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METALLIC NUTRIENTS IN ENSET (*ENSETE VENTRICOSUM*) CORM CULTIVATED IN WOLLISO AND WOLKITE TOWNS IN ETHIOPIA

Ayalew Debebe, B.S. Chandravanshi* and Taddese Wondimu†

Department of Chemistry, Addis Ababa University, PO Box 1176, Addis Ababa, Ethiopia
E-mail: bscv2006@yahoo.com

ABSTRACT: Enset is an adaptable and drought resistant plant with multiple usages including consumption as co-staple diet in some parts of Ethiopia and has been dubbed "a tree against hunger". With the plant gaining increased recognition as a food and cash crop, the need for multi-faceted research initiatives appears to be undisputable to preserve its features, maximize its productivity and document changes that would have occurred over the years. The metallic composition of unprocessed corm collected in Wolkite and Wolliso towns in Ethiopia has been investigated. As well as providing information on health benefits or risks, metallic composition may suggest fortification opportunities to improve its nutritive value or that of others and give an insight into temporal alterations. The levels of calcium, magnesium, potassium, iron, zinc, manganese, chromium, cobalt, copper, nickel, cadmium and lead determined with flame atomic absorption spectrometer (FAAS) in digested unprocessed corm samples varied as follows: Ca 36.1–39.1; Mg 24.9–26.9 and K 14.1–32.2 (mg/g); Zn 11.9–42.3; Cu 1.5–5.2; Co 2.8–10.5; Cr 5.8–7.6; Fe 18.2–54.4; Mn 2–5; Ni 1–4 and Cd 0.6–1.8 (μg/g) with 15.3 μg/g lead being detected in one sample from Wolkite. Method accuracy evaluated as percentage recovery was within 90–110. The levels of metals were higher in samples from Wolliso than those from Wolkite, except for Pb, Mn and Cd. These results indicate that the enset corm, which is low in non-essential nutrients and rich in Ca, Mg, K, Zn and Fe can be recommended as nutritional supplement for deficiencies of Ca, Mg, K, Zn, and Fe.

Keywords/phases: Enset, Ethiopia, indigenous foods, metallic nutrients

INTRODUCTION

Enset [*Ensete ventricosum* (Welw.) Cheesman] grows wild in a number of countries in central and eastern Africa including Congo, Mozambique, Uganda, Tanzania and Zambia (Genet Birmeta *et al.*, 2004). Wild *E. ventricosum* grows on the highlands (1100–3100 masl) of Ethiopia, in small pockets around Bonga town and the Omo River valley. In contrast, cultivated enset grows in a wider area comprising the central, south and south-western parts of Ethiopia, mainly at higher altitudes (1500–3100 masl) (Shank and Chernet Ertiro, 1996; Genet Birmeta *et al.*, 2004).

Enset is a perennial root crop that is domesticated only in Ethiopia, grown mainly in the Southern Nations, Nationalities and People's Regional State (SNNPR) (Shank, 1994; Kamar *et al.*, 2000) followed by Oromiya and Gambella Regional States (Almaz Negash *et al.*, 2002). It is an adaptable and drought resistant plant with nutritional and a variety of non-nutritional usages (Brandt *et al.*, 1997; Ajebu Nurfeta *et al.*, 2008a). Enset is an important staple or co-staple crop for more than 20% of the Ethiopian population (Almaz Negash *et al.*, 2002), being a source of major foods such as *kocho*, *bulla* and *amicho*. Medicinal uses of the different parts of enset include curing fractured and broken bones, assisting with placenta discharge during child-birth, anti-diarrheal medication and as birth control method (Brandt *et al.*, 1997). Parts of fresh

* Author to whom all correspondence should be addressed.
† Current address: Department of Chemistry, Trent University, 1600 West Bank Drive, Peterborough, ON K9J 7B8, Canada.

and dry leaves of enset find applications in packaging, storage, food serving, sanitation, separation and construction work. Starch extracted from enset has proven and potential applications as binding, adhesive, and water absorbing agent in industrial production of textile, paper and pharmaceuticals (Hirose *et al.*, 2010).

Adaptability and resilience against drought are notable features of enset; as a consequence the plant has been dubbed "a tree against hunger" (Brandt *et al.*, 1997). Together with its multiple usages, these features won enset increased recognition and interest to enhance its role aside from use as food crop and economic resource, as highlighted in a recent national workshop (EIAR, 2012). The increased interest in enset has been challenged by a number of factors, most notably disease and environmental degradation (Temesgen Addis *et al.*, 2008; Tsedeke Abate *et al.*, 1993; Brandt *et al.*, 1997).

The preceding discussion clearly highlights the growing need for multidisciplinary research interventions to preserve enset and maximize its productivity. Metallic composition of enset thus appears an aspect that merits studying. Inadequate intake of mineral elements has been noted to be a major nutritional problem in human diet (Aremu and Undoessien, 1990). The nutritional composition of enset would impact the health status of millions of people consuming it as a staple diet. Relative to geographic distribution and cultivation and consumption rates, literature information on major, minor and trace metals content of enset is scarce (Minaleshewa Atlabachew and Chndravanshi, 2008; Yewelsew Abebe *et al.*, 2007; Ajebu Nurfeta *et al.*, 2008b). The mineral content of enset is reported to vary widely depending on the influence of such factors as disease, number of transplantation, sanitation, plant variety and soil contamination (Aremu and Undoessien, 1990; Shank, 1996; Deckers *et al.*, 2001; Golder, 2001; Ajebu Nurfeta *et al.*, 2008b). The general chemical composition indicates that enset is high in carbohydrates and low in proteins and fats (Agren and Gibbson, 1969; Tilahun Amede *et al.*, 2004). Agren and Gibbson (1969) further noted the calcium and iron contents of *bulla* and *kocho* to vary as follows (mg element/100 g edible portion): 82 and 70 for Ca and 3.7 and 7.9 for Fe, respectively.

In a previous study, Minaleshewa Atlabachew and Chandravanshi (2008) have determined the levels of major, minor and trace elements in commercially available enset food products from Wolkite and Wolliso towns, areas widely known to consume enset food products. The traditional methods of processing and storage of raw enset as well as the ensuing reprocessing activities may introduce extraneous materials and render metallic compositional data unreliable. The aim of this study is to determine the levels of metallic nutrients in unprocessed enset corm. For this particular study, four different plants (two from Wolliso town in Oromiya region and the other two from Wolkite town in SNNPR) were selected. Twelve frequently analyzed metallic elements in common food products (K, Ca, Mg, Fe, Zn, Mn, Cr, Co, Cu, Ni, Cd and Pb) were determined in dried and digested enset samples by flame atomic absorption spectrometry.

MATERIALS AND METHODS

Equipment

Flat-bottomed flasks (100 mL) fitted with reflux condenser were used in Kjeldahl apparatus hot plate to digest the enset samples. Buck Scientific Model 210VGP (USA) atomic absorption spectrometer (AAS) equipped with deuterium arc lamp background corrector was used for the determination of the analyte metals (Ca, Mg, Fe, Zn, Mn, Cr, Co, Cu, Ni, Cd and Pb) using air-acetylene (99.8%) flame. Selecta model 2001241 (Spain) oven (110˚C) was used for drying glassware. Thermo savant: model MODUL YOD-230 (USA) was used for freeze-drying the enset samples, and metal sieve: Weite 0.5 mm diameter, Ser. no: 811624, Retscn 5657 HAAN (Germany) was employed for sieving enset samples ground with mortar and pestle.

Reagents and chemicals

All solutions were prepared using analytical grade pure reagents: nitric acid (70%, trace metal grade; Spectrosol BDH, England), perchloric acid (70%, Analar BDH, England), and lanthanum nitrate hydrate (98% Aldrich, Milwaukee, USA) were used for dissolution of samples and controlling ionization interference in AAS measurements. Stock standard solutions containing 1000 mg

metal/L in 2% HNO_3 of the metals K, Ca, Mg, Fe, Zn, Mn, Cu, Co, Cr, Ni, Pb, and Cd (Buck Scientific PURO-Graphic^{tm}) were used for preparing a series of calibration standards. Dilute calibration solutions were made using deionised water immediately before use.

Sampling and sample preparation

Unprocessed enset samples were collected from four different live plants, two from Wolliso town (8°31′N, 37°58′E) in Oromiya Regional State and the other two from Wolkite town (8°15′N, 37°47′E) in Southern Nations, Nationalities and Peoples Regional State. Wolliso and Wolkite towns are located 120 and 155 km, respectively, west of the capital, Addis Ababa. Some physical characteristics of the enset plants recorded at the time of sampling are given in Table 1. One kilogram of corm, edible part of the plant, was taken for each sample from both sites. The soil was removed mechanically and then by washing with distilled water, while the roots were chopped from the plant with plastic knife before the samples were cut into pieces. The samples were packed in clean plastic bags, sealed and transported to the laboratory for processing and analysis. Each enset sample was frozen at -20°C and then freeze-dried to constant mass using Thermo savant freeze dryer. The freeze-dried samples were finely ground in a mortar using a pestle and sieved through 0.5 mm sieve. The prepared samples were kept dry inside desiccators until digestion.

Sample digestion

An accurately weighed aliquot (0.5 g) of powdered enset sample was placed in a 100 mL flat-bottomed flask and 2.0 mL 70% HNO_3 and 2.0 mL 70% $HClO_4$ were added to it. The mixture was heated under reflux for 2.5 hours on a Kjeldahl digestion unit setting the temperature to 240°C. At the end of heating period, the mixture was cooled at room temperature for 5 min, diluted partially to about 40 mL. The cooled and diluted digest and its washing was filtered and transferred in to a 50 mL volumetric flask. Finally, the digest was diluted to the mark with deionised water. The final dilution contained 1% (w/v) lanthanum solution to release calcium and magnesium from their respective phosphates, which are refractory in the determinations by FAAS (Ranjhan and Krishna, 1980). The digests were prepared in triplicate for each sample. A reagent blank containing the same reagents (2.0 mL 70% HNO_3 and 2.0 mL 70% $HClO_4$) and subjected to the same digestion procedure was prepared for correcting effect of the blank.

Table 1. Some characteristics of enset samples obtained from Wolliso and Wolkite.

Plant characteristics	Sample number			
	Wolliso-1	Wolliso-2	Wolkite-1	Wolkite-2
Height (including the leaf), m	4.0	5.0	4.5	6.10
Circumference, m	1.5	1.0	1.0	2.10
Age, year	5.0	6.0	4.0	4.0

Determination of metals in enset samples

The working standard solutions of each metal were prepared from 100 mg/L intermediate standards, which were prepared from stock solutions (1000 mg/L) of each metal. Four point calibration curves were constructed within the range based on the FAAS data of the readings. The concentrations of calibration standards and the analytical wavelengths used are summarized in Table 2. The concentrations of digested sample solutions were determined from these external calibration curves. For determination of macro metals (Ca, Mg and K), samples were diluted prior to analysis.

Table 2. Analytical wavelengths, method detection limits, linear range and correlation coefficients (r^2) for determinations of metals using FAAS.

Metal	Wavelength (nm)	Method detection limit (µg/g)	Linear range (mg/L)	r^2
Ca	422.7	9	0.5–4.0	0.9698
Mg	285.2	4	0.5–4.0	0.9998
K	766.5	-	0.5–4.0	0.9997
Fe	248.3	2	0.01–0.5	0.9499
Zn	213.9	7	0.01–0.5	0.9698
Mn	279.5	2	0.01–0.5	0.9998
Cr	357.9	2	0.01–0.5	0.9699
Co	240.7	3	0.01–0.5	0.9897
Cu	324.7	1	0.01–0.5	0.9798
Ni	232.0	6	0.01–0.5	0.9899
Pb	283.2	7	0.01–0.5	0.9798
Cd	228.9	2	0.005–0.04	0.9598

Study of analyte recovery

The efficiency of the optimized method was checked by digesting the 0.5 g enset samples spiked with standard solutions of the metals. In the first experiment, 0.5 g enset sample was spiked with six different metal standards (0.1 mL of 100 mg/L of Ca, K, Mg, Zn and Cr and 0.1 mL of 10 mg/L of Cd) before digestion. In the second experiment, 0.5 g enset sample was spiked with six different metal standards (0.1 mL of 100 mg/L of Co, Fe, Ni, Cu, Pb and Mn) before digestion. The samples were then digested according to the optimized method, the digests transferred in to 50 mL volumetric flask and diluted to the mark with deionised water. The diluted solutions were analyzed for each metal by atomic absorption spectrophotometer. Each recovery test was performed in triplicate.

Statistical analysis of data

The significance of variation between the samples was studied using one-way ANOVA. This method was used to calculate the presence or absence of significant difference in mean level of each metal between four enset samples. There was no significant difference in the levels of each particular metal, except for Pb, in the four samples of enset ($p = 0.05$).

RESULTS AND DISCUSSION

Optimization of procedure for digestion of enset corm

Various heating programs were tested using different mixtures of 70% HNO_3 and 70% $HClO_4$ (Table 3) in the search for optimum procedure for digesting 0.5 g of dried and powdered enset samples. Samples were digested in single reflux phase in trials 1 up to 5, while two refluxing phases were applied in trials 6 through 8 for refluxing durations ranging from 123 to 278 min. A digestion program that gave clear solutions within the shortest possible time while consuming fewer reagent volumes was regarded optimal. As can be seen in Table 3, four digestion programs (Trials 4, 5, 7, and 8) provided clear digests with no visible residual organic matter, while the remaining 4 trials gave digests either cloudy or pale yellow, both of which indicate the presence of incompletely digested organic matter. External calibration curves that are obtained using aqueous standards cannot be used for evaluating levels of elements in such digests as they may exhibit different transport properties during nebulisation and injection into the flame atomization chamber risking accuracy of analytical results. Therefore, those cloudy or yellowish digests were rejected. Trials 5, 7 and 8 also resulted in complete decomposition of the organic matter as evidenced in the formation of clear solutions but required the longest digestion time of 278 min compared to the 153 min required by trial number 4. Longer digestion times can be prone to analyte volatilization losses. Therefore, a heating program that uses a mixture of 2 mL of each of HNO_3 (70%) and $HClO_4$ (70%) refluxed for 153 min in a single trial was considered optimal as it consumed the least amount of reagents and the shortest time to decompose 0.5 g of dried and powdered corm samples of enset. These results further indicate the importance of $HClO_4$ to effectively decompose the organic matter rather than applying digestion in two trials.

Table 3. Procedures tested for decomposing 0.5 g of enset samples with various mixtures of HNO_3 and $HClO_4$ while refluxing the mixture for different periods of time.

Trial #	Reflux phase	Reagent volume (mL) HNO_3	Reagent volume (mL) $HClO_4$	Time (min)	Appearance of digest before and after filtration and dilution
1	1	2.0	1.0	153	Pale yellow solution
2	1	2.0	2.0	123	Slightly pale yellow solution
3	1	3.0	1.0	153	Slightly pale yellow solution
4*	**1**	**2.0**	**2.0**	**153**	**Clear solution**
5	1	3.5	1.5	153	Clear solution
6	1	2.5	0.5	153	Cloudy solution
	2	1.0	0.5	125	
7	1	2.5	1.0	153	Clear solution
	2	1.0	0.5	125	
8	1	2.0	1.5	153	Clear solution
	2	1.0	0.5	125	

*Optimum digestion procedure

Construction of calibration curves and evaluation of analyte concentrations

As outlined in the materials and methods section, four point calibration curves were constructed within the linear range based on instrument response. The correlation coefficients obtained for each element were better than 0.995, which indicate good linearity of the external calibration curves (Table 2). Completely digested sample solutions exhibit similar transport properties as the aqueous calibration standards. Therefore, levels of the completely digested clear sample solutions were evaluated using these linear calibration curves.

Method detection limits

The limit of detection is the smallest amount or concentration of analyte in the test sample that can be reliably distinguished, with stated significance, from the background or blank level. Detection limit can be determined based on three times the standard deviation of the concentration in a matrix blank (McNaught and Wilkinson, 1997). For the present study, four blank solutions were digested following the same procedure as the samples and each of the blank solutions was analyzed for the elements and the pooled standard deviation of the four blank reagents was calculated. The detection limits were then obtained by multiplying the pooled standard deviation of the reagent blank by three. The detection limits of analyte metals evaluated applying the above mentioned approaches are given in Table 2. Generally, the detection limits determined are lower than the measured concentrations of nutrients in the enset samples, thus clearly showing the reliability of the analytical concentration determined using the current method. Relatively higher detection limits were noted for Ca, Zn, Ni, and Pb, presumably due to higher natural abundances (*e.g.*, Ca) and background contamination (Ni, Pb, Zn).

Recovery test

The validity of the analytical procedure can be checked by: (a) analyzing a series of samples using two different methods, such as the new method and a standard method, (b) analyzing a reference or a certified reference material, (c) performing standard methods of analysis, (d) comparative analysis with other reputable laboratories and (e) analyzing synthetic samples and spiked samples (Welz and Sperling, 1999). In this study, accuracy of the analytical procedure was ascertained by spiking samples with standard solutions containing 0.2 mg metal/L, except for Cd, which was maintained at a lower concentration of 0.02 mg/L, and then measuring the recovery of each nutrient. The percentage recovery of metals obtained after subjecting the spiked samples to the optimized digestion program was between 90 and 110% (Table 4). This implies that the prescribed digestion procedure does not cause any loss of the metallic nutrients determined. The analytical results obtained fell within acceptable ranges, which confirm the reliability of the digestion and analytical procedures used for the enset samples.

Table 4. Percentage recoveries of metallic nutrients determined in spiked samples, which were digested using the optimized procedure.

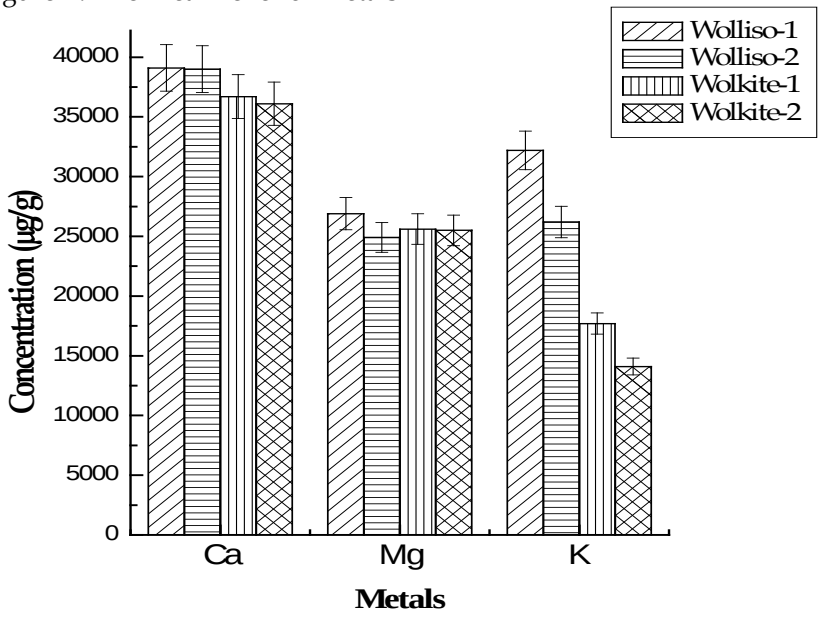
Element	Added (mg/L)	Difference (mg/L)	Recovery (%)
Cd	0.02	0.019±0.001	95±1
Co	0.20	0.182±0.020	91±2
Cr	0.20	0.185±0.002	93±1
Cu	0.20	0.210±0.020	105±2
Fe	0.20	0.190±0.060	95±6
Mn	0.20	0.210±0.020	105±2
Ni	0.20	0.180±0.020	90±2
Pb	0.20	0.220±0.040	110±4
Zn	0.20	0.205±0.070	103±7
Ca	0.20	0.210±0.080	105±8
K	0.20	0.182±0.080	91±8
Mg	0.20	0.180±0.080	90±8

Levels of major and trace metals in enset corm

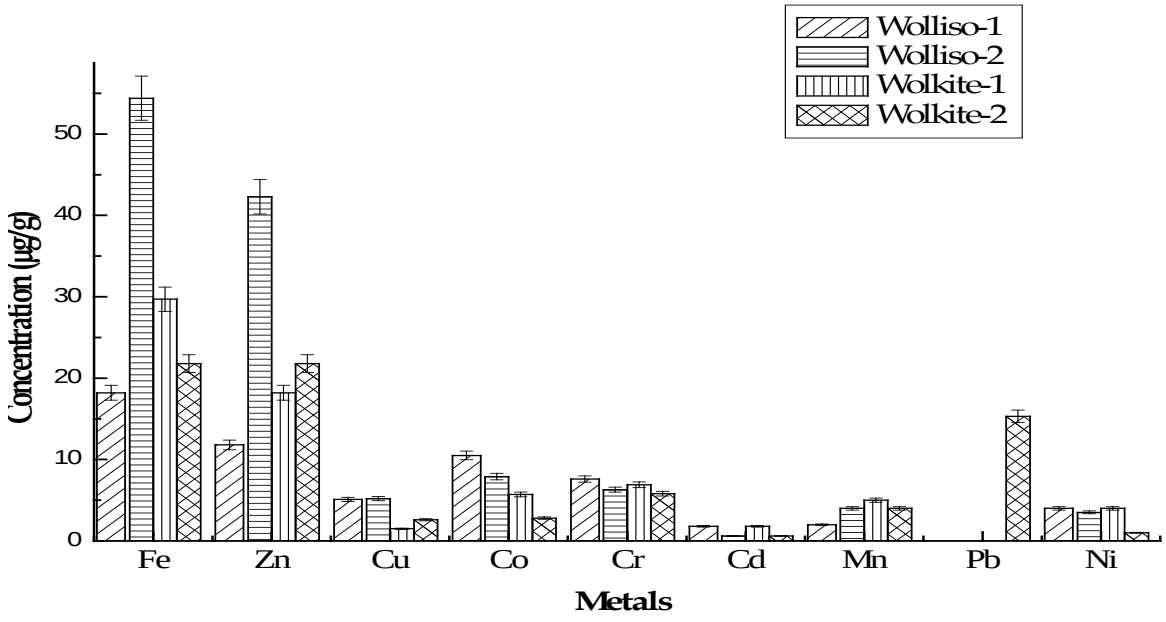
The pseudostem and the corm of enset are the most important food sources for human consumption. Foods derived from enset are low in protein content but have high carbohydrate (Admasu Tsegaye and Struik, 2000). Enset is a major source of carbohydrates, Ca and Fe (Cheesman, 1947; Agren and Gibbson, 1969; Shank, 1996; Bobosha, 2003; Solomon Zewdie *et al.*, 2008). In addition to the nutrients reported in the literature, our study revealed the occurrence of additional mineral nutrients at levels shown in Figure 1.

The distribution and accumulation of metals in plants depends on many factors: species, age of plant, root distribution of plant, physical and chemical nature of the soil, proportion and distribution of the elements, method of cultivation and climatic conditions (Almaz Negash *et al.*, 2002).

The levels of metals in the four samples studied are shown in Figure 1. The mean level of metals in the samples from Wolliso is in the order: Ca > K > Mg > Fe > Zn > Co > Cr > Cu > Ni > Mn > Cd (Pb was below the method detection limit) while that from Wolkite is in the order: Ca > Mg > K > Fe > Zn > Pb > Cr > Mn > Co > Ni > Cu > Cd (Fig. 1 and Table 5).



a) Macro nutrients



b) Trace metallic nutrients

Fig. 1. The metallic composition of unprocessed enset corm collected from Wolliso and Wolkite towns.

Table 5. Comparison of the metallic nutrient composition of unprocessed enset corm determined in this study to processed products reported by Minaleshewa Atlabachew and Chandravanshi (2008), both collected in Wolliso and Wolkite towns.

Metallic nutrient	Range of concentration (μg/g) determined in		
	unprocessed enset corm	processed food products of enset (Minaleshewa Atlabachew and Chandravanshi, 2008)	
		Kocho	*Bulla*
Ca	36,100–39,100	498–584	385–446
Mg	24,900–26,900	180–290	58.4–89.5
K	14,100–32,200	2750–4380	708–875
Fe	18.2–54.4	92.5–135	36.5–59.8
Zn	11.9–42.3	3.4–4.3	2.01–3.53
Cu	1.5–5.2	3.4–4.3	2.01–3.53
Co	2.9–10.5	5.5–6.1	5.01–5.89
Cr	5.8–7.6	5.96–6.42	ND–5.38
Mn	2.0–5.0	8.58–10.1	1.0–4.98
Ni	1.0–4.0	ND–5.61	ND
Cd	0.6–1.8	ND	ND
Pb	ND–15.3	ND	ND

*ND- not detected

Both Wolkite and Wolliso sites have comparable levels of most metals, such as Ca, Mg, Fe, Zn, Cr, Cd, Mn and Ni. The major nutrients Ca, Mg and K dominantly occur in enset corm whereas Fe and Zn are available at higher concentrations among the trace nutrients.

The metallic nutrients Ca, K, Mg, and Cr were accumulated in comparable levels in enset samples from Wolliso and Wolkite towns, irrespective of the site of sampling. The occurrence of Ca, Mg and K at high levels could be related to their natural abundance in the Earth's crust. On the other hand, Cd was the least in all four samples, which may be linked to its low natural abundance in the soil, low absorption constant and liability to complexation with the soil organic matter. Since the enset plants in both sites were collected from the gardens in the nearby villages, contamination by Cd in batteries cannot be ruled out.

Pb was found below method detection limits in three of the samples obtained from Wolliso and Wolkite towns. Unexpectedly high levels of Pb were detected in only one plant from Wolkite town. Such unusually high levels could be attributed to contamination, though to our knowledge, no contamination was made during sampling and transportation. On the contrary, a consistently high level was measured in all the triplicate samples analyzed for Pb. Possible sources of the observed high Pb level could include accidental contamination by lead sources of the soil in which the plant was grown. Accidental spillage of acid-batteries and burial of dry leaded batteries in urban areas cannot be disregarded. Unambiguous explanation could only be made by detailed analysis of the soil and more enset plants from the area.

Among the trace metals, the levels of Fe and Zn were higher than the rest. The high level of Fe noted in the plants may be attributed to high plant requirements, abundance of Fe in the soil and to moderate pH ranges (5.6 to 7.3) of the soil (Bobosha, 2003). Acidic to slightly basic pH of the soil and high abundance of Zn in the region may have contributed to high zinc levels (Bobosha, 2003). The metallic nutrients Fe and Zn were accumulated in comparable levels irrespective of the samples collected from Wolkite, for which similarity in age and the soil contents can be regarded as potential sources. However, this was not observed in Wolliso samples that might be due to age differences among the plants. The accumulations of Ni and Mn in the plants were comparable irrespective of the sites. The level of Cu was comparable with respect to the plants but not with sites, suggesting differences in abundance in the soils of the two sites.

The two sites have identical weather conditions, but among the metallic nutrients determined using the optimized method almost more than three-fourth of them are found in higher

levels in Wolliso relative to Wolkite. From Figure 1a, the levels of Ca and K in corm samples from Wolliso are higher than those from Wolikite for all samples whereas that of Mg is comparable. Similar pattern is seen for Cu and Co as shown in Figure 1b. However, high levels of Zn and Fe were determined in samples from Wolliso-2 (Fig. 1b). Irrespective to sample and sites, Ni, Cr and Mn were comparable except one sample from two sites for Ni and Mn.

Comparison of unprocessed enset with its processed food products (kocho and bulla)

The levels of the metals in unprocessed enset corm have been compared with processed food (*bulla* and *kocho*) collected from Wolliso and Wolkite (Table 5). In general, the levels of metals in unprocessed enset are higher than the reported metal content of processed enset food. *Kocho* and *bulla*, the processed food products of enset are obtained by fermenting the scraped and decorticated edible part of enset leaf sheath and the corm, which involves a number of physico-chemical processes. During these processes, some metals are definitely lost from *kocho* and *bulla* (Minaleshewa Atlabachew and Chandravanshi, 2008).

The Fe level in the processed enset (*bulla* and *kocho*) is higher than in the unprocessed counterpart. This is presumably due to contamination of the product by Fe during the food-processing step since most utensils used are made from Fe. However, for the other metals the levels in the processed enset are smaller than that in the unprocessed product, presumably by the removal of different parts of the plant including fibers, residues and even by some amount the filtrate during processing.

In general, if *kocho* and *bulla* show higher levels of metals in comparison with the unprocessed corm, the increase in nutrients levels may be ascribed to different factors such as storage, processing, and age of harvested (processed) enset plant. In addition, since the processed samples were collected from the market they might be from different farms (sites), variety, soil types, climatic conditions and so on (Minaleshewa Atlabachew and Chandravanshi, 2008).

CONCLUSION

The levels of selected metals (Ca, Mg, K, Fe, Zn, Mn, Cr, Co, Cu, Ni, Cd and Pb) in unprocessed enset corm were determined by FAAS after subjecting the plant to an efficient wet digestion method, the efficiency of which was evaluated by percentage recovery values. A good percentage recovery was obtained (90–110%). The ANOVA results suggest that there were no significant variations in the levels of elements in different enset corm. The toxic metals Cd and Pb were either present in smaller amounts or absent in the enset corm. This study further showed the occurrence of essential metals in appreciable levels, which indicates the possibility of using the plant as a good source of essential metals for those who consume food derived from enset plant.

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