CHAPTER III

Determination of Metal Contents of Wild Edible Fruits

Deficiency of minerals affects billions of people globally. Minerals are of prime importance in determining the nutritional value of fruits. Edible wild fruits play an important role in supplementing staple foods by providing minerals and vitamins [1]. Minerals supplement are of great importance in human diet although they constitute only 4–6% of human body weight. The essential macro minerals such as sodium, potassium, calcium, magnesium, phosphorus, chloride *etc.* are required in the diet in an amount greater than 100 mg per day [2, 3]. Micro elements such as iron, zinc, copper, manganese, iodine, selenium and molybdenum are normally required in the diet in an amount less than 100 mg per day [3]. Micro-elements are important part of hormones, enzymes and cells in the body [4, 5]. Some elements like Cu, Fe, Mn and Se have also been recognized to possess antioxidant properties contributing to the beneficial properties of foodstuffs [6]. The concentration of elements in fruit is known to be affected by the species and cultivar of plant, soil conditions, climatic conditions, use of fertilizers, maturity stage, agricultural chemicals and availability of soil elements [7]. The toxic metals in foodstuff are unfit for human consumption and hence the determination of elemental composition of food is important.

The available informations regarding the elemental composition of five wild edible fruits *viz. G. sapida, O. alismoides, A. dioica, A. bunius,* and *E. operculata* have not been found in literatures to the best of our knowledge. Hence, in this study, for the first time we are reporting the metal profiles of these five fruits from Assam of North East India.

III.1 Materials and Methods

III.1.1 Sample preparation

The dried samples of collected fruits (**Table II.1**) were digested according to wet digestion method of AOAC [8]. Briefly, 1 g powdered sample prepared as per the **Section II.2.3** (**Page no. 67**) was taken in 250 mL beaker and 12 mL of HNO_3 was added. The mixture was kept overnight at room temperature. After that 4 mL perchloric acid ($HClO_4$)

was added to this mixture for total digestion and the mixture was boiled until a white fume was observed. The mixture was cooled down and the volumes of the contents were made to 100 mL with distilled water. Finally, the mixture was filtered using Whatman no.1 filter paper and it was submitted for metal analysis.

III.1.2 Determination of metal contents

Major and minor elements are considered as essential nutrients in food [9]. Therefore, minerals such as sodium, potassium, calcium, magnesium, iron, zinc, copper, manganese, and cobalt were determined using Atomic Absorption Spectrometer (AAS-ICE 3500, Thermo Scientific, UK) at Sophisticated Analytical Instrumentation Centre (SAIC), Tezpur University. The results obtained were presented in mg/100 g of dry weight.

III.1.3 Statistical analysis

All the experiments were carried out for three independent replicates and the data were represented in terms of mean ± standard deviation. OriginPro 8.5 software (MA 01060, OriginLab Corporation, USA) was used for statistical analysis and executed by the one-way ANOVA and *t*-test at $p < 0.05$.

III.2 Results and Discussion

The macro- and micro-elements determined in the wild edible fruits are presented in **Table III.1** and **Table III.2** respectively. The **Fig. III.1** and **Fig. III.2** shows the variation of macro- and micro-elements of five wild edible fruits. High concentration of sodium was found in *O. alismoides* (162.50 ± 1.13 mg/100 g) and lowest in *A. dioica* (3.29 ± 0.04 mg/100 g). The sodium levels of *G. sapida* (3.87 ± 0.02 mg/100 g), *E. operculata* (4.64 ± 0.05 mg/100 g), *A. dioica* (3.29 ± 0.04 mg/100 g) and *A. bunius* (5.38 ± 0.03 mg/100 g) were lower than the values reported in some commercial fruits (6–28 mg/100 g) by Gopalan *et al.* [10]. The sodium content of *E. operculata* (4.64 ± 0.05 mg/100 g) and *A. bunius* (5.38 ± 0.03 mg/100 g) were comparable to that of *Ziziphus mauritiana* (5.03 mg/100 g) reported by Mahapatra *et al.* [11]. Similarly, the sodium contents of some wild fruits reported by Sundriyal and Sundriyal [12] ranged from 23–78 mg/100 g. The sodium content of the fruits may depend on sodium of soils. Sodium plays a significant role in cellular work, fluid distribution and blood pressure [13].

Table III.1: Macro-element analysis of wild fruits (mg/100 g DW)

Plants	Na	K	Ca	Mg
G. sapida	3.87±0.02^{a}	1243.79±8.71^{a}	472.56±0.94^{a}	122.01±0.24^{a}
E. operculata	4.64±0.05^{b}	2219.74±6.66^{b}	714.82±8.58^{b}	172.39±0.52^{b}
A. dioica	3.29±0.04^{a}	1555.96±15.56^{c}	337.85±1.69^{c}	73.77±0.29*c*
A. bunius	5.38±0.03^{c}	3043.85±6.09^{d}	787.90±14.18^{d}	250.71±0.25^{d}
O. alismoides	162.50±1.13^{d}	2776.15±28.89^{e}	206.02±7.69^{e}	252.83±2.81^{e}

Values were expressed as mean of 3 replicates ± standard deviation; DW, Dry weight; The data with different letters in a column are significantly different from each other at $p < 0.05$.

Table III.2: Micro-element analysis of wild fruits (mg/100 g DW)

Plants	Fe	Cu	Zn	Mn	Co
G. sapida	7.57±0.02^{a}	0.91±0.05^{a}	1.32±0.04^{a}	3.21±0.03^{a}	0.29±0.02^{a}
E. operculata	8.28±0.03^{b}	1.49±0.05^{b}	1.83±0.01^{b}	2.82±0.02^{a}	0.35±0.05^{a}
A. dioica	6.65±0.03^{c}	0.64±0.05^{a}	0.93±0.02^{a}	5.01±0.05^{b}	0.26±0.02^{a}
A. bunius	7.58±0.02^{a}	1.77±0.06^{b}	2.91±0.01^{c}	7.62±0.02^{c}	0.39±0.02^{a}
O. alismoides	28.96±0.11^{d}	5.51±0.10^{c}	2.78±0.04^{c}	13.02±0.20^{d}	0.49±0.05^{a}

Values were expressed as mean of 3 replicates ± standard deviation; DW, Dry weight; The data with different letters in a column are significantly different from each other at $p < 0.05$.

The potassium content of the wild edible fruits investigated varied between *G. sapida* (1243.79 ± 8.71 mg/100 g) and *A. bunius* (3043.85 ± 6.09 mg/100 g). Amongst the macro-elements, potassium content was found to be the most abundant mineral in all the fruits. The potassium content of *E. operculata* (2219.74 ± 6.66 mg/100 g) is similar to *Masau* fruits reported by Nyanga *et al*. [14]. High content of potassium was found in *A. bunius* (3043.85 ± 6.09 mg/100 g) followed by *O. alismoides* (2776.15 ± 28.89 mg/100 g) and *E. operculata* (2219.74 ± 6.66 mg/100 g) which were in agreement with results reported by Amarteifio *et al*. [15] and Saka *et al.* [16]. Potassium has diverse roles in the human metabolism and body functions and is important for proper functioning of all body cells, tissues and organs. Food rich in potassium are generally used for the treatment of heart disease and rheumatoid arthritis [17]. The recommended dietary allowance of sodium and potassium intake level per day is not more than 2400 mg for a healthy adult and 4700 mg respectively [18], while the recommended daily allowance of magnesium for men of 19–30 years old is 400 mg per day and 310 mg per day for women of 19–39 years old [19].

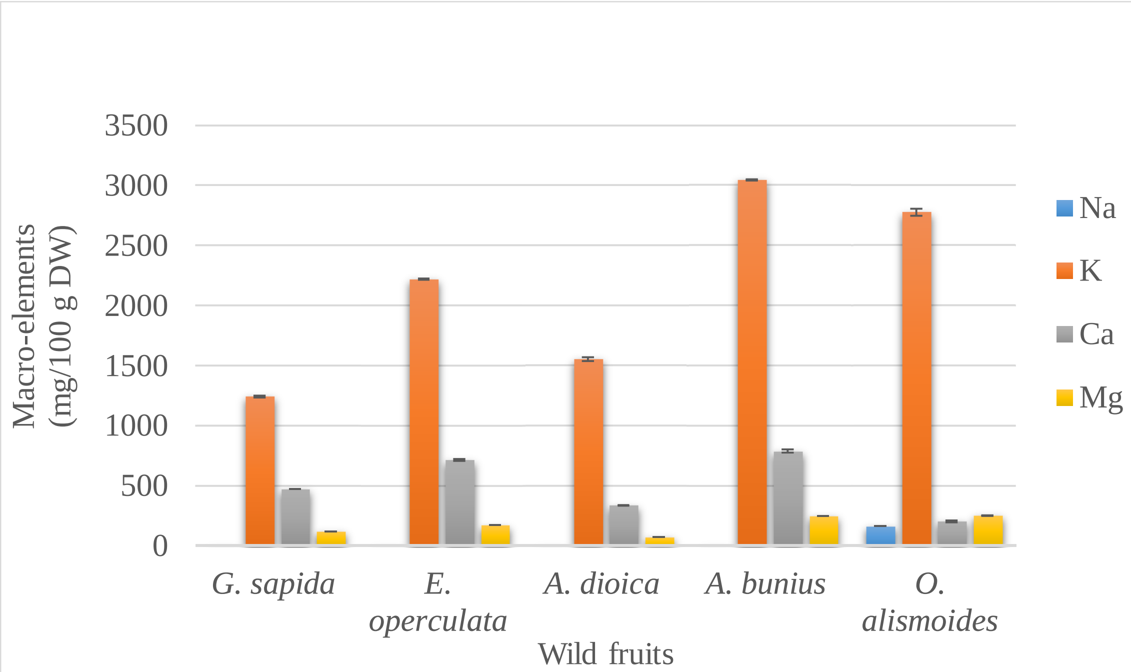

Fig. III.1: Variation of macro-elements in wild edible fruits.

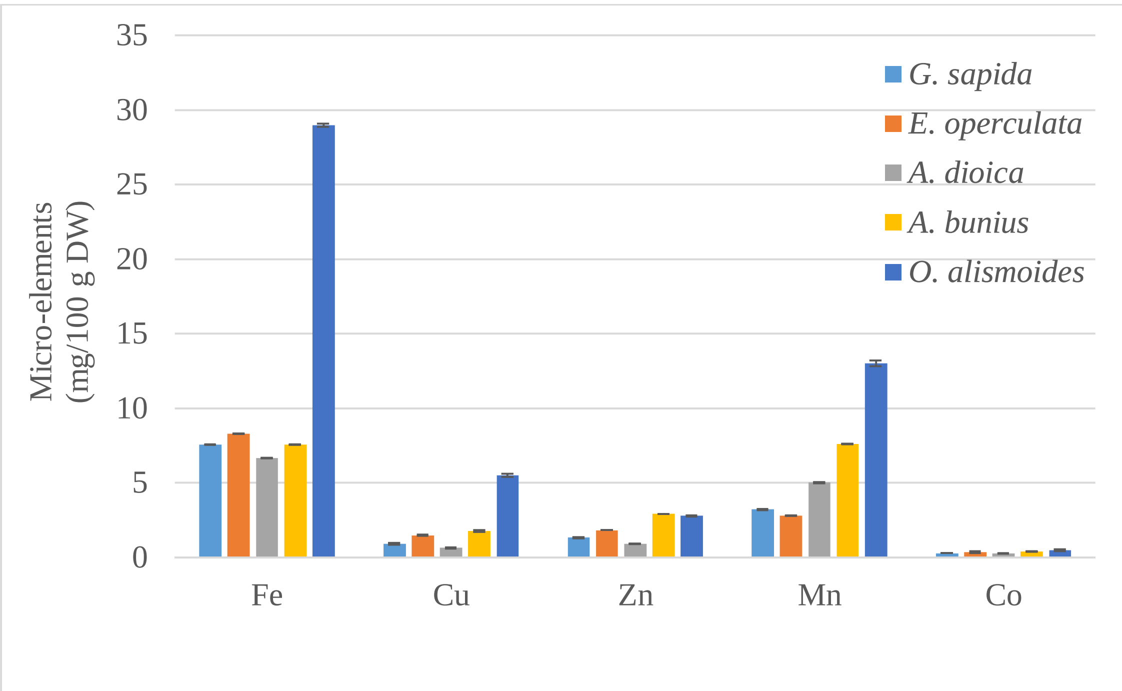

Fig. III.2: Variation of micro-elements in wild edible fruits.

The calcium content was highest in the fruit of *A. bunius* (787.90 ± 14.18 mg/100 g) followed by *E. operculata* (714.82 ± 8.58 mg/100 g), *G. sapida* (472.56 ± 0.94 mg/100 g), *A. dioica* (337.85 ± 1.69 mg/100 g) and *O. alismoides* (206.02 ± 7.69 mg/100 g). Leterme *et al*. [20] reported calcium content of *Annona squamosa* fruit is 991 mg/100 g which was higher in comparison to the values of all the wild fruits studied herein. Calcium content of *O. alismoides* (206.02 ± 7.69 mg/100 g) was found within the range of *Masau* fruits (160.0 ± 0.3 – 254.0 ± 0.1 mg/100 g) reported by Nyanga *et al*. [14]. Similar to the values of *A. dioica* and *O. alismoides,* Seal [21] also reported close value of calcium. Calcium is found to be effective in muscle functioning and in building of skeletal structures while magnesium being a macro-element is essential in the ionic balance and enzyme co-factors [22]. Magnesium cooperates with calcium in coagulation of blood and muscular contraction [23]. The recommended daily intake of calcium ranges from 1000 to 1500 mg for adults. The calcium, magnesium and potassium have essential roles in a variety of body functions including bone health and heart, muscle, nerve and immune systems maintenance. *O. alismoides* fruit showed highest levels of magnesium (252.83 ± 2.81 mg/100 g) and *A. dioica* (73.77 ± 0.29 mg/100 g) showed the lowest magnesium content. The present study also showed high amounts of magnesium in *A. bunius* (250.71 ± 0.25 mg/100 g) and in *E. operculata* (172.39 ± 0.52 mg/100 g). Similarly, Leterme *et al*. [20] and Ekholm *et al*. [7] also reported comparable values of magnesium content. Magnesium is the most frequently found metal ion cofactor for many enzymatic reactions and deficiency of magnesium causes various health disorders including high blood pressure, asthma, angina pectoris, cardiac arrhythmias, coronary artery disease, all types of musculoskeletal disorders, mitral valve prolapse, epilepsy, panic disorder, anxiety, chronic fatigue syndrome and psychiatric conditions [11, 17, 23].

The amounts of iron contained in the fruits investigated varied between 6.65 ± 0.03 mg/100 g in *A. dioica* to 28.96 ± 0.11 mg/100 g in *O. alismoides*. High content of iron was found in *O. alismoides* which was similar to the values of *Terminalia chebula* reported by Seal [21]. The iron detected in *A. bunius, E. operculata* and *G. sapida* fruits were 7.58 ± 0.02 mg/100 g, 8.28 ± 0.03 mg/100 g and 7.57 ± 0.02 mg/100 g respectively which were comparable to that of *Calamus guruba* (8.50 ± 0.19 mg/100 g) and *Melastoma malabathricum* (8.00 ± 0.19 mg/100 g) reported by Nayak *et al*. [24]. The amount of iron in all the fruits studied were found higher in comparison to Taikor fruit (0.08 ± 0.01 mg/100 g) and Satkara fruit (0.15 ± 0.02 mg/100 g) reported by Islam *et al*. [19]. Li *et al*. [25] reported the iron content of five cultivars of Chinese jujube and found to be ranged from 4.68 to 7.90 mg/100 g. Gnansounou *et al*. [23] also reported 14.75 ± 0.25 mg/100 g of iron content in

Dialium guineense fruit which was superior to that of the fruits of this study. Deficiency of iron causes anaemia and immune system dysfunction [26]. The recommended daily intake of iron for adult female is 18 mg and for adult male is 8 mg [18]. Iron is an essential trace element and is necessary for normal functioning of the central nervous system, haemoglobin synthesis and in the oxidation of carbohydrates, proteins and fats [27, 28].

Copper is essential for the production of enzyme in the body and plays a vital role in biological electron transport [29, 30]. Copper deficiency causes abnormal glucose and cholesterol metabolism, reduced energy production and increased oxidative damage [31]. Copper complexes can act as antiulcer, anticancer, anticonvulsant and anti-diabetic agents [32]. The copper concentration was found highest in *O. alismoides* (5.51 ± 0.10 mg/100 g) and the lowest content in *A. dioica* (0.64 ± 0.05 mg/100 g). Nayak *et al*. [24] reported copper content of *Careya arborea* as 1.90 ± 0.04 mg which is comparable to the values of *A. bunius* (1.77 ± 0.06 mg/100 g) and *E. operculata* (1.49 ± 0.05 mg/100 g). The amount of copper in *G. sapida* (0.91 ± 0.05 mg/100 g) and *A. dioica* (0.64 ± 0.05 mg/100 g) were found similar in comparison to *Terminalia bellirica* fruit (0.8 ± 0.02 mg/100 g) and *Morus indica* fruit (0.7 ± 0.01 mg/100 g) reported by Seal [21].

The amount of zinc was found highest in *A. bunius* (2.91 ± 0.01 mg/100 g) and *A. dioica* fruit (0.93 ± 0.02 mg/100 g) showed the lowest zinc content. The zinc levels found in *A. bunius* and *O. alismoides* were close to that of the fruits of raspberry (2.97 ± 0.1 mg/100 g), blackberry (2.30 ± 0.35 mg/100 g), and red currant (2.11 ± 0.54 mg/100 g) reported by Plessi *et al*. [33] and these values are slightly higher to that of *E. operculata*, *G. sapida* and *A. dioica* fruits. The zinc content of all the fruits investigated were found higher than the fruits of *Garcinia pedunculata* (0.15 ± 0.01 mg/100 g) and *Citrus macroptera* (0.21 ± 0.01 mg/100 g) reported by Islam *et al*. [19]. Zinc content of *O. alismoides* and *A. bunius* were also similar to that of *Borojoa sorbilis* and similarly, *E. operculata*, *G. sapida* and *A. dioica* fruits also showed close value of zinc to that of *Zizyphus jujuba* reported by Leterme *et al*. [20]. The recommended dietary allowance for zinc is 11 mg per day for adult men and 8 mg per day for adult women [17]. Excessive zinc intake has been reported to be toxic [34]. Zinc is an essential trace element important for human growth and also increases resistance to infection [18]. It is a cofactor for the antioxidant enzyme super oxide dismutase and is involved in functioning of over 300 different enzymes, and for a number of enzymatic reactions in carbohydrate and protein metabolism [35].

The manganese concentrations of the fruits studied varied from 2.82 ± 0.02 mg/100 g in *E. operculata* to 13.02 ± 0.20 mg/100 g in *O. alismoides*. The highest Mn value was found in

O. alismoides fruit. The Mn contents in wild fruits reported by Eromosele *et al.* [36] were in the range between 0.11 mg/100 g (*Sclerocarya birrea*) and 3.50 mg/100 g (*Zizyphus mauritiana*). These values are lower in comparison to the Mn values of the wild fruits studied herein, except *G. sapida* (3.21 ± 0.03 mg/100 g) and *E. operculata* (2.82 ± 0.02 mg/100 g) which are comparable to the value of *Zizyphus mauritiana*. Daily requirement of Mn for healthy person is 4.50 mg [37]. Manganese is an essential co-factor of metalloenzymes and plays essential role in a number of physiologic processes including carbohydrate, lipid and protein metabolism [31].

The level of cobalt was found highest in *O. alismoides* fruit (0.49 ± 0.05 mg/100 g) followed by *A. bunius* (0.39 ± 0.02 g/100 g), *E. operculata* (0.35 ± 0.05 mg/100 g), *G. sapida* (0.29 ± 0.02 mg/100 g) and *A. dioica* (0.26 ± 0.02 mg/100 g). Both *A. bunius* and *E. operculata* showed similar results of cobalt. *G. sapida* and *A. dioica* also showed the similar content of cobalt. The cobalt content of *O. alismoides* fruit (0.49 ± 0.05 mg/100 g) is similar to the value of *Ziziphus spinachristi* (0.43 mg/100 g) [35]. Cobalt is an essential part of vitamin B12 also known as cyanocobalamin, and is an important nutritional element having therapeutic value in pharmacological doses. Deficiency of cobalt can cause pernicious anaemia and cobalt has also been established to enhance the effects of insulin and its action [31, 38]. As human body cannot synthesize vitamins, the consumption of diets containing these compounds is essential.

III.3 Conclusion

The study revealed that the wild edible fruits contained appreciable amounts of macro- and micro-minerals. *A. bunius* fruits had the highest content of K and Ca whereas *O. alismoides* fruits had the highest content of Na, Mg, Fe, Mn, Co and Cu. The mineral contents of these fruits were comparable to those of some commercially cultivated fruits. This makes the fruit a potential contributor towards a balanced diet for children and adolescents, considering their low cost and abundance. The results highlighted the significance of studied fruits as important sources of nutrients for the rural people and for the benefits of increasing the use of these species as dietary supplements. This study also suggests that consumption of these fruits in adequate amount could be used to overcome malnutrition problems faced by rural population. Future research work could be conducted on processing for value addition, minimizing loss of nutrient content through optimization of preservation techniques.

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