Original Research Article

Food Value of Native and Non-Native Tree Species in Tigray, Northern Ethiopia

ABSTRACT

Indigenous and Adoptedfood-bearing trees play crucial role in fulfilling food security during food shortage and daily basis in rural and urban communities in Tigray. However, information on their nutritional compositions is still lacking. Thus, the objective of study was to assess the macronutrient and mineral values of the most commonly used Indigenous and Adopted food trees. Fruit samples selected according to the degree of maturation, healthy and disease-free stands. Three samples per plant species were collected and analyzed in Ethiopian Health and Nutritional Research Institute laboratory. Result: the protein contents were higher in *Ximinia americana* (8.04±1.1 %) followed by *Cordia africana* (5.09 ±0.9 %) and *Ficus sycomorus* (4.63 ±1.0%) and lower in *Adonosia digitata* (2.02 ± 0.8 %) and *Hyphae thebica* (2.44 ± 1.7 %). Crude fiber and fat had higher in *Tamarindus indica* and fat had higher inFicus sycomorus while lower ash and higher moisture content was recorded in *Adonosia digitata* and *Syzygium guineense*respectively. Ficus sycomorus fruit contain higher Iron (56.5 ± 5.0 milligram/100 gram), calcium (584.3± 14.0 mili gram/100gram) and copper (0.9 ± 0.1 mili gram/100 gram) while the amount of zinc was lower and higher in Hyphae thebica and Ficus sycomorus fruits respectively. The potassium and phosphorus contents were 3030.3, 30.9 for *Tamarindus indica*, 2704.0, 106.6 for *Ximinia americana*, 2002.9, 85.8 for *Hyphae thebica*, 1477.1, 83.3 for *Ficus sycomorus*, 760.5, 26.1 for *Cordia africana*, 1597.7,105 for Syzygium guineenseand 1127.8, 40.4 milligram/100 gram for *Adonosia digitata* respectively. Higher total carbohydrates (71.76, 63.31, 62.79 and 59.28 %) *Adonosia digitata*, *Hyphae thebica*, *Tamarindus indica* and *Cordia africana* and energy values (347.2, 283.4, 264.2 and 258.4Kilocalorie/100 gram) were observed in Tamarindus indica, Cordia africana, Hyphae thebica and Syzygium guineense respectively.

Conclusion: Wild and semi-wild edible trees are important to fulfill the food shortage and has the potential to address nutrient deficiency problems.

Keywords: Indigenous, macronutrient, minerals and nutritional

Introduction

Millions of people depend on wild resources including wild and semi wild edible plant in many developing countries to meet their food needs in time of food crisis (FAO, 2004; Balemie and Kebebew, 2006). In Ethiopia, there are about 370 indigenous food plants (belonging to 70 different families) out of which 182 species (40 families) are shrubs/trees with edible fruits/seeds. Earlier works showed that about 8% of the nearly 7000 higher plants of Ethiopia are edible (Feyssa et al., 2011). Of these, 203 wild and semi-wild plant species are documented (Zemede et al., 2011). Still many more wild and semi wild species are believed to be edible and undocumented yet. More recently, some ethno botanical studies have undertaken in some parts of the country. However, the majority of these studies have dealt with medicinal species and little emphasis has been paid to wild edible semi wild plants.

Many people in Tigray region were using wild edible plant as a source of supplementary food during drought season and struggling time (Weyinmetshet, 2015). This indicates, wild edible plants have the potential to substitute for variety of crops in drought season and hence, should be credited. According to Mulugeta *et al.* (2010) there is chronic malnutrition problem in Tigray. The energy and nutrient density of the complementary foods are low as the foods were prepared from a limited number of local staple cereals. According to Horo and Topno (2015), 20 wild and semi wild plants belong to 13 families and 19 genera are rich in protein, calories, carbohydrates, potassium, iron, calcium, vitamin A and vitamin C. So, there is still a need for documentation, nutritional analysis and domestication of wild edible plants to assist in the nationwide effort to combat food insecurity and ensure dietetic diversity (Lulekal et al., 2011). During challenges of climate variability and drought, wild edible and semi wild plant have the potential to resist as compare to cereal crops and can stand by nutritionally.

In spite of the role of wild edible plants in supporting the rural people of Ethiopia little attention has been given to the inventory and conservation of species (Addis et al., 2005;

Berihn and Molla, 2017). Many of these edible species face the danger of loss due to presence of anthropogenic and environmental disturbance factors. Research conducted on WEPs of Ethiopia was shallow and addressed only in an insignificant portion of the country (Molla et al., 2011). There are number of numerical taxonomic analytical methods available for classifying and recognizing the patterns of phenotypic diversity and the relationships between the species (Gupta et al., 1991; Dias et al.,1993; Amurrio et al., 1995; Li et al., 1995). Since there is very limited studies and records are available, an in depth particular group in concern.

The status of research and development in Ethiopia, specifically in Tigray is generally low. Most of the wild edible plants are threaten because the associated traditional knowledge is in danger of being lost for the present and coming generation which also leads to deplete its potential resource through deforestation or any other. Similarly, the research and development regarding to wild phenotypic diversity, contribution to nutrition and conservation approaches in Tigray is not sufficient. Ethiopia has abundant native wild plant species with great commercial potential as food crops (Molla et al., 2011; Yohannes, 2016). In Ethiopia, where majority of the population is rural people wild edible and semi wild plants are valuable resources in livelihoods for supplementing the staple food, ensuring food security, dietary diversification and sustained income (Asfaw and Tadesse 2001; Bahru et al., 2013; Kidane et al.,2014). In spite of the role of wild edible plants in supporting the rural people of Ethiopia little attention has been given to the inventory and conservation of species (Addis et al., 2005; Berihn and Molla, 2017). Many of these edible species face the danger of loss due to presence of anthropogenic and environmental disturbance factors. Research conducted on WEPs of Ethiopia was shallow and addressed only in an insignificant portion of the country and specifically in Tigray is generally low (Molla et al., 2011).

Materials and methods

Study area and agro-ecology

This study was conducted in the northern Eastern of Tigray Region, considering agro ecological and attitudinal variations. Study district representing woredas were Tahtay adiyabo, Tahtay koraro and Tselemti.

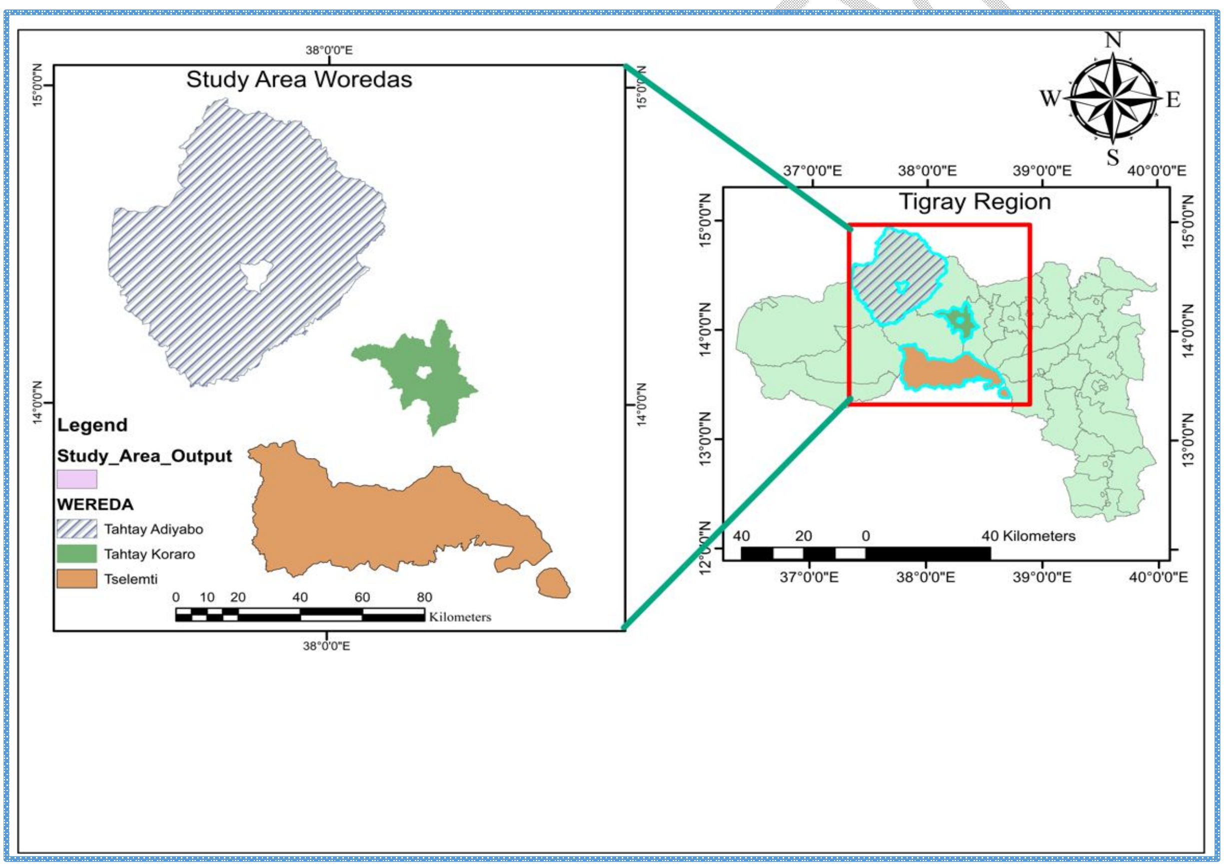

Figure 1 Study Woredas of Tigray Tselemti, Tahtay koraro and Tahtay Adiyabo

Socio-economic and climate characteristics of the study area

Over 90% of the population in the study areas heavily depend on rainfed farming system and are extremely vulnerable to projected climate change which will potentially affect food production and food security of the people in the study areas. In general, annual crop, livestock, and forest products are the main sources of income for the farmers in study districts (Mohajan, 2013). The northern of Ethiopia are very susceptible to drought and drought related environmental and humanitarian crisis (Teshome and Zhang, 2019). Rainfall seasonality across the Northern study sites were unimodal, extends from June to September with maximum rain received from June to August (Mokria et al., 2017).

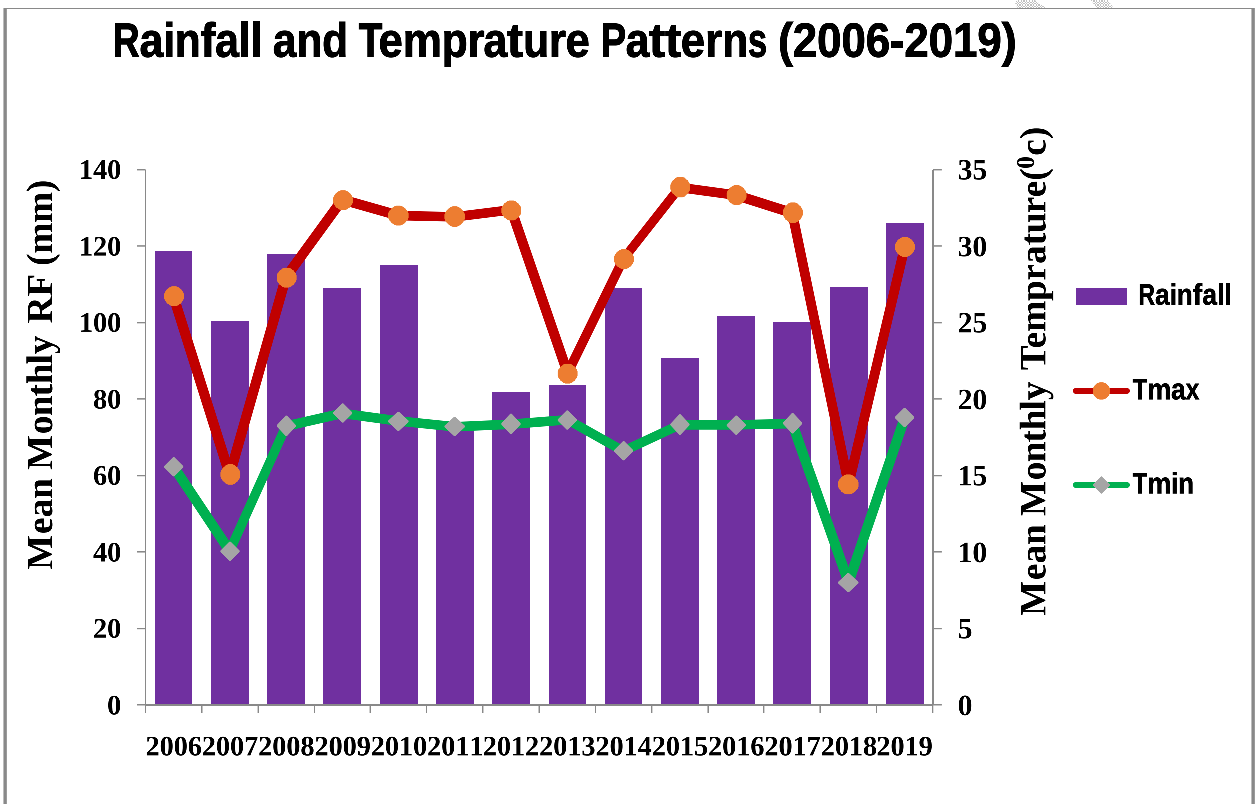

Figure 2 Climate characteristic of the study area

Study species, characteristics and distribution

For this study, we selected *Ximinia americana*,*Cordia africana*,*Ficus sycomorus* , *Adonosia digitata*, *Hyphae thebica*, *Tamarindus indica and Syzygium guineense* based on their geographical distribution across all the study site and wider uses as a source of income, food, nutrition and medicine by the community inhabited across the northern of Ethiopia (Feyssa et al., 2011; Lulekal et al., 2011). For extensive description of species distribution, characteristic, chemical and nutrient composition as well as their wider-scale uses across the region.

Fruit sample collection and processing

Fruit samples were collected from randomly selected ten individual trees per species from each study sites (Chen et al., 2019; Tewolde-berhan, 2014). Sample from the same species and site were accumulated in one bucket to form a composite sample (Nyanga et al., 2013; Tewolde-berhan, 2014) The composite samples were washed with tap water, then laid on plastic flat sheet on the floor of clean house and left for a week for air drying at room temperature (Nyanga et al., 2013; Tewolde-berhan, 2014). All species-specific fruit samples were cut into slices and separately spread on plastic flat-bottomed bowls for drying under room temperature. Finally, dried species-specific composite fruit samples were ground to fine powder in a mixer grinder and sieved through mesh and used for proximate and mineral analysis.

Proximate composition and mineral analysis

Dried and homogenised powdered fruit samples were analyzed fodry moisture, crude ash, crude fibre, crude fat, and crude protein according to the AOAC (1990) official methods (AOAC, 1990; Murthy et al., 2019). The crude protein was computed using AOAC 920.152 – method from the sample percentage of nitrogen content as determined by the Kjeldahl procedure multiplied by a factor (6.25) (Nyanga et al., 2013).

$$\textbf{\% Crude protein} = \textbf{\%N x 6.25} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{Eq. 1}$$

The crude fiber was calculated using AOAC 978.10 method from the loss in weight on the ignition of dried residue following the digestion of fat-free samples with 1.25% each of sulfuric acid and sodium hydroxide solutions. (Eq.2.). Crude fat was determined using AOAC 2003.05 method followed by extraction with a Soxhlet apparatus for 70 min using diethilic ether as the extraction solvent. the solvent was evaporated from the extraction flask (aluminum cup), then the amount of fat is calculated from the difference in weight of the aluminum cup before and after extraction (Silvanini et al., 2014).

$$\textbf{Crude fiber in \%} = \frac{\textbf{(W1} - \textbf{W2) X100}}{\textbf{W3}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{Eq. 2}$$

Where: W1- Crucible weight before drying, W2- Crucible weight after drying, W3- Sample dry weight

Moisture content was determined by drying the fruits at 92°C in an oven until a constant weight was obtained (Method: AOAC 930.04, AOAC 2005).

$$\textbf{Moisture content}\ (\%) = \frac{\mathbf{(W1 - W2\ )X100}}{\mathbf{SW}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \ \mathbf{Eq.3}$$

Where: W_1: the weight of cap and fresh sample, W_2: the weight of dry sample and cap, SW: sample weight.

Furnace method (AOAC 940.26) was applied to determined Ash content, by burning in a muffle furnace at a temperature of 550°C for l hours. Iron (Fe), Zinc (Zn), Copper (Cu), Calcium (Ca) and Potassium (K) were estimated using AOAC official methods AOAC 999. 10 and Atomic Absorption Spectroscopy (AAS). Total carbohydrate was obtained by calculating the difference (Carbohydrate % = 100 – (% moisture + % crude protein + % crude fat + % ash+%crude fiber). Potassium content was estimated by Flame photometer. The nutritive value or energy content was estimated by multiplying the percentages of crudeprotein, crude fat and total carbohydrates by 4, 9 and 4 respectively. Then, the values were converted to kilo calories per 100 gm of the sample (Kassegn, 2016).

Statistical Analysis

A descriptive analysis for each species were conducted to compare with nutritional values of the species. We also compared our findings with previous studies done on the same species in other countries of Africa. Based on literature, values were also compared to other indigenous species of importance, and popular exotic fruit providing tree species. The mean significance difference of the nutritional composition among WEP across sites were analyzed using one-way analysis of variance (ANOVA). The significance of differences between WEPs in mean proximate and mineral composition were tested using the least significant difference test (LSD) with $P < 0.05$. Pearson correlation analyses were conducted to test the relationship between proximate and mineral compositions in each species.

3. Results

3.1. Macronutrient contents

The amount of crude protein, crude fiber, crude fat, ash, moisture content, carbohydrate and the nutritive value was significantly varied among the wild and semi-wild edible fruits (Table 1). The highest percentage value of the fiber, fat and moisture content was recorded in *D. mespiliforms* fruits, nutritive value and carbohydrate in *B. aegyptiaca* fruits whereas the crude protein and ash content was found to be higher in *Z. abyssinica* and *Z. spina-christi* with 8.1 % and 4.9 % respectively (Table 1)

Table 1: Mean macronutrient composition of the wild and semi-wild edible fruits

Macronutrients	Tree species							*P*-value
	T.indica	*X.americana*	*H.thebica*	*F.sycomorus*	*C.africana*	*S.guineense*	*A.digitata*	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Crude protein (%)	3.32 ± 1^{a}	8.04± 1.1^{b}	2.44± 1.7^{b}	4.63± 1^{a}	5.09± 0.9^{c}	4.53 ± 2.1^{d}	2.02 ± 0.8^{c}	0.000
Crude fiber (%)	9.62 ± 0.4^{a}	7.48± 0.9^{b}	16.69± 1.9^{c}	23.27± 2.9^{d}	6.8 ± 1^{b}	11.4 ± 3^{e}	26.3 ± 3.5^{d}	0.000
Crude fat (%)	0.92± 0.3^{a}	3.63± 0.6^{b}	2.59± 0.2^{a}	3.85± 2^{c}	0.47± 0.4^{d}	2.14± 0.3^{a}	0.25± 0.5^{e}	0.000
Moisture (%)	15.63± 2^{a}	14.25± 1.9^{abc}	8.20± 3^{b}	11.73± 2^{ab}	13.48± 5.5^{d}	16.48± 2.0^{bc}	12.86± 5^{e}	0.000
Ash (%)	7.72 ± 1^{a}	8.49± 0.8^{a}	6.77± 0.7^{b}	9.89± 0.7^{a}	12.46 ± 0.2^{c}	12.46 ± 0.4^{b}	4.53 ± 0.4^{d}	0.000
Carbohydrate (%)	62.79± 5^{a}	58.11± 5 ^{b}	63.31± 5^{c}	46.65± 4.9^{d}	59.28± 4.4^{e}	55.05 ± 5.2^{b}	71.76 ± 3.4^{f}	0.000
Nutritive value (Kcal)	347.2 ± 8.4^{a}	241.7 ± 5.4^{bf}	264.2 ± 6.1^{c}	240 ± 5.4^{d}	283.4 ± 6.6^{e}	258.4 ± 9.8^{f}	160.6 ± 9.6^{g}	0.000

Means in a row with similar letters are not significantly different at $P<0.05$.

3.2. Mineral composition

The iron, zinc, calcium, copper, potassium and phosphorus of the indigenous and adopted food trees are depicted in Table 2. *F.sycomorus*fruits contained a higher content of iron, zinc, calcium and copper content. Available potassium was recorded lowest in *C.africana*and highest in *T.indica* among all the studied fruits while the available phosphorus was higher in *X.americana* and*S.guineense* correspondingly.

Table 2**:** Mineral composition of the wild and semi-wild edible fruits

Macronutrients	Tree species							*P*-value
	T.indica	*X.americana*	*H.thebica*	*F.sycomorus*	*C.africana*	*S.guineense*	*A.digitata*	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Fe (mg/100g)	13.8 ± 1.7^{a}	8.5 ± 2^{b}	4.2 ± 0.9^{c}	56.5 ± 5^{d}	6.0 ± 2^{e}	10.6 ± 2.4^{f}	14.4 ±2.9^{a}	0.000
Zn (mg/100g)	0.5 ± 0.1^{a}	0.9 ± 0.1^{b}	0.4 ± 0.1^{a}	1.6 ± 0.2^{d}	0.32 ± 0.1^{a}	1.3 ± 0.2^{e}	1.5 ± 0.4^{de}	0.000
Ca (mg/100g)	255.6 ± 5^{a}	402.9 ± 12^{b}	204.9 ± 9^{c}	584.3 ±14^{d}	362.2 ± 8.3^{e}	515.1 ± 7^{f}	481.8 ± 21.7^{g}	0.000
Cu (mg/100g)	0.5 ± 0.0^{a}	0.5 ± 0.1^{a}	0.6 ± 0.1^{a}	0.9 ± 0.1^{b}	0.1 ± 0.0^{c}	0.6 ± 0.2^{a}	0.5 ± 0.1^{a}	0.000
K (mg/100g)	3030.3 ± 0.3^{a}	2704 ± 8^{b}	2002.9 ± 2^{c}	1477.1 ± 6^{d}	760.5 ± 9^{e}	1597.7 ± 3^{f}	1127.8 ± 8.1^{g}	0.000
P (mg/100g)	30.9 ± 5.0^{a}	106.7 ±11^{b}	85.8 ± 10.9^{c}	83.3 ± 13.2^{c}	26.1 ± 2.1^{a}	105 ± 7.2^{b}	40.4 ± 4.8^{d}	0.000

Means in a row with similar letters are not significantly different at *P*<0.

4. Discussion

4.1. Macronutrient contents

The protein content of the fruits depicted in table 1 ranged from 2.02 ± 0.8(%) for *A.digitata*to 8.04± 1.1(%) for *X.americana*. The protein content of the studied fruits are higher than the reported values in other wild edible fruits, for example, *B. aegyptiaca* (1.40 %), *Z. spina*-christi (2.13 %) and *G. flavescens* (1.51%) in other semi-arid eastern Ethiopia (Feyssa et al., 2011).Similarly, *Cordia africana*, *Ficus sycomorus* , *Hyphae thebica*, *Tamarindus indica and Syzygium guineense* are abundant in crude protein compared to Ahmed, F. A. M., & Sati, N. M. E. (2018) who found 4.1 % (*Z. spina-christi*) and 3.95 % (*Z. abyssinica*) in Sudan.

Crude fiber was higher in *A.digitata*(26.3 ± 3.5 %)compared to *F.sycomorus*(23.27± 2.9 %), *H.thebica*(16.69 ± 1.9 %), *S.guineense* (11.4 ± 3.0 %), *T.indica* (9.62 ± 0.4 %)*X.americana (*7.48 ± 0.9 %)and *C.africana*(6.8 ± 1.0 %).Except the *C.africana,*all the wild fruits contained higher crude fiberthan (Feyssa et al., 2011)in *B. aegyptiaca* (5.94 %), *Z. spina-christi* (3.78 %) and *G. flavescens* (6.68 %) and Adekunle, A. I., & Adenike, J. O. (2012) was found 6.09 ± 0.02 % of crude fiber in *Z. spina-christi* fruits. The crude fat was significantly different among the studied fruit which was higher in *F.sycomorus*(3.85± 2 %) and lower in *A.digitata*(0.25± 0.5 %). The crude fat for all of the studied species was higher compared to Ahmed, F. A. M., & Sati, N. M. E. (2018)who reported 0.9 %, 0.8 % and 0.3 % for *Z. spina-christi*, *Z. abyssinica* and *Z. mauritiana* respectively. Moisture content ranged from 8.20± 3 to16.48± 2.0 %. The highest and lowest moisture content was observed in *H.thebica*and *F.sycomorus*fruit correspondingly. Compared with other studies conducted for *B. aegyptiaca, G. flavescens* and *Z. spina-christi* fruits (Feyssa et al., 2011) all our studied fruits have lower moisture contents. This indicated that the studied wild and semi-wild edible fruits are rich in energy content and less susceptible to deteriorations.

S.guineense(12.46 ± 0.4 %) was found with higher ash content while the *A.digitata*(4.53 ± 0.4 %) contained lower content. The studied fruits have relatively lower ash contents than the studies conducted in *B. aegyptiaca*, *Z. spina*-christi and *G. flavescens*(Feyssa et al., 2011) and *Carissa carandas*L., *Phyllanthus emblica*L. and *Morinda pubescens* (Anand SP and Deborah S, 2016). The total carbohydrates were 71.76 ± 3.4, 63.31± 5, 62.79± 5, 59.28± 4.4, 58.11± 5, 55.05 ± 5.2and

46.65± 4.9 % for *A.digitata*,*H.thebica*, *T.indica*,*C.africana*,*X.americana*, *Syzygium guineense*and *F.sycomorus*respectively. The total carbohydrate of the studied fruit was lower than (Feyssa et al., 2011) who found value of 86.83, 82.04, and 89.46 % in *B.aegyptiaca*, *Z. Spina-christi* and*G. flavescens* respectively. The nutritive or energy value was found higher in *T.indica*(347.2 ± 8.4) followed by *C.africana*(283.4 ± 6.6) and lower in *A.digitata*(160.6 ± 9.6). This calculated nutritive value based on crude protein, crude fat and total carbohydrate is relatively lower compared to (Feyssa et al., 2011).

4.2. Mineral composition

*F.sycomorus*fruit contained the highest iron (56.5 ± 5 mg/100g), zinc (1.6 ± 0.2 mg/100g), calcium (584.3 ±14 mg/100g) copper (0.9 ± 0.1 mg/100g) and contents than *C.africana*, *H.thebica*, *T.indica and S.guineense* fruits. The concentration of zinc and copper of all the studied fruits almost similar with the reported values of other wild edible fruits of *Arbutus pavarii*, *Nitraria* retusa and Ficus *palmate* (Hegazy et al., 2013). However, calcium and iron contents are higher in studied fruits when compared to fruits (Hegazy et al., 2013). Available potassium was significantly lower in *C.africana* (760.5 ± 9 mg/100g) and higher in *T.indica* (3030.3 ± 0.3) among all the studied tree species. According to the WHO (2012) Dietary Reference Intakes (DRI) at least 3510 g/day potassium intake for adultsand less than 3510g/day for children, the potassium content of all the wild and semi wild edible fruit requires additional supplementary foods to fulfill daily potassium intakes for adults but enough for children. Available phosphorus of wild and semi wild edible fruit was 30.9 ± 5.0, 106.7 ±11, 85.8 ± 10.9, 83.3 ± 13.2, 26.1 ± 2.1, 105 ± 7.2 and 40.4 ± 4.8 mg/100g in *T.indicaX.americana H.thebicaF.sycomorusC.africanaS.guineense A.digitata* correspondingly.

5. Conclusion

X.americana, C.africana and F.sycomorus have higher crude protein while the crude fiber content was higher *A.digitata F.sycomorus H.thebica*. Lower fat and ash contents were observed in *A.digitata, C.africana, T.indica, S.guineense, and H.thebica X.americana F.sycomorus*respectively. *S.guineense, T.indica, X.americana and C.africana*fruitshave higher moisture content. Besides, higher energy values and total carbohydrates were observed in *A.digitata, H.thebica, T.indica, S.guineense, C.africana, X.americana and F.sycomorus* fruits. Higher iron, zinc, calcium and copper contents were observed in *F.sycomorus*compared to the other fruits. The fruits of the *T.indica*and*S.guineense*havehigher potassium content while the amount of the phosphorus content was higher in *X.americana and F.sycomorus*.Generally, the results showed thatthewild and semi-edible fruits contain promising amounts of macronutrient and mineral compositions and have the potential to address nutrient deficiency problems.

Declarations and verification

The research work has not been published previously or it is not under consideration for publication elsewhere.

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