Traditional food plants of the upper Aswa River catchment of Northern Uganda - a cultural crossroads

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Abstract

Background
In the parkland agroforestry system of northern Uganda, smallholder farming households rely on a diversity of plant species to fulfil their nutritional requirements, many of which also serve a range of medicinal, cultural and livelihood functions. A longitudinal study of the utilization and management of on-farm plant biodiversity by rural communities was undertaken, over several decades, with a specific focus on wild and semi-cultivated food plants. The purpose of the study was to assemble an inventory of indigenous plant species used as food in four districts within the Aswa River catchment of northern Uganda.

Methods
Focus group discussions were conducted at 34 locations. Plant specimens were collected during field walks, and submitted to the Makerere University Herbarium for identification. Key informant interviews were conducted to document the botanical, ecological, seasonal and alimentary attributes of each species, and details of its processing and utilization.

Results
The study presents the edible plants of four districts in the Aswa River catchment of northern Uganda. A total of 232 key informant interviews yielded 1,303 use reports (URs) for 373 identified specimens of 95 edible species. The data constitute an inventory of on-farm plant species, including cultivated, semi-cultivated and wild plants, integrated into a parkland agroforestry system in which useful trees and other plant species are sustained and managed under cultivation.

Conclusions
Agricultural and on-farm plant biodiversity may be seen as a food security resource, and a nutritional buffer against increasing risks and stressors on low-input smallholder agriculture. Further studies should assess the intra-species biodiversity of these resources, with respect to farmer-valued traits and vernacular (folk) classification systems.

Keywords
agro-biodiversity, underutilized species, wild food plants, food security, parkland agroforestry system
Background

If the best time to plant a tree was 20 years ago, then there is no time like the past in which to document traditional technical knowledge.

This study is based on data collection beginning in 1998, as an inventory of species and a situation assessment of plant utilization and management in the parkland agroforestry system of northern Uganda, characterized by a range of landrace crops and multipurpose tree species which are selectively retained when fallow woodland is cleared for cultivation. Subsequent to the study, civil conflict brought wholesale displacement of communities, resulting in disruption of inter-generational transfer of ethnobotanical technical knowledge on plant biodiversity, and its utilization and management. The data presented here may thus have been drawn from a more extant body of traditional knowledge than that of today - but there are recent indications that the plant species described here are still strongly represented on the farms of the study area.

Globally, wild foods have been assessed in terms of agrobiodiversity (or agricultural biodiversity), a vastly inclusive category that includes the cultivated crop plants, semi-domesticated species, wild crop relatives and other, associated biota - from soil mycorrhiza and other microorganisms to the ‘charismatic megaflora’ of parkland tree species of noted cultural import (such as the baobab, the shea butter tree, tamarind and fig).

From selection to domestication and focus

As noted in many recent studies, the proportion of cultivated plants in agricultural systems is vanishingly small, as compared to the range of species with nutritional and economic value. At least 391,000 vascular plant species have been documented, against which 31,000 of these have a documented use - including at least 5,538 species which provide human food. Of this diversity, however, just a few major crops dominate global agricultural landscapes; 80% of the food derived from plants comes from 17 plant families. Just 150 species dominate intensive monoculture, accounting for the vast bulk of global agricultural production and consumption – and of these, a mere 15 crops feed most of humanity. For us as a species, the opportunity cost of the narrow range of foods we have chosen to cultivate at scale reflects a profound diminution of options, in the face of an uncertain future.

While plant remains are scarce in the archaeological record, it can be presumed that the edible use of gathered plants long predates the advent of agriculture at the end of the last ice age, about 10,000 years ago. Although animal husbandry is far better represented in the archaeological record due to the durability of bone, the earliest evidence of the collection and eventual cultivation of food plants dates back some 18,000 years, to the catchment of a former Nile tributary in upper Egypt.

Over time, as human livelihoods shifted from hunting and gathering of wild foods to sedentary and shifting cultivation, humans generally shifted away from a diversity of plant foods, some gathered and some grown, toward a much more limited repertoire of
cultivated plants selected for favored traits (e.g. a high or reliable yield, sweet fruit, or digestibility based on a minimum level of anti-nutritional factors). This widely dispersed process of farmer selection initially resulted in a wealth of locally-valued landrace varieties suited to local ecologies, but this diversity has been drastically reduced over time through breeding programs focused on uniformity and yield.

Over time, our food systems have evolved from a biodiverse cultivation mosaic, relationally situated within landscape-level ecologies and providing an extensive range of ecosystem services, into a narrow and vertical industrial monoculture characterized by homogeneity, focus and economies of scale.

Although the advent of agriculture was once seen as a dramatic and precipitous ‘revolution’, recent global studies indicate that the transition from the extensive collection of wild plants to the more intensive cultivation of plant crops was a more gradual process—one that is evident today in many traditional agricultural systems, including those of the study area.

As the parameters of human selection have developed away from organoleptic values, such as taste, toward more industrial attributes increased visual conformity, durability and shelf-life, the nutritional value of plant foods has declined. Aside from human selection, this trend has also been attributed to depletion of soil fertility in cultivated landscapes, particularly as fallow periods have been reduced or discontinued. Nutritional erosion of food crops seems likely to continue with the increasingly irregular seasonality of precipitation, and other climate-related variables including higher levels of atmospheric CO₂—which may promote vegetative growth, increasing Carbon:Nitrogen ratios have been shown promote plant synthesis of carbohydrates, rather than proteins and micronutrients.

With conversion of diverse agricultural landscapes into monoculture, formerly internal controls have been externalized as the ecosystem services generated within cross-functional systems have been lost, resulting in dependency on off-farm inputs such as fertilizer and pesticides. As emerging consequences of climate change, irregular seasonality of precipitation and an increasing frequency of extreme weather events present existential challenges to overly ‘brittle’ production systems, which are increasingly vulnerable to the systemic stressors presented by a warming planet.

In the field of agricultural research and development within the global south, national and donor policy has followed investment toward a ‘market driven’ approach, focused on industrial scale production of a few focus crops—pulling smallholder farmers into increasingly input-intensive cereal monocultures, often drawing on fossil water and borrowed capital. These trends, compounded by increasing globalization of food chains, have contributed to a reduction of dietary diversity, and increasing reliance on processed foods derived from agricultural commodities. Global food systems of the Anthropocene era are characterized by nutritional deficits and surpluses, which create public health burdens in developing and developed economies.
Although the loss of agricultural biodiversity through increasing homogeneity of global foodways is a historical process, this change did not occur in as an immediate consequence of domestication, at some earlier time of the distant past – it has accelerated in recent history, and is ongoing today. A reductionist approach to agrobiodiversity - driven by economies of scale, industrial production of processed foods, and proprietary development of plant genetic resources - presents systemic vulnerabilities to risks and hazards both current and foreseen.

**Systemic Risks and Future Resilience**

More diverse food production systems provide enhanced systemic stability and resilience to risks, stressors and shocks through cross-functionality and redundancy of nutritional and ecological functions, and a range of ecosystem services. A topic addressed in countless recent studies (and 175 million Google results, at time of writing), the concept of resilience has notably been defined, as applied to the ecological and management functions within human landscapes, as ‘the capacity to buffer change, learn and develop’.

In the context of agricultural systems, approaches to diversification may oblige a re-appraisal of cultivated species as they emerged under the hand human selection, including landrace crops, wild crop relatives and other wild food plants. Traditional varieties of landrace crops offer reliable harvests for smallholder farmers with little access to input technologies (irrigation, improved seed, pesticides), and they are often grown in polyculture with a range of other plants, both cultivated and wild, in a mosaic of cultivation and fallow across the landscape. Given the seasonal cycles of availability and shortage of cultivated foods in subsistence cropping systems, ‘semi-cultivated’ and wild foods supplement staple crops with micronutrients, and may be drawn upon as a nutritional buffer during times of nutrient scarcity.

Recent ethnobotanical studies have documented the use of wild food plants within specific agricultural systems in Asia, Africa, Europe and elsewhere – notably presenting these resources not as archaic remnants of pre-modern foodways, but as potentially ‘sustainable foods’ which may provide adaptable agronomic traits suited to an uncertain climatic future.

Comprising major and minor crops (known in the literature as ‘neglected or underutilized species’ or, more recently, as ‘orphan crops’), agrobiodiversity presents a set of genetic, economic and nutritional resources which can be valued in different ways. Numerous recent studies have assessed and reviewed the roles and values of wild foods within agricultural systems, and not external to them – situated within a continuum of domestication, and still comprising ‘a significant proportion of the global food basket’.

Beyond a finite set of locally-specific uses, agrobiodiversity itself constitutes an irreplaceable genetic resource base in and of itself. While agronomic attributes relevant to productivity and uniformity are well represented among modern crop cultivars, other plant species – including landrace crop varieties, and wild crop relatives - may contribute to conventional...
plant breeding strategies with their relative tolerance of adverse growing conditions (poor soils, irregular rainfall) or resistance to biotic stressors.\(^\text{35}\) Phytochemically rich foods, diets and landscapes

While animal protein is readily assimilated by the human digestive system, plant-based nutrition relies on complex inter-relationships between the primary nutritional compounds (carbohydrates and proteins in particular), micronutrients and secondary compounds including anti-nutritional factors, some of which have functional properties relevant to micronutrient availability and uptake, or reduction of intracellular oxidative stress.\(^\text{36}\)

In nutrition, as in ecology (and agriculture), diversity is considered to 'enhance the health and function of complex biological systems'.\(^\text{18}\) Phytochemically diverse plant-based diets provide a wide menu of bioactive compounds serving 'nutraceutical' functions, which have been considered as representing a 'food-medicine continuum'.\(^\text{38}\)

Evidence suggests that humans - in common with herbivores and with our fellow primate omnivores - can develop palates attuned to foraged landscapes, based on an innate understanding of the relationships between macronutrients, micronutrients and secondary metabolites in phytochemically rich foods can guide intake combinations in biodiverse plant-based diets.\(^\text{39}\)

Locally-specific food systems, considered at the landscape level, have recently been considered as bio-cultural refugia - 'areas that harbor place specific social memories related to food security and stewardship of biodiversity'.\(^\text{40}\) Documenting technical knowledge and management of plant biodiversity within these systems involves eliciting and codifying tacit knowledge, in order that it may be preserved and shared – not least locally, where transmission of traditional knowledge may be at risk of disruption through an ongoing process of cultural erosion.\(^\text{41}\) Documentation of wild edible plants and their properties, uses and functions can support agricultural decision-making by rural households, and a means of reinforcing household food security and nutritional resilience.\(^\text{42}\)

Human history, culture and food systems of the Aswa catchment

The study area lies occupies the southern catchment of the Aswa River, a major tributary of the Nile, which takes in the rivers Agago and Moroto as it descends the northern Uganda plateau, to merge with its larger confluent at Nimule. Situated between 1 and 3 degrees North, and from 33 and 34 degrees East, the study area is characterized by wooded savanna standing on sandy loams overlaying a lateritic ironstone layer. Annual rainfall of between 800 and 1500 mm is unimodal, and distributed between two peaks from April to September.\(^\text{43}\)

The peoples of the study area, residing in the four current districts of Otuke, Agago, Amuria and Abim, represent four different cultures – the Acholi, Lango, Teso and Jo Abwor - each with a complicated and interlinked history of migration dating back over a thousand years.\(^\text{1}\) Also written as Acwa, Acwaa, Achwa or Acaa
some details of which have been transmitted by oral tradition into living memory⁴⁴. The
inselberg ranges of the Agoro and Labwor hills, and the long massif of Mount Otuke (1600
m) provide geographic and cultural landmarks within oral tradition, from which a chronology
of migrations has been derived according to the royal genealogies of Acholi. Although though
no such framework exists for the acephalous societies of the Abwor, Lango and Teso, the
famines recalled by all four cultures have been correlated to historical data recorded at the
Rodah nilometer, near Cairo, which provides a chronology of eastern African rainfall over
the past thirteen centuries⁴⁵.

Although there is a fundamental and audible distinction between the Ateso language and the
other three languages of the study area - Acholi, Lango and Thur, which share many words
and structures, the four tongues ultimately derive from the Nilotic branch of the Nilo-
Saharan language group, estimated to be over 15,000 years old⁴⁶. Whereas the Lwo cultures
of Acholi and Thur recall a migration from north to south, the Lango and Teso recall an east
to west movement, the four groups ultimately settling together around Mount Otuke for a
period, before dispersing into their current homelands⁴⁷. Several hundred grinding pits can
be observed on the granite face at the southern end of the mountain, along the Abim to Lira
road; the author is unable to locate any archaeological assessment regarding the dates of
these structures, which seem to indicate a substantial population.

While historical linguistic evidence for Lwo language being spoken in northern Uganda since
before 1000 BCE⁴⁸, the migrations of the Lwo people are recalled to have begun in response
to a drought dated to 1031-1058 CE. This event is remembered as resulting in a ‘breakup of
the Nilotic cradleland’ along the Nile Valley⁴⁹ or the Bahr el Ghazal region of present day
South Sudan, and sequential southern migrations of Sudanic and Nilotic peoples⁵⁰. The Lwo,
common ancestors of the Acholi and the jo Abwor, seem to have moved south into the
study area from the sixteenth century, while the ancestral Lango and the Teso migrated
west from a homeland in present day Ethiopia, splitting off from the Jie clan of the
Karimojong cluster between 1780 and 1840⁵¹.

While cattle genetic studies provide some triangulation regarding these human migrations⁵²,
many of which can be linked to climatic events, for the most part cattle have been an
intermittent and secondary factor in each of the four cultures of the study area. Each of the
four cultures consider themselves to be agricultural rather than pastoral societies - ‘people
of the hoe’ for whom cultivation was supplemented by hunting, as reflected in many place
names - Adwari signifying a place of hunting, other places indicating presence of prey, such
as Bar Jobi, place of the buffalo. Historically, the cattle herds of the study area were
devastated by several rinderpest epidemics from the 1890s, and again by a series of well-
organized cattle raids a hundred years later⁵³. As a consequence, the first recorded
observations of livelihoods in the study area, made during the early 20th Century, describe
food systems based on cultivation, hunting and gathering of wild foods including plants,
mushrooms, and termites⁵³,⁵⁴.
Plant biodiversity and utilization

The study area is characterized by the parkland agroforestry system, in which useful tree species are conserved when land is cleared for cultivation, allowing for regeneration of woody species during fallow, and semi-domestication of some of these species through generational selection of farmer-favored attributes over time (e.g. fruit yield, sweetness). The gathering, processing and sale on local markets of woodland products, including wild foods, has been observed to be a gendered activity – the returns to which remain largely controlled by rural women in their custodial role within rural households.

The indigenous plant biodiversity of Uganda has been well documented - classified and mapped according to vegetation type, and on the species level. Utilization of wild and semi-cultivated food plants has been considered in Uganda as a whole, in specific regions, and in a number of regional studies, some in northern Uganda, and one within the study area.

According to Harlan’s reprise of the Vavilovian classification, northern Uganda lies within the ‘African noncenter’ of agricultural origin, distinguished by landrace crops of recognized significance, including finger millet (Eleusine coracana), Sorghum bicolor, pigeon pea (Cajanus cajan), cowpea (Vigna unguiculata) and sissim or sesame (Sesamum indicum), all of which comprise the major food crops of the study area.

This initial impetus for this study arose during a food shortage observed in 1994, during which it was evident that households within the study area had little to fall back on during times of hardship, and that the elderly held, and passed on, a body of traditional technical knowledge of edible wild plants, which was observed to contribute to more favorable food security and nutritional outcomes in their communities. Significantly, this knowledge often involved the processing methods by which potentially secondary compounds in the wild plants eaten only during times of hardship could be neutralized, rendering these ‘famine foods’ more palatable.

The study area is distinguished socially by widespread participation in community-based farming groups, many of them women’s groups, many of which are said to have been formed to facilitate distribution of relief food during a drought of the early 1980s. Culturally, these ‘self-help’ groups draw from traditional shared labor work groups, known in the Lango language as wang tic (for ‘burn the work’), which rotated between the household farms of their members, the group performing collective tasks to be compensated at day’s end with a shared pot of millet beer.

As a means of identifying key informants, the engagement of these groups provided an invaluable social infrastructure, making accessible the local expertise and interest of key informants on the foodways of tradition (tekwaro), and of the ‘early times’ (ikare me con), a pre-historical period known as the aonya (Lango, Acholi, Thur) or asonya (Ateso).
The aim of the study was to compile a full inventory of plant species traditionally utilized by rural communities, drawing upon the expertise and interest of key informants, and leveraging tacit knowledge from those motivated to share it in order to codify plant utilization and its management.

This was achieved through a multi-dimensional and longitudinal study of plant diversity, its use and management by smallholder farming households across the project area, conducted under the auspices of an integrated conservation and development project (ICDP) aimed at documenting and reinforcing sustainable use of the tree and other woodland plant species. At its peak, the project engaged a network of over 10,000 farmers affiliated to more than 400 community-based groups engaged in farming and other economic activities, from which interested individuals became involved in specific project activities.

**Methods**

Data collection began with a period of participative personal observation from 1992, with substantial time spent by the author in rural areas of the then Otuke County, Lira District, now Otuke District, with the engagement, hospitality and support of community-based groups. Formal research instruments were developed during 1999, and were administered during focus group discussions and field walks with individual farmers affiliated to community-based farming groups within the four sub-regions of Lango, Acholi, Teso and Labwor during a one-year period.

A series of 50 focus group discussions were conducted at 34 locations within the four districts (see Table 1). Key informant interviews were subsequently undertaken on the basis of self-selection according to individual interest on the part of each respondent, with respondents invited to participate in the study during focus group discussions. All respondents were informed of the purpose of the study, and assurances were given that full confidentiality of participant would be assured.

Respondents were requested to provide botanical samples of food plants of interest, each of which was documented by completion of a questionnaire indicating the location, date, local names, seasonal availability, palatability classification (i.e. traditional food or famine food), habitat, plant type, part(s) eaten, a description or the plant, its harvesting and processing, storage time, and manner of consumption. Further information was recorded documenting the morphological characteristics, geographical distribution according to vegetation type for each specimen, according to its vernacular name.

A distinction was attempted to be drawn between plant foods commonly consumed throughout the year or in season, and those foods which are only consumed in times of food shortage and hardship, due to their relative unpalatability and often rigorous processing requirements to reduce or mitigate the presence of anti-nutritional factors.
Botanical specimens were prepared, and presented to the Makerere University Herbarium for identification by Latin binomial, for which local vernacular names were recorded in the four languages of the study area.

Data was organized on basis of contemporary botanical identification of each herbarium specimen as per the contemporary botanical nomenclature. Since that time, a number of species have been reclassified, necessitating verification of each identified species by cross-checking the original identification with the Plant List (http://www.theplantlist.org/), a comprehensive online database of plant names for all described plant species, maintained in collaboration between the Royal Botanic Gardens, Kew and the Missouri Botanical Garden.

Results

Drawn from an herbarium collection of 630 specimens, the broader data set documents the nutritional, economic, medicinal and cultural uses of 213 plant species, from annual herbs to trees, with local names recorded in the Lango, Acholi, Ateso and Thur languages. Noting that most species are used in multiple ways by respondents, the results describe the edible plants (31.2%, with 407 use reports); medicinal plants (19.6%, with 255); plants with cultural uses (18.9%, with 246) and plants utilized for their wood (30.5%, with 397 use reports). This paper presents the results of the edible plants segment, while the data on medicinal, cultural and woody utilization will be published subsequently.

Plants as Food

The on-farm plant biodiversity of the study area includes cultivated and semi-cultivated species, many of which are indigenous, along a broad interface between cultivated plants, wild plants and wilding crops from earlier rotations. The most heavily sampled species, Bridelia scleroneura with 13 specimens, yielded the greatest number of individual use reports – 42, across each of the four broader categories, comprising 13 edible use reports (all involving the fresh fruit); two medicinal applications, six cultural uses, and 21 use reports for the wood.

Species used as food include plants bearing edible leaves, fruits (eaten fresh, or used in cooking), roots and tubers, and seeds, including commonplace cultivated species and those collected as wildings or weeds in cultivated fields, and from woodland, wetland and fallow.

The species presented in this paper are intended to include only those species considered endemic to the study area, excluding the landrace crops of recognized significance such as those mentioned above, as well as exotic crops such as maize, cassava and rice, which are of secondary agricultural and nutritional importance. Those exotic crops, and exotic fruit trees including those which may have been present for several centuries, have likewise been...
excluded from consideration in this study because they cannot be considered endemic species

Some indigenous plants which are cultivated as minor crops, and which are considered underutilized or ‘orphan’ crop species, are considered here - including a range of leafy vegetables - *Amaranthus* spp., *Hibiscus* spp., African spider-plant (*Cleome gynandra*) - and seed crops including Bambara groundnut (*Vigna subterranea*), wild sesame relatives *Sesamum calycinum* subsp. *Angustifolium* and *Ceratotheca sesamoides*, and the ‘proto-sesame’ *Hyptis spicigera*. The study does include several some species which are not endemic, but have been widely naturalized within the study area, such as *Senna bicapsularis* and *Lantana camara*.

To understand the convergent foodways of the four cultures of the study area, it is useful to consider the form of a typical meal. While a porridge is often taken in the morning, an afternoon or evening meal is commonly based on a starch component, a pulse component and a leafy green (vegetable component), based around finger millet, *Eleusine coracana*, a landrace crop and a staple food. Finger millet grain is ground to a fine flour between stones, and stirred (‘mingled’) into boiling water to form a porridge, or, with further flour added, into a boiled bread (*kwon* in the Lwo languages, *atap* in Iteso), which outsiders might refer to as a ‘stiff porridge’, though it is eaten as a solid, pasty ‘cup’ in which the relish is scooped by hand.

A standard meal combination would consist of the boiled bread eaten with ground pigeon pea over which shea butter has been drizzled. The same bread can be made with sorghum or maize flour, or can be substituted with mashed cassava tubers or sweet potato. This basic dish is served with a cooked green vegetable, or a vegetable sauce, depending upon palatability of the leaves.

Respondent classification of leafy green vegetables is based on the distinction between the more unpalatable species, from which the secondary compounds must be removed, from others which may be ‘fried’ directly, without such prior processing. For greens with a more pronounced sour or bitter taste, the leaves are processed by parboiling in the ‘first water,’ which is discarded.

Notable on all types of ground throughout the study area are wilding or relict *Cleome gynandra*, which appears in cultivation from around March to October. Its leaves are characteristically bitter with secondary compounds, so the water in which it is parboiled is discarded prior to assembling the final configuration, in which the cooked leaves are combined with an *alodi* paste of sesame and groundnut to sweeten the sauce. The leaves may be served alone, or combined with *Hibiscus* spp., *Amaranthus graecizans*, *Curcurbita pepo* or *Cyphostemma adenocaule*.

Likewise frequent as wilding or relict individuals are several types of *Hibiscus*, known generically as *malakwang* (Lango, Acholi and Thur) or *emalakany* (Ateso), from which leaves
are constitute a popular dish. Whereas Cleome is bitter, Hibiscus is characteristically sour due to its flavonoids and phenolics\(^{72}\); as with Cleome, the parboiling water is discarded prior to mixing with alodi paste, although fermented Hibiscus seeds known as take were formerly used in the manner, as a means of sweetening the sauce.

While four of the samples collected were identified as Hibiscus cannabinus, commonly known as kenaf, two specimens were only identified as Hibiscus sp. Several other studies\(^{73} 74\) identify vegetable Hibiscus as H. sabdariffa (commonly known as roselle), from which the calyces are harvested for the tea known in Arabic as karkade. Katende et al. include H. cannabinus, H. diversifolius as well as H. sabdariffa as malakwang species, with H. acetosella designated as malakwang kulo in Lango\(^{64}\).

Vegetable species which may be eaten directly and without parboiling include Crassocephalum vitellinum, which is usually mixed with Solanum nigrum – in Lango (Otuke District), it is eaten alone only in times of famine. Other vegetables which may be fried directly include Curcurbita pepo, the young tender leaves are picked, the rough surface trichomes are removed, the leaf wilted and then fried or boiled. Vegetables which require parboiling include Cyphostemma adenocaule, Oxalis corniculata, Oxygonum sinuatum, Sesamum calycinum subsp. angustifolium (the leaves of which are mixed with other vegetables to reduce the cooking time, and to ‘make better soup’), and Solanum nigrum.

Commelina africana is eaten alone, or mixed with Hibiscus spp. or Corchorus trilocularis, of which there are two types, commonly mixed; it is not eaten alone, but is combined with other leafy greens such as cowpea or Crotalaria ochroleuca, which is commonly interplanted with cereals and simsim (sesame), and may be boiled fresh, or dried and stored.

The young leaves of Senna bicapsularis are commonly eaten as a sauce in Abim, but are considered a famine food in Agago; in Amuria, Senna obtusifolia is described as ‘one of the traditional vegetables liked best by the Iteso’, where the first cooking water is discarded ‘due to its black color’, the leaves eaten with groundnut paste. In Otuke, it is boiled in water and ‘cooked down to dry’, then added to a Cleome sauce, while in Agago, the leaves can be fried directly, as they are not considered bitter – a distinction suggestive of cultural or individual preference, with possible implication of intra-species diversity within the study area.

Trees which provide edible leaves include Balanites aegyptiaca, the young leaves of which are boiled twice (the initial water being discarded as ‘too sour’), pounded, ground, re-boiled and mixed with groundnut paste. The species is considered a famine food in some places, but a palatable regular food in others (e.g. Abim). In Amuria, the tree is reportedly lopped to that young branches may develop, from which the tender new leaves are picked. In Agago and Abim, the pounded young leaves of Securidaca longipedunculata are likewise prepared and eaten as sauce.
Other trees and shrubs providing edible leaves include *Grewia mollis* (commonly combined with other vegetables, e.g. *Cleome* or *Hibiscus*) and *Justicia exigua*. In Amuria, the young leaves of *Tamarindus indica* are boiled, pounded and boiled again, to make a ‘juice’ for flavoring porridge or bread (*atap*).

In Otuke, the young leaves of *Harrisonia abyssinica* are put into a sauce of pigeon peas, and given to a woman who has just given birth – but this is considered as a medicinal or ‘nutraceutical’ use, and not a regular food.

**Fruits**

A total of 48 fruit species were documented, providing a wide range of fruits mostly eaten fresh, particularly by children. Seasonal availability of fruits is bimodal, with a few fruits available during the dry season (various *Ficus* species, *Tamarindus* and *Borassus*, with most other fruits available during second rains).

With a few notable exceptions, fresh fruits are collected from trees which have been conserved when cultivated land is cleared for fallow. Ripe fruits are usually gathered from the ground under the tree canopy, with the notable exception of *Syzygium guineense* – fruits picked from the tree by children, as the fallen fruits are normally rotten. Other fruit-bearing species include shrubs (e.g. *Carissa edulis*) and annual herbs (notably *Afromomum* and *Solanum* spp.).

A number of fruits are commonly processed, some of which may be stored for extended periods, either pre- or post-processing. Of these, most are processed into pulp or juice and are eaten with porridge, in which a sour taste is appreciated - as when lemon juice is added to porridge made from finger millet flour.

Fruits eaten in this manner include *Aframomum alboviolaceum*, the fruit pods of which are crushed, its juice squeezed into flour for making porridge. Water is used to extract fruit pulp from the peeled fruit pods of *Tamarindus indica* (which can be stored for half a year or more); the pulp is then added to the flour from which a porridge or bread is mingled. Other fruits consumed this way include *Ficus* spp., *Searsia* spp., *Saba comorensis* and *Strychnos innocua*.

Fruits which may be dried and conserved for later consumption include those of *Vitellaria paradoxa* subspecies *nilotica*, from which the fruit pulp may be formed into discs and dried as *yao adanya* (‘patted shea’ in leb Lango), a traditional delicacy which was commonly served, with shea butter, to honored guests. Rarely seen on local markets, the discs can be stored up to two years.

Of the several *Ficus* species listed, *F. sur* fruits are eaten fresh, or squeezed with fresh grass to make juice; they may also be dried and stored for later consumption. *Ficus glumosa*, *F.*
sycomorus and F. thoningii fruits may also be eaten fresh, or they may be dried. Other fruits which may be dried and conserved include those of Cucumis aculeatus, Balanites aegyptiaca, Tamarindus indica, and Ziziphus mucronata – the fruits of which may also be eaten fresh, or dried – and later pounded to separate the seeds from the seed-coat (pulp), which is used as a sweetener, sometimes added to porridge ‘as sugar’.

The fibrous coconut-shaped fruit of Borassus aethiopum may be beaten, to soften it, then eaten fresh, or grated and rinsed with water to make a drink; the harvested fruit can be stored for several months. In the mid-1990s, a concentrated Borassus fruit syrup was sold as a squash on the roadside at the Kafu river bridge; sweet, but not overly so, its taste was resinous yet, with a slightly soapy aftertaste suggesting the presence of saponins. A similar product has apparently been developed in Ghana.

Of the Cucurbitaceae, Cucumis aculeatus and Curcurbita pepo fruit may be dried and stored up to three months, kept separately from the dried leaves and seeds, which may be conserved for a longer time.

**Seeds**

While Hibiscus has been considered above in the form of malakwang or emalakany (the vegetable sauce made from its tender leaves, harvested year-round ‘if there is rain’), in the dry season the vegetative plant is cut, bundled and dried, the calyces threshed to obtain the seed, which can be stored up to two years prior to consumption.

Known as toke in all of the four language groups, the seed of Hibiscus was traditionally a stored food commodity of significance, used even as bride-price within the past few generations, following a series of cattle epidemics around the 1890s, which devastated the cattle herds. Among the grandmothers of current adults were not a few ‘toke brides’ (A. Achen, personal communication 1992).

To prepare toke, the seeds are first dry-roasted, then allowed to cool before being rinsed with water, strained, and pounded into a puree or paste, which is boiled in water as a base for sauces; the watery remnant may be allowed to ferment before being used in place of the alodi paste to cook malakwang.

Fermented seed flour of H. sabdariffa features prominently in traditional diets of the poor in Sudan, where it has been described as a ‘meat substitute’ analogous to the fermented proteinaceous flavoring product dawadawa in West Africa; the fermentation process seems to reduce the protein content somewhat, concentrating the mineral content and

As noted above, the study area is within the ‘non-center’ of origin or diversity for sesame (Sesamum indicum) and its wild crop relatives. Sesame in northern Uganda is widely considered a cash crop, and that as a food it is consumed not as an extracted oil, but
primarily as a component of sauces and stews. This is also the case for the wild crop relatives of sesame *Sesamum calycinum* syn. *S. angustifolium* and *Ceratotheca sesamoides*, occurring as weeds or crop relicts in cultivated fields in the study area.

Another seed crop, which occurs wild and as a relict crop in cultivation and in fallow, is *Hyptis spicigera*, known in Lango as *amola* (*lamola*, Acholi), an ancient crop which has been classified as a ‘proto-sesame’ in western and central Africa. Due to its similar form and alimentary function, *Hyptis* is closely associated with sesame, to which it is culturally associated (if not botanically related), and with which it is occasionally conflated. While consumption of the crop was not noted in Teso, it is well documented in Lango agricultural history; Tarantino lists it among the first food crops planted by the Lango, and is known to be appreciated in the Madi culture of northwest Uganda and in the Western Equatoria region of South Sudan. *Hyptis* seed may be stored up to two years. At maturity, stems are cut for dried in the compound, then and threshed and winnowed.

Like simsim; seeds pounded with ‘local salt and usual salt’ The preparation of *Hyptis* in Lango and Acholi culture goes well beyond a generic paste. Following the dry roasting of the seeds, the half-cooked seeds are pounded to a flour using a mixture of conventional and vegetable salt, then mixed with warm water and molded into a saucer-shaped patties a hand’s breadth in diameter, called *agilgili* (Lango) or *akilikili* (Acholi), which is gently boiled into a semi-moist cake, following which sesame paste is added to the broth.

This dish, which may be served with smoked beef (*olel*, Lango), is considered a traditional delicacy, and its place on the cultural menu is quite distinct; the taste of the *Hyptis* patty is pleasant, slightly nutty with a hint of umami, and despite the small size of the patty, it is very filling, and not more than two are likely to be eaten at a sitting (personal observations).

Actual sesame relatives which are eaten in a similar manner to that crop are *Ceratotheca sesamoides* and *Sesamum calycinum* subsp. *angustifolium*, both of which occur as wild plants or crop relicts, and may be inter-planted with cereals. While specimens of these plants were obtained only in Otuke and Amuria districts respectively, both were seen to be well-represented in Agago District during the 2019 agricultural season.

As with sesame, *Hibiscus* spp. and *Hyptis spicigera*, the mature stems are cut and bundled, let stand to dry and then threshed and winnowed; seeds of both species are said to keep 1-2 years, and are pounded and then stone-ground into a paste which is served as is (as a type of *alodi*), or is used as a base for sauces.

Purely wild species providing edible seeds include the graminoids *Dactyloctenium aegyptium* and *Pennisetum glaucum*. Both grasses are cut and threshed to yield a grain which is ground into flour. In Amuria, the flour of *D. aegyptium* is mingled into boiling water as a porridge ‘when condition is serious’ (i.e. in times of famine), while in Abim the porridge may eaten with *Tamarindus indica* pulp.
In Agago, *P. glaucum* provides a boiled bread (*kwon*), and is sometimes fermented into beer. *D. aegyptium* one of the more ancient grains harvested from wild species, known generically as *kreb* across the Sahara, with a notably high nutritional profile\(^{81}\) - particularly in terms of the essential amino acids\(^{82}\).

Other edible seeds include *Aspilia pluriseta*, *Bidens* sp. and *Cucumis figarei* (from which the seeds are roasted and ‘pounded with salt’ to form a paste), and *Hypoxis angustifolia*, the seeds of which are eaten fresh as a snack in Otuke.

Trees providing edible seeds include *Balanites aegyptiaca* and *Sclerocarya birrea*, from which the seed kernel is pounded and ground to paste as a base for sauces. In Amuria, the seeds of *Ficus glumosa* may be ground with cassava to make bread (*atap*) during times of hunger, while in times of hardship in Otuke, the dried seeds of *Ficus sur* are winnowed, then mixed with dried beer residue and ground into flour which is mingled into bread (*kwon*).

**Roots and tubers**

Roots and tubers included two *Dioscorea* species, and one unidentified species, originally identified as belonging to the genus *Cissus*, but subsequently (if tentatively) identified as *Cissampelos mucronata*.

One species with edible tubers well documented elsewhere is *Hypoxis*, which was only noted for its edible seeds, although the bulb is reportedly considered edible by the Maasai and Kipsigi of Kenya\(^{83}\); at one cave site in South Africa, evidence for consumption of the cooked rhizome has recently been dated to 170,000 BP\(^{84}\).

Beyond the above categories, other plant foods include the hypocotyle axis of the germinated seed of *Borassus aethiopum*, which is sometimes offered for sale on local markets or by the roadside. Germination may be stimulated in pits dug for that purpose, a practice also common in the Eastern Equatoria region of South Sudan\(^{85}\).

**Other plant foods**

Plant foods other than the vegetative products mentioned above include the flower nectar of *Leonotis nepetifolia*, and the food oil *shea butter*, expressed from the seed kernel of *Vitellaria paradoxa* (as distinct from the solid fats of West African origins, the eastern subspecies *nilotica* yields an oil stable to about 20° C).

Another notable edible application of non-edible species is the ‘vegetable salt’ (known locally as traditional salt in the study area, e.g. ‘*kado* Lango’), obtained by the burning and filtration of the leaves and stems of a number of species, mostly trees, including *Gymnosporia senegalensis* (Lam.) Loes (Celastraceae); *Prospopis africana* (Guillet & Perr) Tamb
(Leguminosae), and *Pavetta crassipes* K.Schum. (Rubiaceae). These species have not been included in Table 2, as they cannot be considered as edible plants.

Although referred to as ‘traditional salt’ in the vernacular languages, the alkaline substance is credited by respondents with reducing the cooking time of pulses and vegetables. Elsewhere derived from the ash of bean stover\(^{86}\), the highly alkaline filtrate has been shown to degrade or destroy thiamine and riboflavin, and to reduce the bioavailability of iron and zinc in legumes\(^{87 88}\). reflected in reports that it speeds the cooking of beans and pulses, and also by the fact that it is used as a base for making traditional soap by its saponification of shea butter, resulting in a dark brown product both visually and organoleptically similar to the black soaps of West Africa (personal observations).

### Discussion

This study documents an inventory, and perhaps an archive, of traditional food plants - the use of which may or may not have changed during the last two decades since it was compiled. Since the data collection, much of northern Uganda, including Agago and Otuke districts in particular, suffered massive social and cultural disruption as entire communities were displaced to military camps for half a decade\(^{89 90}\). These events resulted in disruption in the generational transmission of technical knowledge, as many elders did not survive the hardships of war. Recent observations made within the study area during 2019 indicate both negative and positive impacts on the ecological integrity of the agroforestry parkland. Many large, mature trees were cut to meet urban charcoal demand, but a cohort of young trees established itself during those years which has been protected into maturity by returning communities. Under the canopy, traditional food plants remain well represented in the cultivation mosaic, though relatively scarce in local markets.

### Limitations of the study

Design of the study was somewhat *ad hoc*, partly as a result of overlapping areas of inquiry common to multiple studies serving multiple program objectives. As the core area of program emphasis was the Shea Butter Tree *Vitellaria paradoxa* subspecies *nilotica*, the study were conceived to supplement and complement the greater depth of data on that species. As an apparently compensatory implication, relatively little attention was paid to that species by study informants, with only for specimens provided and only one medicinal application noted, against a much longer list of medicinal and cultural uses of the tree and its products documented through other project applied research\(^{91}\).
As the study was conceived as an inventory of species and their uses, no attempt was made to assess preferences or rankings of the species, either within the respondent population or between cultures or locations. Respondents were not asked to list, nor prioritize, other food plants of significance beyond those for which they provided an herbarium specimen.

As a result, some plants were over-sampled (with more than a dozen vouchers for several species), while plants which were not easily sampled due to seasonality, or physical limitations, such as *Borassus aethiopum*, may be under-represented in the collection given the impracticality of sampling the tree, in which the vegetative and floral parts are high above the ground.

During the data collection, it was not possible to draw a clear distinction between foods commonly consumed at present, in the past, such as ther’s and specifically in times of food shortage (‘famine foods’), since the personal tastes and specific circumstances of the informants could not be calibrated according to the data collection instruments.

Although it is tempting to read into the data, developing cultural generalizations (‘people of Labwor people eat *Balanites* leaf and *Dactylotenium* porridge often, while those of Lango consider them famine foods’), there is insufficient data here to justify such conclusions.

Phenotypic diversity between sampled individuals was not evaluated. Beyond the inventory of species by edible use, there were inconsistencies in the classification of species by designation, *i.e.* as a former food of the ‘old times’ (*ikare me aconya*), a famine food, or ‘common today’; there was likewise a degree of subjective disagreement regarding a species within the same district as regards habitat, abundance, establishment and even plant type (herb, creeper or vine - tree or shrub?), which prevents any meaningful consideration of these attributes.

Over the year of the study, each of the four interviewers displayed a different ‘style’ of data collection, with varying degrees of detail provided – some respondents seem to have been more forthcoming at sharing details of tradition and culture than others, possibly depending upon the tenacity of the interviewer, as well as factors such as gender and ethnicity, and the personality and mood of both interviewer and respondent.

Areas of potential for further study include the intra-species biodiversity of the inventoried species. Contemporary studies of diversity in *Vitellaria paradoxa* subspecies *nilotica* within the study area revealed traditional classification systems by which the morphological and organoleptic attributes of shea fruit were known in the four languages of the project area; a subsequent study provided an expanded this ‘folk classification’ framework to include the West Nile region. Diversity in the morphology, proximate composition and nutritional parameters, of *Tamarindus indica* fruit and seed from different geographic origins of Uganda, including the study area, has also been assessed as significant.
Clearly there is scope for assessment of the morphological, phenotypic and nutritional parameters of intra-species diversity of the food plants presented here, preferably linked to locally- and culturally-specific evaluative frameworks.

Conclusions

The data describe patterns of use of plants used as food in four districts of northern Uganda, including an inventory of species consumed by plant part, type of food and seasonality.

Given the trends and events of this period, which brought social disruption affecting oral transmission and generational transfer of extant traditional knowledge, the extent to which the identified species are currently used as food is unknown.

The results of this study are intended as a reference for policy-makers engaged in support to agricultural systems in northern Uganda, and as a resource for further development of the plant foods described herein as a nutritional buffer serving systemic resilience at the local, national and regional levels.

It is hoped that diffusion of these results back to the informant communities may serve as a codified record of this knowledge, which might provide a measure of encouragement to farmers interested in the ancestral crops and wild foods described herein.

List of abbreviations

BCE Before the Common Era
BP Before the Present
FAO Food and Agriculture Organization of the United Nations
UR Use Report

Declarations

Ethics approval and consent to participate

Prior informed consent was obtained from each informant. Informants were informed of the scope and purposes of the study, and were assured that all contributions, made on a voluntary basis, would be kept confidential, and that no commercial use would be made of any of the results of the study.

The author attests that the data collection and analysis was undertaken in accordance with the International Society of Ethnobiology Code of Ethics.

Consent for publication

Not applicable

Availability of data and materials
The data from which this study is drawn will be freely shared with interested researchers by request.

**Competing interests**

The author declares that he has no competing interests.

**Funding**

Funding from 1995-2003 was provided by the US Agency for International Development under cooperative agreements 623-0124-A-00-5113-00, 617-G-00-98-00001-00 and 617-A-00-98-00007-00; by the European Commission under INCO Contract No. IC18-CT98-0261, and by the McKnight Foundation under Grant No. 98-798. Additional observations were made, and interviews conducted, during a regional seed fair at Lacekocot, with support from FAO Uganda under LOA No. 030/08, and in a series of follow-up visits in 2019 with funding from the Nelson Marlborough Institute of Technology.

**Author’s contributions**

Eliot Masters conceived and designed the study, and assembled an applied research team under the auspices of The Shea Project for Local Conservation and Development (The Shea Project), and subsequently undertook data cleaning and analysis, and writing up of all results for publication.

**Acknowledgements**

The author is most grateful to the study participants, in particular the 232 informants who gave generously of their time and knowledge - and often of their hospitality – and to the staff of the Makerere University Herbarium for their diligence in specimen identification.

The author acknowledges the project staff of the Cooperative Office for Voluntary Organisations of Uganda (COVOL Uganda), including a team of five interviewers who covered countless kilometers under conditions of uncertainty and outright insecurity, and the supportive role played by the student interns of the Makerere University College of Agricultural and Environmental Sciences.

Special thanks to Patrick Abwango, Anna Awio, Leonora Okello, Patrick Lomumba and Charles Erongot, who made initial contact with the study informants, informed of the aims and purposes of the study, and arranged for focus group discussions, and to the interviewers Simon Atyang, Lilliane Akot, Charles Erongot, Paul Ojok and David Nkuutu, who also developed collaboration with the Makerere University Herbarium. Special thanks as well to Perpetua Apili, who entered all data, and arranged follow-up visits within the study area during September and October 2019.

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References

1. Jackson LE, Pascual U, Hodgkin T. Utilizing and conserving agrobiodiversity in agricultural landscapes. Agriculture, Ecosystems & Environment. 2007 Jul 1;121(3):196-210.
2. Cheek M. State of the world’s plants report-2016; Royal Botanic Gardens, Kew
3. Willis KJ. State of the world’s plants report-2017. Royal Botanic Gardens, Kew
4. Gepts P. Plant genetic resources conservation and utilization: the accomplishments and future of a societal insurance policy. Crop Science. 2006 Sep;46(5):2278-92
5. Larsen CS. Dietary reconstruction and nutritional assessment of past peoples: The bioanthropological record. The Cambridge world history of food. 2000;1:13-33.
6. Hillman GC. Late Palaeolithic plant foods from Wadi Kubbaniya in Upper Egypt: dietary diversity, infant weaning, and seasonality in a riverine environment. In: Foraging and Farming: the evolution of plant exploitation. London: Unwin Hyman. 1989:207-39.
7. Diamond J. Evolution, consequences and future of plant and animal domestication. Nature. 2002 Aug;418(6898):700-7.
8. Harris DR, Hillman G. An evolutionary continuum of people-plant interaction. In: Foraging and farming: the evolution of plant exploitation. London: Unwin Hyman. 1989:11-26.
9. Davis DR. Declining fruit and vegetable nutrient composition: What is the evidence?. HortScience. 2009 Feb 1;44(1):15-9.
10. Marles RJ. Mineral nutrient composition of vegetables, fruits and grains: The context of reports of apparent historical declines. Journal of Food Composition and Analysis. 2017 Mar 1;56:93-103.
11. Chakraborty S, Newton AC. Climate change, plant diseases and food security: an overview. Plant Pathology. 2011 Feb;60(1):2-14.
12. Myers SS, Zanobetti A, Kloog I, Huybers P, Leakey AD, Bloom AJ, Carlisle E, Dietterich LH, Fitzgerald G, Hasegawa T, Holbrook NM. Increasing CO2 threatens human nutrition. Nature. 2014 Jun;510(7503):139-42.
13. Sardans J, Rivas-Ubach A, Peñuelas J. The C: N: P stoichiometry of organisms and ecosystems in a changing world: a review and perspectives. Perspectives in Plant Ecology, Evolution and Systematics. 2012 Feb 20;14(1):33-47.
14. Robertson GP, Swinton SM. Reconciling agricultural productivity and environmental integrity: a grand challenge for agriculture. Frontiers in Ecology and the Environment. 2005 Feb;3(1):38-46
15. Kremen C, Miles A. Ecosystem services in biologically diversified versus conventional farming systems: benefits, externalities, and trade-offs. Ecology and Society. 2012 Dec 1;17(4).
16. Foley JA, Ramankutty N, Brauman KA, Cassidy ES, Gerber JS, Johnston M, Mueller ND, O’Connell C, Ray DK, West PC, Balzer C. Solutions for a cultivated planet. Nature. 2011 Oct;478(7369):337-42
17. Field CB, editor. Climate change 2014–impacts, adaptation and vulnerability: Regional aspects. Cambridge University Press; 2014 Dec 29.
18. Porter JR, Xie L, Challinor AJ, Cochrane K, Howden SM, Iqbal MM, Lobell DB, Trasvasso MI. Food security and food production systems.
19. Pingali P. Agricultural policy and nutrition outcomes—getting beyond the preoccupation with staple grains. Food Security. 2015 Jun 1;7(3):583-91
20. Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, Garnett T, Tilman D, DeClerck F, Wood A, Jonell M. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. The Lancet. 2019 Feb 2;393(10170):447-92
21. Holling CS. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics. 1973 Nov;4(1):1-23
22. Khoury CK, Bjorkman AD, Dempewolf H, Ramirez-Villegas J, Guarino L, Jarvis A, Rieseberg LH, Struik PC. Increasing homogeneity in global food supplies and the implications for food security. PNAS. 2014 Mar 18;111(11):4001-6
23. Cabell JF, Oelofse M. An indicator framework for assessing agroecosystem resilience. Ecology and Society. 2012 Mar 1;17(1).
24. Lin BB. Resilience in agriculture through crop diversification: adaptive management for environmental change. BioScience. 2011 Mar 1;61(3):183-93.
25. Tendall DM, Joerin J, Kopainsky B, Edwards P, Shreck A, Le QB, Krüttli P, Grant M, Six J. Food system resilience: defining the concept. Global Food Security. 2015 Oct 1;6:17-23.
26. Folke C, Carpenter S, Elmqvist T, Gunderson L, Holling CS, Walker B. Resilience and sustainable development: building adaptive capacity in a world of transformations. *AMBIO: A journal of the human environment*. 2002 Aug;31(5):437-40.

27. Guarino L, Lobell DB. A walk on the wild side. *Nature Climate Change*. 2011 Nov;1(8):374-5.

28. Becker B. The contribution of wild plants to human nutrition in the Ferlo (Northern Senegal). *Agroforestry Systems*. 1983 Sep 1;1(3):257-67.

29. Fentahun MT, Hager H. Exploiting locally available resources for food and nutritional security enhancement: wild fruits diversity, potential and state of exploitation in the Amhara region of Ethiopia. *Food Security*. 2009 Jun 1;1(2):207. doi:10.1007/s12257-009-0017-7

30. Luckai J, Pieroni A, Tardio J, Pardo-de-Santayana M, Söukand R, Svanberg I, Kalle R. Wild food plant use in 21st century Europe, the disappearance of old traditions and the search for new cuisines involving wild edibles. *Acta Societatis Botanicorum Poloniae*. 2012;81(4). https://doi.org/10.5586/asbp.2012.031.

31. Pieroni A, Hovsepyan R, Manduzai AK, Söukand R. Wild food plants traditionally gathered in central Armenia: archaic ingredients or future sustainable foods?. *Environment, Development and Sustainability*. 2020 Mar 13:1-24. https://doi.org/10.1007/s10668-020-00678-1

32. Chivenge P, Mabhaudhi T, Modi AT, Mafongoya P. The potential role of neglected and underutilised crop species as future crops under water scarce conditions in Sub-Saharan Africa. *International Journal of environmental research and public health*. 2015 Jun;12(6):5685-711

33. Bharucha Z, Pretty J. The roles and values of wild foods in agricultural systems. *Philosophical Transactions of the Royal Society B: Biological Sciences*. 2010 Sep 27;365(1554):2913-26

34. Hammer K, Arrowsmith N, Gladis T. Agrobiodiversity with emphasis on plant genetic resources. *Naturwissenschaften*. 2003 Jun 1;90(6):241-50

35. Zeven, A.C. (1998). ‘Landraces: A review of definitions and classifications’. *Euphytica* 104: 127–139

36. Croft KD. Antioxidant effects of plant phenolic compounds. *Antioxidants in Human Health and Disease*. 1999:109-21.

37. Kalra EK. Nutraceutical-definition and introduction. *AAPS PharmSci*. 2003 Sep 1;5(3):27-8.

38. Leonti M. The co-evolutionary perspective of the food-medicine continuum and wild gathered and cultivated vegetables. *Genetic Resources and Crop Evolution*. 2012 Oct 1;59(7):1295-302.

39. Provenza FD, Meuret M, Gregorini P. Our landscapes, our livestock, ourselves: restoring broken linkages among plants, herbivores, and humans with diets that nourish and satiate. *Appetite*. 2015 Dec 1;95:500-19.

40. Barthel S, Crumley C, Svedin U. Bio-cultural refugia—safeguarding diversity of practices for food security and biodiversity. *Global Environmental Change*. 2013 Oct 1;23(5):1142-52.

41. Sujarwo W, Arinasa IB, Salomone F, Caneva G, Fattorini S. Cultural erosion of Balinese indigenous knowledge of food and nutraceutical plants. Economic Botany. 2014 Dec 1;68(4):426-37.

42. Shumsky SA, Hickey GM, Pelletier B, Johns T. Understanding the contribution of wild edible plants to rural social-ecological resilience in semi-arid Kenya. *Ecology and Society*. 2014 Dec 1;19(4).

43. Farbrother HG, Muro JM ‘Water’. In: Jameson JD (Ed.). *Agriculture in Uganda*. 2nd ed . Oxford University Press, 1971. DOI: https://doi.org/10.2307/1159179

44. Onyango-Odongo JM, Webster JB. Chronology for the Lwo-Speaking Peoples: Introduction. *The Central Luo during the Aconya*. 1976.

45. Herring RS. Hydrology and chronology: The Rodah nilometer as an aid in dating interlacustrine history. In: *Chronology, migration and drought in interlacustrine Africa*. 1979:38-86.

46. Gomes V, Sánchez-Diz P, Amorim A, Carracedo Á, Gusmão L. Digging deeper into East African human Y chromosome lineages. *Human Genetics*. 2010 May 1;127(5):603-13.

47. Uzoigwe GN. The Beginnings of Lango Society: A Review of Evidence. *Journal of the Historical Society of Nigeria*. 1973 Jun 1:397-411.

48. Atkinson, RA. The Evolution of Ethnicity among the Acholi of Uganda: The Precolonial Phase Source: Ethnohistory, Vol. 36, No. 1. Ethnohistory and Africa (Winter, 1989), pp. 19-43

49. Webster JB. Noi! Noi!: Famines as an Aid to Interlacustrine Chronology. In: Webster JB. *Chronology, migration and drought in interlacustrine Africa*. Longman; 1979:1-37.

50. Jameson JD (Ed.). *Agriculture in Uganda*. 2nd ed Oxford University Press, 1971.

51. Herring RS. The view from Mount Otuke: migrations of the Lango Omiro. In: Webster, ed., *Chronology, Migration and Drought*. Longman 1979:283-316.

52. Rege JE, Tawah CL. The state of African cattle genetic resources II. Geographical distribution, characteristics and uses of present-day breeds and strains. *Animal Genetic Resources* 1999 Apr;26:1-25

53. Driberg JH. The Lango: A Nilotic Tribe of Uganda. London: T Fisher Unwin Ltd; 1923.
84 Wadley L, Backwell L, d’Errico F, Sievers C. Cooked starchy rhizomes in Africa 170 thousand years ago. *Science*. 2020 Jan 3;367(6473):87-91.
85 Grosskinsky B. Study on wild food plants of Eastern Equatoria, South Sudan. Final report to German Agro Action, Nairobi 1998.
86 Bergeson TL, Opio C, Arocena JM. Elemental composition and potential health impacts of phaseolus vulgaris L. ash and its filtrate used for cooking in Northern Uganda. *African Journal of Food, Agriculture, Nutrition and Development.* 2016;16(4):11351-66.
87 Edijala JK. Effects of processing on the thiamin, riboflavin and protein contents of cowpeas (Vigna unguiculata (L) Walp) II. Alkali (‘potash’) treatment. *International Journal of Food Science & Technology.* 1980 Aug;15(4):445-53.
88 Walker AF, Kochhar N. Effect of processing including domestic cooking on nutritional quality of legumes. *Proceedings of the Nutrition Society.* 1982 Jan;41(1):41-51.
89 Nanyunjo J. Conflicts, poverty and human development in Northern Uganda. UNU-WIDER. *The Round Table.* 2005 Sep 1;94(381):473-88.
90 Gelsdorf K, Maxwell D, Mazurana D. Livelihoods, basic services and social protection in Northern Uganda and Karamoja. ODI Secure Livelihoods Research Consortium Working Paper; 2012 Aug.
91 Bratcher V. Cultural values of the Lango and Iteso concerning the Shea tree: An ethnographic study. B.A. Dissertation, 79 pp.
92 Nkuutu D, Lovett PN, Masters ET, Ojok P, Obua J. Tree management and plant utilisation in the ‘Agroforestry Parklands’ of Northern Uganda. In: The Shea Butter Tree (*Vitellaria Paradoxa* subspecies *nilotica*): Proceedings from the First Regional Conference for Eastern and Central Africa, Lira, Uganda 2000 Jun (pp. 26-30).
93 Gwali S, Okullo JB, Eilu G, Nakabonge G, Nyeko P, Vuzi P. Folk classification of Shea butter tree (*Vitellaria paradoxa* subspp. *nilotica*) ethno-varieties in Uganda. *Ethnobotany Research and Applications.* 2011 Jul 1;9:243-56.
94 Okello J. Morphological and nutritional characteristics of *Tamarindus Indica* (Linn) fruits in Uganda. Unpublished Master’s thesis, Makerere University, Uganda. 2010 Oct.
95 Okello J, Okullo JB, Eilu G, Nyeko P, Obua J. Morphological variations in *Tamarindus indica* Linn. fruits and seed traits in the different agroecological zones of Uganda. *International Journal of Ecology.* 2018 Jan 1;2018.
96 Okello J, Okullo JB, Eilu G, Nyeko P, Obua J. Physicochemical composition of *Tamarindus indica* L.(Tamarind) in the agro-ecological zones of Uganda. *Food Science & Nutrition.* 2018 Jul;6(5):1179-89.
97 International Society of Ethnobiology. International Society of Ethnobiology Code of Ethics (with 2008 additions);2008 Online at: [http://ethnobiology.net/code-of-ethics/](http://ethnobiology.net/code-of-ethics/)