Micronutrient and Phytic acid Contents of Wild Edible Fruits Collected from Temcha Watershed of Amhara Region (Ethiopia) to Combat Hidden Hunger

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Abstract

Abstracts Background: Locally available and easily accessible, underused complementary foods including wild edible fruit species are affordable and potentially more acceptable than other options to address the problem of 'hidden hunger' or micronutrient deficiency. Study aimed to collect and determine the nutritional composition of wild edible fruits with its bioavailability collected from Temcha watershed. Methods: Semi structured interviews were administered to collect all wild edible plants and its associated knowledge through the participation of informants systematically selected from six sub districts in the study area. Mineral and pyhtate content and molar ratio of phytate to mineral ratio were determined using standard methods. Results: Based on the total use value of all wild edible plants, the top 18 wild edible fruits were selected for dietary analysis. The zinc contents of the analyzed fruits were ranged in between 0.06 ± 0.02 mg/100g -88.89 ± 0.42 mg/100g. The iron content of the analyzed fruits were ranged in between 5.84 ±0.00 mg/100 g – 148 ± 0.93 mg/100g and the calcium contents were in between 53.25 ± 0.45 mg/100g – 1280 ± 0.77 mg/100g. The phytate content of each fruits were ranged in between 6.9 ± 0.00 mg/100g – 51.4 ± 0.04 mg/100g. Conclusions: Combination of Ficus sycomorus and either of all wild edible fruits satisfy the daily-recommended allowance of calcium for male and female age 10-18 (1300 mg/100 g). Almost all WEFs provides optimum amount of iron for Children up to 10 years required 11.6 – 17.8 mg / day except Embelia schimperi, Ficus sur, Rossa abyssinica, Rubus studinary & Ximenia americana. The different amount of zinc (0.66 - 89 mg /100 g) contributes to control progressive stunting in children in the study area. The phytate concentrations of wild edible fruits do not have a negative impact on the bioavailability of calcium, iron and zinc. The micronutrient content of wild edible fruits provided a lot of contribution for the study area communities and those who shared similar feeding culture elsewhere in the country. Key words: Micronutrients, temcha watershed, wild edible fruits,

Background

Deficiencies of micronutrients are a major global health problem. More than 2 billion people in the world today are estimated to be deficient in key vitamins and minerals, particularly vitamin A, iodine, iron and zinc (WHO, 2001a). Energy-rich staple crops assure caloric adequacy, and policy makers have historically made them a focus in the quest for global food security. However, staples, generally derived from cereal, starchy tuber and root vegetables, contain small quantities of limiting nutrients per unit of energy, and by themselves are not enough to address the problem of 'hidden hunger' or micronutrients deficiency (Stephenson *et al.,* 2010; Tontisirin *et al.,* 2002). Increasing consumption of micronutrient-dense foods (such as a diversity of fruit, pulses, vegetables and some animal source foods) seen as a practical, cost-effective and sustainable way to improve nutrient quality and diets (Johns and Sthapit, 2004). Evidently Vinceti *et al.* (2013) reported that for supplementation and fortification, locally available and easily accessible, underused complementary foods including wild edible fruit species are affordable and potentially more acceptable than other options.

Phytic acid is one of anti-nutrient produced by plants for their own defense against herbivorous, insects, pathogens or adverse growing conditions (Herbourne, 1989). Despite this, plnt based food containing phytic acid chelates metal ions, especially zinc, iron, and calcium (Egli *et al.,* 2004), forming insoluble complexes in the gastrointestinal tract that cannot be digested or absorbed in humans because of the absence of intestinal phytase enzymes (Iqbal, 1994). Phytate also complexes endogenously secreted minerals such as zinc (Sandström, 1997) and calcium (Morris and Ellis, 1985) making them unavailable for reabsorption into the body. However, it is noteworthy that myo-inositol phosphates with less than five phosphate groups (i.e., IP-1 to IP-4) do not have a negative effect on zinc absorption (Lönnerdal *et al.,* 1989) whereas myo-inositol phosphates with less than three phosphate groups do not inhibit iron absorption (Sandberg *et al.,* 1999).

The groups most vulnerable to micronutrient deficiencies are pregnant women, lactating women and young children, mainly because they have a relatively greater need for vitamins and minerals and are more susceptible to the harmful consequences of deficiencies. Micronutrient deficiencies increase the general risk of infectious illness and of dying from diarrhoea, measles, malaria and pneumonia. These conditions are among the 10 leading causes of disease in the world today (WHO, 2001b). To reverse such kind of health problem, the study aims to explore locally available underutilized food sources to see its potential for combating a "hidden hunger" after checking its anti-nutritional factor for maximum utilization.

Methods

2.1 Study Area Description

The study undertaken in Temcha Watershed (TW) found in Machakel and Dembecha Districts along the Abay River basin. The river originates from the south-west direction of Choke Mountain and drains in to Abay River after the slope. The watershed targeted for the study is delineated by using Arc GIS 10 software. The watershed lies in between $10^{0}23'$ to $10^{0}41'$N latitude and $37^{0}16'$ to $37^{0}45'$ E longitude which constitutes 73, 054 hectares of land. Administratively, the study area falls in Dembecha District (Western Gojjam) and Machakel District (Eastern Gojjam) in Amhara Regional State (Figure 1). Temcha Watershed is fully covers 10 of the 24 kebeles (sub district) and partially four additional kebeles in Machakel District. It also covers eight of 29 Kebeles and partially five additional kebeles in Dembecha District. Temcha River naturally divded Dembecha District from Machakel District.

2.2 Data collection methods

2.2.1 Site and participant selection

This study on wild edible plants was conducted from purposely-selected six kebeles with the participation 374 informant. The total number of informants who participated in this study was determined by using the formula developed by Cochran (1977).

$$n = \frac{N}{1 + N\,e^2}$$

Where n = sample size, N = population, and e = sampling error (precision level = 0.05). By using all the above information, 374 households were selected sytematically and interviewed.

2.2.2 Ethnobotanical data and Wild edible plants collection

Prior to undertaking dietary nutrient analysis on food samples from wild edible fruits, WEFs species were collected through interviews and field observations as described by Martin (1995) and Cotton (1996).Voucher specimens were collected and identified using Flora of Ethiopia and Eritrea. The identified plants were stored at National Herbarium Addis Ababa University.

2.2.3 Plant part collection for analysis

2.2.3.1 Plant source

The wild edible fruits were collected from TW after written and oral consent were received from the Districts and sub districts at which the watershed is located and the local people or community that manages the watershed respectively. All the fruits were collected from the wild. Plant specimens were collected and identified using Flora of Ethiopia and Eritrea. The identification process was confirmed by Sebsebe Demissew, the curator of the Herbarium and a Professor of Plant Systematics and Biodiversity in Addis Ababa University. Eventually, the voucher specimens deposited at National Herbarium found in Addis Ababa University.

2.2.3.2 Pant part collection

The edible plant parts, fruits, were collected after the ripening stage (from January 2016 - July 2016) from different forest patches along TW. Healthy and disease free fruit samples were collected in plastic bags and were allowed to dry under shade so as to prevent the decomposition of the chemical compounds present in them. All the dried materials were powdered in blander for further study following standard protocols. Each of the dried food samples ground in to fine powder partly using pestle and mortar and F2-102 micro plant grinding machine to fine particles and sieved through a mesh sieve of 1 mm. All dried sub samples were pooled together and the pulverized materials stored in umber (normally dark yellowish-brown in color to protect light not to oxidize the sample) bottles and taken to the Food Science and Nutrition Laboratory, Addis Ababa University for detailed analysis.

2.3 Data analysis methods

2.3.1 Wild edible fruit selection for analysis

All of the listed use values (UV) was calculated using the formula developed by Phillips and Gentry (1993) after grouped in to different use categories adapted from the classification method proposed by Cook (1995) into the following use categories as per the economic botany data collection standard. These are Fodder (Including animal feed and honeybee forage); Medicines (Including human and veterinary medicines); Food, including beverages; Materials, including handicrafts, dyes, construction; materials, roof thatch, hygienic substances, and toys; Energy (Charcoal and fire wood); Environmental uses (including erosion control, shade/shelter, soil improvers, ornamentals, hedges).

2.3.2 Determination of calcium (Ca), zinc (Zn) and iron (Fe)

The analysis of Ca, Zn, and Fe was done based on the official methods of 999.11 of AOAC (2005). Atomic absorption spectrophotometer (AAS) was used to determine the concentration of the analyzed micronutrient.

The content of each mineral was calculated using the following formula:-

$$\text{Metal content}\left(\frac{\text{mg}}{100\text{gm}}\right) = \frac{(\text{Cs} - \text{Cb}) * \text{V}}{10\text{xW}}$$

Where: Cs: Concentration of sample in ppm, Cb: Concentration of blank in ppm, V: Volume (ml) of extract, W: Weight (g) of samples

2.3.3. Determination of Phytate

The phytate contents of fruit flour sample from selected WEF species was determined according to the method stipulated by Wheeler and Ferrel (1971).

The following formula was used to calculate the phytic acid content of the samples.

$$Phytic\ acid\ (\frac{\mu g}{100gm}) = \frac{[(As - Ab) - [Intercept]10}{Slope * w * 3}$$

Where: As = sample absorbance, Ab = blank absorbance, W = weight of sample

2.3.4. Determination of molar ratio of phytae / mineral

The mole of phytate and minerals was determined by dividing the weight of phytate and minerals with its atomic weight (phytate: 660 g / mol; Ca: 40 g / mol; Fe: 56 g / mol; Zn: 65 g / mol). The molar ratio between phytate and mineral was obtained after dividing the mole of phytate with the mole of minerals (Morris and Ellis, 1989).

Results

3.1 Complete list of WEFs and season of fruit ripening period and exact date of collection

A total of 18 wild edible plants were collected from the three catchments of the watershed (Table 1)

3.2 Mineral contents (micro nutrient contents) (Zn, Fe and Ca) of WEFs

Of the micronutrient analyzed, calcium content is the most abundant mineral followed by iron and zinc in all WEFs (Table 2).

3.2.1 Iron content

Iron which is commonly deficient in many diets is abundant in this wild edible fruits and the dietary iron content was determined based on the concentration of the standard iron regression curve (R^2 = 9998) (Figure 2). The concentration of iron varied within the range of 5.84 mg / 100 g for *Gardenia ternifolia* and 148.93 mg / 100 g for *Cordia africana*. Some of the top iron containing WEFs are *Cordia africana* (148.93 ± 0.21), *Ficus vasta* (45.34 ± 0.06), *Rhus glutinosa* (35.50 ± 0.37), *Syzygium guineense* (29.88 ± 0.21) and *Ritchiea albersii* (25.83 ± 0.75).

3.2.2 Calcium content

The concentration of calcium from the extracted wild edible fruits is determined from the standard calcium regression curve (R^2 = 9994) (Figure 3). The range of calcium in the different plants under study is between (1280.77 mg / 100 g) for *Ficus sycomorus* and (53.25 mg /100 g) for *Ximenia americana*. The 8 top wild edible fruits that contain large amount of calcium in the edible parts are *Ficus sycomorus (*1280.77 ± 22.98), *Ficus vasta (*972.98 ± 12.53), *Ficus sur* (659.33 ± 5.15), *Cordia africana* (573.20 ± 4.09), *Rhus glutinosa* (565.13 ± 9.84), *Rubus steudneri (*558.60 ± 4.63), *Rubus apetalus* (538.65 ± 0.00) and *Rosa abyssinica* (483.12 ± 2.69) (Table 2).

3.2.3 Zinc content

Zinc contents of selected WEFs were analyzed from the concentration of the standard zinc regression curve (R^2 = 9979) (Figure 4). The concentration of zinc value is ranging from (0.66 ± 0.02) for *Syzygium guineense* and (88.89 ± 0.42 mg / 100 g) for *Rhus glutinosa.* The top most zinc containing WEFs are *Rhus glutinosa* (88.89 ± 0.42), *Embelia schimperi (* 45.12 ± 1.11), *Phoenix reclinata* (27.71 ± 0.49), *Ritchiea albersii* (27.01 ± 0.13) and *Cordia africana* (17.27 ± 0.54)(Table 2).

3.3. Phytate contents and Molar ratios of Phytate and micronutrient analyzed in this study

3.3.1 Phytate contents

The analyzed wild edible fruits contain different amount of phytate. This content is determined from the regression equation of calibration curve (R^2 = 0.9823 and R^2 = 0.9943) (Figure 5). Its value is in between 6.9 ± 0.00 mg /100 g for *Gardenia ternifolia* to 51.4 ± 0.041 mg / 100 g for *Clausena anisata*. The top seven wild edible fruits that contain high phytate are *Clausena anisata* (51.4 ± 0.04), *Ficus vasta* (50.7 ±

04), *Capparis tomentosa* (49.8 ± 0.00), *Ficus sur* (48.6 ± 0.00), *Ritchiea albersii* (45.6 ± 0.00), *Ehretia cymosa* (40.9 ± 0.00) and *Cordia africana* (40.7 ± 0.46)(Table 3).

3. 3.2 Molar ratios of Phytate and micronutrient analyzed in this study

Molar ratios of [phytate]: [iron], [phytate]: [zinc] and [phytate]: [calcium] provides an estimate of the relative bioavailability of these minerals in the wild edible fruits. The results showed that molar ratio of phytate with calcium ranged in between 0.001 ± 0.00 for *Gardenia ternifolia* to 0.044 ± 0.00 for *Ximenia americana*. Molar ratio of phytate with iron ranged in between 0.023 ± 0.00 for *Cordia africana* to 0.478 ± 0.01 for *Ximenia americana* and molar ratio of phytate with zinc ranged in between 0.023 ± 0.00 for *Cordia africana* to 4.137 ± 0.00 for *Ficus sur*.

Discussion

4.1 Mineral contents (micro nutrient contents) (Fe, Ca and Zn,) of WEFs

Some WEFs had significant level of micronutrients and identified as promising species for promotion as backyard planting especially farming systems suffering from crop loss, food shortage and chronic malnutrition.

4.1.1 Iron

The recommended nutrient intake for iron is varying depending up on the type of human social group (children, males, females post-menopausal and lactating), ages and mean body weight (FAO / WHO, 2001). According to FAO/WHO (2001), children up to 10 years required 11.6 – 17.8 mg / day. Whereas males whose ages range from 11- 18 years require 27.4 - 37.6 mg / day, Females with similar age require 28 - 65.4 mg / day. *Cordia africana* (148.93 ± 0.21), *Ficus vasta* (45.34 ± 0.06), *Rhus glutinosa* (35.50 ± 0.37) and *Syzygium guineense* (29.88 ± 0.10) provides optimum amount of iron for both males and females whose age is in between 11 and 18 (FAO / WHO, 2001). Whereas, a combination of the rest of WEFs provides optimum amount of iron for both males and females whose age is in between 11 and 18. Almost all WEFs either alone or a combination of them provides optimum amount of iron for children up to 10 years. From data taken from Ethiopian food composition table (EHNRI, 1997), Cultivated cereal crops *Eleusine coracana*) that gives 37.9 mg /100 g and Teff (*Eragrostis tef*) flour which has highest iron content of 150 mg /100 g.

4.1.2 Calcium

In this study, the three plants found in the Moraceae family contain a large amount of calcium. If a person aged between 10 and 18 years eats at 100 g dry weight basis either of these two plants can meet the daily needs of calcium (1300 mg / 100 g) (FAO / WHO, 2001). Furthermore, combination of *Ficus sycomorus* and either of all wild edible fruits studied, when it has been eaten in 100 g dry weight basis, it satisfies the daily needs of calcium of male and female individuals in the range of 10-18 age.

The World Health Organization recommended supplementations of 1.5 - 2 g (1500 mg – 2000 mg) of calcium daily for all pregnant women in populations with usual calcium intake averaging less than 900 mg /day to prevent pre-eclampsia / eclampsia that is responsible for an estimated 16 % of the maternal mortality (Khan et al., 2006). The national survey conducted by the Ethiopian Public Health Institute (ENFCS, 2013) indicated that the average calcium intake by the Ethiopian women is about 317.32 mg / day. This is far below the estimated average need for women (1300 mg / day) of 10 - 18 years and 1000 mg /day for above 19 years. Therefore, WEFs had a lot of contribution to provide reasonable amount of calcium for the community. The good news in relation with calcium in the study area is, people harvest *Ficus sur* fruit and sold the dried fruit in the local market. These largely supplement cereal based diets in the study area to get the daily-recommended intake of calcium.

4.1.3 Zinc

The effect of zinc on iron absorption observed when the zinc: iron ratio exceeded 3:1in a given meal (Davidsson et al., 1995). Whereas when the zinc : iron ratio increased to 5 : 1, there was a marked negative effect upon iron absorption (56 % decline). Among the analyzed data, eating *Embelia schimperi* fruit might affect absorption of zinc because the zinc: iron ratio of *Embelia shimperi* diet is 7:1. The rest of the wild edible fruits will not have such kind of problems because the ratio is within the normal range. Zinc is a cofactor for over 100 enzymes, involved in modulating enzyme activity or are an integral part of enzyme prosthetic groups (Shenkin, 2006). Therefore, the different amount of zinc from these wild edible fruit species contributes a lot to the study area community and the knowledge can be extended to similar areas of Ethiopia.

4.2 Role of Phytic acid content and bioavailability of calcium, iron and zinc in wild edible plants

The available literature indicates that Phytate might be exerting its inhibitory effect on the bioavailability of calcium, iron and zinc from the diet that had molar ratios above the cut-off points (Liener et al., 1980, Larsson et al., 1996). Whether or not high levels of consumption of phytate-containing foods will result in mineral deficiency will depend on what else is being consumed. The phytate contents of WEPs in this study resulted in the range of 6.93 ± 0.00 for *Gardenia ternifolia* to 51.38 ± 0.041 for *Clausena anisata*. The recommended critical values and the results are as follows: The molar ratio of phytate with zinc in the analyzed WEFs varied from 0.03 for *Embelia schimperi* and 4.12 for *Ficus sur.* [phytate]: [zinc] ≥ 15 (Morris and Ellis., 1985) for zinc. It is lower than the critical molar ratios of Phytate: Zinc, which indicates the high bioavailability of zinc consumed from WEFs.

Molar ratio of phytate with iron varied from 0.02 for *Cordia africana* and 0.48 for *Ximenia americana* but [phytate]: [iron] ≥ 1 (Hallberg et al., 1989) for iron. This is also below the range indicating the high bioavailability of iron. Molar ratio of phytate with calcium is in the range of 0.04 for *Ximenia americana* and below 0.01 in most WEFs but [phytate]: [calcium] ≥ 0.24 (Morris and Ellis., 1985) for calcium. Molar ratio of phytate with calcium is in the range of 0.04 for *Ximenia americana* and below 0.01 in most WEF and this is also below the range indicating the high bioavailability of calcium.

The ([Ca][Phy]/ [Zn] molar ratios of the analyzed edible fruits varied from 0.18 for *Embelia schimperi* to 68.06 for *Ficus sur.* [phytate] × [calcium]) / [zinc] >200 for the combined effect of phytate and calcium on zinc (Gibson *et al.,* 1991). These values are lower than the critical molar ratios of [Ca][phytate]/ [Zn], which indicates high bioavailability of zinc in all wild edible fruits tested. Therefore, the phytate concentrations of WEFs do not have a negative impact on the bioavailability of calcium, iron and zinc from WEFs diet. This result supports very low levels of phytate contents of roots and tubers and most leafy vegetables and fruits than cereals as reported by Reddy (2002).

Conclusions

The nutritional values of WEFs had a lot of contribution to meet the daily-recommended allowance of different micronutrients like calcium, iron and zinc for a certain age group in the community. *Cordia africana* and *Phoenix reclinata* collected from the lower and middle catchments and *Ritchiea albersii* and *Rhus glutinosa* and *Rubus apetalus* were distributed throughout the watershed provided a reasonable amount of calcium, iron and zinc contents to the community. *Ficus sur* and *Rubus steudneri* were collected from the three catchments in the watershed while *Ficus sycomorus* was restricted to the lower catchment were claimed to be the best source of calcium. All these provided information on their usefulness both from the community consensus results and the dietary test results regarding their potentials for nutritional and medicinal applications.

Abbreviations

WEFs	Wild Edible Fruits
WHO	World Health Organization
TW	Temcha Watershed
UVs	Use Values
FAO	Food and Agricultural Organization
AOAC	Association of Official Analytical Chemists
EHNRI	Ethiopian Health and Nutrition Research Institute

Declarations

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Authors’ Contributions

‘HR’, ZA’ and ‘SD’ have designed the proposal, data collection, data analysis, interpretation and later developed this manuscript. ‘AZ’ has supervised the micronutrient analysis and phytic acid determination during laboratory experiment. Both authors read and approved the final manuscript.

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Ethics approval and consent to participate

Prior to plant sample collection, a formal letter request of cooperation was submitted to the Machkel District and Dembecha District where Temcha Watershed is administered and the administrative offices has approved the request and give me a letter of acceptance. Accordingly, the necessary oral consents were obtained from each informant who participated during ethnobotanical data collection of the wild edible fruits after explaining the objectives of the work.

Availability of data and materials

The data used and analyzed in this study are available from the corresponding author on reasonable request.

Consent for publication

This is not applicable, since any photographs or videos were not taken.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1 Complete list of WEFs collected from TW (H = habit, MC = mode of consumption, EDC = Exact date of collection, FRP = Fruit ripening period or calendar)

No.	Scientific name	Family Name	Local name (Amharic)	H	Parts used	MC	FRP	EDC
3	*Capparis tomentosa*	Capparaceae	Gumero	S	Ripe Fruit	Raw	June-July	29/08/08
4	*Carissa spinarum*	Apocynaceae	Agam	S	Ripe Fruit	Raw	March	28/06/08
5	*Clausena anisata*	Fabaceae	Limich	S	Ripe Fruit	Raw	May-June	29/08/08
6	*Cordia africana*	Boraginaceae	Wanza	T	Ripe Fruit	Raw	January - February	25/06/08
9	*Ehretia cymosa*	Boraginaceae	Wulaga	T	Ripe Fruit	Raw	March	29/08/08
10	*Embelia schimperi*	Myrsinaceae	Enkoko	S	Ripe Fruit	Raw	January-February	28/06/08
12	*Eriosema cordifoliium*	Fabaceae	Enkerkafo	H	Root tuber	Raw	June-July	
13	*Ficus sur*	Moraceae	Sholla	T	Ripe Fruit	Raw and Dried	March-April	25/06/08
14	*Ficus sycomorus*	Moraceae	Abuar	T	Ripe Fruit	Raw	April	7/7/2007
15	*Ficus vasta*	Moraceae	Warka	T	Ripe Fruit	Raw	March-April	6/7/2008
16	*Gardenia ternifolia*	Rubiaceae	Gobin/guabilo	T	Ripe Fruit	Raw	February-March	7/7/2008
23	*Phoenix reclinata*	Arecaceae	Chifar	T	Ripe Fruit	Raw	May-June	29/08/08
24	*Rhus glutinosa*	Anacardaceae	Ashkamo	S	Ripe Fruit	Raw	April-June	29/08/08
25	*Ritchiea albersii*	Capparidaceae	Chomye	T	Ripe Fruit	Raw	May-June	29/08/08
26	*Rosa abyssinica*	Rosaceae	Kega	S	Ripe Fruit	Raw	February-March	13/07/08
27	*Rubus apetalus*	Rosaceae	Yedega enjor	S	Ripe Fruit	Raw	February-March	6/7/2008
28	*Rubus steudneri*	Rosaceae	Yewof enjory	S	Ripe Fruit	Raw	February-March	6/7/2008
32	*Syzygium guineense*	Myrtaceae	Bedessa	T	Ripe Fruit	Raw	May- June	29/08/08
34	*Ximenia americana*	Olacaceae	Enkoy	S	Ripe Fruit	Raw	May-June	

Table2 Mineral contents of selected WEFs in TW

List of plants	Zink(mg /100 g)	Fe (mg /100 g)	Ca (mg /100 g)
Capparis tomentosa	2.34 ± 0.05	14.68 ± 0.05	98.41 ± 0.08
Carissa spinarum	8.86 ± 0.07	12.59 ± 0.34	254.22 ± 0.20
Clausena anisata	2.50 ± 0.05	13.63 ± 0.07	419.36 ± 3.02
Cordia africana	17.27 ± 0.54	148.93 ± 0.21	573.21 ± 4.09
Ehretia cymosa	4.30 ± 0.06	16.19 ± 0.41	293.94 ± 1.61
Embelia schimperi	45.12 ± 1.11	6.22 ± 0.11	250.38 ± 0.80
Ficus sur	1.16 ± 0.00	9.18 ± 0.11	659.33 ± 5.15
Ficus sycomorus	5.65 ± 0.06	21.46 ± 0.28	1280.77 ± 22.98
Ficus vasta	2.27 ± 0.02	45.34 ± 0.06	972.98 ± 12.54
Gardenia ternifolia	4.01 ± 0.12	5.84 ± 0.00	438.84 ± 6.17
Phoenix reclinata	27.71 ± 0.49	17.24 ± 0.39	156.11 ± 0.49
Rhus glutinosa	88.89 ± 0.42	35.50 ± 0.37	565.14 ± 9.85
Ritchiea albersii	27.01 ± 0.13	25.83 ± 0.75	235.43 ± 3.02
Rosa abyssinica	8.31 ± 0.13	7.75 ± 0.10	483.12 ± 2.69
Rubus apetalus	2.69 ± 0.00	14.81 ± 0.91	538.65 ± 0.00
Rubus steudneri	2.71 ± 0.01	6.86 ± 0.04	558.60 ± 4.63
Syzygium guineense	0.66 ± 0.02	29.88 ± 0.10	433.33 ± 0.98
Ximenia americana	1.53 ± 0.00	6.77 ± 0.21	53.25 ± 0.45

Table3 Phytic content, molar ratio of phytic acid and calcium with zinc and molar ratio of phytate with micronutrients (calcium, iron and zinc)

List of plants	Phytic acid µg /g	Molar ratio of [Phytate] [Calcium]/[Zinc]	Molar ratio of phytate with calcium	Molar ratio of phytate with iron	Molar ratio of phytate with zinc
Capparis tomentosa	498.46 ± 0.00	5.15 ± 0.11	0.031 ± 0.00	0.288 ± 0.00	2.105 ± 0.05
Carissa spinarum	336.77 ± 0.00	2.38 ± 0.01	0.008 ± 0.00	0.227 ± 0.00	0.375 ± 0.00
Clausena anisata	513.75 ± 0.041	21.24 ± 0.63	0.007 ± 0.00	0.320 ± 0.00	2.023 ± 0.05
Cordia africana	406.77 ± 0.46	3.32 ± 0.12	0.004 ± 0.00	0.023 ± 0.00	0.232 ± 0.00
Ehretia cymosa	409.09 ± 0.00	6.88 ± 0.13	0.008 ± 0.00	0.214 ± 0.00	0.938 ± 0.01
Embelia schimperi	136.13 ± 0.00	0.18 ± 00	0.003 ± 0.00	0.186 ± 0.00	0.029 ± 0.00
Ficus sur	486.35 ± 0.00	68.06 ± 0.34	0.004 ± 0.00	0.450 ± 0.00	4.137 ± 0.01
Ficus sycomorus	391.61 ± 0.00	21.83 ± 0.15	0.002 ± 0.00	0.155 ± 0.00	0.683 ± 0.00
Ficus vasta	507.15 ± 044	53.49 ± 1.3	0.003 ± 0.00	0.095 ± 0.00	2.204 ± 0.03
Gardenia ternifolia	69.27 ± 0.00	1.87 ± 0.03	0.001 ± 0.00	0.101 ± 0.00	0.171 ± 0.00
Phoenix reclinata	358.06 ± 0.00	0.5 ± 0.01	0.014 ± 0.00	0.176 ± 0.00	0.127 ± 0.00
Rhus glutinosa	316.64 ± 0.00	0.49 ± 0.01	0.003 ± 0.00	0.076 ± 0.00	0.035 ± 0.00
Ritchiea albersii	455.77 ± 0.00	0.98 ± 0.01	0.012 ± 0.00	0.150 ± 0.00	0.166 ± 0.00
Rosa abyssinica	371.94 ± 0.46	5.32 ± 0.1	0.005 ± 0.00	0.407 ± 0.00	0.441 ± 0.00
Rubus apetalus	342.90 ± 0.47	16.89 ± 0.03	0.004 ± 0.00	0.197 ± 0.01	1.257 ± 0.00
Rubus steudneri	299.35 ± 0.00	15.16 ± 0.18	0.003 ± 0.00	0.370 ± 0.00	1.088 ± 0.00
Syzygium guineense	107.86 ± 0.00	17.31 ± 0.54	0.002 ± 0.00	0.031 ± 0.00	1.601 ± 0.05
Ximenia americana	381.61 ± 0.46	3.27 ± 0.03	0.044 ± 0.00	0.478 ± 0.01	2.460 ± 0.00

Figures

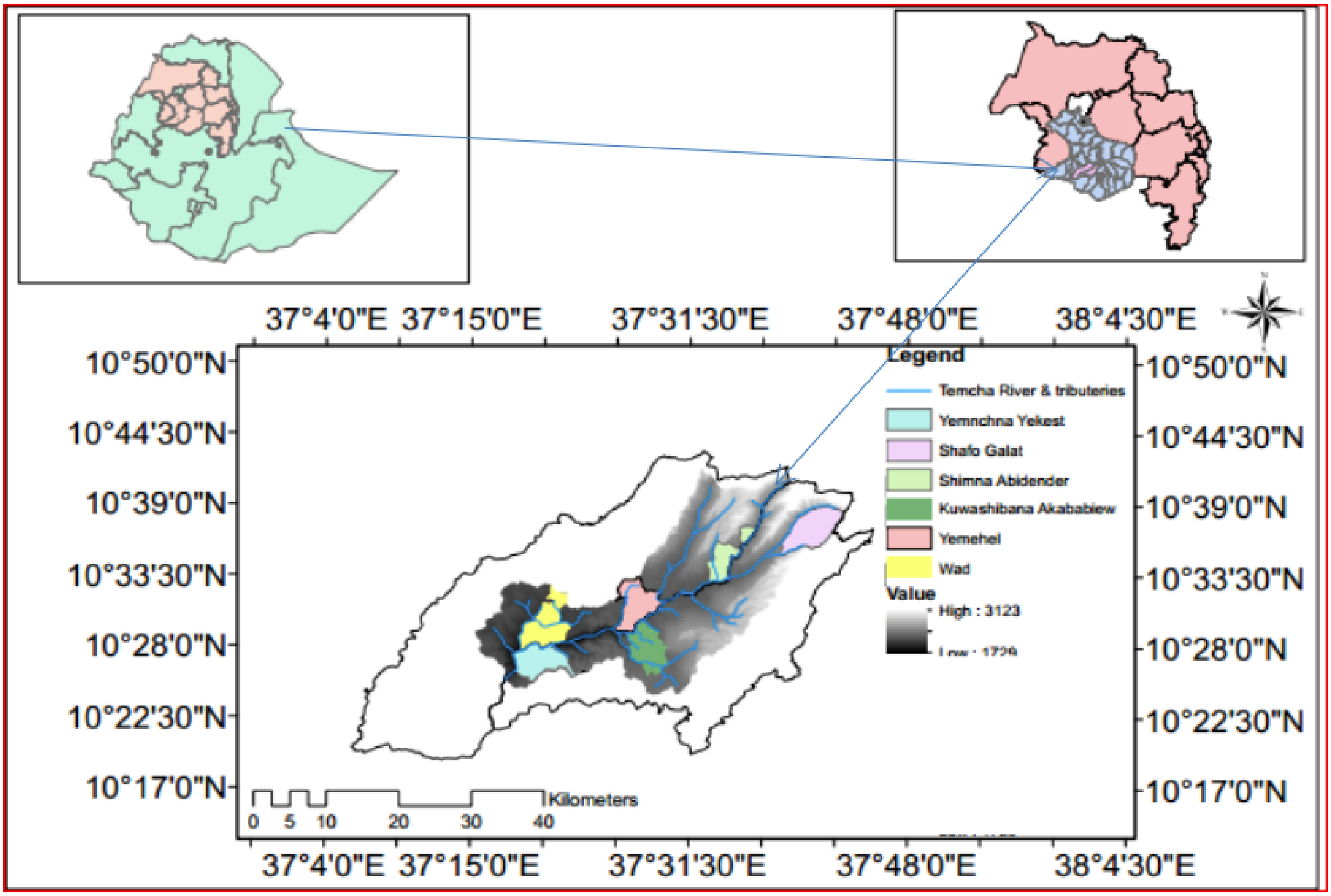

Figure 1

Map of Ethiopia showing regional states, districts, Temcha Watershed and sampled kebeles (Developed using Arc GIS 10). (Source of the shape file: accessed from Ethiopian Mapping Agency)

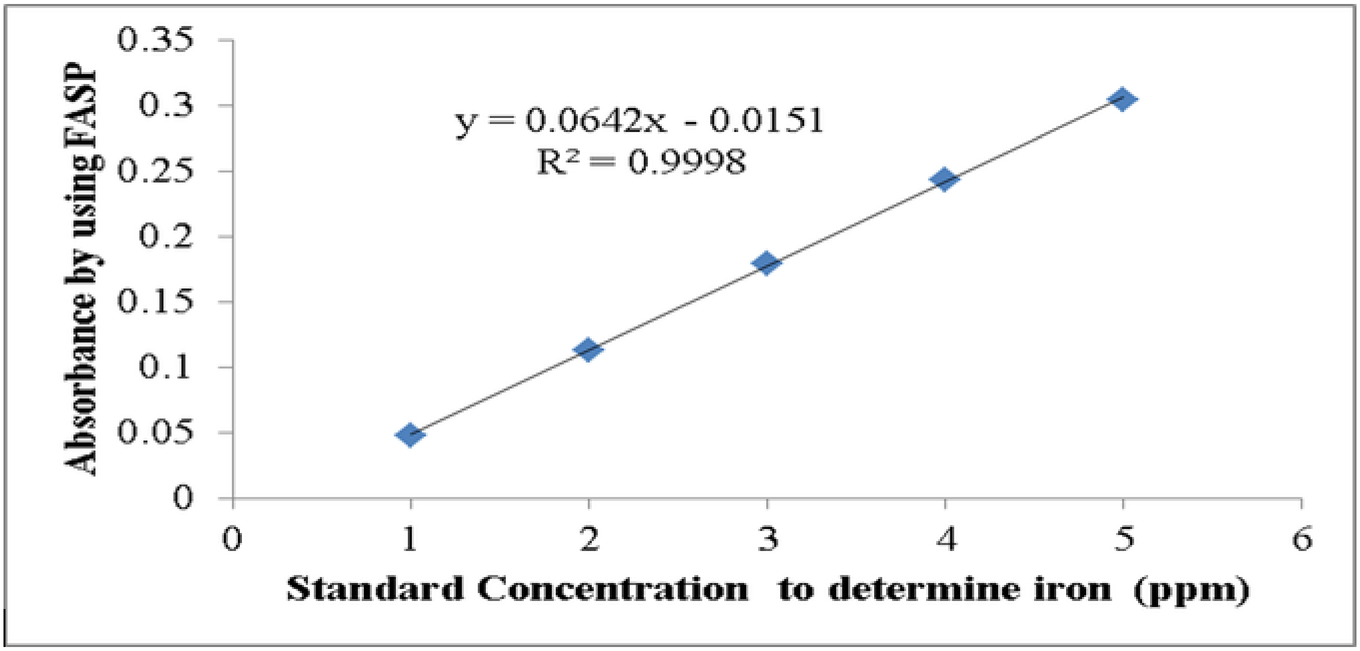

Figure 2

Standard calibration curves to determine iron

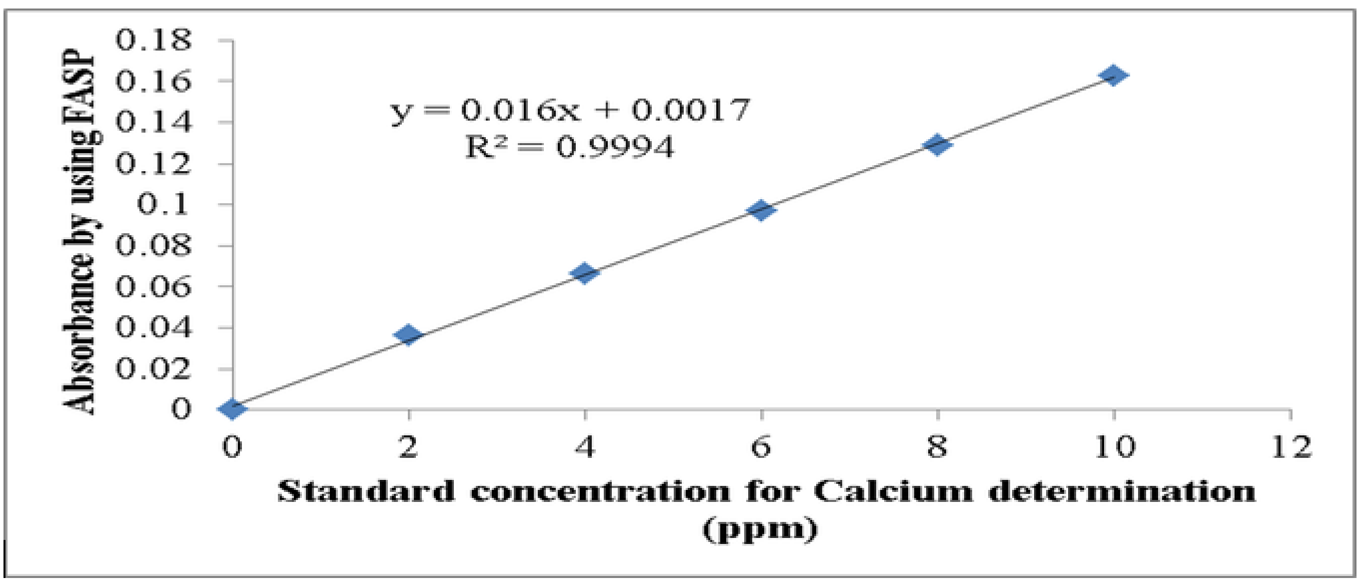

Figure 3

Standard calibration curve to determine Calcium

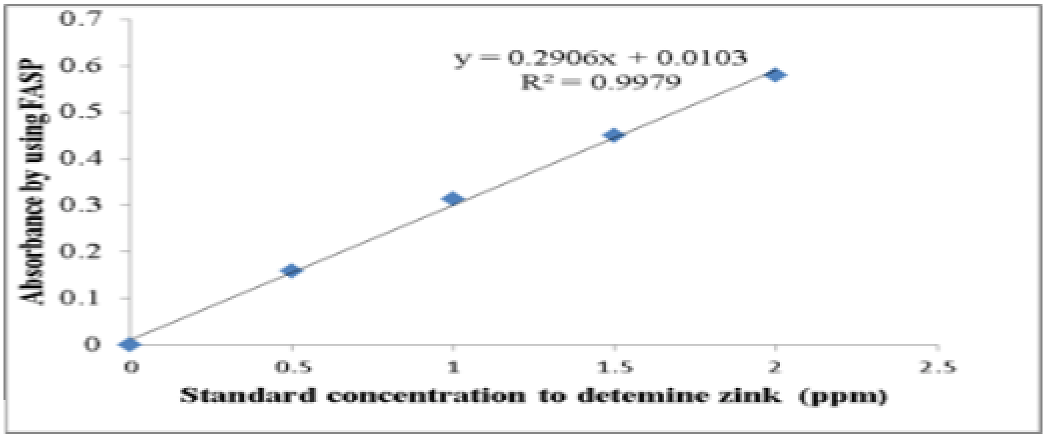

Figure 4

Standard calibration curve to determine Zinc

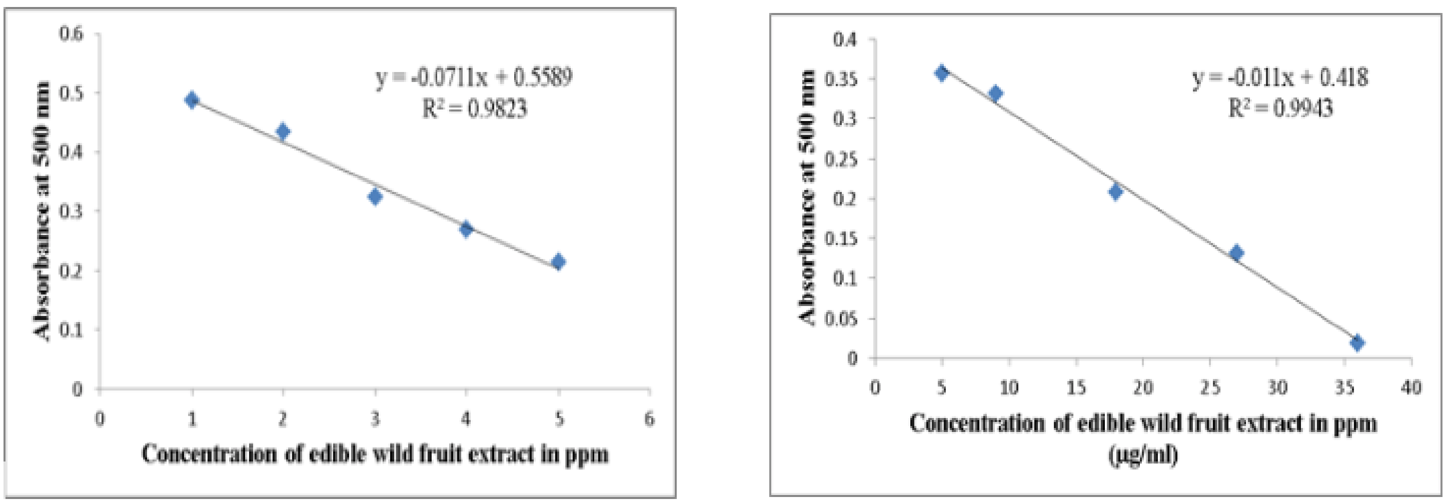

Figure 5

Calibrations curve for Phytic acid determination