Traditional use of wild edible plants in the communities adjacent to Mabira Central Forest Reserve, Uganda

Patience Tugume and Clement Nyakoojo

Research

Abstract

Background: Wild edible plants have been collected and consumed by humans since pre-historic times. They act as safety nets in times of food shortage and improve the livelihoods of rural communities. Evidence has proven that they contribute to nutritional health. However, dependence on wild edible plants is being threatened by loss of indigenous knowledge, environmental degradation, and limited scientific validation.

Methods: This study focused on documentation of indigenous knowledge, identity of, and use of wild edible plants in 13 villages of Mabira Central Forest Reserve (CFR). Data were collected through structured and semi-structured interviews, field visits, and free listing. A literature review was carried out to obtain nutritional data on the identified plants.

Results: The twenty-seven plant species identified were distributed in 24 genera and 22 families. The majority of wild edible plant species were trees (41%) while climbers (3%) were the least likely to be edible. Fruits (66%) were the major parts consumed while tubers and roots were the least (4%). Most fruits (74%) were consumed raw; in contrast all the vegetables were cooked. *Aframomum angustifolium* (Sonnerat) K. Schum was the predominant wild food consumed by 74% of the 57 households surveyed. Reviewed nutritional data showed that the identified plants possess a variety of minerals and antioxidants that improve human health and nutrition.

Conclusion: Wild edible plants play a significant role in the nutritional health of consumers. Therefore, research on priority plants for domestication, value addition and standardization into food supplements is recommended. Results on such aspects might motivate local communities to conserve forest biodiversity through sustainable use and management of wild edible plants.

Key words: Indigenous knowledge; livelihoods; nutritive value; Mabira Forest Reserve; wild edible plants.

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Background

Local people in many remote rural areas of the world exploit a variety of plants for nutrition, as medicines, and to meet other daily needs (Ahenkan & Boon 2010, Phondani 2011). Wild edible plants (WEPs) are all plants that are gathered from the non-forested and forested environs (Termotec *et al.* 2011). They have always been significant in almost all cultures; being used for food, medicines, fuel among other uses (Heywood 1999). They continue to be a major source of nutrition for various communities especially during periods of food shortage (Akinnifesi *et al*. 2007, King 1994, Simitu 2005). Globally, an estimated one billion people use wild edible plants to meet their nutritive and therapeutic needs (Aberoumand 2009). Although several studies on food security have emphasized cultivated foods (Ericksen *et al.* 2009) and ignored WEPs, the tradition of eating wild plants is still common

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(Balemie & Kebebew 2006). Many edible plants that used to be wild have been domesticated or localized and they contribute to 95% of the world's plant food intake (Balemie & Kebebew 2006). The practice is more prominent in communities adjacent to forests where diverse utilization of wild plant species as food sources has led to the accumulation of a vast indigenous knowledge base. The WEPs prevent food insecurity in rural communities, especially in the vulnerable groups that are exposed to the risk of undernourishment. Since malnutrition is a rampant phenomenon in developing countries, policy development should emphasize the role of wild food plants in nutritional security and promote conservation of their habitats (Bharucha & Pretty 2010).

Widespread food scarcity has triggered malnutrition in most of the world's populations (Godfray *et al*. 2010). It is estimated that two billion people suffer from micronutrient deficiencies that make them more susceptible to disease, thus hindering economic growth (FAO 2012). Therefore, access to, and utilization of wild edible plants provide a potentially cheap solution to address the challenges of food shortage and malnutrition (Lachapelle *et al*. 2004). In Africa, many communities still gather and consume WEPs (Asfaw 2000) to supplement their diets and a study by Agea *et al*. (2013) confirmed that WEPs act as an alternative to cultivated food plants especially for poor households. The importance of WEPs is attributed to their free and easy accessibility plus nutritional richness especially vitamins and micronutrients (Maroyi 2011, Samnasang & Moreno-Black 2000).

In Uganda, research on WEPs has received attention from several researchers (Agea *et al*. 2013, Katende *et al*. 1995, Katende *et al*. 1999). However, FAO (2009) stresses that the conservation and promotion of sustainable utilization of WEPs have been neglected and require urgent corrective measures such as inventorying, *in situ* conservation of wild relatives and promotion of commercialization. The dependence of rural communities on wild edible plants poses a threat to biodiversity conservation especially where unsustainable harvesting techniques are used. As a result, indigenous knowledge about the use of the plants is disappearing fast from traditional communities (Bagine *et al*. 1997, Höft *et al.* 1999) despite the importance of this knowledge in the promotion of biodiversity conservation and rural development (Asfaw & Tadesse 2001, Lulekal 2005). Sustainable development in communities adjacent to forests is possible only if the forests are conserved and resources therein properly managed. It is important to develop a comprehensive database of WEPs (Frison *et al*. 2009) especially for communities that are most vulnerable to malnutrition (Afolayan & Jimoh 2009) and establish the nutritional value of such WEPs. This will not only preserve indigenous knowledge about the utilization of WEPs but also act as a motivator to conserve their habitats.

Documentation of wild edible plants collected from forests in Uganda with an ethnobotanical approach that includes assessment of diversity and availability is important for conservation and management of these resources. Documentation is also essential given the rapid loss of WEPs habitats due to deforestation. Forested land in Uganda is being lost at a rate of 1.86% per annum (FAO 2010). This high rate of deforestation in Uganda is likely to lead to extinction of the country's wild food sources, negatively impacting on the livelihoods of communities dependent on them. Therefore, it is imperative that indigenous knowledge regarding the identity and use of wild foods by rural communities is documented. Gathering such information is appropriate in making more informed and rational decisions regarding the management of the Mabira Forest Reserve. Local knowledge regarding WEPs can also help in identifying priority species for domestication, commercialization, and development of nutraceuticals. Based on the above background this study sought to (i) make an inventory of wild edible plants in Mabira CFR (ii) determine their mode of consumption and (iii) carry out a literature review on the nutritive value of utilized WEPs. The results of this study highlighted the priority WEPs for possible domestication and standardization into nutritional supplements. This will not only provide communities with a source of nutrients but will also motivate them to sustainably use the available WEPs.

Materials and methods

Study area

The study was conducted in communities adjacent to Mabira CFR. Mabira CFR is located 20 km north of the Lake Victoria shoreline immediately to the west of Victoria Nile and was established in 1932. The forest reserve lies partly in Buikwe, Mukono, and Kayunga districts and occupies an area of 306 km^2 with an altitudinal range of 1070 – 1340 m above sea level. It is situated between latitudes 0º 22' and 0º 35'N and between longitudes 32º 56'and 33º 02'E. The reserve occupies gently undulating country characterized by numerous flat-topped hills and wide shallow valleys. The underlying rocks are composed of micaceous schists and shales of the Buganda-Toro system with ridges of quartzite and amphibolite. The soils are generally ferralitic sandy clay loams, with black waterlogged clays in the valley bottoms. The climate is tropical characterized by two rainfall peaks from April to May and October to November

with an annual average of 1250-1400 mm. The minimum and maximum temperature ranges are 16-17°C and 28-29°C respectively. Mabira CFR is an important forest ecosystem in Uganda and a watershed between the Lake Victoria Basin and Lake Kyoga.

The forest stands of Mabira CFR are majorly composed of indigenous tree species (74.1%) including *Milicia excelsaI* (Welw.) C.C. Berg, *Maesopsis eminii* Engl., *Holoptelea grandis* (Hutch.) Mildbr., *Alstonia boonei* De Wild, *Futumia* spp and *Celtis* spp with the balance (25.9%) being comprised mainly of *Broussonetia papyrifera* (L.) L'Her ex Vent. especially in previously heavily encroached areas (Moyini 2006). Despite being an invasive species, *Broussonetia papyriferra* has helped in natural regeneration of indigenous species including *Antiaris africana* Engl., *Prunus africana* (Hook. f.) Kalkm., *Lovoa trichilioides* Harms, and *Celtis* spp.

The forest reserve is zoned into production, ecotourism/recreation, buffer, and strict nature reserve. The strict nature reserve is the preferred habitat of the Uganda mangabey (*Lophocebus ugandae*) and other endangered species (Baranga 2007). Mabira was subjected to gross human encroachment during the 1970s and early 1980s but this was reversed between 1988 and 1989 when all the encroachers were evicted and a re-afforestation programme embarked on by the forest department. The encroachers originated from the neighboring districts (Howard 1991). In addition, the reserve has 27 official village enclaves whose residents derive a considerable proportion of resources for their livelihood from the forest (Primack 2000). Signs of previous human activities in the forest are quite evident with harvesting of crop produce such as oranges, jackfruits, bananas, and passion fruits still taking place in abandoned gardens. Despite efforts by some stakeholders to save the forest, it remains threatened. On 12th April 2007 Ugandan security forces clashed with protesters in Kampala provoked by the central government's plan to give away a third of Mabira CFR to Mehta Group for conversion into sugarcane plantations. The government backtracked its decision amid outrage from the public, civil society organizations, and a coalition of national and international institutions.

A small proportion (36%) of Uganda's land is devoted to forestry activities. The Permanent Forestry Estate (PFE) is managed by the NFA (64.4%), UWA (33.6%), NFA and UWA (4.7%), and local governments (0.3%) (Obua *et al.* 2010). Due to population growth in the last 30-40 years demand for forest products has increased thus hampering forest management capacity. Mabira CFR is managed by a partnership between the National Forestry Authority (NFA) and the local people under the Collaborative Forest Management (CFM) arrangement with some adjacent communities organized into community-based organizations (CBOs) in accordance with the current forestry policy and legal framework (NFA 2017). For instance, a collaborative management programme was initiated at Nagojje and Najjembe that engages local communities in controlling illegal activities in return for sharing benefits. The area has a sector manager and forest supervisors in addition to employees contracted to support the day to day running of the activities in the forest. The management plan (1997-2007) prohibits harvesting of resources mainly firewood and charcoal production in large quantities for commercial purposes but allows extraction of food materials, medicine, construction, poles and fallen logs for firewood in low quantities for subsistence use (Bush *et al.* 2004).

Sample selection and data collection

An ethnobotanical survey was conducted from August to December 2019. Data on wild edible plants used by communities around Mabira CFR were collected from a total of 13 villages. The villages were selected on the basis of available anecdotal information that indicated dependence of residents from these villages on WEPs for sustenance (Tugume *et al*. 2015). Ethnobotanical information was collected through informed consent, structured and semi-structured interviews with household members present at the time of the survey. In each village 12 households were randomly selected for questionnaire administration giving a total of 156 households. Pre-structured questionnaires were used to obtain information about wild edible plants collected from the forest and their mode of preparation and consumption. Free listing was used to collect information; that is, respondents were asked to mention any plant that came into their minds until they could not mention any more (Ojelel & Kakudidi 2015). Field excursions were done along forest trails with the help of forest guides to collect plants mentioned during the interview. Plant identification was partly carried out in the field basing on previous studies (Katende *et al*. 1995 , Katende *et al*. 1999). Complete plant identification was carried out at the National Herbarium, Makerere University. To ensure accuracy of scientific names, plant names were checked according to the international plant name index. Plant data and related information were entered into a database and comprised the scientific name, local name, plant part consumed, growth form and mode of preparation. Questionnaire responses were coded, entered and analyzed. The frequency of mention of utilization of wild edible plants was calculated to identify the priority species. Secondary

data about the nutritive value of identified WEPs were gathered from published sources including scholarly journal articles, books, reports, and conference proceedings. The search engines and databases used included: Web of Science, Research4Life, Pubmed, Google scholar, and Science Direct. 'Wild edible plants' was the key word for English language searches only in combination with other relevant terms. The searches were then refined to look out for specific information pertaining to the nutritional content of the plant species that had been identified in the study.

Results

Socio-demographic characteristics of respondents

A total of 156 respondents were interviewed out of which (57) 37% gathered wild edible plants from the forest. The age of respondents ranged from 8 to 78 with a mean of 31 years and the majority (61%) were males. Regarding marital status, 56% were single. It is also important to note that 59% of the respondents had completed primary-level education. The respondents were mainly students (45%) and farmers (44%) and most of them had lived in the villages for more than 10 years (Table 1). Majority of respondents (96%) had lived in the communities adjacent the forest reserve for more than 10 years.

Diversity of wild edible plants

Twenty-seven (27) plant species in 24 genera belonging to 22 families were documented (Table 1). Local people collected these species not only for household consumption but also for sale. All the plant families were represented by one species except for the Solanaceae, Rutaceae, and Amaranthaceae that were represented by two species each. *Aframomum angustifolium* (Sonnerat) K. Schum was the most widely used wild food plant accounting for 74% of the plants consumed by the households. It was followed by *Artocarpus heterophyllus* Lam., a species that has been domesticated by some households in Uganda. Other introduced species that have been domesticated for food include *Ananas comosus* (L) Merr*, Citrus limon* (L.) Osbeck*, Citrus sinensis* (L.) Osbeck*, Mangifera indica* L.*, Musa* spp.*, Physalis peruviana* L.*, Psidium guajava* L., and *Saccharum officinarum* L. Such plants have spread to the wild as a result of animal dispersal and forest encroachment that resulted in abandoned fields after the CFR was established. Purely wild edible plants native to Uganda identified include *Basella alba, Canarium schweinfurthii, Myrianthus arboreus, Garcinia buchananii, Discorea minutifolia, Discorea adoratissima, Rubus pinnatus,* and *Afromomum anguistifolium*. The high incidence of use of these plants indicates the potential of their economic value and traditional significance to households. Most species had a low frequency of use due to their scarcity (S. Mubiru, pers. comm). According to most respondents, the numbers of WEPs in Mabira CFR have drastically declined to the extent that many species are no longer available in the forest. This affirms the low frequencies of most species. The major wild edible plant products were fruits and vegetables. Fruits were mostly consumed as ripe snacks while vegetables were cooked.

Table 1. Socio-demographic characteristics of respondents from communities adjacent Mabira CFR

Characteristics of respondents	Descriptive statistics
Age (years)	Mean 31±20.7 (n= 57) Min 8 Max 78
Gender (%)	Male 61 Female 39
Marital status (%)	Single 56 Married 40 Widowed 4
Education level (%)	Non-formal 5 Primary 59 Secondary 33 Tertiary 3
Main occupation (%)	Farming 43.9 Business ownership 5.2 Student 44.7 Civil service 3.5
Period of stay (years)	More than 10 years 96% Less than 10 years 4%

Table 2. Wild edible plants used by communities around Mabira CFR.

Family	Scientific name (local name)	Growth form	Part/(s) consumed	Native or Introduced	Mode of preparation	Nutrient composition	Other uses of the plant in the study area
Amaranthaceae	*Amaranthus dubius* Mart. ex. Thell. (Dodo)	H	L	Introduced	C	Vitamin C, Crude protein, Crude fiber, fat, Calcium Iron (Ngugi & Kabuye 1999)	Medicinal
	Amaranthus sp (Buga)	H	L	Introduced	C		Medicinal
Anacardiaceae	*Mangifera indica* L. (Miyembe)	T	F, R	Introduced	R		Medicinal, Firewood, Charcoal, Windbreak
	Pseudopodias microcarpa (A. Rich.) Engl. (Nziru)	T	F, R		R		
Aracaceae	*Elaeis guineensis I* Jacq. (Ebinazi)	S	O	Introduced	C	Crude protein, Crude fiber, Fat, Calcium, Iron (Dike 2010)	Soap and candle manufacture, Medicinal, Income
Basellaceae	*Basella alba* L. (Enderema)	H	L	Native	C	Vitamin C, Crude protein, Crude fiber, Fat, Calcium, Iron (Lyimo *et al*. 2003)	Socio-cultural
Bromeliaceae	*Ananas comosus* (L) Merr. (Enanasi)	S	F, R	Introduced	R		
Burseraceae	*Canarium schweinfurthii* Engl. (Mpafu)	T	F	Native	R	Protein, Starch, Cellulose, Calcium, Potassium (Georges *et al.* 1992)	
Fabaceae	*Tamarindus indica* L. (Enkonge)	T	F, R, L	Native	R	Crude protein, Crude fiber, Fat, Calcium, Iron (Ngugi & Kabuye 1999)	Socio-cultural, Aphrodisiac, Firewood, Construction
Cecropiaceae	*Myrianthus arboreus* P. Beave. (Bigungwa)	T	F, R, L	Native	R		Income, Medicinal, Agroforestry
Clusiaceae	*Garcinia buchananii* Baker (Nsaali)	T	R/F	Native	C, R		Food, Dye, Social cultural, Medicinal, Agroforestry
Cucurbitaceae	*Cucurbita maxima* Duchesne (Ensuju)	H	FR/Se, L	Introduced	R	Crude protein, Crude fiber, Fat, Calcium (Gonclaves *et al*. 2007)	Medicinal, Income
Discoreaceae	*Dioscorea minutiflora* Engl. (Kaama)	H	B	Native	C		
	Dioscorea odoratissima Pax (Amakolongo)	H	B	Native	C		

Lauraceae	*Persea americana* Mill (Vakedo)	T	F, Se, L	Introduced	R	Crude protein, Crude fiber, fat, Calcium (Dike 2010)	Charcoal, Firewood, Windbreak, Medicinal
Moraceae	*Artocarpus heterophyllus* Lam. (Fene)	T	F, Se	Introduced	R	Crude fat, fiber & protein, Ash Carbohydrate, Calcium, Magnesium, Iron, Zinc, Copper (Bello *et al*. 2008)	Charcoal, Firewood, Windbreak, Timber, Shade, Socio-cultural
Musaceae	*Musa acuminata* (Menvu)	H	F	Introduced	R	Ash, Magnesium, Manganese, Zinc (Adeyami & Oladifi 2009)	Socio-cultural, Income
Myrtaceae	*Psidium guajava* L. (Amapeera)	T	F	Introduced	R	Fat, Calcium, Iron (Lyimo *et al*. 2003)	Construction, Hunting, Medicinal
Passifloraceae	*Passiflora edulis* Sims (Butunda)	C	F	Introduced	R		Socio-cultural, Decoration, Income
Poaceae	*Saccharum officinarum* L., (Ebikajo)	S	S	Introduced	R		Sugar Industry, Fodder, Income
Punicaceae	*Punica granatum* L. (Enkomamawanga)	S	F	Introduced	R	Vitamin C, Crude protein Crude fiber, Fat, Calcium, Iron (Al-Maiman & Ahamad 2002, Favadi *et al*. 2005)	Medicinal
Rosaceae	*Rubus pinnatus* Wild (Enkenene)	S	F	Introduced	R		Animal health, Medicinal
Rutaceae	*Citrus limon* (L.) Osbeck (Enimu)	T	F, Se	Introduced	R	Vitamin C	Medicinal, Firewood, Timber, Income
	Citrus sinensis (L.) Osbeck (Emicungwa)	T	F, se	Introduced	R	Vitamin C, Crude protein, Oluremi *et al*. 2006)	Firewood, Medicinal, Income
Solanaceae	*Physalis peruviana* L. (Entutunu)	H	F	Introduced	R	Crude protein, Calcium, Iron (Rodrigues *et al*. 2009).	Medicinal, Socio-cultural, Income
	Solanum nigrum L. (Ensuga)	H	L	Introduced	C	Crude protein, Crude fiber, Fat, Calcium, Iron (Akabugwo *et al*. 2007, Ngugi & Kabuye 1999)	Medicinal
Zingiberaceae	*Aframomum angustifolium* (Sonnerat) K. Schum (Amatungulu)	H	F	Native	R	Vitamin C, Crude protein, Crude fiber, Fat, Calcium, Iron, Sodium, Potassium, Magnesium, Copper, Carbohydrate (Acipa *et al*. 2013, Wehmeyer 1966)	Socio-cultural, Medicinal

Growth form is indicated as: H=Herb, S=Shrub, T=Tree and C=climber. Mode of consumption: C=Cooked, R= Raw (uncooked). Plant part or extract used: F = Fruit, O = Oil, S = stem, R = root, L = Leaf, Se = Seeds.

This table lists the wild edible plant species consumed in the study area, their nutritional composition, according to various authors, and other ethnobotanical uses of plant species in the study area

Growth habits and parts consumed
Trees comprised most of the WEPs (41%). This was followed by herbaceous plants (37%) and shrubs (18%); while climbers were the least represented (4%) (Figure 1). Fruits were the commonly consumed plant part and contributed 66% of the WEPs.

Mode of preparation
Most of the plant parts especially fruits were eaten raw (74%) and only 26% of the plant parts, mostly vegetables, underwent the cooking process. Wild fruits were often eaten as snacks when ripe whereas leafy vegetables were cooked to make soup.

Preservation
No preservation was reported for any plant parts.

Income from WEPs
The WEPs of Mabira CFR have a wide array of local uses that include; medicinal, income generation, fuel wood production, construction, and cultural practices among others (Table 2). Low revenues were collected from selling WEPs since a majority of households extracted them for home consumption. The maximum income obtained from sale of WEPs was Shs 2385000 ($ 650) per annum while the least income was less than a dollar.

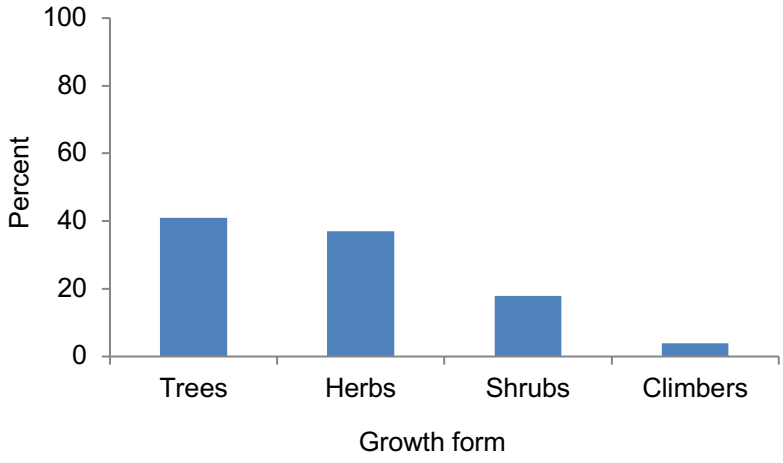

Figure 1. Contributions of different growth forms to the WEPs of Mabira CFR.

Discussion

Socio-demographic characteristics of respondents
The dominance of males in collection of WEPs differs from findings of Agea *et al.* (2011) where most respondents were women because their spouses delegated them to respond to interviewers. A longer stay in the villages would imply that a resident would be familiar with the areas where WEPs could be found. This implies that residents would have had time to become more knowledgeable about the ecological structure, composition, and seasonal patterns of the forest and thus able to collect WEPs. This result concurs with other studies about extraction of forest resources (Kartoolinejad *et al*. 2007, Pattanayak *et al*. 2003). The low education levels imply high levels of unemployment, hence higher poverty levels which would trigger increased collection of wild edible plants from the forest.

Age is a vital factor in WEPs collection since the activity involves expenditure of energy and travelling for long distances in search for them. For that reason, young people tend to be the ones involved in WEPs extraction from the forest. Older people lack the necessary physical strength to gather WEPs from the forest as it involves long walks.

Diversity of wild edible plants
The high incidence of WEPs in the study area is similar to a scenario reported in a study conducted by Hazrat *et al*. (2011) in which only six wild fruit species were gathered due to that fact that insufficient quantities could be collected. The numbers of species and families revealed by this study are low compared to those documented by Agea *et al*. (2011) and Ojelel *et al.* (2019). This might be attributed to highly variable sample collection niches in the study areas.

The low frequencies of most species might be due to forest degradation as evidenced by large areas of cleared forest caused by Illegal logging, human settlement, and agricultural encroachment. Overall 7421 ha were degraded by encroachers before their total eviction in the late 1980s (Baranga 2007). The decline in the numbers of WEPs in Mabira CFR is also the common phenomenon in developing tropical countries (Sunderlin *et al*. 2005). Reduction in the diversity of WEPs is an indicator that some of these foods have been overexploited, which has resulted in their eventual depletion (Maikhuri *et al*. 2001). This might deplete the store of genetic material available for future adaptation (Wanjohi *et al*. 2020). Therefore, there is need to form collaborative partnerships between the conservationists and local communities to widen the social base of conservation so as to promote sustainable utilization of the wild plants (Hamilton *et al*. 2016).

The predominance of fruits and vegetables in wild plant foods has been highlighted by Agea *et al*. (2011), Asase and Oteng-Yeboah (2012) and Ojelel *et al.* (2019). The consumption of fruits as snacks and vegetables after cooking is in agreement with a study by Nabatanzi and Nakalembe (2016). Fresh fruits are sources of nutrients including ascorbic acid, provitamin A carotenoids, minerals, and nutraceuticals with health promoting benefits (Aworh 2015). Fruits and vegetables have received increased attention in promoting health due to the protective properties of the non-bioactive compounds they contain. This increases their use in human diets (Aworh 2015). Of the identified species, *Mangifera indica*, *Psidium guajava*, *Punica granatum,* and *Tamarindus indica* which are non-native but naturalized were identified in Darfur in Western Sudan and the first three were heavily utilized in Jebel Marra (Hegazy *et al*. 2020).

Some of the wild edible plants identified in the current study have formed part of the human diet since time immemorial and are among the 75000 species believed to be edible (King 1994). It is estimated that humans have domesticated about 200 species as food crops but only about 30 of these contribute 95% of the world's plant food intake (FAO 1995). In the Miombo woodlands of Malawi, more than 75 species of edible fruits have been recognized, although not all are in common use (Akinnifesi *et al* 2007). The popular fruit species from the Miombo Region *Uapaca kirkiana* Müll. Arg., *Parinari curatellifolia* Planch. ex Benth.,*Strychnos cocculoides* Baker, *Ficus sur* Forssk, *Diospyros mespiliformis* Hochst. ex A. DC.and *Azanza garkceana* Goron Tula differ from those identified in this study.

The dominance of leafy vegetables in Mabira CFR is in agreement with findings of Maroyi (2013) who observed that 81% of wild edible plants from the forest in Shurugwi under Chief Nhema, Zimbabwe were vegetables. Wild edible vegetables *Cleome gynandra* L.*, Corchorus tridens* L.*, Cucumis anguria* L.*, Cucumis metuliferus* E. Mey and *Moringa oleifera* Lam. are mostly used as a safety net in times of drought and are mostly served along with the staple food. In Amuria County in Uganda, the family Malvaceae had the largest number of species followed by Anarcadiaceae, Moraceae, and Solanaceae. *Vitellaria paradoxa* C.F.Gaertn.*, Mangifera indica* L., and *Tamarindus indica* L. were the most mentioned edible plant species in Obalanga (Ojelel & Kakudidi 2015).

The reduced availability of WEPs from Mabira CFR is an indicator of overexploitation, which is likely to negatively impact on poor households who resort to forest foods as safety nets in periods of food shortage. Some wild food plants like *Amaranthus dubious* Mart. ex. Thell., *Mangifera indica* L., and *Tamarindus indica* L. were also reported in other parts of Uganda (Agea *et al* 2013, Ojelel & Kakudidi 2015) and Zimbabwe (Maroyi 2011). The use of the same species in different geographical regions could be attributed to their wide occurrence but also to knowledge sharing resulting from migrations and intermarriages. The WEPs of the forest reserve had several other uses many of which are mentioned by Wanjohi *et al.* (2020). Medicinal plants were the second most important after food species and were represented by 16 families. Dependence of communities adjacent to forests on wild medicinal plants is common in Uganda (Namukobe *et al*. 2011).

Growth forms and parts consumed

The diversity of growth forms of WEPs is attributed to the forest nature of the habitat that supports mainly trees. The high percentage of fruit consumption might be attributed to their mode of consumption that in most cases did not require cooking, making them more convenient for most families. Large scale consumption of fruits by local communities has been highlighted by other researchers (Ojelel *et al*. 2019, Wanjohi *et al*. 2020). No edible below-ground plant parts were observed or recorded by the authors in contrast to Ojelel *et al* (2019). Infrequent utilization of climbers by the local communities was also reported by Agea *et al*. (2011).

Mode of preparation

In the study area, wild fruits are often eaten as snacks and leafy vegetables cooked to make soup as in other areas in Uganda (Tabuti 2007, Agea *et al*.

2013) where they form essential components to the local communities' diet.

Preservation

Lack of preservation of WEPs could be attributed to the decrease in the availability of the plant sources that leads to low quantities being collected from the wild. Preservation is a coping strategy to increase availability during periods of scarcity. Its absence means such communities are not well prepared to fight off hunger during periods of harsh climatic conditions. These findings contrast with those of Maroyi (2011) and Shiva and Verma (2002) which indicated that households preserved WEPs to extend their shelf life so that they could be used in times of scarcity.

Income from WEPs

The low income from the sale of WEPs was attributed to low quantities collected as a result of reduced availability especially as a result of illegal tree felling for commercial purposes. Despite previous efforts to curb forest encroachment, illegal activities continue to occur. The situation is further compounded by socio-economic factors stemming from the existence of villages or 'enclaves' within the reserve whose populace derive a variety of natural resources from the forest (Baranga, 2007, Tugume *et al.* 2015). This finding enhances the assertion that dependence on WEPs is more significant for the poor and marginalized rural families. WEPs provide rural families with additional income opportunities through collection and sale in local markets (Moreno-Black & Prince 1993).

Nutritive value of some of the wild edible plants

Wild edible plants are important nutritional supplements in many parts of the world (Saha *et al*. 2004). They complement other foods eaten by the rural people of Mabira CFR communities since they are cheap compared to conventional foods. The WEPs of Mabira CFR contain a variety of nutrients like Vitamin C, crude protein, crude fiber, fat, calcium, iron, carbohydrate, manganese, and copper among others. A study by Kiremire *et al*. (2010) revealed that WEPs contribute mineral salts, amino acids, and fatty acids to the diets of rural people. A study on West African foods showed that WEPs had higher mineral values than cultivated species (Smith *et al*. 1996). Fruits are particularly important sources of vitamins and minerals because they are eaten raw without undergoing any processing that may destroy certain vitamins or remove part of the minerals. Mature fruits of *Canarium schweinfurthii* Engl. contain a high amount of lipids varying between (30 -50%). The pulp of *Tamarindus indica* L. fruit is relatively poor in protein (87.9g kg^{-1}) (Ishola *et al*. 1990). *Mangifera indica* L. is one of the most important sources of dietary antioxidants such as ascorbic acid, carotenoids, and phenolic compounds (Shieber *et al*. 2000). Vitamin C is required for scurvy prevention and is important in collagen formation, inorganic non-absorption, inhibition of nitrosonaamine formation, and immune system enhancement. Ascorbic acid acts as an oxidant and therefore offers protection against stress related diseases (Diplock *et al*. 1998). *Psidium guajava* L. is rich in tannins, phenol, triterpenes, flavonoids, essential oils, saponins, carotenoids, lectins, vitamins, fiber, and fatty acids (Sunttornusk 2002).

According to a study by Al-Maiman and Ahamad (2002), fresh juice of *Punica granatum* L. contained 84.5% of moisture, 14.1% sugar, 1.05% protein, and 0.33% ash. Total protein, ascorbic acid, fa,t and phenolic compounds in the seeds of this fruit were 4.06%, 0.23%, 0.15%, and 2.92% respectively in addition to high amounts of potassium, sodium, magnesium, and calcium. A study by Lyimo *et al*. (2003) found out that the protein content of vegetables ranged from 0.6 – 5.0 % with higher contents in *Basella alba* L*., Amaranthus* sp*, Phaseolus vulgaris, and Corchorus* sp*.* Minerals are important components of the human diet because they serve as cofactors for many physiological and metabolic functions. Over 95% of palm oil consists of mixtures of tricyglycerols (TGs) of monocylglycerols, dicylglycerols, and free fatty acids (Sundram *et al*. 2003).

Despite the contribution of WEPs to nutritional health, their domestication has not been embraced in the study communities which poses a potential risk of their overexploitation. This calls for the need to focus on improvement based on breeding and conventional forest plant selection to horticultural approaches based on quality germplasm production for wider cultivation to serve the needs of the communities (Akinnifesi *et al*. 2007). The contribution of wild edible plants to the nutritional status of Ugandans needs recognition in line with the Uganda Food and Nutrition Policy which aims to promote the improvement of the nutritional status of population beyond increasing agricultural production to finding solutions to the large number of undernourished children in the country. Forest foods are thus important in supplementing the nutritional benefits of food crops. In line with the overall goal of the Uganda National Food and Nutrition Policy, the government needs to incentivize subsistence or commercial production of WEPs in order to encourage their cultivation.

Gaps identified

Some plant species in the study area used for other purposes are used in various other parts of Uganda

as food. This implies that communities in Mabira CFR are unaware of some of the nutrients in WEPs. A study by Agea *et al.* (2011) identified the following plants as edible but in the current study area they were all reported as being used only for medicinal purposes: *Asystasia gangetica* (L.) T. Anderson, *Phaseolus lunatus* L., *Crassocephalum crepidiodes* (Benth.) S. Moore, *Oxygonum sinuatum* (Hochst. & Steud. ex Meisn.) Dammer, *Hibiscus acetosella* Welw. ex Hiern., *Vernonia amygdalina* Delile, *Bidens pilosa* L., *Carissa edulis* (Foirssk.) Vahl., *Mondia whytei* (Forssk.) Vahl., and *Vangueria apiculata* KJ. Schum. (Tugume *et al.* 2016).

In Nakisunga County, the following plant species were reported as being used for medicinal purposes for both humans and livestock: *Abrus precatorius* L., *Phaseolus lunatus*, *Carissa edulis*, *Mondia whitei*, *Vangueria apiculata*, *Cleome gynandra*, *Solanum anguivi* Lam., *Vigna ungiculata, Acalypha bipartita* Müll. Arg., *Zanthoxylum chalybeum* Engl., *Amaranthus graecizans* L., *Physalis minima* L., *Kedrostis foetidissima* (Jacq.) Cogn. and *Rhus vulgaris* Meikle (Nabatanzi and Nakalembe 2016). However, in the current study area they were used as food sources (Tugume *et al.* 2016). In Amuria district, Ojelel and Kakudidi (2015) identified *Mondia whitei*, *Bidens pilosa*, *Abrus precatorius*, *Hoslundia opposita* Vahl, and *Ficus natalensis* Hochst. as being used for food. This information calls for comprehensive documentation of indigenous knowledge on wild edible plant species used by communities in different geographical locations in order to create awareness of their potential as food sources during periods of food shortage. It also acts as a foothold for value addition in the commonly used species for formulation of nutraceuticals, which could be marketed for both local and international markets.

Conclusion

The study shows that 27 WEPs were being consumed by residents in communities around Mabira CFR. These plant species play a significant role in the nutritional health of consumers by providing cheap sources of nutrients and a source of income to improve livelihoods. Useful species should also be domesticated to avoid their loss due to habitat degradation. Forest conservation is paramount if these WEPs are to be preserved for use by local people in the study area. In addition, value addition should be emphasized in order to develop food supplements that can be sold both in local and national markets.

Recommendation

There is need for further research to assess the density and spatial distribution of wild edible plants in Mabira CFR. This could include the effect of slope direction and altitude on their distribution. Since there is evidence of overexploitation the residents should be sensitized about the significance and strategies of conservation of the plants. The managers of the CFR should propagate and plant the WEP species and timber species as a component of their reforestation program. Their conservation principles should emphasize forest management practices that promote the nutritional security of the local communities.

Declarations

List of abbreviations: CBOs: Community Based Organizations**;** CFM: Collaborative Forest Management**;** CFR: Central Forest Reserve**;** FAO: Food and Agriculture Organization**;** PPE: Permanent Forestry Estate **;** WEPs: Wild Edible Plants**;** WHO: World Health Organization

Ethics approval and consent to participate: All participants gave their prior informed consent before any study.

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

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Author's contributions: P.T. conceptualized the study, designed the methods, conducted the ethnobotanical survey, analyzed the data and drafted the manuscript. C.N. conceptualized the idea of this manuscript and participated in reviewing the manuscript. Both authors read and approved the final manuscript.

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