PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 10 (1): 40-50, 2011
ISSN 1680-5194

Wild Edible Fruits of Importance for Human Nutrition in Semiarid Parts of East Shewa Zone, Ethiopia: Associated Indigenous Knowledge and Implications to Food Security

Debela Hunde Feyssa[1], Jesse T. Njoka[1], Zemede Asfaw[2] and M.M. Nyangito[1]
[1]Department of Land Resources and Agricultural Technology, University of Nairobi, College of Agriculture and Veterinary Sciences, Nairobi, Kenya
[2]Department of Biology, Addis Ababa University, College of Natural Sciences, Addis Ababa, Ethiopia

Abstract: Nutrient value assessments and ethnobotanical studies of three wild edible fruit species [*Ziziphus spina-christi (L.) Desf., Balanites aegyptiaca (L.) Del., Grewia flavescens A. Juss.*], were carried out from October 2009 through June 2010 in east Shewa Zone, Ethiopia. Field data collection was combined with laboratory food content analyses with the aim of identifying promising wild edible fruit plants. Also, optimal use of preferred wild edibles particularly in addressing future food security issues of rural people in the drylands was assessed. Composite fruit samples randomly collected in six sites of Fantalle and Boosast districts were subjected to standard laboratory chemical analyses. Values for total carbohydrates, crude protein, crude lipid, moisture and total ash contents of the fruit pulps ranged from 76.67-86.12%, 1.45-4.20%, 3.58-4.02%, 35.18-57.41%, 8.11-16.40% for *Z. spina-christi*, 85.55-89.61%, 0.001-003, 49.03-68.26%, 10.18-12.88% for *B. aegyptiaca*; 83.74-93.68%, 0.64-3.14%, 18.90-61.35%, 3.16-7.25% for *G. flavescens*, respectively. The calculated energy (based on total carbohydrates) was highest for *G. flavescens* (373.6 Kcal/100 g), followed by *B. aegyptiaca* (354.24) and *Z. spina-christi* (344.48 Kcal/100 g). The results indicated that these fruit species, which are popularly used by the local communities, contain appreciable amounts of nutrients and energy and thus are useful food supplements. These species should be integrated into dryland agroforestry systems for sustainable use and conservation, as well as, preservation of the associated knowledge through the positive practice of the indigenous bio-cultural knowledge. In this case, lessons can be drawn from some farmers of Boosat District, who are currently using two of the species in traditional agroforestry practices.

Key words: Dryland agroforestry, ethnobotany, nutritional value, wild edible fruits

INTRODUCTION

Food and nutritional security are key issues for human wellbeing. Researchers, governments and organizations working with food and nutrition are concerned with the nutritional status of the general population especially children, pregnant women and lactating mothers in the developing countries (Andersen *et al*., 2003; Sena *et al*., 1998). In these countries, natural disasters, underdeveloped economies, political instability, population explosion, soaring prices of food commodities, poor implementation of agricultural policies, inadequate food intake among people are common (Adebooye and Phillips, 2006). In developing countries, starch-based foods are major sources which supply both energy and protein requirement. Thus, protein deficiency prevails among the problems recognized by the Food and Agricultural Organization (FAO) (Ladeji *et al*., 1995). To alleviate the situation, efforts should be focused on sustainable use of under-utilized and lesser-known wild plants as sources of nutrient supplements in enhancing food and nutrition security. In this regard researchers (Cook *et al*., 2000; Lockeett *et al*., 2000; Ogle *et al*., 2001) have reported the nutritional composition of various types of wild edible plants in use in the developing world. Wild edible plants are used to supplement household food in Ethiopia (Fentahun and Hager, 2009). *Ziziphus spina-christi, B. aegyptiaca* and *G. flavescens* are widely distributed in semiarid Ethiopia from 0-1900 m.a.s.l. (Vollesen, 1989; Sands, 1995; Vollesen and Demssew, 1995) and are among the underutilized wild edible plants in Ethiopia. *Ziziphus spina-christi* is distributed in Acacia bushlands in alluvial soils and along dry riverbeds, edges of cultivation and gardens, while *B. aegyptiaca* is abundant in semiarid areas of Ethiopia and other parts of Africa (Sands, 1995). Fresh new shoots of *B. aegyptiaca*, is available in the dry season and commonly used as animal forage. But in periods of food shortage, people

Corresponding Author: Debela Hunde Feyssa, Department of Land Resources and Agricultural Technology, University of Nairobi, College of Agriculture and Veterinary Sciences, Nairobi, Kenya, Home institute: Jimma University, Ethopia

cut the newly growing shoots with the leaves, cook and eat as vegetable (Teketay and Eshete, 2009). The species has multiple uses (Bekele, 2007). However, there is paucity of information on the actual conservation status of the species. Also, there is scanty information on the fruit nutritional quality of the species in Ethiopia. The species is currently under heavy use from the local population. *Grewia flavescens* is wild edible plant largely consumed by children in the past. Currently all age categories are using it as food. Information on management, nutritional composition of this species is inadequately documented or non existence than the the other two species. Research and development on conservation, management and sustainable utilization of these species is extremely low and thus a as remained as a research gap in Ethiopia (Teketay and Eshete, 2009; Taddesse and Alem, 2009). Therefore, bridging this research gap through further analysis on the nutrient composition of major food substances (carbohydrates, proteins, fat, minerals and moisture) and the dryland systems of these key wild edible plants is timely and essential. This will facilitate sustainable use and management of these wild edible plants for household nutrition and food security and also enhance *in situ* and *ex situ* conservation of the species. Therefore, the objective this study was to determine the nutritive value of *Z. spina-christi, B. aegyptiaca* and *G. flavescens* fruits for human consumption. The specific objectives were: Identify nutritionally promising wild edible plants by through an ethnobotanical survey in transhumant and settled farmers land use systems; Identify the major food substance contents of *Z. spina-christi, B. aegyptiaca* and *G. flavescens* fruits and Make comparative analysis of the major food contents of wild *fruits* across the two land use systems to show future line of work on their contribution to nutrition and food security of the semiarid rural people.

MATERIALS AND METHODS

Study area: The study was conducted in the semiarid zone of east Shewa in Fantalle and Boosat (weredas) districts located between 7°12'-9°14'N latitudes and 38°57'-39°32'E longitudes in the northern part of Great East African Rifty Valley in Ethiopia from October, 2009 through April, 2010. The area lies in the Somalia-Maasi center of plant endemism (White, 1983) described as the *Acacia-Commiphora* woodland vegetation type (Demessew and Friis, 2009). The climate of the area is harsh with erratic and variable rainfall. The highest mean annual rain fall of semi arid east Shewa was 171.05 mm and lowest is 23.04 mm. The highest mean monthly rainfall 243.11 (July and August) and the lowest mean monthly rainfall is, 5.78 mm November respectively. The main rainy season is from June to September known as 'Kiremt' and low rainfall from February to May known as 'Belg". The highest mean maximum temperature is 36.73°C in June and the lowest (31.24°C) in December. Economic activities of the area can be described as the agropastoral type with Boosat Wereda (administrative level in Ethiopia equivalent to the district) marked with mixed agriculture of livestock and crop production (BPED, 2000). Fantalle wereda is more of livestock production with transhumant and rudimentary crop agriculture practiced in favourable years. The vegetation of the area includes many wild edible plants. However, the vegetation is declining due to the effects of anthropogenic factors and climate change. This has affected both natural resources and the livelihoods of people in the study area.

Ethnobotanical study and experimental sample collection: Prior to undertaking laboratory nutrient analysis on fruit samples, focus group discussion, interview and repeated field observations and data collection were conducted to identify the key species for the analysis as described in (Martin, 1995; Cotton, 1996). Preference ranking exercises gave *Ziziphus spina-christi, Balanaities aegyptiaca* and *Grewia flavescens* as priority species for further study. Fruits of these species were sampled from Fantalle (Galcha, Qobo and Dheebiti Kebeles) and Boosat (Trii Biretti, Digalu Tiyo and Xadacha Kebeles-lowest administrative unit in Ethiopia) districts from November, 2009 through April, 2010. The plant species were identified *in situ* and confirmed by the help of taxonomists at the National Herbarium, Addis Ababa University, Ethiopia. Fruits samples were harvested in sample bags and taken to the laboratory for analysis at the College of Agriculture and Veterinary Medicine, Jimma University, Ethiopia.
In order to obviate the effects of different environmental factors and soil types in particular on nutrient contents, care was taken to obtain the fresh samples from replicate locations within and between districts following standard procedure (Armstrong and Hilton, 2004) for ripe fruits of *Z. spina-christi, B. aegyptiaca* and *G. flavescens*.
Fruits were oven dried in sample bags at 65°C for 72 h then further dried at 105°C for 4 h to constant weight following standard protocols (AOAC, 1990; Abuye *et al*., 2003). The fruits were ground into fine powder using pestle and mortar partly and F2-102 micro plant grinding machine to fine particles and sieved through 20-mesh sieve of 1 mm. For each replicate sample from the study sites, all dried sub-samples were pooled together. Each composite powder sample from the localities were analysed in duplicate per land use, giving a total of 6 replicates for one wild edible plant species.

Proximate analysis: Nutrient contents were analysed on dry matter basis including moisture, carbohydrate, ash, crude fat, crude fiber and crude protein using the recommended methods of the Association of Official Analytical Chemists (AOAC, 1990).

Determination of moisture and ash content: For moisture content determination, 2 gm dry matter of fresh fruits of the sample in duplicates were weighed in petri dishes and dried in an oven overnight for 12 h at 105°C using the method described by (Osborne and Voogt, 1978; AOAC, 1990). The dried fruits and seeds were cooled in a dessicator and weighed. The percentage loss in weight was expressed as percentage moisture content.

Total ash content was determined by the incineration of two grams of sample in a proclean dish placed in a muffle furnace at 550°C for 4 h as described by (Pearson, 1976). The percentage residue weighed was expressed as total ash content.

Determination of crude lipid and crude fibre content: Two grams of dried sample in duplicates were weighed into porous thimble and its mouth plugged with cotton. The thimble was placed in an extraction chamber, which was suspended above weighed receiving flask containing 100 ml diethyl ether (boiling point of 40-60°C) and below a condenser 1:30 to 2 h. The flask was heated on a heating mantle for 3 h to extract the crude lipid. After the extraction, the thimble was removed from the Soxhlet apparatus and the apparatus reassembled and heated over water bath for solvent recovery. The flask was heated on heating mantle for eight hours to extract the crude lipid. The receiving flask containing the crude lipid was disconnected, cleaned with dry cloth, oven dried a 100°C for 30 min, cooled in a desiccator and weighed.

Crude fiber was estimated by acid-base digestion known as Coarse Fiber Determinater, with 1.25% H_2SO_4 (w/v) and 1.25% NaOH (w/v) solutions. The residue after crude lipid extraction was put into a 600 cm^3 beaker and 200 cm of boiling 1.25% H_2SO_4 added and washed with 25 cm^3 ethanol. The filter paper containing the residue was dried in an oven at 130°C to constant weight and cooled in a desiccator. The residue was scrapped into pre-weighed porcelain crucible, weighed, ashed at 550°C for two hours, cooled in a desiccator and reweighed. Crude fiber content was expressed as percentage loss in weight on ignition.

Determination of crude protein and carbohydrate: Micro-Kjeldahl was used to determine the nitrogen content of the samples. One grams dried powdered sample was placed into a 100 cm^3 Kjeldahl digestion flask. A Kjeldahl digestion tablet and 10 cm^3 of concentrated sulfuric acid were added and the sample was boiled until frothing stopped and the digest sample became clear. Then 100 ml distilled water, 10 ml of the aliquot solution and 20 ml of 45% sodium hydroxide solution were added into a distillation flask containing the digested sample and steam distilled. The ammonia liberated was collected over 50 ml 4% boric acid-mixed indicator solution, cooled and titrated with standard 0.01N HCl solution in order to obtain nitrogen content. Crude protein was computed from sample percentage nitrogen content as determined by the Kjeldahl procedure, multiplied by a factor (6.25) for conversion of nitrogen to protein from the fact that most proteins contain approximately 16% nitrogen. The general factor of 6.25 is used to calculate protein in items that do not have a specific factor (AOAC, 1990). Available carbohydrate was calculated by subtracting total sum of crude protein, crude lipid, crude fiber and ash from 100% DW sample (AOAC, 1990).

Determination of energy value: The sample calorific value was calculated in kilocalories (kcal) multiplying by physiological energy factor composition (4, 4 and 9) of percentage proteins, fats and carbohydrates were used respectively as used in (FAO, 1968; USDA, 1999; Asibey-Berko and Tayie (1999). The conversions factors are for physiological energy, which is the energy value remaining after losses due to digestion and metabolism and deducted from gross energy (USDA, 1999) where one kcal equals 4.184 kJ.

To estimate the yield of WEP focus group discussion was conducted at 6 study sites with 14 key informants from each study sites. Each of them has given an estimated amount of yield per plant per year when harvested from the wild. This was done for three sizes of each plant species, smaller, medium and relatively bigger plant. The value given for one item by 14 discussants from each study sites (14x6 = 84) informants were averaged to get the pooled total average of six study sites for three levels of plants.

Statistical analysis: Data was analyzed through r analysis of variance and means separated by LSD at 0.05 levels according to methods described by (Snedecor and Cochran, 1980) using SPSS version 16 and SAS. Ethnobotanical information was described in descriptive statistics and qualitatively described under specific items following procedures of (Martin, 1995; Cotton, 1996) as used by (Balemie and Kebebew, 2006).

RESULTS

Nutritional contents of *Z. spina-christi*, *B. aegyptiaca* and *G. flavescens* fruits: Nutrient composition analysis of fruits of the three wild edible plants showed mineral content of 8.11-16.40, 10.18-12.88 and 3.16-7.25% for *Z. spina-christi*, *B. aegyptiaca* and *G. flavescens* respectively. Proteins and carbohydrates were 1.45-4.20%, 76.67-86.12% for *Z. spina-chrsti*, 1.05-1.92%, 85.55-89.61% for *B. aegyptiaca* and 0.64-3.14%, 83.74-93.68 for *G. flavescens* respectively (Annex. 1).

Comparative analysis of nutrient contents

Comparison of nutrient contents between species: Analysis of variance indicated that there were significant differences ($p<0.05$) between the three species for all the parameters measured except percentage of CP and NFE (Table 1) The result also indicated that *G. flavescens* produced high percentage of DM, CF and OM as compared to other two species. On the other hand, *Z. spina-christi* produced higher percentage of crude fat (EE). Generally, different species contains different nutrient composition indicating their complementarities in household nutrition.

Comparison of nutrient contents of the fruit trees across land use systems: Analysis of variance indicated that there were no significant difference ($p>0.05$) between the two land use systems for all the parameters measured except percentage of CF and EE (Table 1). Percentage crude fiber had a significant variation with the highest percentage from the settled farmers (Boosat District) land use (Table 1). This suggests that promoting these wild edible plants for fiber production in these semiarid areas would need to consider the variations of land use and appropriate management, in this case production in transhumant systems (Fantalle District).

Interaction effects of fruit tree species with land use system: There was a significant interactive effect ($p<0.05$) between different tree species along the land use type for all the parameters. DM, Moisture, CF, CP and EE (Table 2). *G. flavescens* had the highest % EE, DM and CF for the sample analyzed from settled farmers land use system (Table 2). Also, land use had significant effect on the nutritional content of *G. flavescens*.

Comparison of energy content of wild fruits: The mean calculated energy value of lipids ranged from 33.21-36.18 kcal for *Z. spina-christi*, the highest being for sample collected from transhumant land use. For *B. aegyptiaca* from 0.09-027 Kcal and for *G. flavescens* from 0.009-58.76 kcal. Energy from protein ranged from 5.8-16.8 kcal for *Z. spina-christi*, 4.2-7.68 for *B. aegyptiaca*; 2.056-12.57 kcal for *G. flavescens*. Energy for total carbohydrate is 306.68-344.48, for *Z. spina-christi*, 342.2-354.24 kcal for *B. aegyptiaca*, 334.96-373.46 kcal for *G. flavescens* kcal (Annex 2). The result indicated that carbohydrate content has highest contribution to energy need of people who consume these species of wild edible plants.

Community preference is normally based on various factors such as taste; availability, accessibility, cultural, psychological and inherited ancestral practices. Hence, when recommending nutritionally high valued wild edible plants, socio-cultural and socioeconomic factors should be taken into account. For those wild edible plants with higher nutrition value and less community preference, their recommendation for agro biodiversity should go hand in hand with awareness creation on their uses. In the case of these three wild edible plants, the community has preference and has been using them as food. Hence, promoting their inclusion into dryland agro biodiversity and dryland agroforestry is desirable.

Indigenous knowledge on wild edible plants, multipurpose use and yield: Indigenous people of the study area have diverse knowledge of use and yield status of wild plant species. Focus group discussion conducted in study sites, *Z. spina christi* was ranked the top priority plant for the community when 10 uses were considered (Table 3).

Also, the result of measured fruits yield showed that for most of the species, settled farmers harvested yield was higher than the transhumant (Table 4). This can be attributed to their life styles, transhumants mostly relay on livestock products while farmers' largely relay on plant products for their food.

DISCUSSION

Nutritional potential of wild edible plants and trends of utilization: There is variation in nutrient for some major food substances composition between three species. Variations in nutrients and energy from the samples analyzed indicated the existence of heterogeneous sources of nutrients and energy from wild edible plants of the same species from different sites. This can be attributed to environmental factors such as soil, temperature, rain fall which have an impact on nutritional contents of the plants. In spite of the variations within and between sample sites in many aspects the nutrient composition analysis indicated that these wild edible plants have significant amount of nutrients and energy to supplement meals for household food, if properly valued it can be a good income sources for households. Observations from east Shewa, besides direct nutritional contributions by carbohydrates, lipids, proteins, minerals and energy; the diversity of wild edible trees is a source of variety and taste in local meals. Earlier studies made by (FAO, 1995) on non-timber forest products focusing on nutrition and in India on nutrient composition of specific plants (Parvathi and Kumar, 2002) have reached similar conclusion. In east Shewa, their role and value are hardly recognized in formal production, macro-economic and conservation planning as they are overshadowed by the values of the more conventional food crops and charismatic species such as *Eragrostis teff*, *Triticum aestivum Hordeum vulgare*, *Sorghum bicolor*, *Zea mays* and others.

The fruits are rich in valuable nutrients and are accessible throughout the year with significant overlap with the times of acute food and nutrient scarcity. Nevertheless, owing to the peoples' livestock and cereal-based dietary habits by both transhumant and

Table 1: Mean separation methods for tree species and land use systems

Tree type	DM (%)	Moisture (%)	Ash (%)	CF (%)	CP (%)	EE (%)	NFE (%)	CHO (%)	OM (%)
B. aegyptiaca	45.66^{b}	54.33^{a}	11.75^{a}	5.94^{b}	1.40	0.009^{c}	80.89^{a}	86.83^{a}	88.24^{b}
Z. spina-christi	52.41^{b}	47.59^{a}	12.09^{a}	3.78^{c}	2.13	3.722^{a}	78.25^{a}	82.04^{b}	87.90^{b}
G. flavescens	67.82^{a}	32.17^{b}	5.73^{b}	6.68^{a}	1.51	3.288^{b}	82.78^{a}	89.46^{a}	94.26^{a}
CV (%)	10.74	18.23	23.47	5.92	33.4	5.25	3.57	3.24	2.56
LSD (5%)	10.48	10.48	2.97	0.41	NS	0.158	NS	3.59	2.97
Land use systems									
Settled farmers	55.74^{a}	44.26^{a}	9.87^{a}	5.91^{a}	1.48^{a}	3.46^{a}	79.26^{a}	85.17^{a}	90.12^{a}
Transhumant	54.88^{a}	45.14^{a}	9.84^{a}	5.02^{b}	1.88^{a}	1.21^{b}	82.02^{a}	87.05^{a}	90.15^{a}
CV (%)	10.74	18.23	23.47	5.92	33.4	5.25	3.57	3.24	2.56
LSD (5%)	NS	NS	NS	0.340	NS	0.129	NS	NS	NS

DM = Dry Matter, CF = Crude Fiber, CP = Crude Protein, EE = Ether Extract (crude fat), NFE = Nitrogen Free Extract, CHO = Total Carbohydrate, OM = Organic matter. Means with the same letter are not significantly different

Table 2: Interaction effect of tree with land use systems

No	Two way interaction	DM	Moisture	CF	CP	EE	NFE	CHO	OM
1	Set farm* *B. aegyptiaca*	43.05^{C}	56.94^{a}	6.16^{b}	1.45^{ab}	0.007^{C}	81.29^{a}	87.46^{a}	88.91^{a}
2	Set farm* *Z. spina-christi*	44.91^{C}	55.08^{a}	3.84^{C}	2.24^{a}	3.815^{b}	77.62^{a}	81.46^{a}	87.52^{a}
3	Set farm* *G. flavescens*	79.25^{a}	20.74^{C}	7.73^{a}	0.75^{b}	6.575^{a}	78.87^{a}	86.61^{a}	93.94^{a}
4	Trans* *B. aegyptiaca*	48.28^{bC}	51.71^{ab}	5.72^{b}	1.30^{ab}	0.011^{C}	80.49^{a}	86.21^{a}	87.57^{a}
5	Trans* *Z. spina-christi*	59.91^{b}	40.08^{b}	3.72^{b}	2.03^{a}	3.630^{b}	78.89^{a}	82.62^{a}	88.28^{a}
6	Trans* *G. flavescens*	56.39^{bC}	43.60^{ab}	5.64^{C}	2.26^{a}	0.002^{C}	86.69^{a}	92.33^{a}	94.59^{a}

Set farm = settled farmers land use, Trans = transhumant land use. Means with the same letter are not significantly different, LSD (5%)

settled farmers, cultural perceptions and attitudes, the current state of fruit utilization is very low with increasing trend to maximize utilization as food and income generation.

Analysis of practical situations by participatory observation on use of wild edible plants has revealed that they are incorporated into livelihood strategies of many rural people and playing an important role in bridging communities over the hunger season that precedes the harvest and also in providing people with the necessary energy to harvest from their farm as also reported elsewhere (Bell, 1995). In the present study, nutritional analysis of the fruits of the three most preferred species showed that they contained important nutrients (Annex 1). Comparison of the result of the present study with the nutrient content of some cultivated fruits noted by Srivastava and Kumar (1998) showed that they are superior in protein content to banana (1.2 and 0.3%), guava (0.9 and 0.3%) respectively; mango (0.6 and 0.4%, respectively) and papaya (0.6 and 0.1%) respectively. Their carbohydrate contents are also greater than conventional fruits. These parameters are higher for nutrition contents of *Z. spina-christi* from North Western Ethiopia, Amhara National Regional State which reported, protein, 3.21%, fat, 1.18%, carbohydrates, 80.74% (Fentahun and Hager, 2009). The results of the current study of *Z. spina-christi*, *B. aegyptiaca* and *G. flavescens* fruits from east Shewa were compared with data on some Ethiopian major food crops and indicated superiority of nutritional quality availing their potentials for adoption in dryland agroforestry (Table 5).

In terms of energy three of WEPs are greater than *Sorghum bicolor* porridge, which is stable food of semi-arid people. Also percentage CHO, crude fat and ash were (>50%) higher than the farm crops (Table 5). This indicates that the possibility of integrating the production of WEPs and farm crops to get improved household nutrition/food security.

The comparative analysis demonstrated that wild fruits have high potential as sources of vital nutrients especially for children who are prone to malnutrition and who are key fruit collectors. Thus, where cereals form the major part of the food intake are unavailable, the variety and quality of the diet, especially for children, would be reduced essentially to carbohydrates. The data suggested 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 specific level nutritional contents and value of wild fruits are therefore recommended as urgent research agenda.

Comparison of inter species nutritional composition of the wild fruits: Nutritional composition of wild edible plants was compared with domesticated crops. The study on three wild edible plants which indicated that an edible part that is rich in one nutrient is deficient in the other. For example, the fruits of *Z. spina-christi, B. aegyptiaca, G. flavscense* have variations for different nutrient contents. *G. flavsencse* is rich in carbohydrates followed by *B. aegyptiaca* and *Z. spina-christi*. *Z. spina-christi* is highest in protein followed by *G. flavscense and B. aegyptiaca* respectively. This indicates that the consumer can be advised to prepare the correct mix of the edibles to obtain the best quality food and the practice. Since this nutritional analysis is conducted on 3 preferred wild edible plants, further studies including

Table 3: Average pooled summary of use categories of WEP by pair wise ranking

WEP	Fd	Me	Fe	Shd	Erc	Fw	Sp	Frg	Fi	Hhu	TAUV	Rank
Z. spina-christi	5.00	4.50	5.00	5.00	5.00	5.00	4.50	5.00	4.83	4.83	48.67	1st
B. aegyptiaca	4.50	4.50	4.83	4.33	4.67	4.70	4.16	4.00	4.50	3.83	44.00	2nd
G. flavescens	3.00	2.00	4.00	4.00	4.80	4.00	3.00	4.00	2.00	2.00	32.83	3rd

Fd = Food, Hmd = human medicine, Fe = Fencing, Shd = Shade, Erc = Erosion control, Fw = Fuel wood, Sp = Spiritual, Frg = Forage, Fi = Farm implement, Hhu = household utensils, TAUV = Total Average Use Value, value scale (0-5), where, 0 = for no use and 5 = for best use

Table 4: Average pooled summary of yield in kg of harvest at wild condition by communities of six study sites (value scales are 0-5, 5 being the highest), smaller to bigger stands for tree size

	Boosat district			Fantalle district		
WEP	Smaller	Medium	Bigger	Smaller	Medium	Bigger
Z. spina-christi	53.33	151.67	320.00	3.67	6.00	14.00
B. aegyptiaca	26.67	106.67	250.00	3.00	5.33	11.00
G. flavescens	18.33	49.00	116.67	3.67	7.67	17.00

surveys and nutritional analysis on other species would lead to robust data on the wild edible plants of east Shewa, Ethiopia and semiarid Africa. Research on wider areas on other wild edible plants consumed by other communities in Ethiopia would help to build the national database and better understanding on sustainable utilization and management of wild edible plants.

Indigenous use and management practices of the species: Indigenous knowledge system is used as a base to modern system. A modern system is always initiated through external interventions such as government agencies and NGOs. It is the local knowledge that is unique to given culture or society. It forms the basis for local level decision making in natural resources and host area of other activities in rural communities (Woytek and Gorjestani, 1998 cited in Nyarik *et al*., 1999). It also enhances nutrition and health aspect of people.

Participant observation, focus group discussion, semi structured interview with settled farmers and transhumant have revealed that, these wild edible plants are used by households as supplementary food during famine, at normal time and during food shortage. However, the local people have expressed their views that, people consider these species as famine food which is a hindrance to its full integration to dietary list. Hence, in spite of their contribution to household food basket, they remained partly a ‘hidden product’. Agroforestry, farm border, live fencing and enclosure for *Z. spina-christi, B. aegyptiaca* and live fencing for *G. flavescens* are conservation practices observed in the study area.

The indigenous dryland agroforestry practices by settled farmers and pasture-tree practices by transhumant need be promoted with proper policy and extension services. This seeks the integration of local indigenous technical knowledge and appropriate technologies for proper and improved utilization of the wild edible fruits for improved people’s food security and livelihoods. Given the impeding climate change and population pressure resulting in resource degradation and depletion by over harvesting, these climatically adapted wild edible plants reduce vulnerability of rangeland people to food insecurity to adapt to climate changes. Consequently, sustainable utilization contributes to the maintenance of biodiversity and associated indigenous knowledge.

Level of wild fruits utilization: The ripe fruits of *Z. spina-christi* are edible and are found in large quantities in local markets. In spite of the rampant food and nutritional insecurity of people living in the study areas, the current level of fruit consumption appears to be relatively low. In addition to, *Z. spina-christi*, *B. aegyptiaca* and *G. flavescens* there are other wild edible plants which are perceived to be of high nutrition value but their consumption is not well promoted by formal production system. Infrequent consumption of wild plants is a universal phenomenon in both the Oromiya National Regional State and Ethiopia 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) and South Africa, wild fruit consumption per household per year may be about 104 kg (Shackleton and Shackleton, 2004). This is an indication that Ethiopia needs to work more on sustainable utilization and management of these wild edible plants to improve food security of rural populations to adapt to climate change.

Level of integration of wild edible plants to formal production systems: *Ziziphus spina-christi*, *B. aegyptiaca* and *G. flavescens* were underutilized from a research and development point of view, have not received any major emphasis from government’s agricultural development plan. However, the fruits remained integral part of the culture and consumables of millions of diverse semiarid Ethiopians and also can be for large regions of Africa if the species are improved and necessary awareness and enabling polices, appropriate technology for production are put in place.

Table 5: Nutrient composition of some major Ethiopian farm Crops Vs`WEPs

Species	Energy (Kcal/100 gm)	Moisture (%)	Protein (%)	CHO (%)	Fiber (%)	Ash (%)	Fat (%)
H. vulgare L., bread	158.00	52.20	4.10	36.00	2.90	1.70	1.00
Z. mays L., bread	192.00	52.00	4.50	40.60	1.30	0.80	1.90
Sorghum bicolor porridge	104.00	73.40	2.30	23.50	0.70	0.40	0.40
Ergrostis tef, injera*	166.00	56.30	4.90	36.30	2.20	1.30	1.00
Triticum aestivum, bread	208.00	44.80	6.60	45.60	1.70	2.30	0.70
*B. aegyptiaca***	117.67	54.33	1.40	86.83	5.94	11.75	0.009
*Z. spina-christi***	122.38	47.59	2.13	82.04	3.78	12.09	3.722
*G. flavescens***	131.14	32.17	1.51	89.46	6.68	5.73	3.288

Source: EHNRI-FAO (1995:1-33), CHO = Carbohydrate. ** = WEPs from the present study, * = (local Ethiopian thin spongy bread)

The trees are drought resistant and can be cultivated in a very wide range of climatic and agroecological zones which make them of great value in agricultural and human development sectors in areas where intensive agriculture is not currently feasible.

The results of the present study suggested that, fruit trees can contribute substantial amounts of dietary carbohydrates, proteins, lipids, fiber, minerals and moisture for rural livelihood even if they are consumed uncooked and unprocessed. In spite of its contribution the field observation and focus group discussion have shown that, some indigenous fruits and seeds of trees are popularly eaten and should be integrated in the rural development plan. Still large numbers of them are less popular and are not integrated in the rural development plan. None of these wild edible plants are integrated in formal production systems either locally or nationally.

Future prospects of wild edible plants with emphasis to *Z. spina-christi*

Harvesting techniques: Local people of the two districts harvest the fruits by manual shaking or beating the tree branches to induce the mature fruits to fall onto the ground and rarely on cloth sheet below the tree. However, for tall trees they use, hand picking after climbing with the help of ladders or clipping using wooden hook or loop fixed to a long stick (e.g. bamboo) is better as less fruits are subject to damage. However, this is not common. They pick fruits from mature *Z. spina-christi* trees 3-6 times in a season as the fruits do not mature at the same time. Local transhumant or settled farmers noted that they can manually harvest about 60 kg (30 ETB) per day from properly matured tree. They also practice harvesting the fruits with the stalks attached to increase storage life to about 30 days maximum. Indigenous people indicated that, fruits harvested around noon or early morning before sunrise generally have a better storage life. Literature sources also recommended that fruits harvested around noon generally have a better storage life and after harvest the fruits can be cooled by dipping in cold water for 2 h or by exposing to cold air for 4 h to extend their shelf life (Azam-Ali *et al.*, 2006). This practice from India has shown little overlap with practices of people of east Shewa, Ethiopia.

Contribution to ecosystem services and human well being

Income generation: *Ziziphus spina-christi* is economically and socieconomically important tree in the study area. Major production areas are in the semi-arid and arid areas of Ethiopia, where it grows abundantly and is consumed on subsistence scale by households. In India the area under production was 88,000 ha in 1995, giving a production of about 0.9 million tons of fruit (Azam-Ali *et al.*, 2006). *Z. spina-christi* can provide sustained production irrespective of occurrence of drought and can yield between 50 kg and 200 kg of fruit/tree depending on the climatic conditions. *Z. spina-christi* trees can provide additional income to farmers if incorporated into their agricultural system or grown on marginal or unused land. In east Shewa, to ensure a profitable income, local market price and demand chain for the fruit must be established. Appropriate extension services with an enabling policy are recommended to be put in place.

Fuel wood, timber and fodder: The wood of the *Z. spina-christi* tree is valued as fuel wood and produces a good charcoal. Fuel wood can be collected after pruning, the amount is dependent on degree of pruning, however focus group discussions have revealed on average 20-30 kg/tree/year can be produced if regularly pruned. The wood of mature tree is used for construction of houses, fencing cultivated plots and construction of livestock boma. The leaves and fruits are popular for livestock fodder. From dry season participatory observation in 2009 and 2010 and east shewa local people's responses established that, the tree is very nutritious and grows and regenerates very quickly, even under stress conditions in dry seasons.

Medicinal uses: In east Shewa the bark is used to treat hepatitis 'dhibe sinbira' by Oromo language. Pieces of crushed bark are concocted with crushed leaves of *X. americana*, *Ocimum urticifolium* and bark of

Terminalia brownii. The boiled mixture is filtered and 3 glasses are served every 2 days. Other *Ziziphus* species (*Z. spina-christi* and *Z. jujuba*) are used throughout India and Asia and Africa. All parts of the plant are used, from the fruit pulp and seed to the leaves, bark and flowers. Ailments such as diarrhoea, dysentery, ulcers, eye infections, coughing, asthma and vomiting can be treated with infusions, pastes and powders. It also has antifungal activity and can be used against fungal infections (Azam-Ali *et al*., 2006). *B. aegyptiaca* and *G. flavsecense* also have medicinal and forage values.

Environmental benefits: In the study area, east Shewa, wild edible plants have tangible and intangible values. *Z. spina-christi, B. aegyptiaca and G. flavsecense* have multiple environmental benefits as they provide year round protection to the soil. The strong root system also helps to maintain soil structure and therefore conserve the soil. *Z. spina-christi* trees can grow under conditions of extreme stress from drought, salinty and water logging and can therefore be grown on degraded or marginal lands. *Z. spina-christi* has been used in the soil conservation of dune lands, where it stabilizes the soil by the storage and recycling of plant nutrients. The tree has also been used as a live fence and windbreak in India (Azam-Ali *et al*., 2006).Similar practice with the study area, east Shewa, Ethiopia and Semi-arid Africa.

Propagation of *Z. spina-christi*: *Z. spina-christi, B. aegyptiaca* and *G. flavescense* are versatile wild edible plants and can be grown on a homestead, plantation, and grassland or as dryland agroforestry trees in semiarid Shewa, Ethiopia and suitable for marginal lands where other crops have no or limited production. Studies out of Africa explained that, *Z. spina-christi* can be grown in semi-arid or arid regions, and although it tolerates very high summer temperatures (49-50°C), fruit-set can be affected at temperatures above 35°C. However, trees are often grown successfully at temperatures of 39-42°C. *Z. spina-christi* trees can withstand very short periods of freezing temperatures, however, frost can damage the young twigs and developing fruits and may kill the tree. For healthy growth, *Z. spina-christi* trees should not be planted in areas experiencing a minimum temperature less than 4°C for extended periods. It can tolerate temperatures as low as -2°C if occasional and for short periods (Azam-Ali *et al*., 2006). Participatory observation and ecological studies in east Shewa, Ethiopia have confirmed similar results of the wide ecological amplitude being abundantly found 930-1550 m.a.s.l.

For rainfed production of *Z. spina-christi*, a minimum average yearly rainfall of 400 mm is required. Performance of the *Z. spina-christi* tree is adversely affected in humid areas having more than 1500mm annual rainfall. Fruit yields are higher in high rainfall years and lower in low rainfall years. The incidence of pests is also lower in low rainfall areas. *Z. spina-christi* is highly drought tolerant. Its deep taproot system enables it to survive long periods without water, even when the surface soil completely dries out. The tree has no specific soil requirements. It is able to flourish in poor soils, e.g. rocky or highly sandy well drained. It has the ability to improve soils for crops, where they are overly sandy or saline. *Z. spina-christi* can be grown to 1000 m above sea level (Azam-Ali *et al*., 2006).

Conclusion: From the results of nutrient analyses it can be shown that *Z. spna-christi*, *B. aegyptiaca* and *G. flavescens* fruits can be important indigenous source of nutrients to supplement other major sources of food. These plants are sources of higher carbohydrates, protein, energy, minerals and relatively less fats. In this particular case the finding has shown that the nutritive wild edible plants have public consensus on their palatability and other multiple socioeconomic values. They are valuable plants particularly during dry season for adaptation to climate change and ecosystem services. In spite of the exiting potential, these nutritional contribution of wild fruits to the people's diets remains underutilized. In order to remedy this situation, a wider and sustained acceptance of wild fruits as important dietary components must be fostered by appropriate agricultural extension services and enhancing nutrition policy. Hence, these species of wild edible plants can be integrated to dryland agroforestry systems to improve livelihoods of dryland people and for income generation with further study in agronomy and nutrient aspects.

ACKNOWLEDGMENTS

The accomplishment of this research work was with the genuine interest of the people of east Shewa (Fantalle and Boosat) districts, Ethiopia who gave adequate information on the uses and management of the species of study and the natural resources of the area. We appreciate and thank the entire administrative structure of two districts of east Shewa Zone that facilitated the fieldwork. The full financial support of Rockefeller through Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) and Association of African Universities (AAU) who partially supported the survey part of the work are highly appreciated. Unreserved support and contributions of University of Nairobi, CAVS, LARMAT, Kenya and Jimma University, College of Agriculture and Veterinary Medicine, Ethiopia for hosting and providing logistic, technical and managerial supports are also thankfully acknowledged.

Annex 1: Average nutrient composition of *Z. spina-christi*, *B. aegyptiaca* and *G. flavescens* fruits in the study area

	Z. spina-christi					
	Th	Th	Th	Sf	Sf	Sf
Nutrients	Ga	Q	De	Xa	Tb	Dt
DM (%)	50.10	53.02	64.82	46.17	42.59	45.97
Moisture (%)	49.90	46.98	35.18	52.46	57.41	54.03
Ash (%)	16.40	14.14	9.38	15.30	8.11	14.03
CF (%)	3.95	3.46	3.61	3.91	3.10	4.52
Protein (%)	3.20	4.20	1.45	2.19	2.04	2.50
En (Kcal/g)	12.80	16.8	5.80	8.76	8.16	10.00
Fat (%)	3.73	3.69	3.58	3.70	3.73	4.02
En (Kcal/g)	33.57	33.21	32.22	33.30	33.57	36.18
NFE (%)	72.72	74.50	81.99	74.91	83.02	74.92
En (Kcal/g)	290.88	298.00	327.96	299.64	332.08	299.68
Total CHO	76.67	77.97	85.60	78.82	86.12	79.45
En (Kcal/g)	306.68	311.88	342.40	315.28	344.48	317.80
OM (%)	83.60	85.86	90.62	84.70	91.89	85.97
	B. aegyptiaca					
	Th	Th	Th	Sf	Sf	Sf
Nutrients	Ga	Q	De	Xa	Tb	Dt
DM (%)	46.33	50.97	47.54	49.040	31.74	48.39
Moisture (%)	53.67	49.03	52.46	50.260	68.26	51.61
Ash (%)	12.68	11.72	12.88	12.130	10.95	10.18
CF (%)	5.68	5.70	5.79	6.260	5.63	6.59
Protein (%)	1.44	1.05	1.55	1.170	1.92	1.26
En (Kcal/g)	5.76	4.20	6.20	4.680	7.68	5.04
Fat (%)	0.01	0.02	0.01	0.002	0.002	0.003
En (Kcal/g)	0.09	0.18	0.09	0.018	0.018	0.027
NFE (%)	80.19	81.51	79.77	80.430	81.480	81.96
En (Kcal/g)	320.76	326.04	319.08	321.720	325.920	327.84
Total CHO	85.87	87.21	85.55	86.700	87.110	89.61
En (Kcal/g)	343.48	348.84	342.20	346.800	348.440	354.24
OM (%)	87.32	88.28	87.12	87.870	89.100	89.82
	G. flavescens					
	Th	Th	Th	Sf	Sf	Sf
Nutrients	Ga	Q	De	Xa	Tb	Dt
DM (%)	38.651	62.0057	65.26	76.64	81.10	80.02
Moisture (%)	61.34	37.943	34.74	23.36	18.90	19.98
Ash (%)	7.245	4.633	4.482	6.54	8.48	3.16
CF (%)	5.525	5.525	5.7	7.90	7.21	8.09
Protein (%)	3.142	2.001	1.829	0.64	0.99	0.64
En (Kcal/g)	12.56	8.004	7.316	2.56	3.96	2.56
Fat (%)	0.004	0.002	0.001	6.40	6.80	6.531
En (Kcal/g)	0.036	0.018	0.009	57.6	61.2	58.78
NFE (%)	84.085	87.839	87.987	78.52	76.53	81.57
En (Kcal/g)	336.34	351.356	351.948	314.08	306.12	326.28
Total CHO	93.36	93.69	86.42	83.74	89.66	89.61
En (Kcal/g)	358.44	373.456	374.748	345.68	334.96	358.64
OM (%)	92.76	95.36	95.52	93.46	91.52	96.84

DM = Dry Matter, CF = Crude Fiber, NFE = Nitrogen Free Extract, En = Energy, Om = Organic Matter; Th = Trnshumant, Sf = Settled Farmers, Ga = Galcha, Q = Qobo, De = Dheebiti, Xa = Xadacha, Tb = Trii biretti

Annex 2: Calculated energy content of wild edible plant species in the study area

	Z. spina-christi					
	Th	Th	Th	Sf	Sf	Sf
Nutrients	Ga	Q	De	Xa	Tb	Dt
Protein (%)	3.20	4.20	1.45	2.19	2.04	2.50
En (Kcal/g)	12.80	16.8	5.80	8.76	8.16	10.00
Fat (%)	3.73	3.69	3.58	3.70	3.73	4.02
En (Kcal/g)	33.57	33.21	32.22	33.3	33.57	36.18
NFE (%)	72.72	74.50	81.99	74.91	83.02	74.92
En (Kcal/g)	290.88	298.00	327.96	299.64	332.08	299.68
Total CHO	76.67	77.97	85.60	78.82	86.12	79.45
En (Kcal/g)	306.68	311.88	342.4	315.28	344.48	317.8

Annex 2 contd.

	B. aegyptiaca					
Nutrients	Th Ga	Th Q	Th De	Sf Xa	Sf Tb	Sf Dt
Protein (%)	1.44	1.05	1.55	1.170	1.92	1.26
En (Kcal/g)	5.76	4.2	6.2	4.680	7.68	5.04
Fat (%)	0.01	0.02	0.01	0.002	0.002	0.003
En (Kcal/g)	0.09	0.18	0.09	0.018	0.018	0.027
NFE (%)	80.19	81.51	79.77	80.430	81.48	81.96
En (Kcal/g)	320.76	326.04	319.08	321.720	325.92	327.84
Total CHO	85.87	87.21	85.55	86.700	87.110	89.61
En (Kcal/g)	343.48	348.84	342.2	346.800	348.440	354.24

	G. flavescens					
Nutrients	Th Ga	Th Q	Th De	Sf Xa	Sf Tb	Sf Dt
Protein (%)	3.142	2.001	1.829	0.64	0.99	0.64
En (Kcal/g)	12.568	8.004	7.316	2.56	3.96	2.56
Fat (%)	0.004	0.002	0.001	6.40	6.80	6.53
En (Kcal/g)	0.036	0.018	0.009	57.60	61.20	58.78
NFE (%)	84.085	87.839	87.980	78.52	76.53	81.57
En (Kcal/g)	336.340	351.356	351.948	314.08	306.12	326.28
Total CHO	93.364	93.687	86.420	83.74	89.66	89.61
En (Kcal/g)	358.440	373.456	374.748	345.68	334.96	358.64

REFERENCES

Abuye, C.K., H. Urga, D. Knapp, A.M. Selmar, J.K. Omwega, Imungi and P. Winterhalter, 2003. A compositional study of *Moringa stenopetala* leaves. East Afr. Med. J., 80: 247-252.

Adebooye, O.C. and O.T. Phillips, 2006. Studies of seed characteristics and chemical composition of three morphotypes of *Mucuna urens* (L.) Medikus-*Fabaceae*. Food Chem., 95: 658-663.

Andersen, L.T., S.H. Thilsted, B.B. Nielsen and S. Rangasamy, 2003. Food and nutrient intakes among pregnant women in rural Tamil Nadu, South India. Public Health Nutr., 6: 131-137.

Armstrong, A.R. and A.C. Hilton, 2004. The use of Analysis of Variance (ANOVA) in applied microbiology Aston University, Birmingham. Microbiologist, December. 2004, http://www.blackwellpublishing.com/Microbiology/pdfs/anova.pdf www.sfam.org.uk (Accessed 10 May, 2010).

Asibey-Berko, E. and. F.A.K. Tayie, 1999. Proximate analysis of some under utilized Ghanaian Vegetables. Ghana J. Sci., 39: 91-92.

AOAC, 1990. Official methods of analysis, 14th Edn., Association of Official Analytical Chemists, Washington DC.

Azam-Ali, S., E. Bonkoungou, C. Bowe, C. DeKock, A. Godara and J.T. Williams, 2006. Ber and other jujubes, *Ziziphus* species. Fruits for the Future 2 (revised edition). Southampton, UK: International Centre for Underutilised Crops, pp: 289.

Balemie, K. and F. Kebebew, 2006. Ethnobotanical Study of Wild Edible Plants in Derashe and Kucha Districts, South Ethiopia. J. Ethnobotany Ethnomedicine, 2: 1-9.

Bell, J., 1995. The Hidden Harvest: In: Seedling, The quarterly Newsletter of Genetic Resources Action International Webpage:http://www.grain.org/publications.

Bekele, E., 2007. Study on Actual Situation of Medicinal Plants in Ethiopia. http://www.endashaw.com. JAICAF (Japan Association for International Collaboration of Agriculture and Forestry).

BPED (Bureau of Planning and Economic Development), 2000. Physical Socioeconomic Profiles of 180 Districts of Oromiya Region. Finfinne, Ethiopia, pp: 1-300.

Cook, J.A., D.J. VanderJagt, A. Pastuszyn, G. Mounkaila, R.S. Glew, M.R.H. Millson and R.H. Glew, 2000. Nutrient and chemical composition of 13 wild plant foods of Niger. J. Food Comp. Anal., 13: 83-92.

Cotton, C.M., 1996. Ethnobotany Principles and applications. Chichester, New York John Wiley and Sons Ltd.

Demessew, S. and I. Friis, 2009. Natural Vegetation of the Flora area. IN: Flora of Ethiopia and Eritrea. Vol. 8. General Part and Index to Vols 1-7. pp: 27-32, in: Hedberg, I., Friis, I. and Persson, E. (Eds). National Herbarium, Biology Department, Science Faculty, Addis Ababa, University, Addis Ababa and Department of Systematic Botany, Uppsala University, Uppsala, Sweden.

EHNRI-FAO, 1995. Food Composition Table for use in Ethiopia, Health and Nutrition Research Institute and FAO, Addis Ababa. Part IV, pp: 1-33.

Fentahun, M.T. and H. Hager, 2009. Exploiting locally available resources for food and nutritional security enhancement: Wild fruits diversity, potential and state of exploitation in the Amahara Region of Ethiopia. Food Sec., 1: 207-219.

FAO, 1995. Non-wood forest products in nutrition. In: Non-Wood Forest Products for Sustainable Forestry, Yogyakarta, Indonesia, 17-27 January, 1995. Non-Wood Forest Products, vol. 3. FAO, Food and Nutrition Division, Rome.

FAO, 1968. Food composition Table for Use in Africa. Energy factor. pp: 226.

Ladeji, O.Z., S. Okoye and T. Ojobe, 1995. Chemical evaluation of the nutritive value of leaf of fluted pumpkin (*Telferia occidentalis*). Food Chem., 53: 353-355.

Lockeett, C.T., C.C. Calvert and L.E. Grivetti, 2000. Energy and micronutrient composition of dietary and medicinal wild plants consumed during drought: Study of rural Fulani, Northeastern Nigeria. Int. J. Food Sci. Nutr., 51: 195-208.

Martin, G.J., 1995. Ethnobotany: A methods manual. London, UK: Chapman and Hall.

Nyariki, D.M., A. Kitalyi, V.O. Wasonga, I.M. Isae, E. Kyagaba and M. Lugenja, 1999. Indigenous techniques for assessing and monitoring range resources in East Africa. Occasional Paper no 2. Nairobi: World Agroforestry Center, pp: 1-66.

Osborne, D.R. and P. Voogt, 1978. The analysis of nutrients in foods. Food science and technology series. London; New York: Academic Press, vii, pp: 251.

Ogle, B.M.H.T., A. Dao, G. Mulokozi and L. Hambraeus, 2001. Micronutrient composition and nutritional importance of gathered egetables in Vietnam. Int. J. Food Sci. Nutr., 52: 485-499.

Parvathi, S. and V.J.F. Kumar, 2002. Studies on chemical composition and utilization of the wild edible vegetable athalakkai (*Momordica tuberosa*), Plant Foods Human Nutr., 57: 215-222.

Pearson, D., 1976. The Dictionary of Nutrition and Food Technology. Fifth edition. Butter Worth Publisher, London.

Ruel, M.T., N. Minot and L. Smith, 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.

Sands, M.J.S., 1995. Balanataceae, In: Pittosporaceae to Araliaceae, Flora of Ethiopia and Eritrea, Vol. 3: 433-436. (Hedberg, I and Edwards, S, Eds.). The National Herbarium, Addis Ababa University, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden.

Snedecor, W. and W. Cochran, 1980. Statistical methods. Iowa State University Press, Ames Iowa, seventh edition.

Sena, L.P., D.J. VanderJagt, C. Rivera, A.T.C. Tsin, I. Muhammadu, O. Mahamadou, M. Milson, A. Pastosyn and R.H. Glew, 1998. Analysis of Nutritional components of eight famine foods of the republic of Niger. Plant Foods Human Nutr., 52: 17-30.

Shackleton, C. and S. Shackleton, 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: 658-664.

Srivastava, R.P. and S. Kumar, 1998. Fruit and vegetable preservation. Principles and practices, 2nd Edn., International Book Distributing Co., New Delhi.

Taddesse, W. and S. Alem, 2009. The Role and Status of Selected Wild Edible Fruit Trees in Rural Livelihood of Ethiopia. Institute of Agriculture Research, AA, Ethiopia, pp: 1-22.

Teketay, D. and A. Eshete, 2009. Status of Indigenous Fruits in Ethiopia. In: IPGRI-SAFORGEN-Review of Appraisal on the Status of Indigenous Fruits in Eastern Africa. In the framework AFREA/FORNESSA, (Chikamai, B, Eyog. Mating and Mbogga, M, Eds.), pp: 2-35.

USDA, 1999. US Department of Agriculture, Agricultural Research Service, USDA Nutrient Data Laboratory. 1999. USDA Nutrient Database for Standard Reference, Release 13.

Vollesen, K., 1989. Rhamnaceae. In: Pittosporaceae to Araliaceae, Flora of Ethiopia and Eritrea, Vol. 3: 385-339. (Hedberg, I and Edwards, S, Eds.). The National Herbarium, Addis Ababa University, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden.

Vollesen, K. and S. Demssew, 1989. Tiliaceae.In: Canellaceae to Euphorbiaceae. In: Flora of Ethiopia and Eritrea, 2(2): 145. (Edwards, S and Taddesse, M, Eds.). The National Herbarium, Addis Ababa University, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden.

White, F., 1983. The Vegetation of Africa: A Descriptive Memoir to Accompany the UNESCO/AETFAT/UNSO Vegetation of Africa, pp: 44-117. UNESCO, Botanic Institute, BIBL, UPPSALA.