: H.A.W., MM. Drafting - original draft: H.H.G., R.M.Y.D.; Writing - proofreading and editing: W.O., A.A., A.E.S., M.M., H.A.W.

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Literature cited

Abebe BA, Chane Teferi S. 2021. Ethnobotanical study of medicinal plants used to treat human and livestock ailments in Hulet Eju Enese Woreda, East Gojjam Zone of Amhara Region, Ethiopia. Evidence-Based Complementary and Alternative Medicine. 6668541. doi: 10.1155/2021/6668541

Adam MMA. 2018. Assessment of urban forest /trees status and their role environmental improvement in Omdurman locality, Sudan. M.Sc. thesis, University of Khartoum.

Adam YO. 2014. Local knowledge on trees utilization and their existing threats in Rashad District of Nuba Mountains, Sudan. Journal of Forest and Environmental Science 30(4):342-350. doi: 10.7747/JFES.2014.30.4.342

Agize M, Demissew S, Asfaw Z. 2013. Ethnobotany of medicinal plants in Loma and Gena Bosa districts (Woredas) of Dawro Zone, Southern Ethiopia. Top class Journal of Herbal Medicine 2(9): 194-212

Ahmad KS, Kayani WK, Hameed M, Ahmad F, Nawz T. 2012. Floristic diversity and ethnobotany of Senhsa, District Kotli, Azad Jammu and Kashmir (Pakistan). Pakistan Journal of Botany 44:195-201.

Ahmed RH, Mustafa DE, Mohamed YS. 2019. Anti-diabetic plants used in Sudanese folk medicine and their phytochemical constituents: A Review. Journal of Advanced Research in Pharmaceutical Sciences and Pharmacology Interventions 3(1):1-8.

Angiosperm Phylogeny Group. 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Botanical Journal of the Linnean Society 161(2):105-121. doi: 10.1111/j.1095-8339.2009.00996.x

Angiosperm Phylogeny Group. 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society 181(1):1-20. doi: 10.1111/boj.12385

Ballal ME, Salih NKE, Abdel Magid TD. 2014. Ethno-botany of natural forests of Nuba Mountains, South Kordofan State, Sudan. Journal of Forest Products and Industries 3(1):13-19.

Darbyshire I, Kordofani M, Farag I, Candiga R, Pickering H. 2015. The plants of Sudan and South Sudan: An annotated checklist, Royal Botanic Gardens, Kew Publishing, London, UK.

Doka IG, Yagi SM. 2009. Ethnobotanical survey of medicinal plants in West Kordofan (Western Sudan). Ethnobotanical Leaflets 13:1409-1416.

El-Amin HM. 1990. Trees and shrubs of the Sudan. Ithaca Press, Exeter, UK.

El Ghazali GEB, El Tohami MS, El Egami AAB, Abdalla WE. Mohamed G. 1994. Medicinal plants of Sudan, Part II, medicinal plants of Northern Kordofan. University press Khartoum, Khartoum, Sudan.

El-Kamali HH. 2009. Ethnopharmacology of medicinal plants used in North Kordofan (Western Sudan). Ethnobotanical Leaflets 13:89-97.

Erinoso SM, Aworinde DO. 2018. Current outlook and future promise of ethnobotany in Nigeria: A review and personal observation. African Journal of Plant Science 12(4):73-80. doi: 10.5897/AJPS2017.1571

Esquivel-Garcia R, Perez-Calix E, Ochoa-Zarzosa A, Garcia-Perez ME. 2018. Ethnomedicinal plants used for the treatment of dermatological affections on the Purepecha Plateau Michoacan, Mexico. Acta Botánica Mexicana 125:95-132. doi: 10.21829/abm125.2018.1339

Gibreel HH. 2008. A Taxonomic study on trees and shrubs of El Nour natural forest reserve, Blue Nile State, Sudan. M.Sc. thesis, University of Khartoum.

Hamad EM. 2021. Ethnobotany and conservation of some plants species in two localities in West Kordofan State. M.Sc. thesis, University of Khartoum.

Haston EM, Richardson JE, Stevens PF, Chase MW, Harris DJ. 2009. The linear Angiosperm Phylogeny Group (LAPG) III: A linear sequence of the families in APG III. Botanical Journal of the Linnean Society 161(2):128-131. doi: 10.1111/j.1095-8339.2009.00974.x

Havva O, Necattin T. 2019. Investigation of plants with ethnobotanical use in Gaziantep province (Turkey). GSC Biological and Pharmaceutical Sciences 7(2):71-78. doi: 10.30574/gscbps.2019.7.2.0076

Idu MD, Erhabor JO, Efijuemue HM. 2010. Documentation on medicinal plants sold in markets in Abeokuta, Nigeria. Tropical Journal of Pharmaceutical Research 9(2):110-118. doi: 10.4314/tjpr.v9i2.53696

Ismail IM. 2020. Phytosociology and biodiversity indices of the woody plants of Alfula Area, West Kordofan, Sudan. Agriculture and Forestry Journal 4(1):40- 46.

Issa TO, Mohamed YS, Yagi S, Ahmed RH, Najeeb TM, Makhawi AM, Khider TO. 2018. Ethnobotanical investigation on medicinal plants in Algoz area (South Kordofan), Sudan. Journal of Ethnobiology and Ethnomedicine 14:31. doi: 10.1186/s13002-018-0230-y

Li F, Zhuo J, Liu B, Jarvis D, Long C. 2015. Ethnobotanical study on wild plants used by Lhoba people in Milin County, Tibet. Journal of Ethnobiology and Ethnomedicine 11:23. doi: 10.1186/s13002-015-0009-3

Macia MJ, Garcia E, Vidaurre PJ. 2005. An ethnobotanical survey of medicinal plants commercialized in markets of La Paz and El Alto, Bolivia. Journal of Ehnopharmacology 97(2):337-350. doi: 10.1016/j.jep.2004.11.022

Musa MS, Abdelrasool FE, Elsheikh EA, Ahmed LAMN, Mahmoud AE, Yagi SM. 2011. Ethnobotanical study of medicinal plants in the Blue Nile State, South-eastern Sudan. Journal of Medicinal Plants Research 5(17):4287-4297. doi: 10.5897/JMPR.9000589

Musa MS. 2011. Botanical and ethnobotanical studies on medicinal plants in the Blue Nile State. M.Sc. thesis, University of Khartoum.

Salih NKE, Ali AH. 2014. Wild food trees in Eastern Nuba Mountains, Sudan: Use, diversity, and threatening factors. Journal of Agriculture and Rural Development in the Tropics and Subtropics 115(1):1-7.

Seyoum Y, Teketay D, Shumi G, Wodafirash M. 2015. Edible wild fruit trees and shrubs and their socioeconomic significance in Central Ethiopia. Ethnobotany Research and Applications 14:183-197.

Singh B, Singh B, Kishor A, Singh S, Bhat MZ, Surmal O, Musarella CM. 2020. Exploring plant-based ethnomedicine and quantitative ethnopharmacology: Medicinal plants utilized by the population of Jasrota Hill in Western Himalaya. Sustainability 12(18):7526. doi: 10.3390/su12187526

Trotter RT, Logan MH. 1986. Informant consensus: a new approach for identifying potentially effective medicinal plants. In: NL Etkin (ed.). Plants in indigenous medicine and diet: biobehavioral approaches. Redgrave Publishing Company, Bedford Hills, New York, Pp. 91-112.

Tugume P, Kakudidi EK, Buyinza M, Namaalwa J, Kamatenesi M, Mucunguzi P, Kalema J. 2016. Ethnobotanical survey of medicinal plant species used by communities around Mabira Central Forest Reserve, Uganda. Journal of Ethnobiology and Ethnomedicine 12:5. doi: 10.1186/s13002-015-0077-4

Ullah M, Sarfraz M, Ullah H, Khan MU, Kanwal M. 2021. Ethnomedicinal uses of different plants for the treatment of asthma in Pakistan. Biomedical Journal of Scientific and Technical Research 36(5):28896-28902. doi: 10.26717/BJSTR.2021.36.005917

Wanjohi BK, Sudoi V, Njenga EW, Kipkore WK. 2020. An ethnobotanical study of traditional knowledge and uses of medicinal wild plants among the Marakwet Community in Kenya. Evidence-Based Complementary and Alternative Medicine 3208634. doi: 10.1155/2020/3208634