Original Research Article

Dietary value of wild and semi-wild edible fruits in Northwestern Tigray, Ethiopia

ABSTRACT

Background*: Wild and semi-wild edible fruit-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 wild and semi-wild edible fruit trees.*

Method*: 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 Ziziphus abyssinica (*8.1 %*) followed by Ziziphus spina-christi (*6.2 %) *and Vangueria edulis (*6.1 %*) and lower in Mimusops kummel (*2.6 %*) and Diospyros mespiliforms (2.7 %). Crude fiber and fat had higher in Diospyros mespiliforms and Ficus vasta while lower ash and higher moisture content was recorded in Diospyros mespiliforms and Mimusops kummel respectively. Vitamin C was higher in Ficus vasta, Balanites aegyptiaca and Ziziphus spina-christi fruit. Ficus vasta fruit contain higher Iron (55.5 miligram/100 gram), calcium (584.3 mili gram/100gram) and copper (0.9 mili gram/100 gram) while the amount of zinc was lower and higher in Mimusops kummel and Ziziphus abyssinica fruits respectively. The potassium and phosphorus contents were 3030.3, 30.9 for Balanites aegyptiaca, 2704.0, 106.6 for Ziziphus spina-christi, 2002.9, 85.8 for Vangueria edulis, 1477.1, 83.3 for Ficus vasta, 760.5, 26.1 for Mimusops kummel, 1597.7,104.9 for Ziziphus abyssinica and 1127.8, 40.4 miligram/100 gram for Diospyros mespiliforms respectively. Higher total carbohydrates (76.8, 65.6, 64.1 and 57.4%) and energy values (337.2, 301.7, 298.4 and 264.2 Kilocalori/100 gram) were observed in Balanites aegyptiaca, Ziziphus spina-christi, Ziziphus abyssinica and Vangueria edulis correspondingly.*

Conclusion*:* While the nutrient composition of the *Wild and semi-wild* fruits is generally favorable, some minerals and vitamins may still require supplementation from other dietary sources to meet the recommended daily intakes, especially for vulnerable populations like infants, children, and pregnant/lactating women.

Keywords: *macronutrient; minerals; vitamin C, wild and semi wild edible fruits*

1. Introduction

Food and nutrition security is a significant global challenge in the present era [1]. It is estimated that approximately two billion people suffer from micronutrient deficiencies, which not only make them more vulnerable to diseases but also hinder economic growth [2]. The problem of food security is particularly severe in sub-Saharan African countries that heavily rely on food imports [3]. However, the continent possesses highly biodiverse environments that harbor valuable wild edible plants, which are often overlooked and neglected [4].

In Ethiopia, there is a rich diversity of wild and semi-wild edible fruit-bearing tree species [5]. About 413 kinds of wild edible plant species are consumed in Ethiopia [6]. These wild wild edible species play a crucial role in ensuring food security and fulfilling supplementary dietary needs [7], a valuable source of income generation for local communities [8]. Previous studies indicates that many of the wild edible plant species contain higher concentrations of vitamins and other important nutrients compared to domesticated agricultural plant varieties [5].

Edible fruit-bearing tree and shrub species are utilized to restore degraded lands and conserve biodiversity, thereby enhancing ecosystem productivity [9]. Furthermore, wild edible woody species serve as an alternative livelihood option, providing a source of traditional medicine by rural communities, particularly by women and youth [10]. Despite the vital roles that wild and semi-wild edible plant species play, their food and nutritional contributions, as well as their medicinal value, have not been thoroughly investigated in Ethiopia [11]. Similar to other areas, wild and semi-wild edible fruits are not only relied upon during times of drought but also play a significant role in meeting food consumption needs and generating income in Tigray region. However, despite their substantial contribution, there is limited information available on the macronutrient and mineral composition of the most commonly used wild and semi-wild edible trees. Therefore, the objective of this study was to provide scientific insights and document the macronutrient and mineral composition values of the wild and semi wild edible plants (WSWEP) of *Ziziphus abyssinica* (Za), *Balanites aegyptiaca* (Ba), *Ziziphus spina-christi* (Zsc), *Ficus vasta* (Fv), *Vangueria edulis* (Ve), *Mimusops kummel* (Mk), and *Diospyros mespiliformis* (Dm) tree species.

2. Material and Methods

2.1. Fruit sample collection and preparation

Healthy and disinfected ripe fruits were collected from phenotypically healthy trees. All the fruit samples were washed to remove any unwanted materials and marked for drying. The seeds were separated from the pulp manually using a knife before being submitted to the laboratory, with only the edible part of the fruit used for the study. To ensure appropriate and comprehensive sampling, each sampling unit was replicated three times. A total of 21 samples (7 tree species x 3 replications) were collected. The samples were dried under shade to prevent the decomposition of chemical compounds. The dried samples were then labeled, kept in tight plastic bags, and carried to the laboratory. In the laboratory, the crushing, grinding, and homogenization process was performed, and 100g of the dry sample was used to analyze the macronutrient, vitamin C, and mineral compositions of the selected wild and semi-wild edible fruits.

2.2. Crude protein determination

Initially, all nitrogenous contents were converted into ammonium by the action of concentrated sulfuric acid (H_2SO_4), Orthophosphoric acid, hydrogen peroxide and catalyst. Then, digested at 350^0c for 2-3 hours until it becomes colorless. After cooling, it was distilled by steam distillation with 40% of sodium hydroxide and the ammonium is released as a form of ammonia. Finally, the condensed nitrate acid is trapped by 1% boric acid and titrated by 0.1 Normality hydrochloric acid **(**NHCl). Accordingly, crude protein was computed from the sample percentage of nitrogen content as determined by the Kjeldahl procedure multiplied by a factor (6.25).

$\%\text{ protein } = \text{percentage of nitrogen content x } 6.25$------------------------------Eq.1

2.3.2. Crude fiber estimation

1-2 g fat-free or low-fat content was treated with 200 milliliter (ml) 1.25 % H_2SO_4; boil for 30 minutes (min), placing a watch glass over the mouth of the beaker. After exactly 30 min, the residue was treated with 28% potassium hydroxide and also it was boiling gently for a further 30 min and stir occasionally. After conducting the filtration process, the residue was washed in crucible twice more with a hot, distilled water filter. The washed residue or dry crucible was dried in the electric oven at 130°C for 2 hours, again cool for 30 min in a desiccator and then weigh= W_1, transfer crucible to muffle furnace for 30 min at 550 -600°C and then cool in a desiccator and weigh = W_2. Therefore, the percentage of crude fiber was calculated as follows.

$\text{The crude fiber in } \% = \frac{(W1-W2)X100}{W3}$---Eq. 2

Where: W1- Crucible weight before drying

W2- Crucible weight after drying

W3- Sample dry weight

Dry a clean box was inverted lid in the drying oven at 92°C for 1 hour and covers the box with the lid and cooled it in the desiccators for 30 min and weighed. 5-10 g (gram) {W_1} sample was transferred to the drying box, dried at 92°C overnight and cooled again in a desiccator for 30 min and weighted. Next, the sample was checked for complete dryness by placing the box with the sample uncovered in the drying oven at 92°C for another 1 hour, cooled and weighed it {W_2}. Lastly, the moisture content was calculated according to [12] as below.

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

Where:

W_1: the weight of cap and fresh sample

W_2: the weight of dry sample and cap

SW: sample weight

2.3.3. Fat determination by diethyl ether

3.5 g of sample was weighed and cover with fat-free cotton and attach it with the magnetic ring to hang the thimble to the extraction chamber. The extracted material was put on the cool water and treated with 70 ml diethyl ether to the clean aluminum cup through the condenser to regulate the heating device. After doing that, the aluminum cup was removed from the extraction unit and put it in the drying oven at 92°C for at least 30 min and makes it cool in a desiccator for at least half an hour and . then the aluminum cup was weighed immediately after it is taken out of the desiccator and collects the condensed solvent by connecting the tubes into a bottle. After all these processes, the crude fat was extracted with ether free of peroxide from a sample in a soxlet apparatus and the solvent was evaporated from the extraction flask (aluminum cup). So, the amount of fat is calculated from the difference in weight of the aluminum cup before and after extraction as below.

$$\text{Fat}\ (\%) = \frac{W_f X100}{SW} \text{--Eq.4}$$

Where, Weight of fat, W_f = Weight of aluminum cup after extraction minus weight of aluminum cup before extraction

SW= weight of samples

2.3.4. Ash determination

A 2.5g sample was weighed in a crucible and heated in a muffle furnace at 550°C for 1 hour. Exactly after 1 hour, the crucible was taken out of the furnace. It was then allowed to cool and moistened with a few drops of deionized water, and the water was evaporated on a hot plate. The sample was heated again in the furnace for half an hour, cooled, and treated with a few drops of deionized water and 5 drops of concentrated nitric acid (HNO3). This process was repeated consequently until the weight became constant [12].

2.3.5. Determination of total Ascorbic Acid (Vitamin C) spectrophotmetrically

5g of the sample was extracted with 100ml of 6% trichloroacetic acid using a mortar and pestle for 2-5 minutes at room temperature. The suspended solids were removed by centrifugation or filtration. In a conical flask containing the sample solution, 1-2 drops of saturated bromine solution were added. One tube was set aside to serve as a blank, and to each of the remaining tubes, 1ml of 2,4-Dinitrophenyl hydrazine was added. All the test tubes were then placed in a water bath at 37°C for 3 hours, cooled in an ice bath for approximately 5 minutes, and 5ml of 85% H2SO4 was added while the tubes were still in the ice bath. All the tubes were then mixed with 1ml of 2% Dinitrophenyl hydrazine and allowed to stand at room temperature for 30 minutes. Finally, the absorbance of the standards, blanks, and test samples was measured spectrophotometrically at 515 nanometers.

2.3.6. Determination of trace metals (Zn, Ca, Fe, Cu) by Flame Atomic Absorption Spectroscopy (FAAS)

Before measuring the required samples, the crucibles were washed with 6N HCl, and the glassware was washed with 10% nitric acid. The washed items were then placed in an oven at 100°C for 30 minutes, cooled in a desiccator for 30 minutes. 2.5g of the sample was measured and charred on a hot plate, starting at a low temperature under a hood. The samples were then ashed in a muffle furnace at 550°C for 1 hour. Subsequently, the crucible was taken out of the furnace, cooled, and moistened with a few drops of deionized water. The ash was ashed again for 30 minutes at 550°C, cooled, and then treated with some drops of deionized water and 5 drops of concentrated HNO3. Ash content was treated with 5-10 ml of 6N HCl to wet it completely and carefully taken to dryness on a low-temperature hot plate. Next, 15 ml and 10 ml of 3N HCl were added step-by-step and the crucible heated on the hot plate until the solution just boiled, cooled, and filtered through filter paper into a graduated flask. After the removal of organic materials by dry ashing, the residue was dissolved in dilute acid and sprayed into the Flame Atomic Absorption Spectroscopy, and the absorption of the metals was measured at a specific wavelength [12]. Phosphorous was determined using official methods of analysis [13]. The total carbohydrate was obtained by calculating the difference (the sum of protein, fat, ash and crude fiber on a dry basis is subtracted from 100) and the potassium content was estimated by Flame photometer. The nutritive value or energy content was estimated by multiplying the percentages of crude protein, crude fat and total carbohydrates by 4, 9 and 4 respectively [14].

2.4. Statistical Analysis

The mean value of the macronutrient, vitamin C and mineral contents of the WSWEP fruits were computed using a statistical package for social science software version 20 at a 5% significance level.

3. Results and Discussion

3.1. Proximate compostion of WSWEP

The nutrient composition varied considerably among the WSWEP fruits (Table 1). The protein content of the studied WSWEP fruits ranged from 2.6% to 8.1%, with Za having the highest and Mk having the lowest protein content. Compared to previous studies, the protein content reported in this study was higher than the values reported for Ba (1.40%), Zsc (2.13%), and G. flavescens (1.51%) in other semi-arid eastern Ethiopia [8]. Similarly, the protein content of Zsc, Fv, Ba, Ve, and Za were comparatively higher than the values of 4.1% (Zsc), 3.95% (Za), and 2.9% (Ziziphus mauritiana) reported in a previous study from Sudan [15].

The crude fiber content was significantly higher in Dm fruit (26.3 ± 3.5%) compared to other WSWEP fruits, including Fv (16.5 ± 1.9%), Ba (2.1 ± 0.4%), Ve (25.6 ± 2.9%), Za (11.4 ± 3%), Mk (6.8 ± 1%), and Zsc (7.3 ± 0.9%). Compared to previous studies, the crude fiber content in all the WSWEP fruits, except for Ba, was higher than the values reported for Ba (5.94%), Zsc (3.78%), and G. flavescens (6.68%) in [14], and the previously reported crude fiber content of 6.09 ± 0.02% in Zsc fruit [10]. The crude fat was significantly different among the studied fruit which was higher in Fv (6.0 ±2.0 %) and lower in Za (1.0 ± 0.3). The crude fat for all of the studied species was higher compared to [15] who reported 0.9 %, 0.8 % and 0.3 % for Zsc, Za and *Z. mauritiana* respectively. Moisture content ranged from 10.7 ± 2 to 37.4 ± 5 %. The highest and lowest moisture content was observed in Dm and Mk fruit correspondingly. Compared with other studies conducted for Ba, *G. flavescens* and Zsc fruits [14] 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.

The Zsc fruit had a higher ash content of 4.9 ± 0.8%, while the Mk fruit had a lower ash content of 1.4 ± 0.2%. The studied fruits generally had relatively lower ash contents compared to the values reported for Ba, Zsc, and G. *flavescens* [14], as well as *Carissa carandas* L., *Phyllanthus emblica L.*, and *Morinda pubescens J.E. Smith* [16]. The total carbohydrates were 76.8 ± 5%, 65.6 ± 5%, 57.4 ± 5%, 44.2 ± 4.9%, 51.0 ± 4.4%, and 64.1 ± 5.2% for Ba, Zsc, Ve, Fv, M k, and Za respectively. The total carbohydrate content of the studied fruits was lower than the values of 86.83%, 82.04%, and 89.46% reported by [14] for Ba, Zsc, and G. flavescens, respectively. The calculated nutritive or energy value was found to be highest in Ba (337.2 ± 15.4), followed by Zsc (301.7 ± 32.2), and lowest in Dm (150.6 ± 22.6). This calculated nutritive value, based on the crude protein, crude fat, and total carbohydrate content, is relatively lower compared to the findings reported in the literature [14, 17].

Table 1: Proximate composition of the seven selected WSWEP (Mean ± SD)

WSWEP	Macronutrients						
	Crude protein (%)	Crude fiber (%)	Crude fat (%)	Moisture (%)	Ash (%)	Carbohydrate (%)	Nutritive value (Kcal)
Ba	4.6 ± 1^{a}	2.1 ± 0.4^{a}	1.3 ± 0.3^{a}	10.7 ± 2^{a}	4.5 ± 1^{a}	76.8 ± 5^{a}	337.2 ± 8.4^{a}
Z sc	6.2 ± 1.1^{b}	7.3 ± 0.9^{b}	1.6 ± 0.6^{b}	12.4 ± 1.9^{abc}	4.9 ± 0.8^{a}	65.6 ± 5^{b}	301.7 ± 5.4^{bf}
Ve	6.1 ± 1.7^{b}	16.5 ± 1.9^{c}	1.1 ± 0.2^{a}	15.9± 3^{b}	2.9 ± 0.7^{b}	57.4 ± 5^{c}	264.2 ± 6.1^{c}
Fv	4.7 ± 1^{a}	25.6 ± 2.9^{d}	6.0 ± 2^{c}	14.7 ± 2^{ab}	4.8 ± 0.7^{a}	44.2 ± 4.9^{d}	250 ± 5.4^{d}
Mk	2.6 ± 0.9^{c}	6.8 ± 1^{b}	2.1 ± 0.4^{d}	36 ± 5.5^{d}	1.4 ± 0.2^{c}	51.0 ± 4.4^{e}	233.4 ± 6.6^{e}
Z a	8.1 ± 2.1^{d}	11.4 ± 3e	1.0 ± 0.3^{a}	12 ± 2.0^{bc}	3.2 ± 0.4^{b}	64.1 ± 5.2^{b}	298.4 ± 9.8^{f}
Dm	2.7 ± 0.8^{c}	26.3 ± 3.5^{d}	2.9 ± 0.5^{e}	37.4 ± 5^{e}	2.3 ± 0.4^{d}	28.4 ± 3.4^{f}	150.6 ± 9.6^{g}
P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Means in colomun with similar letters are not significantly different at *P*<0.05.

3.2. Mineral composition

Minerals play an important role in supporting the optimal functioning of the immune system [18]. They contribute to various processes, such as supporting immune cell development, regulating inflammatory pathways, and enhancing the body's ability to fight off infections and illnesses. The recommended daily intakes of minerals vary based on age and life stage The iron, zinc, calcium, copper, potassium, and phosphorus contents of the studied WSWEP fruits are depicted in Table 2. The result showed that the Fv fruit contained the highest Fe (55.5 ± 5 mg/100g), Zn (1.6 ± 0.2 mg/100g), Ca (584.3 ± 14 mg/100g) and Cu (0.9 ± 0.1 mg/100g) contents than Ba, Zsc, Ve, Mk, Za and Dm fruit. The concentration of Zn and Cu of all the studied fruits almost similar with the reported values of other wild edible fruits of *Arbutus pavarii* , *Nitraria* retusa and Ficus *palmate* [17].

The available potassium content was significantly lower in Mk (760.5 ± 20.4 mg/100g) and higher in Ba (3030.3 ± 0.3 mg/100g) compared to the other studied tree species. According to the Dietary Reference Intakes (DRI) reported in [19], the recommended potassium intake is at least 3,510 mg/day for adults and less than 3,510 mg/day for children. Therefore, the potassium content of all the studied WSWEP fruits would require additional supplementary foods to fulfill the daily potassium intake. The available phosphorus content varied among the studied WSWEP, as shown in Table 2. Zsc (106.7 ± 11 mg/100g) and Za (105 ± 7.2 mg/100g) were found to have the highest available phosphorus content among the studied WSWEP, which could fulfill the recommended daily allowance for infants aged 0-6 months. However, according to the recommended daily allowance of phosphorus content reported by [20] (100 mg/day for infants 0-6 months, 275 mg/day for infants 7-12 months, 460 and 500 mg/day for young children 1-3 and 4-8 years, 250 mg/day for males and females aged 9-18 years, and 700 mg/day for both adults and older), the studied WSWEP would still require additional supplementary foods to meet the recommended phosphorus intake.

Table 2: Mineral composition (mg on dry basis) of the seven selected WSWEP (Mean ± SD)

WSWEP	Minerals					
	Fe (mg/100g)	Zn (mg/100g)	Ca (mg/100g)	Cu (mg/100g)	K (mg/100g)	P (mg/100g)
Ba	13.8 ± 1.7^{a}	0.5 ± 0.1^{a}	255.6 ± 5^{a}	0.5 ± 0.0^{a}	3030.3 ± 0.3^{a}	30.9 ± 5.0^{a}
Z sc	8.5 ± 2^{b}	0.9 ± 0.1^{b}	402.9 ± 12^{b}	0.5 ± 0.1^{a}	2704 ± 8^{b}	106.7 ±11^{b}
Ve	4.2 ± 0.9^{c}	0.4 ± 0.1^{a}	204.9 ± 9^{c}	0.6 ± 0.1^{a}	2002.9 ± 2^{c}	85.8 ± 10.9^{c}
Fv	55.5 ± 5^{d}	1.6 ± 0.2^{d}	584.3 ±14^{d}	0.9 ± 0.1^{b}	1477.1 ± 6^{d}	83.3 ± 13.2^{c}
Mk	6.0 ± 2^{e}	0.32 ± 0.1^{a}	362.2 ± 8.3^{e}	0.1 ± 0.0^{c}	760.5 ± 9^{e}	26.1 ± 2.1^{a}
Z a	10.6 ± 2.4^{f}	1.3 ± 0.2^{e}	515.1 ± 7^{f}	0.6 ± 0.2^{a}	1597.7 ± 3^{f}	105 ± 7.2^{b}
Dm	14.4 ±2.9^{a}	1.5 ± 0.4^{de}	481.8 ± 21.7^{g}	0.5 ± 0.1^{a}	1127.8 ± 8.1^{g}	40.4 ± 4.8^{d}
P-value	0.000	0.000	0.000	0.000	0.000	0.000

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

3.3. Vitamin C

The studied WSWEP fruits exhibited varying vitamin C contents. The Fv fruit had the highest vitamin C content at 55.4 ± 9.5 mg/100g. This was followed by the Ba fruit at 51.4 ± 6 mg/100g, the Zsc fruit at 42.4 ± 4 mg/100g, the Mk fruit at 22.7 ± 3.3 mg/100g, the Za fruit at 17.6 ± 2.4 mg/100g, the Dm fruit at 6.4 ± 1 mg/100g, and the Ve fruit at 4.4 ± 0.3 mg/100g. The recommended daily intakes of vitamin C vary based on age and life stage. For infants aged 0-6 months, the recommendation is 25 mg/day. This increases to 30 mg/day for children 7 months to 6 years old, 35 mg/day for children 7-9 years, and 40 mg/day for adolescents. Adults and older individuals are advised to consume 45 mg/day of vitamin C, while pregnant women should increase their intake to 55 mg/day and lactating women to 70 mg/day [19]. The WSWEP fruit analysis revealed that Fv (55.4 ± 9.5 mg/100g) can fulfill the recommended daily vitamin C intake for infants, children, adolescents, adults, and pregnant women, but not for lactating women. Ba (51.4 ± 6 mg/100g) can meet the requirements for infants, children, adolescents, and adults, but additional supplementary food would be needed for pregnant (55 mg/100g) and lactating (70 mg/100g) women. Zsc (42.4 ± 4 mg/100g) can provide sufficient vitamin C for infants, children, and adolescents. In comparison to previous studies, the WSWEP fruits Fv, Ba, Zsc, and Mk contain higher vitamin C levels than *Cordia africana* (20.2 mg/100g dry weight) fruit reported in Tigray [21].

4. Conclusion

The nutritional diversity of Wild and Semi-Wild Edible Plants (WSWEP) fruits is quite remarkable, offering a range of essential nutrients that contribute to various aspects of human health. Their nutrient composition, including protein, crude fiber, fat, moisture, ash, and carbohydrates, can vary significantly, which enhances their potential to provide varied nutritional benefits. These fruits are particularly rich in minerals like iron, zinc, calcium, copper, potassium, and phosphorus, which are vital for many physiological functions. For instance, iron supports red blood cell formation, zinc plays a role in immune function, and calcium is critical for bone health. The high levels of these minerals in WSWEP fruits suggest they could be valuable in meeting the body's mineral requirements, especially in populations at risk for deficiencies. Some WSWEP fruits, such as Fv, Ba, and Zsc, contain substantial amounts of vitamin C, an essential nutrient known for its antioxidant properties and its role in immune support and collagen synthesis. These fruits could help individuals, especially infants, children, and adults, to meet their daily vitamin C needs. This is particularly beneficial for populations with limited access to other vitamin C-rich foods. While WSWEP fruits offer a wealth of nutrients, there may still be some gaps in their ability to fully meet the recommended daily intake of all essential vitamins and minerals. For certain groups, such as pregnant or lactating women, and young children, additional supplementation from other food sources may be necessary to ensure comprehensive nutritional coverage. Overall, WSWEP fruits hold great promise as supplementary sources of essential nutrients, potentially enhancing the dietary intake of many vulnerable populations.

Declarations and verification

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

Abbreviations

g=gram

mg/100g=milligram per 100gram

min=minutes

ml= milliliter

NHCl=Normality hydrochloric acid

HNO_3=concentrated nitric acid

H_2SO_4= concentrated sulfuric acid

Ethics approval and consent to participate

Not applicable

Consent for publication

All authors approve and consent for the article to be published.

Availability of data and materials

All necessary data are available on the corresponding author and possible to submit with the reasonable request.

References

[1] Duguma, H. T. (2020). Wild edible plant nutritional contribution and consumer perception in Ethiopia. *International Journal of Food Science, 2020*.

[2] FAO, WFP and IFAD (2012). The State of Food Insecurity in the World Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition. Rome, FAO. ISBN 978-92-5-107316-2

[3] FAO, WFP and IFAD (2011). The State of Food Insecurity in the World, How does international price volatility affect domestic economies and food security? Rome, FAO. ISBN 978-92-5-106927-1

[4] Bala Ravi, S., Hoeschle-Zeledon, I., Swaminathan, M. S., and Frison, E. (2006). Hunger and poverty: the role of biodiversity-Report of an international consultation on the role of biodiversity in achieving the UN millennium development goal of freedom from hunger and poverty.

[5] Asfaw, Z. (2008, March). The future of wild food plants in southern Ethiopia: ecosystem conservation coupled with enhancement of the roles of key social groups. In *International Symposium on Underutilized Plants for Food Security, Nutrition, Income and Sustainable Development 806* (pp. 701-708).

[6] Lulekal, E., Asfaw, Z., Kelbessa, E., and Van Damme, P. (2011). Wild edible plants in Ethiopia: a review on their potential to combat food insecurity. *Afrika focus*, *24*(2), 71-122.

[7] Teklehaymanot, T., and Giday, M. (2010) Ethnobotanical study of wild edible plants of Kara and Kwego semi-pastoralist people in Lower Omo River Valley, Debub Omo Zone, SNNPR, Ethiopia. Journal of ethnobiology and ethnomedicine, 6(1), 23.DOI: 10.1186/1746-4269-**6**-**23**

[8] Tahir, M., Abrahim, A., Beyene, T., Dinsa, G., Guluma, T., Alemneh, Y and Mohammed, A. (2023). The traditional use of wild edible plants in pastoral and agro-pastoral communities of Mieso District, eastern Ethiopia. *Tropical Medicine and Health*, *51*(1), 1-15.

[9] Ruffo, C. K., Birnie, A., and Tengnäs, B. (2002). Edible wild plants of Tanzania.

[10] Guinand, Y., and Lemessa, D. (2001). Wild-food plants in Ethiopia: Reflections on the role of wild foods and famine foods at a time of drought. *The potential of indigenous wild foods*, *22*, 31.

[11] Belete, G., Asfaw, Z., and Tamirat, T. (2021). Diversity of wild edible fruit bearing woody species in different land use and management system in Dangur district, north western Ethiopia. *Journal of Global Ecology and Environment*, 12-22.

World Health Organization (2004). Vitamin and mineral requirements in human nutrition. World Health Organization, Second edition, ISBN 92 4 154612 3

[12] AOAC (2005). Official methods of the AOAC International. Determination of lead, cadmium, and minerals in foods by Atomic Absorption spectrophotometry Eth (method 999.11). Gaithersburg.

[13] AOAC (1984). Official Methods of Analysis. Association of Official Analytical Chemists 14th Edition, Arlington.

[14] Adekunle IA and Adenike OJ (2012). Comparative Analysis of Proximate, Minerals and Functional Properties of Tamarindus indica pulp and Ziziphus spina-christi Fruit and Seed, *Greener Journal of Agricultural Sciences* Vol. 2 (1), pp. 021-025. **DOI**: 10.15580/GJAS.2013.3.11-020

[15] Ahmed FAM and Sati N E (2018). Chemotaxonomic study and botanical overview of some Ziziphus spp. in Sudan, International Research Journal of Biological Sciences,Vol. **7(5),** 32-39

[16] Anand SP and Deborah S (2016). Nutritional analysis of wild edible fruits from Boda and Kolli hills, Tamil Nadu, *International Journal of Nutrition and Agriculture Research 3(2)*: *85 – 92.*

[17] Hegazy AK, Al-Rowaily S L, Faisal M, Alatar AA, El-Bana M I and Assaeed AM (2013). Nutritive value and antioxidant activity of some edible wild fruits in the Middle East. *Journal of Medicinal Plants Research 7*(15): 938-946. DOI 10.5897/JMPR13.2588

[18] Weyh, C., Krüger, K., Peeling, P., and Castell, L. (2022). The role of minerals in the optimal functioning of the immune system. *Nutrients*, *14*(3), 644.

[19] WHO (World Health Organization) (2012). Guideline: Potassium intake for adults and children, Geneva.

[20] Institute of Medicine (1997). Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D, and floride. Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. Washington, DC: National Academies Press

[21] Tewolde-Berhan S, Remberg S F, Abegaz K, Narvhus J, Abay, F and Wicklund T (2013) Ferric reducing antioxidant power and total phenols in Cordia africana fruit. *African Journal of Biochemistry Research 7*(11): 215-224. **DOI**: 10.5897/AJBR2013.0692