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Exploiting locally available resources for food and nutritional security enhancement: wild fruits diversity, potential and state of exploitation in the Amhara region of Ethiopia

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Abstract This paper features the composition of wild fruits, their exploitation and their potential contribution to improved food and nutritional security in three districts of the Amhara region of Ethiopia. Data were gathered through structured, semi-structured and key-informant interviews which were administered to the heads of 92 randomly chosen households. Focus group discussions and direct field explorations by the researchers were also undertaken. The results revealed that altogether 44 wild fruit species are available for use in the study areas. The fruits are rich in valuable nutrients and are accessible year-round with significant overlap at times of acute food and nutrient scarcity. Nevertheless, owing to the peoples' cereal-based dietary habits, cultural perceptions and attitudes, the current state of fruit utilization is very low. Consequently, the potential nutritional contribution of wild fruits to the people's diets remains largely unexploited. In order to remedy this situation, a wider and sustained acceptance of wild fruits as important dietary components must be fostered.

Keywords Diversity · Famine · Food security · Fruit · Nutrition · Wild fruits

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Introduction

The uses of wild foods, of which wild fruits form a part, as a diet supplement in times of plenty, as a component of local responses to increasing food insecurity and as one of the major coping mechanisms at times of food shortage and famine is widely documented (Abbink 1993; Bell 1995; Edwards 1992; Guinand and Dechassa 2000; Mojeremane and Tshwenyane 2004; Getachew et al. 2005; Redzic 2007). They are incorporated into the normal livelihood strategies of many rural people and play an important role in tiding communities over the hunger season that precedes the harvest and also in providing people with the necessary energy to harvest their fields (Bell 1995). For instance, while the Yanomami Indians in Venezuela regularly use about 20 wild plant species, in the event of food shortages, they add another 20 species which are usually ignored in normal times (FAO 1999). Likewise, in Botswana, when arable agriculture fails in poor rainfall years, indigenous fruit trees bridge the gap and improve food security for rural households (Mojeremane and Tshwenyane 2004). In Zimbabwe, vulnerability to poverty was found to be determined, among other factors, by the degree to which indigenous fruits are used or are available to overcome lean times (Mithöfer and Waibel 2004).

Foods from wild sources also play a prominent role in rescuing lives at times of famine and war. For instance, wild foods had a critical role to play in major famines such as those of the Sudan in 1973 and 1984–1985 (Bell 1995), Bihar, India, 1965–1966, Bangladesh 1974–1975 (FAO 1999) and during the recent war in Bosnia-Herzegovina (Redzic 2007). Similarly, for many rural Ethiopians, reliance upon wild food plants for survival during famine (referred to locally as "*Kifu Qen*" meaning wicked days) is commonplace and well documented (Abbink 1993; Guinand and Dechassa 2000; Kebu and Fassil 2006). For example, in

the drought stricken years of 1966–1969, the Konso people of Southern Ethiopia coped by increasing the consumption of wild food plants (Guinand and Dechassa 2000).

Furthermore, wild foods may contribute to diet diversity and flavour thereby constituting an essential part of an otherwise bland and nutritionally poor diet (Bell 1995; FAO 2005). They can also serve as a dietary replacement for populations that normally consume unhealthy food (Redzic 2007). Wild fruits provide vitamins, flavourings and compounds of nutritional, gastronomic and social importance such as alkaloids, essential oils and phenolics, derived from secondary metabolism (FAO 1999) which may be lacking in the normal agricultural product of a country. Some wild fruits compare favourably with better known cultivated fruits. For instance, the vitamin C content of orange is around 57 mg/100 g but the fruit of the baobab tree has 360 mg/100 g and *Ziziphus jujube* var. *spinosa* 1,000 mg/100 g (FAO 1992). Moreover, households harvesting wild fruits can boost rural employment and generate income through processing and therefore adding value (Akinnifesi et al. 2005). Also, the innate resilience of wild species to rapid climate change, which is often lacking in exotic species, makes them exceedingly important.

In Ethiopia, the number of wild and semi-wild edible plant species is estimated at well over 200 (Edwards 1992; Getachew et al. 2005). Several studies document the occurrence of wild edible species in different areas of the country (Azene et al. 1993; Zemede and Mesfin 2001; Edwards 1992; Abbink 1993; Guinand and Dechassa 2000; McBurney et al. 2004; Fentahun et al. 2005; Getachew et al. 2005; Tigist et al. 2006; Kebu and Fassil 2006) but most of these studies are concentrated in the western and southwestern parts of the country, leaving most parts of the Amhara region unaddressed.

In the Amhara region, intractable problems of food insecurity, poverty and malnutrition are widespread with suffering among women and children being especially acute. Almost three quarters of rural children under the age of six are stunted (Austrian Development Cooperation 2004). This problem derives, in part, from a diet of limited variety and can only be remedied by substantial external assistance, an approach that is not sustainable. Lasting solutions to the problem require strategies that broaden and sustain the resource base. Wild fruits offer an opportunity for this as they are locally available and adapted to local conditions.

Unfortunately, the importance of wild fruits as a food supplement and means of survival during times of drought and famine has largely been overlooked by the research and development community. The present study, therefore, sought to appraise wild fruits as a resource, to examine the extent to which they are exploited and to assess their potential contribution to combating food and nutritional insecurity in some selected sites of the Amhara region.

Materials and methods

Characteristics of the study area

The study was undertaken in Adiarkay, Debark and Dejen districts of the Amhara region, Ethiopia between July 2006 and January 2007 (Fig. 1). Adiarkay and Debark districts

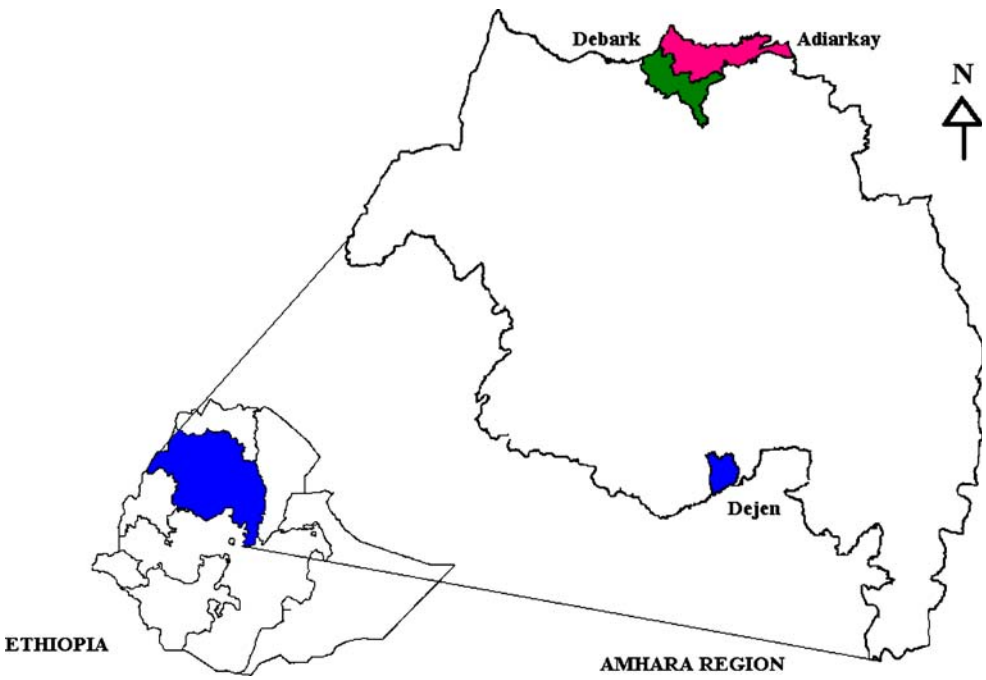

Fig. 1 Location of the study area: *left*=Ethiopia; the Amhara region and the study districts in it

are located adjacent to each other at the north-eastern and western fringes of the slopes of the Semen Mountains and are part of the North Gondar Administrative Zone. They are bordered by Tigray in the north, east and northwest, and the eastern border of Adiarkay is defined by the Tekeze River. The Dejen district is located at the southern end of the East Gojjam Administrative Zone and is delimited by the Blue Nile River which separates the Amhara region from the Oromiya Region.

The study sites are characterized by a very fragile marginal environment that has for centuries been threatened by catastrophic deforestation and land degradation, occasioned by poor land management and wild fires. The elevation constitutes diverse altitudinal zones ranging from about 1,000 to 4,200 m above sea level (ASL) and is roofed by Mount Ras Dejen at 4,620 m (Table 1). The relief at Adiarkay and Debark is, for the most part, mountainous with rugged ridges and ravines. In Dejen, the relief is both plateau and mountainous with valleys and gorges in the lowlands. Adiarkay and Dejen experience a warm temperate climate that tends to be hot to warm and moist in the specific study sites while most of Debark is cool highland.

People and economic activity

Based on figures published by the Central Statistical Agency of Ethiopia (CSA 2005), the population of Adiarkay, Debark and Dejen districts are estimated at 146,751, 168,100 and 121,296, respectively. The estimated areas of these three districts are 2,231.90, 1,512.22 and 628.56 km^2, respectively, giving population densities of 65.8, 111.2 and 193 people per km^2, respectively. The majority of the inhabitants overwhelmingly rely on subsistence agriculture, which is dominated by the cultivation of grain crops and animal husbandry. Because of low agricultural productivity the people are very poor. Thus, quite a large proportion of the population, especially in Adiarkay and Debark, are dependent on supplementary food aid. However, despite their neediness, the people have strong principles and are proud of their culture, religion, ethnicity and identity. Christianity is the dominant religion, the majority of the people being Orthodox Christians with a few Catholics and Protestants of different sects. There are also a few Muslims. The mother-tongue is Amharic, a Semitic language, which is the regional as well as the national official language. A small proportion of the people are bi-lingual, speaking both Amharic and Tigrinya.

Table 1 Geographical location of the study sites

Sites	Latitude (N)	Longitude (E)	Altitude (m)
Debir	13.15	37.92	2885
Dibbahir	13.24	37.89	2116
Bermariam	13.40	37.00	1620
Adiaregay	13.45	38.06	1553
Kurar	10.08	38.19	1360

Source: Field recordings and Agricultural Development offices of the respective sites

Site selection and sampling

In consultation with district agricultural experts, a total of five peasant associations (hereafter called sites) that are known to face periodic food shortages and are partially or chronically food insecure were chosen in the three districts. These were Adiaregay and Bermariam in Adiarkay, Debir and Dibbahir in Debark and Kurar in Dejen. The study sites are distributed within the three traditionally recognized agro-ecological zones which are principally classified on the basis of altitude, annual rainfall and temperature differences. Accordingly, Adiaregay, Bermariam and Kurar represent the *Kolla* zone (warm semi-arid lowlands, elevation less than 1,500 m ASL, temperatures of 20–27.5°C and 200–800 mm rainfall). Dibbahir represents the *Woinadega* zone (temperate, cool, sub-humid highlands of 1,500–2,400 m elevation, temperatures of 16.0–20.5°C and 800–1,200 mm rainfall) and Debir the *Dega* zone (cool, humid highlands of 2,400–3,200 m elevation, temperatures of 11.5–16.0°C and 1,200–2,200 mm rainfall). From 10 to 21 household heads from each site were randomly chosen, giving a total of 92 informants (85% men and 15% women).

Method of data collection and analysis

First, so as to document background information about the study areas, secondary data was collected from archives and by interrogation of different organizations. For primary data collection, structured and semi-structured interviews were administered to sample informants. This was aimed at documenting informants' personal attributes, cataloguing wild fruit species and understanding people's practices, opinions, perceptions and preferences towards wild fruits. In the semi-structured interview arrangements, all interviewees were met on a one-to-one basis and asked the same standard questions in the local Amharic language, using open- and close-ended questionnaires. Following this and depending on the answers, a series of specific questions were asked on the subjects of interest, including expansions or clarifications as needed as well as in-depth interviews with household heads using pre-tested structured questionnaires.

Some of the key questions asked included: How many wild edible fruit species are known to you and which ones are valued most? Who in the family collects wild fruits? Are there fruits preferentially eaten by children or adult women or men? How often are fruits collected? Are there

fruits which are only used under famine conditions? How are the fruits used? To what extent are the fruits consumed? Does the consumption of wild fruits have any unpleasant effects, and if so, how are they handled? What do the local people feel about wild fruits? Why are wild fruits not domesticated?

The study was guided by local agricultural experts from district and site agricultural offices. They were helpful in identifying key informants who were knowledgeable and thought to have particular insights and opinions about the subject under investigation. Key informants were interviewed by means of semi-structured interviews using a checklist of questions. The informants included agricultural development experts, Peasant Association heads, prominent elders and religious leaders.

To help comparison of patterns evident among individual interviews and reconcile contradictory information among informants, Focus Group Discussions were undertaken with 8–10 persons consisting of both men and women elders, children and prominent individuals. Open-ended discussion guidelines were used and the discussions were chaired and recorded verbatim by the researcher. In addition, field explorations with key informants were undertaken to observe and record the plants cited, to collect samples for botanical identification and fruit for quantitative nutrient analysis. Because of limited time and budget as well as the limited number of fruits that were ripe at the time of the field investigation, only four wild fruit species that are highly valued by the people were collected. Triplicate samples were analyzed for their nutrient composition at the Ethiopian Health and Nutrition Research Institute, Addis Ababa, following the basic methods of Association of Official Analytical Chemists, AOAC (1984). The nutrients determined and the specific methods used were: fat (soxhlet method), protein (Kjeldehal method), crude fiber (Weende method modified by Hum), ash (dry ashing method), carbohydrate (by difference), phosphorus (Fiske and Subbarow Method as described in Hawk et al. 1947), vitamin C (UV visible spectroscopic method) and iron (atomic absorption spectroscopic method). A complete analysis was not possible owing to lack of laboratory supplies at the Institute.

For wild fruit species that could not be confirmed on the spot, voucher specimens were transported to the National Herbarium at Addis Ababa University where they were deposited and identified. Data were analyzed both qualitatively and quantitatively.

Responses from open-ended questions were grouped into classes that expressed similar ideas while percentages, based on valid responses only were calculated from closed-ended questions. Statistical Package for the Social Sciences (SPSS) 2006 for Windows, Version 15, was employed for data analysis.

Results and discussion

Fruit diversity

This study showed that 44 wild species producing edible fruit belonging to 30 genera and 24 families are available for use in the study areas (Table 2). This is a high number and is comparable to other area-specific inventories elsewhere in Ethiopia (Guinand and Dechassa 2000; Getachew et al. 2005). Moreover, such a high number of species demonstrates a large body of knowledge handed down from one generation to another—in other words a rich lore. The greatest contribution of edibles comes from the Moraceae family, which is represented by five species, the runners-up being the Rhamnaceae and Tiliaceae at four species each. Likewise, by comprising five species the genus Ficus appears to be the richest followed by Grewia and Ziziphus, each with three identified and one unidentified species. However, genera and families with large number of species are not necessarily the most important. Little use, for example, is made of *Ficus vasta* Forssk., a member of the Moraceae family.

Seasonal availability

Local people had good knowledge of the features of each fruit species, including their time of fruiting and ripening which varied by site as well as by species. Some species of Ficus have a narrow harvest window but for other species, such as *Rosa abyssinica* Lindley, it is markedly wider. Species such as *Carissa spinarum* Linn. and *R. abyssinica* ripen more than once a year, the major fruiting season often yielding a bumper harvest. There appears also to be considerable intra-species variation in fruit ripening time such as that found in *Ziziphus spina-christi* (L)Desf. and *Diospyros mespiliformis* Hochst. Ex. A.D. Also, owing to climatic variation, inter-site fruiting season differences are quite large. Consequently, there is considerable overlap in ripening among the different species, both within and between localities, resulting in year-round fruit availability. As shown in Fig. 2, the majority of fruit ripen from the month of January onwards with fewer ripening between September and January. Of the 22 most common species, 12 ripened between January and March and eight between June and August. The month with the highest number of ripe fruit was March with 11 while in both September and December there were only four.

Potential contribution to food security

Seasonal food shortages, when storage bins are empty and the new crop is still in the field, are common in all parts of Ethiopia and usually last from July to September

Table 2 List of wild edible species recorded across the study sites

Botanical name	Family	Common/English name	Life form
Acacia etbaica Schweinf	Fabaceae	Red thorn	Tree
Carissa edulis (Forsk.) Vahl	Apocynaceae	Simple-spined Carissa	Shrub/tree
Carissa spinarum Linn.	Apocynaceae		Shrub/tree
Cordia africana Lam.	Boraginaceae	East African cordia	Tree
Cordia ovalis R.Br.	Boraginaceae		Shrub/tree
Diospyros mespiliformis Hochst. Ex. A. DC.	Ebenaceae	African ebony, jackal-berry	Tree
Dovyalis abyssinica (A.Rich.) Warb.	Flacourtiaceae	Kei apple	Shrub/tree
Ekebergia capensis Sparrm	Meliaceae		Tree
Ensete ventricosum (Welw.) Cheesman	Musaceae	False/wild banana	Herb
Euclea schimperi Murr.	Ebenaceae		Shrub
Ficus sur Forssk.	Moraceae	Cape fig	Tree
Ficus sycomorus L.	Moraceae	Wild fig, bush fig	Tree
Ficus thonningii Blume	Moraceae	Bark-cloth fig	Tree
Ficus vallis-choudae Delile	Moraceae	False cape fig	Tree
Ficus vasta Forrsk.	Moraceae		Tree
Flueggea virosa (Willd.) Vigot	Euphorbiaceae	Snowberry tree	Shrub
Gardenia ternifolia Schumach and Thonn	Rubiaceae		Tree
Grewia bicolor A. Juss.	Tiliaceae	False brandy bush	Shrub
Grewia ferruginea Hochst.ex A. Rich.	Tiliaceae		Shrub/tree
Grewia flavescens Juss.	Tiliaceae		Shrub
Grewia species	Tiliaceae		Shrub
Lantana camara L.	Verbenaceae	Lantana	Shrub
Lepisanthes senegalensis (Poir)Leenh.	Sapindaceae	Senegal cherry	Tree
Mimusops kummel A. DC.	Sapotaceae		Tree
Myrsine africana L.	Myrsinaceae	African boxwood	Shrub/tree
Oncoba spinosa Forssk.	Flacourtiaceae	Snuff-box tree	Tree
Opuntia ficus-indica (L.)Miller	Cactaceae	Indian fig	Shrub
Phoenix reclinata Jacq.	Arecaceae	False/wild date palm	Palm
Piliostigma thonningii (Schumach.) Milne-Redh.	Fabaceae	Camel´S foot, monkey bread	Tree
Rhus glutinosa A. Rich.	Anacardiaceae		Tree
Rhus vulgaris Meikle	Anacardiaceae		Shrub
Rosa abyssinica Lindley.	Rosaceae	Abyssinian rose	Shrub/climber /tree
Rubus apetalus Poir.	Rosaceae	Wild raspberries	Shrub
Rubus steudneri Schweinf.	Rosaceae	Wild raspberries	Shrub
Sterculia africana (Lour) Fiori	Sterculiaceae		Tree
Strychnos innocua Del.	Loganiaceae	Monkey/wild orange	Tree
Syzygium guineense (Willd.)DC:	Myrtaceae	Water berry	Tree
Tamarindus indica L.	Fabaceae	Tamarind, Indian date	Tree
Vangueria madagascariensis J.F Gmel.	Rubiaceae		Shrub/tree
Ximenia americana L.	Olacaceae	Wild/hog plum	Shrub/tree
Ziziphus abyssinica Hochst. ex A. Rich	Rhamnaceae	Jujube	Shrub/tree
Ziziphus mucronata Willd.	Rhamnaceae	Cape/buffalo thorn	Shrub/tree
Ziziphus species	Rhamnaceae	Jujube	Shrub
Ziziphus spina-christi (L).Desf.	Rhamnaceae	Christ´s Thorn, Jujube	Tree

(Getachew 2001). Wild fruits ripening at this time, of which there are several (Fig. 2), are therefore important. Moreover, during the Lent fasting period, (55 days, usually occurring during February, March and April) when the majority of Orthodox Christians subsist on only one or two meals a day that are devoid of animal products, the collection and use of wild fruits serve as a timely supplement and important provider of essential nutrients to the cereal-dominated diet. More generally, the year-round availability of fruits of different species within and across the study areas provides supplementary food and nutrition and presents an opportunity for trade. These could be powerful motives for local people to conserve wild fruit species and encourage their domestication.

Potential for meeting nutritional security

People in the study areas do not overtly recognize the nutritional contribution of wild fruits except in times of famine and as a snack food at other times. However, when they are asked why they like certain fruits more than others they imply that it is because of their nutritional significance, their responses often emerging as "because they become body".

In the present study, analysis of the fruit of the four most highly valued species showed that they contained important nutrients (Table 3). Comparison of these values with the nutrient content of some cultivated fruits shows that they are superior in protein and fat content to: banana (1.2% and 0.3%, respectively), guava (0.9% and 0.3%, respectively), mango (0.6% and 0.4%, respectively) and papaya (0.6% & 0.1%, respectively) (Srivastava and Kumar 1998). Their carbohydrate content is also greater than these fruit. The vitamin C content of *Mimusops kummel* (148.6 mg/100 g) is far greater than that of mango (16 mg/100 g), papaya (12 mg/100 g) and orange (57 mg/100 g) and is close to guava (212 mg/100 g; FAO 1992). The phosphorus contents of *Z.spina-christi* (261.8 mg/100 g) is exceptionally high and compares well with avocado (80 mg/100 g), banana (36 mg/100 g), guava (28 mg/100 g), mango (16 mg/100 g) and papaya (40 mg/100 g). Similarly, the iron content of *D.mespiliformis* is higher than that reported for several cultivated fruits.

These results demonstrate that wild fruits have great potential as sources of vital nutrients especially for growing children who are prone to malnutrition and who are key fruit collectors. In the study areas and much of the region, especially rural areas, the tradition is that the bread-winner of the household, which is almost in all cases the husband, is served first with the best food. In contrast, children's nutritional well-being comes second to filling their stomachs. Hence, their diet is often nutritionally deficient. Women, depending on the husband–wife relationship, may join their husbands or dine on the food fed to the children. Thus, where cereals form the major part of the food intake and wild fruits are unavailable the variety and quality of the diet, especially for children, would be reduced essentially to carbohydrates.

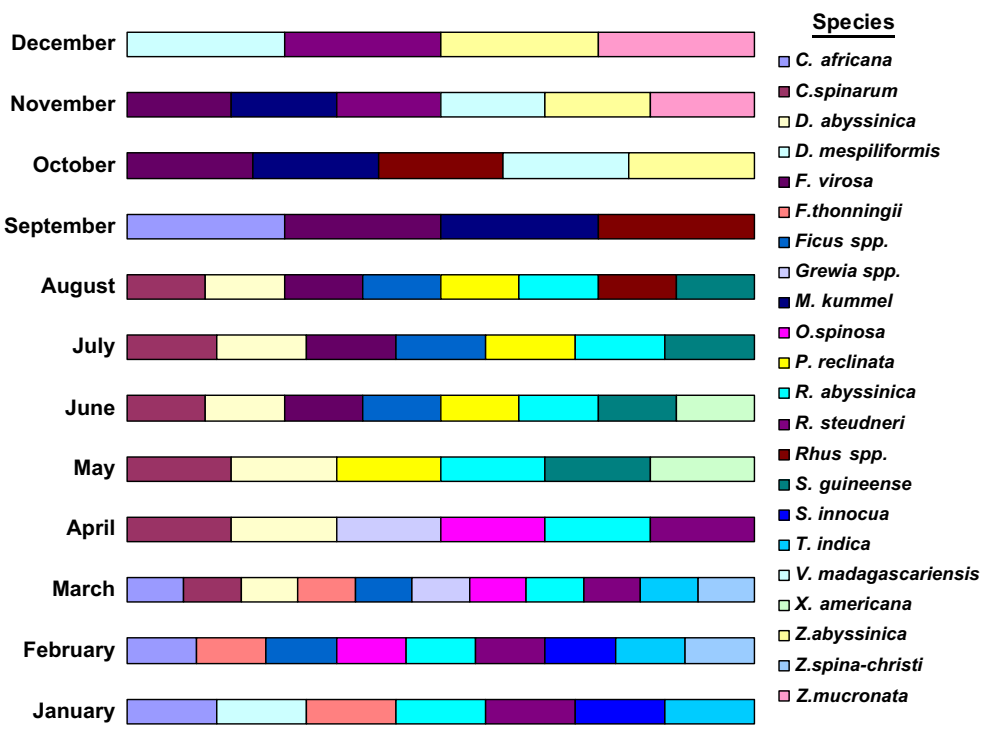

Fig. 2 Fruiting calendar of wild plants: segments in each month (*horizontal bar*) designates the type and number of fruit species ripening in that specific month

Table 3 Nutrient compositions of wild edible fruits

Fruit species	Percent						mgs/100g		
	Moisture	Fat	Protein ($N \times 6.25$)	Fiber	Ash	Carbohydrate (including fiber)	Phosphorus	Vitamin C	Iron
Mimusops kummel	13.10	1.62	2.19	20.46	2.60	80.49	31.28	148.60	2.95
Diospyros mespiliformis	32.60	1.65	1.44	27.74	2.75	61.56	46.81	13.41	19.33
Tamarindus indica	41.29	1.08	2.38	7.72	2.28	52.97	37.78	11.31	2.08
Ziziphus spina-christi	7.64	1.18	3.21	4.73	7.23	80.74	261.78	35.15	–

The nutritional value of wild fruit species in Ethiopia, before the present study, was unknown (Demel and Abeje 2004) probably explaining, at least to some extent, their neglect (McBurney et al. 2004) and hampering educational efforts to improve diets (Grivetti and Ogle 2000).

Although the present study was limited by budgetary and time constraints, the data suggest that wild fruits in the study areas, and almost certainly elsewhere, have great potential not only to bridge a hunger gap but also to supply essential nutrients at times of need. Further studies of the nutritional value of wild fruits are therefore warranted.

Level of fruit exploitation

Despite the tragic food and nutritional insecurity of people living in the study areas, the current level of fruit consumption appears to be very low. Apart from such fruits as *R.abyssinica*, *Z. spina-christi* and *D .mespiliformis*, which are perceived to be of high value, the consumption of most fruit species appears to be infrequent and limited to casual encounters, 52.2% of informants stating that consumption was sporadic (Table 4). This is contrary to reports from other countries such as South Africa where wild fruit consumption per household per year may be as much as 104 kg (Shackleton and Shackleton 2004). Infrequent consumption of cultivated fruits as well as wild ones is a universal phenomenon in both the Amhara region and the country as a whole at 1.3 kg capita^{-1} year^{-1} compared with up to 37.4 kg capita^{-1} year^{-1} for sub-Saharan Africa (Ruel et al. 2005).

The selection of food has social, political and economic dimensions. Several factors such as the advent of cultivation, preference for modern agricultural crops, level of indigenous knowledge and economic pursuits of people are widely thought to contribute to the low level of use of wild plants, including wild fruits (Zemede and Mesfin 2001; Pauline and Linus 2004). Nevertheless, people's high dependence on cereal-based food, chiefly tef (*Eragrostis abyssinica* (Jacq.) Link), remains a major part of the explanation. People in the study areas and in the region in general keep away from the consumption of most of the famous foods widely utilized in other parts of the country and elsewhere in the world. For instance, Enset (*Ensete ventricosum* Welw.), which is a staple food for millions in southern Ethiopia, is not at all considered for food. Likewise, mushrooms, which are considered to be delicacies, even in the developed world, are completely excluded from the menu. Similarly, people are very selective with regard to meat. For example, pork is taboo and except for chicken and to some extent Francolin and Guinea fowl (both of them wild), avian species remain unpopular. Most of these taboos have cultural origins while a few of them are religious, such as the avoidance of pork by members of the Ethiopian Orthodox church and by Muslims.

The dependency on such a limited variety of food sources predicates food insecurity and underlines the need for diversification in order to mitigate problems arising from climatic vagaries, pests, diseases and price fluctuations.

Individual decisions regarding food acquisition and consumption are seldom independently made or value-free. Rather, they are guided by local cultural perceptions, attitudes and beliefs (FAO 1995). The overriding negative connotations attached to wild fruits are at the root of their disregard to a significant degree. For instance, Guinand and Dechassa (2000) state that, in Ethiopia, strong traditions, beliefs and religious taboos obstruct people's psychological and mental willingness to use wild plants. These authors claim that where these factors are less stringent, as in the southern part of the country, there is greater use of wild foods. Certainly, in the study areas, local taboos discourage the consumption of wild edible fruits. Wild fruit gathering is generally interpreted as being indicative of famine and its consumption connotes indignity and social stigma. For instance, some 3 % of the informants stated that they would be ashamed to domesticate wild fruits (Table 4). Ignorance of the value of wild fruit (20% of informants) and their free availability (29% of informants: Table 4) are other reasons for their lack of utilization.

These are not, however, the only reasons why fruit consumption is low. Improved supply of food crops

Table 4 Summary of informants' responses to questions about various aspects of wild fruit utilization (*N*=92)

Questions	Responses
Proportion of informants who are familiar with 10 or more species by age group category	43.6%=Youngsters 8.1%=Adults
Of those who mentioned 10 or more species	88.9%=Youngsters 11.1%=Adults
Who collects in the family most?	29.3%=Adults 70.7%=Children
Who consumes wild fruits in the family most?	10.9%=Children 6.5%=Women+children 82.6%=All
How often are wild fruits consumed?	52.2%=Sporadically 47.8 %=Regularly
How are wild fruits used?	71.7%=Raw 28.3%=Raw and processed
Does adversity intensify wild fruit consumption?	47.8%=Yes 52.2%=No
Any undesirable effects with the consumption of wild fruits?	Yes=78.3% No=21.7%
Which fruit is valued most (*N*=89)	15.7%=*Ziziphus spina-christi* 14.6%=*Rosa abyssinica* 13.3%=*Diospyros mespiliformis* 12.0%=*Carissa spinarum* 10.8%=*Cordia africana* 10.8%=*Tamarindus indica* 8.4%=*Syzygium guineense* 7.2%=*Ximenia americana* 7.2%=*Mimusops kummel*
Why you do not domesticate species that produce wild fruits?	20.0%=Ignorance 2.9%=Feel shame 28.6%=Freely available 22.9%=Undermining their value 5.7%=Establishment problem 2.9%=Site requirement differences 5.7%=Land shortage 2.9%=Labour shortage 8.6%=No reason

(Arnold 1995; Scoones et al. 1992) and external famine interventions (Webb and Braun 1994) could lead to dependency on non-local resources and lower the incentive to raise local products. For example, the neglect and insignificant consumption of wild fruits, especially in Adiarkay and Debark districts, could be partly attributed to access to relief food.

Overall, the low dependence of people on wild food sources is not surprising in a community to whom even commercially well-known fruits and vegetables are novel. The study, therefore, strongly suggests the need for social marketing and nutritional education in order to achieve sustainable behavioural changes of the community towards wild fruit consumption.

Potential for combating food crises

When food security is threatened, for example by the deleterious effects of climatic shocks on agricultural production, people rely on a variety of coping mechanisms. Although fruit of several wild species are an essential part of food security in moderately unfavourable conditions, some are added only when a crisis occurs (Abbink 1993; FAO 1999; Guinand and Dechassa 2000; Demel and Abeje 2004; Kebu and Fassil 2006). In the study areas, wild fruits that are used during only famines were not acknowledged by the community. Nevertheless, despite divergent ideas among informants (Table 4) the use of wild fruits seems to increase substantially when a crisis occurs (Table 5: Guinand and Dechassa 2000). Specifically people recount the widespread drought and subsequent famine of 1984–1985 when people, especially the poor, survived by increasing their consumption of wild fruits. Memories of reliance on *Z.spina-christi*, which had been intensively consumed, bartered and sold during that time, were commonplace and the local adage, "*Bedur Fire Yesew Zer Yiterfal*", roughly translated to mean "wild fruits rescue humanity", substantiates the value of wild fruits at times of adversity. Increased rates of collection of wild foods are often a forerunner of large scale asset disposal or migration (Scoones et al. 1992). Thus, in the study areas, where droughts caused by the capricious climate and food insecurity are common phenomena, the monitoring of wild fruit collection could act as an early indicator of impending famine.

Collectors of wild fruits

Fruit gathering and consumption are highly dependent on age. Generally, during normal periods, fruit is collected mainly by children but is consumed by all members of the family, practices that concur with previous reports from other parts of Ethiopia (Table 4; Edwards 1992; Packham 1993; Bell 1995; Guinand and Dechassa 2000; Getachew 2001; Getachew et al. 2005; Tigist et al. 2006). Young people below the age of 30 are more familiar with wild fruits than adults, 43.6% of the former knowing >10 species compared with 8.1% o f the latter (Table 4). Moreover, of those who were familiar with >10 species 88.9% were youngsters (Table 4). Indeed, some 12 species are consumed by children but, unfortunately, most of these are gradually given up as they become older. Adults in most cases avoid or disdain the consumption of wild fruits as

Table 5 Wild edible fruits of different categories

Attributes	Number (%), *N*=48	Fruit species
Fruits consumed mainly by children	12 (25%)	*F. virosa, Ficus* spp., *F. thonningii , Rhus spp., O. spinosa, S. africana, S. innocua, Rubus* spp., *E. ventricosum, C.africana, Grewia* spp., *E. ventricosum*
Fruits that are consumed in higher quantities during famine	7 (14.6%)	*R. abyssinica, M. africana, Ficus spp, F. virosa, Carissa* spp., *Rhus* spp., *P. reclinata*
Fruits subjected to some form of home processing	12 (25%)	Juice—*Carissa* spp., *Tamarind, C.africana, Z.spina-christi*
		Local beer—*Z. spina-christi, R.abyssinica, Rubus* spp., *Tamarind, Ficus* spp., *C. africana*
		Flavor drinks—*C. africana, Carissa* spp.
Fruits with unpleasant characteristics	15 (31.3%)	*C. africana*—unripe fruits cause transitory stomach cramp, queasiness and lung sickness
		C. spinarum—excessive use causes feelings of queasiness, burning sensation of the stomach, diarrhoea and difficulty in eating other foods afterwards
		D. abyssinica—difficult in eat other foods afterwards, tartness
		D. mespiliformis—sharp taste
		F. virosa—unripe fruits cause transitory stomach cramp
		Ficus spp.—unripe fruits or those attacked by ants or worms cause transitory stomach cramp and nauseate goats
		L. senegalensis—seeds cause instantaneous death of goats and camels
		M. kummel—gastric problems, dry mouth and thirst
		O. ficus-indica—constipation
		R. abyssinica—burning sensation of the stomach, throat ache, skin irritation; juice causes a feeling of nausea
		Rhus species—difficult to eat other foods afterwards
		Rubus spp—burning sensation of the stomach
		S. guineense—burning sensation of the stomach, vomiting, mouth colouring, juice cause lung sickness
		T. indica—tartness or astringency
		Z.spina-christi—fresh fruits attacked by ants or worms cause transitory stomach cramp, and excessive use causes queasiness

they regard them of little food value and, in the case of fruits from *Ficus* species, claim that they harbour worms. For example, for 23% (*N*=92) of household head respondents, domestication of wild fruits does not appeal to them as they look down on their value (Table 4). This is certainly because grown-ups succumb to the culture of the society which regards the consumption of wild fruits as a source of shame. Similar reports from Eastern Africa indicate that fruit consumption decreases from young to adult people but in this case again increases with old people (Kweka et al. 2004).

Gender differences did not affect wild fruit consumption significantly. Interestingly, however, pregnant women appeared to be fond of eating wild fruits. This is in line with the suggestion that lactating women consume greater quantities of bush foods from which they acquire additional vitamins (FAO 1995). Indeed, children and pregnant and lactating women are the most vulnerable to nutrient deficiencies (Scoones et al. 1992). In the study areas and in much of the Amhara region children are given tasks such as taking care of animals, collecting fuel wood and fetching water, which are mostly performed outside. Apart from their major tasks inside the home women are also entrusted with fetching water and collecting fuel wood whereas men's undertakings mainly focus on farm operations. Thus children and women have better contact with the natural environment than men and are likely to have greater access to and familiarity with wild fruits. This in turn would lead to their greater consumption and better nutrition, a positive result as children and women, particularly those who are pregnant, are prone to malnutrition (Bell 1995).

Mode of fruit utilization and processing potential

Most of the wild fruits in the study areas are eaten fresh and raw as has been widely reported elsewhere (Table 4; Guinand and Dechassa 2000; Murray and Boxall 2002; Van den Eynden et al. 2003; Musinguzi et al. 2006; Tigist et al. 2006; Redzic 2007). Some such as those from *Vangueria madagascariensis* J.F. Gmel are dried before consumption and others such as those from *Z.spina-christi*, *Ficus* species and tamarind are eaten both fresh and dried. A few fruits are processed by boiling, roasting or fermentation to give refreshing juices, beers to which the fermenting agent (*Rhamnus prinoides* L'Hér.) may be added, or as flavourings to drinks (Table 5). *Carissa* spp., tamarind, *Cordia africana* Lam. and *Z.spina-christi* are processed into refreshing juices either by boiling or by adding lukewarm or cold water. The juice is sometimes diluted with water and sugar or honey may be added. Some juices are used on special occasions. For instance, Carissa juice is drunk on Islamic holidays, such as Maulid. Fruits of *Z.spina-christi*, *R.abyssinica*, *Rubus* spp., *T.indica*, *Ficus* spp. and *C. africana* are brewed either with the addition of leaves of *R. prinoides* to give the local alcoholic drinks, "*Tela*" and "*Tej*" (a Mead) or without it to give the non-alcoholic drink "*Beerz*", a hydromel. Juices of *C.africana* and *Carissa* are usually added to flavour local drinks prepared from other sources. A nightlong infusion of fermented tamarind pulp, which is referred to "*Areke*", is eaten as a bread dip and is used mainly as a curative against various diseases such as amoebic dysentery and rheumatism. The fruits of *Phoenix reclinata* Jacq. are stored for a week to promote ripening before consumption. The use of fruits in the form of juice or beer has also been reported for *S. guineense* and *X. americana* (Kebu and Fassil 2006), *T. indica* (Demel and Abeje 2004; Pauline and Linus 2004) and *Ficus sycomorus* L. (Tabuti 2007).

There is significant potential for the improvement of the diet of the Amhara people by incorporating processed wild fruits. For example, fruits of *Carissa edulis* (Forsk.) Vahl, *Dovyalis abyssinica* (A.Rich.) Warb., *Rubus* spp., *Opuntia ficus-indica* (L.)Miller, *R. abyssinica* and *S. guineense* can be processed into jams, marmalades and jellies as practised elsewhere in the world (Edwards 1992; Zemede and Mesfin 2001) and vinegar can be made from the fruit of *Carissa* species (MacLachlan 2002). *O. ficus-indica*, is widely commercialized in other parts of the world and, in the neighbourhoods of the study areas, fruits of *M. kummel* are made into jams and jellies (Demel and Abeje 2004) and those of *T. indica* are processed into juice, confectioneries, soup mixes, non-alcoholic drinks, composite seasoning and oil (Williams 1997). Products of *T. indica* are highly developed and widely used in Asia but so far are little used in Africa (Leakey 1999) and hardly at all in Ethiopia.

Processing fruits would enhance their utilization by reducing wastage and improve their marketing prospects, thereby further increasing their contribution to household food security and nutrition. This, in turn, would lead to better recognition of the value of fruit species and thus promote their conservation.

Anti-nutritional factors

A plant customarily recognized as innocuous may prove harmful or toxic, depending on the susceptibility of the individual, the part used, the growth stage of the plant, the way it is prepared, the season in which it is used and the purpose for which it is used (Dawit et al. 2001). As shown in Table 4, the majority of respondents (78.3%, n=92) across the study areas asserted that the fruits of 15 wild species incited harmful reactions which prevented their popular appreciation (Table 5). Harmful reactions and, in extreme cases, death upon consuming wild plants have been reported in previous studies in Ethiopia (Guinand and Ugas 1999; Getachew et al. 2005; Kebu and Fassil 2006) and seeds of some plants, such as *Strychnos spinosa* Lam. and *X. americana* L are known to be toxic (Amare 1976). Fortunately, there were no deaths in the present study and the adverse symptoms that were reported were generally transitory. These included nausea, vomiting, diarrhoea, constipation and heart-burn. Symptoms were more pronounced when fruits were eaten unripe, in excess or on an empty stomach. Some fruits are not liked because, for some people, they are too tart or have unpleasant after effects such as a dry mouth. For instance, consumption of *C. spinarum* Linn., *Rhus* species and *D. abyssinica* leave a transitory feeling of tooth-ache which makes the eating of other foods such as pepper difficult.

Some wild fruits are toxic to animals, those of *Ficus* spp. causing nausea in goats and consumption of seeds of *Lepisanthes senegalensis* (Poir) Leenh. by goats (as was also reported by Kebu and Fassil 2006) and camels may be lethal. The exocarp of the fruit of *L. senegalensis* is sometimes consumed by humans, especially children, which may cause accidental poisoning. Accidental poisoning by consumption of wild plants is common elsewhere in Ethiopia, especially during times of famine as occurred in 1974 in Wollo and in 1984 in the area named Gamogofa Province at that time (Amare 1974).

In order to mitigate anti-nutritional factors various techniques are practised such as roasting in the case of the fruits of *M. kummel* and tamarind seeds and the addition of lime, known locally as "*Abole*" to overcome the tartness of fresh fruits and infusions of tamarind.

Although acute symptoms may not occur, prolonged consumption of food containing natural toxins could cause chronic toxicity with such manifestations as stunting, indigestion and aggravation of malnutrition, markedly affecting people's productivity (FAO 1995). In the present study, although temporary deleterious effects on health are acknowledged, long term influences are not perceived. This highlights the need to bring the possibility of long term harmful consequences to public notice and to undertake the research required to understand anti-nutritional factors and devise mechanisms to lessen their occurrence and their effects.

Conclusion

This study has shown that, by being available at the time of critical food shortages and generally constituting a good level of essential nutrients, wild fruits in the study areas have a substantial potential for diversifying food sources and ameliorating nutritional insecurities. Although the poorest sections of the communities in the study areas do make part of their living out of the collection and trading of wild fruits, their potential has hardly begun to be exploited owing to food habits, cultural perceptions and attitudes. Therefore, in order to exploit the benefits of wild fruits to the full there is a need to foster their consumption through measures that ensure wider acceptance and to achieve sustainable behavioural changes. These may include vigorous promotion, public awareness campaigns and social marketing. It was also found that some species do not appeal to people because of their transitory undesirable characteristics. These warrant research in order to understand the underlying anti-nutritional factors.

Owing to the current trend of decreasing agro-biodiversity (Hadgu et al. 2009), there is a danger that wild fruit species will be lost. Hence, there is an urgent need to incorporate research into wild fruits and to promote their use as part of a strategy to improve food security, nutrition and livelihoods. Moreover, such improvements in the less-favoured environments of the present study, where the prospects of high input agriculture are low, are likely to be sustainable and prevent degradation of the fragile environment. Priority species for promotion and research in the light of farmers` preferences and their potential for food and nutritional supplements and income generation are *Z. spina-christi*, *R. abyssinica, D. mespeliformis*, *S. guineense*, *T. indica* and *M. kummel*.

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References

Abbink J (1993) Meén ritual, medicinal and other plants: a contribution to south-west Ethiopian Ethnobotany. J Ethiop Stud 26(2):1–21

Akinnifesi FK, Jordaan D, Ham C (2005) Building opportunities for small holder farmers to commoditize indigenous fruit trees and products in southern Africa: processing, markets and rural livelihoods. Book of abstracts. In: Tielkes E, Hülsebusch C, Häuser I et al (eds) The global food and product chain-dynamics, innovation, conflicts, strategies. University of Hohenheim, Deutscher Tropentag, Stuttgart-Hohenheim

Amare G (1974) The role of wild plants in the native diet in Ethiopia. Agro-ecosysts 1:45–56

Amare G (1976) Some common medicinal and poisonous plants used in Ethiopian folk medicine. Addis Ababa University, Addis Ababa

Arnold JEM (1995) Socio-economic benefits and issues in non-wood forest products use. In Report of the expert consultation on non-wood forest products, Yogyakarta, Indonesia, 17-27 January 1995. Non-Wood Forest Products 3. Rome, Food and Agriculture Organization

Association of Official Analytical Chemists, AOAC (1984) Official methods of analysis of the Association of Official Analytical Chemists. AOAC, Washington DC

Austrian Development Cooperation (ADC) (2004) ETHIOPIA: Subprogram Food Security Support of Agriculture and Rural Development with Emphasis on Natural Resources Management. Federal Ministry for Foreign Affairs, Austrian Development Cooperation Ethiopia Subprogram Food Security 2004–2006

Azene BT, Birnie A, Tengnas B (1993) Useful trees and shrubs for Ethiopia: identification, propagation and management for agricultural and pastoral communities. Nairobi, Regional Land Management Unit (RELMA) and Sida

Bell J (1995) The hidden Harvest. In Seedling, the quarterly newsletter of Genetic Resources Action International (GRAIN). www.grain.org. Accessed 9 October 2007

Central Statistical Agency of Ethiopia, CSA (2005) Statistical report on population size and characteristics for 1994. Part I. Addis Ababa, Central Statistical Agency

Dawit A, Kelbessa U, Asfaw D et al (2001) Survey of poisonous plants in Southern Ethiopia. Ethiop J Health Dev 15(3):209–221

Demel T, Abeje E (2004) Status of indigenous fruits in Ethiopia. In Chikamai B, Eyog-Matig O, Mbogga M (eds) Review and appraisal on the status of indigenous fruits in Eastern Africa. A synthesis report for IPGRI-SAFORGEN. http://www.bioversityinternational.org/Networks/saforgen/publications.htm. Accessed 10 June 2008.

Edwards SB (1992) Traditional tree crops in Ethiopia. Historical records and economic importance. pp159–168 in Natural Resources Management for conservation and development. Proceedings of the second Natural Resources conservation conference, 10-13 May 1990. Addis Ababa, Institute of Agricultural Research

FAO (1992) Forests, trees and food. Rome, Food and Agriculture Organization

FAO (1995) Non-Wood Forest Products and nutrition. Report of the International Expert Consultation on Non-Wood Forest Products. Yogyakarta, 17–27 January 1995. Non-Wood Forest Products 3. Rome, Food and Agriculture Organization

FAO (1999) Use and potential of wild plants in farm households. Rome, Food and Agriculture Organization

FAO (2005) Building on gender, agrobiodiversity and local knowledge. A training manual. Rome, Food and Agriculture Organization

Fentahun M, Ermias A, Mahitemework M (2005) Enhancing conservation and utilization of wild edible plants. Mirimir. A quarterly newsletter of Ethiopian Agricultural Research Organization, 1/2 April–June, 2005. Addis Ababa, Ethiopian Agricultural Research Organization

Getachew O (2001) Food source diversification: potential to ameliorate the chronic food insecurity in Ethiopia. In Kenyatta C, Henderson A (eds) The potential of indigenous wild foods. Workshop proceedings, 22–26 January 2001. Sudan, United States Agency for International Development

Getachew A, Kelbessa U, Dawit D (2005) Ethnobotanical study of edible indigenous plants in some selected districts of Ethiopia. Hum Ecol 33(1):83–118

Grivetti LE, Ogle BM (2000) Value of traditional foods in meeting macro- and micronutrients needs: the wild plant connection. Nutr Res Rev 13(1):31–46

Guinand Y, Dechassa L (2000) Indigenous food plants in southern Ethiopia: reflections on the role of 'famine foods' at the time of drought. Addis Ababa, United Nations Emergencies Unit for Ethiopia (UNEUE)

Guinand Y, Ugas M (1999) Underdeveloped, drought prone, food insecure: reflections on living conditions in parts of the Semen Mountains. Assessment Mission: 18–29 September 1999. United Nations Development Programme Emergencies Unit for Ethiopia

Hadgu M, Rossig WA, Kooistra L, van Bruggen AH (2009) Spatial variation in biodiversity, soil degradation and productivity in agricultural landscapes in the highlands of Tigray, northern Ethiopia. Food Security (in Press)

Hawk PB, Oser BL, Summerson WH (1947) Practical physiological chemistry. Blakiston, Philadelphia, pp 579

Kebu B, Fassil K (2006) Ethnobotanical study of wild edible plants in Derashe and Kucha Districts. South Ethiopia. J Ethnobiol Ethnomed 2:53

Kweka D, Chikamai B, Eyog-Matig O (2004) Regional Consultation on indigenous fruit trees in Eastern Africa. KEFRI Muguga 6–7th December 2004. Nairobi, IPGRI/SAFORGEN

Leakey RRB (1999) Potential for novel food products from agroforestry trees: a review. Food Chem 66(1):1–14

MacLachlan M (2002) Manual of highland Ethiopian trees and shrubs. Injibara, SIM forestry study project

McBurney RPH, Griffin C, Paul AA et al (2004) The nutritional composition of African wild food plants: from compilation to utilization. J Food Compos Anal 17(3–4):277–289

Mithöfer D, Waibel H (2004) Seasonal vulnerability to poverty and indigenous fruit use in Zimbabwe. Rural Poverty Reduction through Research for Development and Transformation conference. Deutscher Tropentag, October 5–7, 2004. Berlin, University of Hannover

Mojeremane W, Tshwenyane SO (2004) *Azanza garckeana*: a valuable edible indigenous fruit tree of Botswana. Pakistan J Nutr 3 (5):264–267

Murray G, Boxall P (2002) The distribution, abundance, and utilization of wild fruits by the Gwich'in in the Mackenzie River delta. Sustainable forest management network project report, 2002–7. Edmonton, University of Alberta

Musinguzi E, Kikafunda JK, Kiremire BT (2006) Utilization of indigenous food plants in Uganda: a case study of south-western Uganda. African Journal of Food, Agriculture, Nutrition and Development, 6(2). http://www.ajfand.net/Vol6No2.htm. Accessed 26 August 2008

Packham J (1993) The value of indigenous fruit-bearing trees in miombo woodland areas of south-central Africa. London, Rural Development Forestry Network. Overseas Development Institute

Pauline M, Linus W (2004) Status of indigenous fruits in Kenya. In Chikamai B, Eyog-Matig O, Mbogga M (eds) Review and appraisal on the status of Indigenous fruits in Eastern Africa. A synthesis report for IPGRI-SAFORGEN. http://www.bioversity international.org Accessed 11 July 2007.

Redzic SJ (2007) Wild edible plants and their traditional use in the human nutrition in Bosnia-Herzegovina. Ecol Food Nutr 45 (3):189–232

Ruel MT, Minot N, Smith L (2005) Patterns and determinants of fruit and vegetable consumption in sub-Saharan Africa: a multi-country comparison. Background paper for the joint FAO/WHO Workshop, 1–3 September 2004, Kobe, Japan. World Health Organization

Scoones I, Melnyk M, Pretty JN (eds) (1992) The hidden harvest. Wild foods and agricultural systems. A literature review and annotated bibliography. London, International Institute for Environment and Development

Shackleton C, Shackleton S (2004) The importance of non-timber forest products in rural livelihood security and as safety nets: a review of evidence from South Africa. S Afr J Sci 100(11–12):658–664

Srivastava RP, Kumar S (1998) Fruit and vegetable preservation. Principles and practices, 2nd edn. International Book Distributing Co., New Delhi

Statistical Package for the Social Sciences for Windows (SPSS) Release 15.0.0 (6 September 2006). SPSS Inc. 1989–2006

Tabuti JRS (2007) Status of non-cultivated food plants in Bulamogi County, Uganda. Afr J Ecol 45(1):96–101

Tigist W, Zemede A, Ensermu K (2006) Ethnobotanical study of food plants around `Dheeraa` town, Arsi, Ethiopia. Sinet: Ethiopian Journal of Science 29(1):71–80

Van den Eynden V, Cueva E, Cabrera O (2003) Wild Foods from Southern Ecuador. Econ Bot 57(4):576–603

Webb P, Braun J (1994) Famine and food security in Ethiopia. John Wiley and Sons Ltd, Chichester

Williams JT (1997) Uses and products of tamrind. In Williams JT, Smith RW, Haq N et al (eds) Tamarind, *Tamarindus indica* L. Southampton, Southampton Centre for Underutilized Crops

Zemede A, Mesfin A (2001) Prospects for sustainable use and development of indigenous food plants in Ethiopia. Econ Bot 55(1):47–62

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