



Wild Plants Used as Nutraceuticals from Nebbi District, Uganda

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Authors' contributions

This work was carried out in close collaboration between all authors. All the authors were involved in the work and preparation of the final manuscript. Author AG wrote the original concept and designed the study. Authors HOO and KMM were involved in supervising and guiding the progression of the study. They also proof read and advised on protocol and data analysis. All the authors have read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: To inventory the wild plant species used both as food and medicine and how they are used in Panyago Sub County, Nebbi district.

Study Design: Ethnobotanical study.

Place and Duration of Study: The villages of Kaal, Padoch South, Nyakaduli and Pacer South, Panyago Sub County, Jonam County in Nebbi district, between May and July 2011.

Methodology: Data were collected from the local people using questionnaires, Focus Group Discussions (FGD's) and field observations. Both purposeful sampling and simple random sampling methods were used to obtain the required information. Triangulation was achieved by combining the different data collection techniques and tools.

Results: Forty six plant species belonging to 28 different plant families were reported to have overlapping uses as both foods and medicines. They were reported to treat 32 conditions, the commonest being stomach or abdominal aches. Leaves were the most frequently used parts of the plants as food (45.1%), while roots were the most commonly used parts of the plants as medicine (33.8%). Some of the plant species were reported to have the same parts used both as medicine and eaten as food (26.1 %) while other plant

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species had different parts used either as food or medicine. Infusions were the most commonly used methods of preparation, while most medicines were administered orally. An additional nine plant species belonging to eight plant families were reported to be used as famine foods, with no apparent medicinal benefits.

Conclusion: Several species of wild plants are used as nutraceuticals or as medicines by the people of Nebbi. Notably, many of the plants have overlapping uses as food and medicine. Many families still rely heavily on these plant species but are not consistently transferring the knowledge to the younger generations.

Keywords: Nutraceutical; food; medicine; wild.

1. INTRODUCTION

Currently, there is a global outcry over food insecurity [1]. This is worsened by the soaring food prices [2,3]. Uganda is not an exception, with a high average annual population growth rate of 3.2% and low annual growth rate of food production of about 1.5 % [4,5]. The proportion of undernourished people is highest in sub-Saharan Africa at 30 % [6,7], especially among children, women and the elderly [8]. Although Uganda has fertile soils and good climate, food insecurity exists throughout the country, but varies both geographically and amongst livelihood groups [9]. Families in Nebbi have only one harvest or agricultural season per year causing a serious burden on the nutritional status, livelihood and health of the local people.

Globally, mankind is dependent on a handful of widely cultivated plant species for food security [10,12]. During the course of history, some 12,000 plant species have been used as food, but only 2,000 have been domesticated and only about 150 are commercially cultivated [13]. About 30 species of plants have been reported to provide about 90% of the world's nutritional needs [13], and only 12 crops are known, to contribute between 85–90% of world's caloric intake [14]. By contrast, wild foods provide a greater dietary, nutritional and medicinal diversity [12,15]. Millions of people in developing countries depend on wild resources, for wild medicinal and edible plants [16]. A food plant may be used for medicine, and to treat ill health or to maintain wellness [17,18]. Hippocrates, 400–377 B.C. is famously quoted to have said 'Let food be your medicine and medicine be your food' [19].

Globally the majority of food plants are neglected or underutilized and are mostly wild [21,22]. The number of non-cultivated edible plant species in Uganda has been reported to be far higher than those cultivated [20]. This has created growing fear of the over reliance by humans on a narrow food base [20,23]. This has led to the growing or renewed interest in the documentation, collection, conservation and consumption of wild edible plants or wild crop relatives [24,25]. These actions are consistent with the multi-pronged approach required for the conservation and promotion of sustainable utilization of neglected food plants [10].

Wild plants may be defined as those that grow spontaneously in self-maintaining populations in natural or semi-natural ecosystems and can exist independently of direct human action [11]. Despite society's primary reliance on crop plants, the tradition of eating wild plants has not completely disappeared [26]. In many societies, a large number of wild edible plants are regarded as emergency or hunger gap or famine foods [22,14,25]. Wild food plants are accepted by rural communities through custom as appropriate and desirable [26]. Despite

their wide-spread use, no efforts have been made to document wild plant species in Nebbi district.

2. MATERIALS AND METHODS

2.1 Study Area

Nebbi District is located in the North-Western part of Uganda, in the equatorial belt extending from Democratic Republic of Congo (DRC). Nebbi District lies between 2° 44' north, 31° 24' E at an altitudinal range of 945–1,219 m above sea level with an average rainfall of 1,500 mm and high temperatures of the modified equatorial climatic type [27] (Fig. 1). This study was conducted in Kaal, Padoch South, Nyakaduli and Pacer South villages in Panyango sub county, Jonam County.

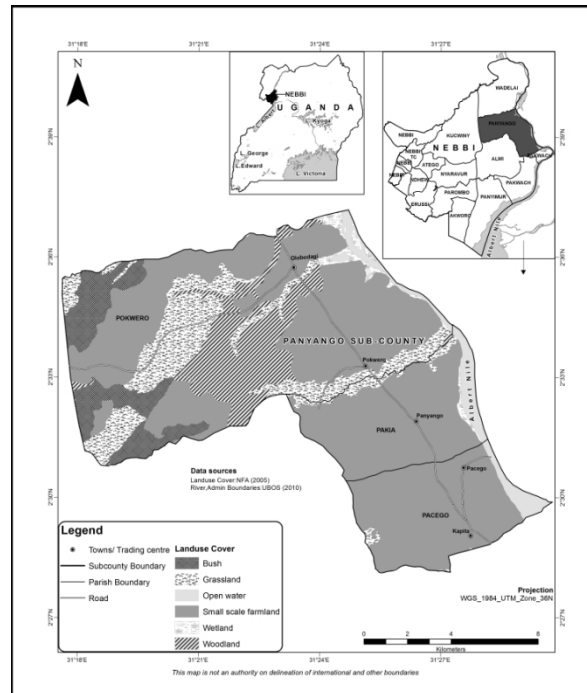


Fig. 1. Location of Jonam County in Nebbi District in North-western Uganda

2.2 Data Collection

Questionnaires were used for data collection. Questions on which plants are eaten for both food and used as medicine were asked, as well as the type of plant (habit), the part or parts eaten, where the plant grows, how it is harvested, when it is harvested, and who harvests it, how it is prepared as medicine or food, and the conservation status of the plant species among others. The questionnaires consisted of open-ended questions addressed to the respondents during interviews. The interviews were conducted in the local language with the assistance of an interpreter and a field assistant. Two Focus Group Discussions (FDG's) were carried out to obtain in-depth information, authenticate claims from other people and explore spontaneous remarks from respondents.

Field walks were taken to make observations on how the different plants were collected, prepared and used. The researchers systematically observed and recorded how the plants were harvested, where they were harvested from and how they were prepared and administered. The combination and use of the different data collection techniques and tools served the purpose of triangulating the data collected.

Prior to any contact with the local community, the study was introduced to the local area authorities through the district administrators. The purpose and objectives of the study were explained so as to sensitize the authorities. Prior informed Consent (PIC) was sought from the respondents before engaging them in the interview process, to remove any suspicion or doubt. Both purposeful sampling methods and simple random sampling methods were used to obtain the required information. The snow-ball technique was used as the purposeful sampling method of choice to identify and locate key informants such as healers. The rest of the households were randomly selected by using the simple random sampling method. The redundancy criterion for selecting the sample size from the given villages. However, the sample size for the simple random sampling units was set at 30% of the total households per village.

2.3 Collection of Voucher Specimens

Voucher specimens of each of the plant species mentioned and documented in the study were collected, prepared and taken to the Herbarium at Makerere University for identification and classification. All the specimens were collected in accordance with standard plant collection procedures described in [28]. The scientific names of plant species were identified based on the plant list at <http://www.theplantlist.org>

3. RESULTS AND DISCUSSION

A total of 102 respondents; 52 males and 49 females were used in this study. There were more males (51.5%) than females (48.5%) interviewed. The majority of the respondents were between 26-36 years of age (22.8%), followed by those between 48-58 Years (19.8%) and those 70 years & above (18.8%) (Table 1). The youngest respondents were those between the ages of 15-25 years and they were also the fewest, making up 13.9% of the total population interviewed

Table 1. Age characteristics of respondents

15-25 Years	26-36 Years	37-47 Years	48-58 Years	59-69 Years	70 years & above
14 (13.9%)	23 (22.8%)	12 (11.9%)	20 (19.8%)	13 (12.9%)	19 (18.8%)

A total of 46 plant species belonging to 28 families were reported to have overlapping uses as both food and medicine (Table 2). Leguminosae and Solanaceae families had the highest variety of nutri-medicinal plants, with 5 plant species each. This was followed by Tiliaceae and Malvaceae with 3 plant species each. Acanthaceae, Amaranthaceae, Apocynaceae, Cannabaceae, Lamiaceae and Moraceae families each had 2 plant species. The rest of the families had only one plant species each. The most frequently used plant species were herbs (47.8.7%), followed by trees (28.3) and shrubs (19.6%). Scramblers and climbers had the lowest numbers each, contributing (2.2%) of the life forms of the plant species.

Table 2. Wild nutri-medicinal plants of panyango subcounty nebbi district

Family	Scientific name, & Local name, (Alur)	Life form	Part (s) used as food	Part (s) used as medicine	Condition (s) treated	Mode of preparation & application as medicine	Frequency of mention
Acanthaceae	<i>Asystasia gangetica</i> (L.)T. Anderson (Owuru)	H	L & St	L & St	Ringworm Tonsillitis Gum disease	Ash from leaves & stem cooked with beans Powder & mixed in Vaseline or fresh juice applied topically	2
	<i>Acanthus</i> spp (Omvuru)	H	L	L	Toothaches Gum/oral disease	Ash from leaves & stem cooked with beans Burnt to ash & applied to aching teeth or gum	6
Amaranthaceae	<i>Amaranthus graecizans</i> L. (Omvuga)	S	L	R & L	Lower back pain Postpartum pain	Leaves eaten as sauce Crushed & rubbed & Decoction	18
	<i>Amaranthus hybridus</i> L. subsp. <i>cruentus</i> (L.) Thell. (Dodo)	H	L	R	Pregnancy complications	Leaves eaten as sauce Infusion	16
Anacardiaceae	<i>Sclerocarya birrea</i> (A. Rich.) Hochst. (Nunga)	T	Fr & Sd	R & B	Stomach ache Hemorrhoids Prolapsed rectum Diarrhoea	Leaves and seeds eaten as sauce Infusion	23
Apocynaceae	<i>Carissa edulis</i> (Forssk.) Vahl (Acoga)	S	Fr	R	General pain Menstrual pain Syphilis Spiritual issues	Juice made from fruit or fermented to make alcoholic beverage	55

Table 2 Continued

					Body weakness Malaria Scorpion stings Fresh wounds	Decoction Infusion Poultice Inhalation of smoke Nectar from flower eaten Sap applied to wounds	4
Arecaceae	<i>Thevetia peruviana</i> (Pers.) K. Schum. (Landuru) <i>Borassus</i> <i>aethiopicum</i> Mart. (Tugu)	T	Fl	Sp			
		T	Fr & L	B	Cough	Fruit eaten as snack & leaves as sauce Decoction	10
Asclepiadaceae	<i>Leptadenia hastata</i> Vatke (Alungu)	Sc	L& Fl	Sp & R	Flu, Wounds Cough, fever Body weakness Wounds	Topical application, Powder & Infusion	42
Asteraceae	<i>Bidens pilosa</i> L. (Ayegomon)	H	Fl	L		Inflorescence used as a substitute for tea leaves Crushed & applied to affected areas Leaves chewed	42
Boraginaceae	<i>Cordia monoica</i> Roxb. (Somboro)	S	L	L	Throat infections Appeasing spirits Bad omens		10
Cannabaceae	<i>Celtis integrifolia</i> Lam (Aling) <i>Celtis mildbraedii</i> Engl. (Okweng)	T	Fr	R		Fruit eaten as snack Cold water bath	13
		T	Fr	L	Skin diseases	Fruit eaten as snack Ash in Vaseline	14
Capparaceae	<i>Capparis</i> <i>erythrocarpos</i> Isert. (Ongonongono)	S	Fr	R	Diarrhoea Cataracts	Infusion for eye drops	19
Cleomaceae	<i>Cleome gynandra</i> L. (Akeyo)	H	L, St	R	Eye & ear infections Cataracts Stomach aches Food poisoning	Infusion ear & eye drops & chewing	71

Table 2 Continued

Convulvulaceae	<i>Ipomoea shupangensis</i> Baker. (Odrugu /ombokorao)	H	L	L	Tooth aches	Boiled with salt & put on teeth	9
Cucurbitaceae	<i>Coccinia grandis</i> (L.) Voigt. (Tun-anyira)	C	Fr	Fr	Bed wetting	Eating of the fruits	6
	<i>Cucumis metuliferus</i> E.Mey. ex Naudin (Okuju)	C	Fr	Fr	Sore spleen	Fruit eaten raw as salad or cooked	36
	<i>Peponium vogelii</i> (Hook.f.) Engl. (Okuju)	C	Fr	Fr	Sore spleen	Fruit eaten raw as salad or cooked	36
Ebenaceae	<i>Diospyros mespiliformis</i> Hochst. ex A.DC. (Cumu)	T	Fr	B	Cough	Decoction	1
Euphorbiaceae	<i>Erythrococca bongensis</i> Pax. (Acululu)	S	L	L	Malaria Appetiser Imunobooster Energizer Fresh wounds	Leaves eaten as sauce Cooked as sauce & topical application	34
Leguminosae	<i>Acacia seyal</i> Delile (Lalwilwi / Katuka)	S	Sd	R	Prolapsed rectum	Seed eaten as snack Decoction	7
	<i>Cajanus cajan</i> (L.) Millsp. (Lapenda)	H	Sd	R & L	Flatulence, Colic Nasal swellings	Seed eaten as sauce Decoction, inhalation, infusion, topical application, juice	11
	<i>Senna obtusifolia</i> (L.) H.S.Irwin & Barneby (Lapirondyek/	S	L	R	Stomach ache	Warm water infusion	13

Table 2 Continued

Ombokodriek)							
	<i>Tamarindus indica</i> L. (Chwaa)	T	Fr	B, Sd, R	Dysentery Scorpion stings Red eyes	Fruit eaten as snack & juice made from fruit Fruit juice, Infusion & Topical application	24
	<i>Vigna unguiculata</i> (L.) Walp. (Obo ayom /Obo alwala)	H	L	R	Syphilis & gonorrhea & Sexually transmitted infections	Leaves eaten as sauce Decoction	3
Lamiaceae	<i>Hoslundia opposita</i> Vahl. (Ovungele)	S	Fr	L & R	Wounds Abdominal pain	Fruits eaten as snack Poultice applied to wounds & infusion to abdominal pains	36
	<i>Leonotis nepetifolia</i> (L.) R. Br (Otwilo)	S	Fl	L	Malaria	Nectar from flowers eaten Infusion	7
Loganiaceae	<i>Strychnos innocua</i> Delile(Akwalakwala)	T	Fr	R	Impotence STI's, Nasal infections	Fruit eaten as snack Decoction	19
Malvaceae	<i>Grewia trichocarpa</i> Hochst. exA.Rich. (Opobo)	T	Sd	B	Stomach ache Gum disease	Seeds eaten as snack Decoction & rubbing on area	7
	<i>Hibiscus sp</i> (Ombirwa)	H	L	L	Malaria	Leaves eaten as sauce Decoction	6
	<i>Hibiscus cannabinus</i> L.(Malakwang)	H	L	L & Ap	Wounds Gum disease	Leaves eaten as sauce Paultice & ashes	14
Moraceae	<i>Ficus sycomorus</i> L.	T	Fr	R	Hunchback	Fruit eaten as snack	7

Table 2 Continued

	(Olam)						Cold water bath & compress	
Moraceae	<i>Ficus thonningii</i> Blume (Bongo)	T	Fr	R	Colic	Fruit eaten as snack Juice squeezed into mouth	5	
Olacaceae	<i>Ximenia americana</i> L (Olemo)	T	Fr	R	Stomach ache	Fruit eaten as snack Infusion	15	
Pedaliaceae	<i>Sesamum indicum</i> L (Landi)	H	Sd	L	Eye infections	Paste made from seeds and eaten Infusion (eye drops)	3	
Polygonaceae	<i>Oxygonum sinuatum</i> (Hochst. & Steud ex Meisn.) Dammer (Okure)	H	L	Ap	Skin diseases Oral & anal sores	Leaves eaten as sauce Powder mixed with Vaseline	8	
Rhamnaceae	<i>Ziziphus mucronata</i> Willd. (Olango)	H	Fr	R	Food poisoning	Fruit eaten as snack Infusion of root powder or cooked in soup	4	
Solanaceae	<i>Solanum angustifolium</i> Mill.	H	L	R & L	Cleaning uterus after child birth	Leaves eaten as sauce Infusion	25	
	<i>Lycopersicon esculenta</i> Mill. (Nyanya)	H	Fr	Fr	Sores in the mouth	Juice extracted from fruit Fruit juice	5	
	<i>Physalis micrantha</i> Link (Tongulugwal)	H	Fr	L	Epilepsy	Fruit eaten as snack Infusion from powder	6	
	<i>Physalis peruviana</i> L. (Tongulugwal)	H	Fr	L	Epilepsy	Fruit eaten as snack Infusion from powder	1	
	<i>Solanum nigrum</i> L. (Ociga)	H	L	L	Wounds Nasal swellings	Juice squeezed from leaves	16	

Table 2 Continued

Talinaceae	<i>Talinum portulacifolium</i> (Forsk) Asch.ex Schweinf (Arum)	H	L	R	Stomach ache	Leaves eaten as sauce Infusion	15
Tiliaceae	<i>Corchorus olitorius</i> var. <i>incisifolius</i> Asch. & Schweinf.(Otigo-kaal)	H	Ap	L	Constipation	Above ground parts cooked as sauce	6
	<i>Corchorus olitorius</i> L. (Otigo-Akweyo)	H	Ap	L	Constipation	Above ground parts Cooked as sauce or with other vegetables	7
	<i>Corchorus tridens</i> L. (Otigo-Afuku)	H	Ap	L	Constipation	Above ground parts cooked as sauce or used as medicine vegetables or meat	1
Zygophyllaceae	<i>Balanites aegyptiaca</i> (L.) Delile (Thoo)	T	Fr	B	Joint aches Stomach pain Fever	Fruit eaten as snack & cooking oil extracted from seed Decoction	27
<p>Key: B=Bark Fl=Flowers H=Herb R=Roots St=Stem T=Tree C=Climber Fr=Fruits L=Leaves Sc=Scrambler S=Shrub</p>							

Some of the plant species (26.1 %) such as *Capparis erythrocarpos* and *Cleome gynandra*, had the same parts eaten as food and used as medicine. Some other plant species such as *Cajanus cajan* and *Borassus aethiopicum* had different parts used as either food or medicine (73.9%) (Table 2).

The most commonly mentioned plant species by respondents as both food and medicine were *Cleome gynandra* L., (10.3%) *Carissa edulis* (8.0%), *Leptadenia hastata* (6.1%), and *Bidens pilosa* (6.1%), while the least frequently mentioned plant species were; *Diospyros mespiliformis* (0.14%), *Asystasia gangetica* (0.3) and *Vigna unguiculata* (0.4%). Most of the plant species were collected from the bushes (39.1%) (Table 1) while the minority were gathered from roadsides and the shores of the River Nile (3.4%) (Table 2).

A total of 32 conditions were reported by the respondents in the study area to be treated (Table 2). The most commonly treated conditions were stomach aches or abdominal pains (12.0%) and wounds (8.4%). These were followed by infections of the eyes, cataracts and malaria all at 6.0%. Among those least mentioned conditions were, ear infections, epilepsy, flu and hemorrhoids contributing less than 2% of diseases mentioned. Fifty percent of all the plant species were used to treat only one disease while 11.4% of the plant species were used to treat two conditions and 36.6% were used to treat more than two diseases (Table 2). The most commonly used method of preparation of medicines was infusions, which were, cold water (11.8%), hot water (7.4%) or warm water infusions (4.4%). This method was followed by decoctions (25.0%). The least modes of preparation and administration were; compress, and mouth and nasal drops all at 1.5%. Oral administration was found to be the most frequently used route of drug administration at 63.0%. The medicinal preparations were given to the patients to drink either in the form of tea, infusions, decoctions, soups and in porridge.

Leaves were the most frequently used parts of the plants as food (45.1%), followed by fruits (30.1%). The least commonly consumed plant parts as food were seeds (9.9%), followed by flowers at (8.5%) and stems at (5.6%) (Fig. 2).

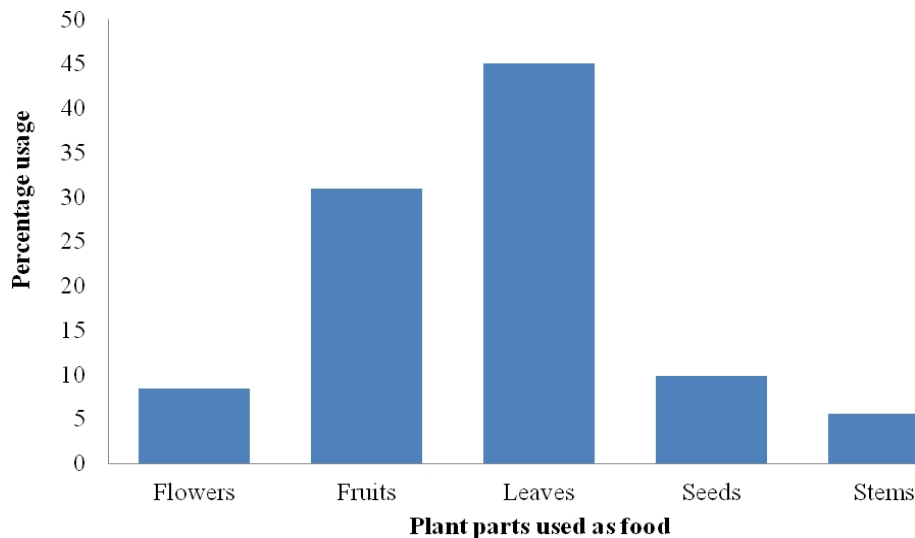


Fig. 2. Parts of the nutri-medicinal plants used as food

Roots were the most frequently used parts of the nutri-medicinal plants as medicine (33.8%), followed by the leaves (30.9%) and the bark (11.8%), in that order. The least utilized parts of the plants for medicine were fruits (8.8%), sap and seeds each at (5.88%) and stems (2.9) (Fig. 3).

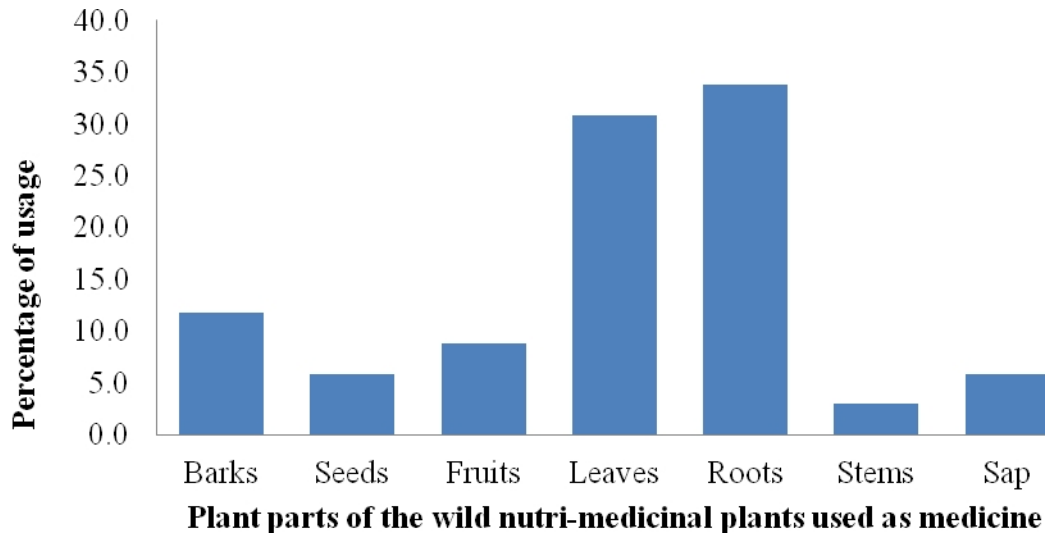


Fig. 3. Parts of the nutri-medicinal plants used as medicine

Nine wild plant species were also documented as being used as food with no apparent medicinal uses (Table 3). Some of the plant species such as *Nymphaea lotus* and *Dacyloctenium aegypticum* were exclusively used as famine foods. These plant species belonged to eight different plant families. The family Leguminosae had two different plant species whereas the rest of the plant families had only one plant species each. Most of the wild food plant species (33.3) were trees, whereas trees and shrubs each made up 22.2% of the life forms. Climbers and grasses were the fewest, each making up 11.1% of the plant species.

There were more men interviewed than women. Women and the elderly particularly those above of 50 years were found to be the most knowledgeable on the wild food plants, Traditional healers, and those engaged in collecting non-timber forest products (NTFP) especially craft materials were found to possess specific knowledge on wild food plants. Fewer young people were interviewed, and they were found to have the least knowledge of these plant species. This phenomenon can be explained by the fact that the younger children spend most of their time in school and are not available at home. They also spend little time with their parents and other relatives who would have taught them about these plants. It is also possible that some of the youth are simply not interested in learning about these plants.

Table 3. Wild food plants of panyango subcounty nebbi district

Family	Scientific Name & Local name, (Alur)	Life form	Part eaten as food	Form of consumption	Frequency of mention
Cucurbitaceae	<i>Lagenaria siceraria</i> (Molina) standl. (Ovudu)	C	Fr	Eaten as sauce	2
Lamiaceae	<i>Vitex doniana</i> Sweet (Oyelo)F	T	Fr	Eaten as a snack	1
Leguminosae	<i>Crotalaria ochroleuca</i> G.Don. (Alwaro)	H	L& Fl	Eaten as sauce	3
	<i>Acacia hockii</i> De Wild. (Oryang)	S	Sd	Eaten as a snack	3
Moraceae	<i>Ficus dicranostyla</i> Mildbr. (Kavugi)	T	Sd	Eaten as a snack	1
Nymphaeaceae	<i>Nymphaea lotus</i> L. (Lorya)	H	Sd	Eaten as porridge or bread	11
Poaceae	<i>Dactyloctenium aegypticum</i> (L.) Willd. (Okor)	G	Sd	Eaten as porridge or bread	17
Rubiaceae	<i>Oldenlandia affinis</i> (Roem. & Schult.) DC. (Ambvuturu)	S	L	Eaten as a snack	2
Sapotaceae	<i>Vitellaria paradoxa</i> C.F. Gaertn. (Yao)	T	Fr &Sd	Eaten as a snack or oil made from seeds	8

In comparison to the 46 species of wild nutri-medicinal plants belonging to 28 families, documented in the study area, 20 wild nutraceutical plants of semiarid Ethiopia belonging to 15 plant families were recorded [29]. *Cleome gynandra*, *Carissa edulis*, *Leptadenia hastata*, *Bidens pilosa*, *Hoslundia opposita* and *Erythrococca bongensis* were recorded as the most frequently utilized plant species for both food and medicine. The frequency of use of a particular plant species was inferred to be by how often the plant was cited by the respondents, thus the most commonly used plant species were the most frequently mentioned. The frequency of mention could also be used as an indicator of the prevalence of a particular condition and the efficacy of the plant species. It has been observed that generally plants which are used in some repetitive fashion are more likely to be biologically active [30].

The majority of the nutri-medicinal plants were herbs. Similarly, [31, 32 and 25] reported most of the plant species in their studies to be herbaceous. On the contrary, [33, 29] identified trees as the most predominant life forms in their study areas among the wild edible plant species, while [34] reported shrubs to be the most predominant life forms in their study. Most of the plant species especially those that required processing before consumption were harvested by women whereas the children and men extracted ripe fruits which were mainly eaten as snacks. Similar trends were reported by [35,22].

Some of the plants were reported to have the same parts eaten as food and used as medicine concurrently such as *Leptadania hastata* and *Asytasia gangetica*, although the modes of preparation differed. Other plant species such as *Cajanus cajan* had different parts used as either food or medicine. Several authors have reported the use of wild plant species for both food and medicine, for example, [33,36,37] among others. In some of the plant species, only one part was used as either food or medicine; e.g. the fruits of *Carissa edulis*, were used as food whereas the root was used as medicine. Other plant species had different or multiple parts of the same plant being used as food, medicine or both; for example the fruit & seeds of *Sclerocarya birrea* were eaten as food while the bark and roots were used as medicine.

It was also observed that women and children form the bulk of the people reliant on herbal medicine [38]. The roots were the most frequently used plant parts for medicine. These were followed by the leaves, whereas the stems were found to be the least utilized. This is similar to the observations made by [38] while [32] reported all the different parts of medicinal plants to be used when preparing medical concoctions, with a significant proportion made using leaves and roots. On the contrary, [29] reported the leaves to be the most commonly used parts of the wild nutraceutical plants as both human and livestock medicine.

3.1 Mode of Preparation and Administration as Food

Most of the plant species documented were cooked and consumed as the main sauce, eaten as a side dish, and also eaten raw as snacks. Vegetables do not often form the main dishes but are cooked mixed with other foods such as beans. These findings are in agreement with those of [31,16,25]. Some plant species were processed by drying them and crushing them to powder for storage purposes. These powders would come in handy during shortages, and would just be reconstituted with water and groundnut paste and prepared for a meal or mixed with dry roast meat. The leaves of certain plants were also reported to be dried and preserved for periods of scarcity [37].

Wild gathered vegetables supplement the cultivated crops. Alternatively, others were utilised for making fruit juice, alcoholic beverages for example *Carrisa edulis* porridge or bread, ash or potash salt, sucking nectar from flowers especially by children, oil, paste, and tea. Very few species are used as roasted grain or as hot drinks like tea substitutes such as the dried inflorescences of *Bidens pilosa*. Some plant species were processed by drying them and crushing them to powder for storage purposes. These powders would come in handy during shortages, and would just be reconstituted with water and groundnut paste or mixed with dry roast meat. [25] reported similar preparation methods.

3.2 Mode of Preparation and Administration as Medicine

Thirty two conditions were reported by the respondents to be treated in the study area. The most commonly treated ailments were stomach aches or abdominal pains, eye infections including cataracts and malaria. This may serve as an indicator of the commonest diseases suffered by the people of this area. The plant materials were mainly crushed and extracted by soaking them in either cold or warm water. Boiling of plant parts as a method of herbal medicine preparation was also reported by [39,40]. Most of the medicinal preparations were administered orally as teas, infusions, decoctions, soups and in porridge.

A peculiar mode of preparation and administration involved cutting the roots of *Leptadenia hastata* into small pieces, drying them and pulverizing them. The powder is then applied by breast feeding mothers on their nipples. This plant is believed to treat cough and fevers in children below the age of 6 months. *Leptadenia hastata* was also one of the most preferred vegetables by the local people in Ethiopia [16]. For certain conditions such as back aches or scorpion stings, small incisions were sometimes made on the affected area with a sharp object such as a razor blade and the medicine rubbed in [31] reported a similar method of application for back aches. Additionally, plant species such as *Leptadenia hastata* were crushed and the juice dropped into the nostrils for treating nasal wounds or swellings. A similar method of application with *Clematis hirsutum* was reported by [31] which was crushed and inserted in the nasal opening and inhaled.

3.3 Collection, Preparation and Consumption of Wild Nutraceutical Plants

Most of the wild nutraceutical plants were harvested from the wild and farmlands or gardens, with the minority harvested along the river Nile and by the roadsides or foot paths. Other authors including [20,42,31,16,43] made similar findings in their studies. On the contrary, Watkins [22] noted that many fruiting trees and shrubs were located near rivers in his study area. Their ability to grow fast and be harvestable within short periods makes them useful in sustaining nutritional requirements in periods of food shortage.

While some plant species were gathered only when in season, for example *Dactyloctenium aegypticum* in the dry season, others were available all year round and were harvested whenever need arose, e.g. *Cleome gynandra* and *Corchorus olitorius* among others. Some of the plants were reported to proliferate and have luxurious growth especially during dry spells, e.g. *Leptadenia hastata*. This served as an alternative food source when other crops have either failed or been destroyed. Other plants such as *Nymphaea lotus* were only eaten during famine or food shortage and were not eaten during times of plenty.

Many of the plant species documented were consumed by all members of the household especially those that were prepared as the main sauce. Other plants were mainly consumed

by young children, for example the fruits of *Hoslundia opposita*. Women and children were the main gatherers of these wild plants. They were also the main parties involved in the preparation, consumption and marketing of wild-food plants. Other authors including [44,16,32,34] had similar findings.

Certain plant species documented as famine foods such as *Nymphaea lotus* was only harvested by men since it grew along the shallow zones of the river Nile and required the use boats for harvesting; hence it was left to men with access to boats to harvest. Market visits revealed a low variety of wild food plants sold, as was also reported by [38]. The vendors revealed that most of the plant species were locally available in the bushes for those who cared to look for them and were not highly demanded since most households had free access to them, thus they were not sold in the markets.

3.4 Knowledge Dynamics of Wild Nutraceutical Plants

Knowledge of these plants was acquired and passed on orally by elders to young people, but also from peers and friends. Some of the information was passed on to others while working in the fields through direct participation and also through observing others using them. Children also learnt from their mothers while in the fields. It was also observed that many of the young people are in formal school, thus do not have much time to interact with the elders who are the custodians of this knowledge. The learning process is thus hampered. Other authors such as [21,45] documented similar trends. This can be attributed to changes in culture, personal preferences, social stigma, the tedious process of preparing certain food items, changes in habitats causing the scarcity or disappearance of certain plant species, discouragement by past leadership in growing them, the introduction of cash crops such as cotton. The reasons given by the respondents were similar to those reported in other areas of Uganda [32]. For example *Erythrococca bongensis* although commonly eaten in the past, it is no longer commonly eaten because of its bitter taste and its association with poverty.

3.5 Conservation Issues

A high percentage (39.1%) of the plant species documented was harvested from the wild with only a handful deliberately grown around homesteads. Similar findings by several other authors have been made [39,40,34]. There has been no deliberate effort to domesticate some of these plant species even those of very high utility and commercial value like *Balanites aegyptiaca* and *Tamarindus indica* among others. As more land is opened up for cultivation, certain plant species are lost as their natural habitats are destroyed. Other plant species were harvested for competing uses such as timber; firewood and charcoal making such as *Carissa edulis*. Some plant species were encouraged to grow and deliberately protected once found growing in the gardens or homesteads. Others were difficult to access since people had to cross the river Nile and venture into the game reserve to harvest them. Whereas some of these plants grow abundantly in many habitats, some of them grow in restricted habitats and some are under threat because of demand for timber and other uses combined with slow growth rates.

None of the plant species documented had any formal protection status. However, some of them such as *Cochorus olitoralis* and *Cleome gynandra* among others were consciously protected by allowing them to grow in fields and home gardens. A few of the plant species were grown in home gardens by the women and were served as a quick supply of sauce

when need arose. This shows the value attached to each of these plant species and can act as a conservation incentive. Such efforts can contribute to the overall conservation efforts of such plant species. A similar scenario was reported by [34,22].

The fact that many of the plant species documented can be eaten as vegetables or sauce can provide an incentive for the local people to domesticate them and possibly cultivate them. They are believed to be for the poorer families and some people may not want to be seen eating them. Others are also believed to be of a low status and are either bitter or unpalatable; making them less preferred despite some other benefits they may obtain from them. As a result, some plants have been relegated to the realms of famine foods and are only eaten during acute food shortages. This stigma has also been reported in other parts of Africa [41,1].

Research has shown that some of these are misconceptions and may be ill founded for example, [39] noted the general lack of public awareness in Uganda of the values of wild plants and the need to use them sustainably. The fact that roots are the preferred therapeutic parts of the plant species, poses a threat to the sustainability of the use of these plants. The use of roots as medicine may have serious consequences on the continued survival of some plant species.

Whereas the majority of plant species had different parts of the same plant used as either food or medicine for example *Borassus aethiopicum*, a few other species such as *Leptadenia hastata* were reported to have the same parts of the plant eaten both as food and medicine at the same time. Thus the harvesting pressure on such plant species is likely to be lower than on other plants with multiple uses. This increases the harvesting pressure on the plant for the multiple uses its different parts have to offer. This has consequences on the conservation status of these plants, as it becomes increasingly difficult for them to survive during harvesting. These plant species such as *Ficus dicranostyla*, also had several other use categories including insecticides specifically against termites, fuel wood, fencing and timber. These also increased the harvesting pressure of these same resources.

4. CONCLUSION

From this study, we conclude that several species of wild plants are used as nutraceuticals or as medicines by the people of Nebbi. Notably, many of the plants have overlapping uses as food and medicine. The leaves being the most frequently used parts of the plant species as food, while the roots being the most commonly used parts as medicine.

CONSENT

Not applicable. However, Prior Informed Consent (PIC) was still obtained from the respondents of the study, prior to any interviews.

ETHICAL APPROVAL

Not applicable.

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COMPETING INTERESTS

All the authors hereby declare that they have no competing interest exits.

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