

1 **Inorganic nutrients and heavy metals in some wild edible plants consumed by rural**
2 **communities in Northern Uganda: implications for human health**

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12 **ABSTRACT**

13 For centuries, wild edible plant species have sustained local communities across Africa by
14 supplementing households' diets in seasons of food shortage. Wild edible plants contain
15 inorganic nutrients, which are essential for the proper functioning of organisms. However,
16 their nutritional contents have not been well researched and are generally poorly understood.
17 This study aimed to quantify the levels of inorganic micro-and macronutrients as well as
18 heavy metals (Mg, Ca, K, Fe, Zn, Cd, Hg and Pb) in selected wild edible plants traditionally
19 consumed among the Acholi communities in northern Uganda, and associated health risks of
20 consuming them. The leaves and young stems of 12 wild edible plants, viz: *Acalypha*
21 *rhomboidea*, *Asystacia gangetica*, *Crassocephalum sacrobasis*, *Crotalaria ochroleuca*,
22 *Heterotis rotundifolia*, *Hibiscus cannabinus*, *Hibiscus sp.*, *Hibiscus surattensis*, *Ipomoea*
23 *eriocarpa*, *Maerua angolensis*, *Senna obtusifolia* and *Vigna membranacea* were air-dried and
24 crushed to powder. The powders were then macerated using aqua regia solution and analysed
25 in triplicates using the Atomic Absorption Spectrophotometry (AAS). The target hazard

26 quotient (THQ) of Pb was calculated for non-carcinogenic health risks. Mg, Ca, K, Fe, Zn
27 and Pb were detectable in all the wild edible plants sampled. All inorganic nutrients
28 (mg/100gdw), were below the Recommended Daily Allowance (RDA); Mg (9.4 ± 0.19 to
29 10.4 ± 0.15), Ca (119 ± 5.82 to 1265 ± 14.9), Fe (3.29 ± 0.02 to 11.2 ± 0.09), Zn (0.52 ± 0.02
30 to 2.36 ± 0.03). Hg and Cd were below detectable limits in all the samples tested. The content
31 of Pb (0.69 ± 0.11 to 1.22 ± 0.07) was higher than the CODEX and EU limits of 0.1ppm but was
32 below the recommended threshold of 1. The health risk assessment revealed no potential
33 hazards both in children and adults. However, there is a need to study the bioavailability of
34 Pb when the vegetables are consumed due to factors such as indigestion and antinutritional
35 compounds.

36
37 **Key words:** Inorganic nutrients, heavy metals, Target Hazard Quotient, food safety, wild
38 edible plants, Acholi sub-region

40 1. Introduction

41 Micronutrient deficiencies remain a significant global public health challenge. More than two
42 billion people in the world suffer from micronutrient deficiencies. This is mainly due to the
43 assimilation of diets that lack essential micronutrients, particularly vitamin A, iodine, iron
44 and zinc (Phillips et al., 2014; Hannah & Max, 2017; Tribaldos, Jacobi & Rist, 2018). The
45 majority of these people live in low- to middle-income countries. The groups most vulnerable
46 to micronutrient deficiencies are young children, pregnant women, lactating mothers and the
47 elderly. This can be mainly attributed to their relatively substantial demand for vitamins and
48 minerals and they are more susceptible to the negative outcome of deficiencies (Black, 2003;
49 Smith et al., 2006). For example, for a pregnant woman, micronutrient deficiencies have been
50 linked to the altered length of gestation, and impaired foetal development and growth, which

51 can lead to pregnancy loss, greater risk of dying during childbirth, and birth to a small or
52 mentally impaired baby (Gernand et al., 2016). For a young child, micronutrient deficiencies
53 increase the risk of dying due to infections and contribute to impaired physical and mental
54 development.

55
56 The consumption of wild edible plants is seen as a sustainable solution to inorganic
57 micronutrient deficiencies. Many communities, particularly in northern Uganda, consume
58 wild edible plants (Acipa et al., 2013; Anywar et al., 2014; Nyero et al., 2021). Wild edible
59 plants are essential in supplementing staple foods by supplying vitamins, minerals,
60 phytochemicals and antioxidants. They have also been reported to be good sources of macro-
61 and micronutrients or trace elements, including B, Cu, Fe, Mn, Mo, Zn, Na, K, Mg, Ca, N, S,
62 and P (Anywar et al., 2017; Cantwell-Jones et al., 2022). Inorganic micronutrients are
63 particularly needed in the body in small amounts to drive essential processes, including
64 energy metabolism, nerve functions and muscle contraction (Maret, 2017). Zinc plays a vital
65 role in transmitting information within and between cells. Therefore, these food plants could
66 help overcome macro-and micronutrient deficiencies since the local community easily
67 accesses them cheaply. However, wild edible plants grow in natural environments. They are
68 therefore vulnerable to contamination with heavy metals like Cd, Ag, Se, Fe, Mg, Zn, Cu,
69 Mo, Pb, Hg and Ni from different sources, including soil and run-off water (Manzoor, et al.,
70 2018). These wild edible plants take up the metals by absorbing them from contaminated soil,
71 water and deposits on plant parts with high exposure to polluted air (Shahsavani et al., 2017;
72 Afonne & Ifediba, 2020). However, given that wild edible plants are regularly and readily
73 consumed in most rural areas because of their abundance, nutrient richness and potential
74 health benefits, their continued consumption may pose severe health risks for the consumers
75 (Volpe et al., 2015). Human exposure to toxic metals is a global environmental health burden

76 today (Badea, et al., 2018; Hassanen, et al., 2021). This is because heavy metals can
77 bioaccumulate in living organisms and can be toxic at elevated levels (Maurya et al., 2019;
78 Obeng-Gyasi, 2019). For instance, Pb is one of the systemic environmental toxicants
79 implicated in causing cancer, neurological and cardiac problems, kidney damage, and
80 hemolytic anemia (Schober et al., 2006; Meshref et al., 2014). Lead has been used worldwide
81 for centuries and is present in products such as car batteries, gasoline and paints leading to
82 increased toxicity in humans (Obeng-Gyasi, 2019). In blood, Pb toxicity disrupts the
83 functions of the digestive, circulatory, central nervous, respiratory and reproductive systems
84 and everyday activities of enzymes (Szymanski, 2014). Children are at a higher toxicity risk
85 than adults because their body tissues are still young and susceptible to Pb contamination
86 (Naranjo, 2020). Another heavy metal of concern is Cd because it is mostly responsible for
87 kidney and liver dysfunction, which is indicated by the passing of proteins in urine (Matović
88 et al., 2015; Satarug, 2018). Long-term exposure to Cd may cause numerous types of cancer
89 (Genchi et al., 2020). Knowledge of the inorganic nutrients content in food is needed,
90 especially in the current dietary shift to fast foods, which lack the required nutrients for body
91 health (Jaworowska et al., 2013). Consumption of heavy metals contaminated plants negates
92 the benefits of eating such plants and results in heavy metal poisoning. Investigations of the
93 heavy metals in wild edible plants are thus essential for environmental safety and for
94 reducing the risks associated with their consumption. Hence, there is a need for continuous
95 scientific assessment of the heavy metals in wild edible plants, especially those grown in
96 urban areas with contaminations from industrial and domestic wastes (Visconti et al., 2019).
97 Although certain heavy metals such as Co, Mn, Ni, Cu and Fe are essential components for
98 various biological activities within the body, their elevated levels can cause numerous health
99 consequences to humans. Thus, this study aimed to determine the contents of inorganic

100 micro-and macronutrients and heavy metals in selected wild edible plants consumed in the
101 Acholi sub-region.

102

103 **2. Materials and Methods**

104 **2.1. Collection and preparation of plant samples**

105 Healthy leaves and young stems of twelve wild edible plants from two sub-counties in Omoro
106 district within the Acholi sub-region of northern Uganda were collected using standard
107 methods according to the World Health Organization guidelines on good agricultural and
108 collection practices for medicinal plants (WHO, 2004)^b. These plants were *Acalypha*
109 *rhomboidea* Raf., *Asystasia gangetica* (L.) T. Anderson, *Crassocephalum sacrobasis* (DC.)
110 S. Moore, *Crotalaria ochroleuca* G.Don., *Heterotis rotundifolia* (Sm.) Jacq.-Fél, *Hibiscus*
111 *cannabinus* L., *Hibiscus sp.*, *Hibiscus surratensis* L., *Ipomoea aeriocarpa* R.Br., *Maerua*
112 *angolensis* DC., *Senna obtusifolia* (L.) Irwin & Barneby and *Vigna membranacea* A. Rich.
113 Voucher specimens of the plant species were collected and taken to the Makerere University
114 herbarium for identification. The plant samples were shade dried at room temperature for 5 to
115 10 days or until the parts were completely dried. The dried samples were grounded into a fine
116 powder using an electric grinder.

117

118 **2.2. Determination of inorganic nutrients and heavy metals in edible plants**

119 The powder samples from each plant were used for the elemental assay using a standard
120 procedure based on AOAC methods (Williams, 1984). Eight inorganic elements were chosen
121 because of their various roles in the human body's physiological and biochemical functions.
122 These elements were Mg, Ca, K, Fe, Pb, Zn, Hg, and Cd. Quantification tests for the elements
123 were done in triplicate. About 2 g of powder sample was weighed into a clean boiling tube.
124 Distilled water (5.0ml) and concentrated nitric acid (25ml) were added and mixed by shaking

125 gently. The mixture was refluxed over a water bath at 90°C for 4 hours, cooled and 10ml of
126 70% perchloric acid added. The tubes were refluxed over a water bath at the same
127 temperature for one hour and later cooled to room temperature. Concentrated hydrochloric
128 acid (2ml) was then added to the sample, made to 100ml with distilled water and filtered. All
129 glassware used in the analysis was washed, soaked in aqua regia for two hours, then rinsed
130 with deionised water and dried in the oven. All reagents used in this study were of analytical
131 grade: hydrochloric acid ‘AnalaR’ (sp. gr. 1.18, BDH), nitric acid ‘AnalaR’ (sp. gr. 1.42,
132 BDH), perchloric acid ‘AnalaR’ (sp. gr.1.70 BDH), stock solutions 1000ppm (Sigma-
133 Aldrich) of Mg, Ca, K, Fe, Pb, Zn, Hg and Cd were serially diluted to make standard
134 solutions in the concentrations of 0.125, 0.25, 0.50, 1.00 ppm for calibration. To both
135 standard and sample solutions, 1% (w/v) lanthanum solution was added to overcome potential
136 interferences. The samples were then analyzed using a graphite furnace flame Atomic
137 Absorption Spectrophotometer (Shimatzu model AA-63000, Japan). The mineral
138 concentrations were expressed as mg/100g dry weight (dw) and compared with the
139 Recommended Daily Allowances (Allowances, 1989; WHO, 2004^a; EFSA, 2016).

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141 **2.3. Statistical analysis**

142 The data were analyzed using the statistical package for social sciences, SPSS version 26.0,
143 and presented as mean \pm standard deviation. Differences in inorganic nutrient and heavy
144 metal contents among plant species were evaluated using analysis of variance (ANOVA)
145 followed by Turkey Post-Hoc test as the multiple comparison procedure.

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147 **2.4. Human health risk assessment**

148 The heavy metals health risk assessment was done using the standard method (Rahmdel et al.,
149 2018). The estimated daily intake (EDI) and target hazard quotient (THQ) were calculated to

150 determine the potential effects of the heavy metal contamination on the health of both
151 children and adults.

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153 **2.4.1. Estimated Daily Intake**

154 The estimated average daily intake, EDI (mg/Kg body weight/day) represented an estimate of
155 the daily exposure dose of pollutant/heavy metals to which consumers might be exposed
156 through their diets. The EDI was calculated using the formula = $C \times CR \times IR / BW$ (García-Rico
157 and Tejeda-Valenzuela 2020; Xiong et al., 2020), Where C is the concentration of heavy
158 metal, CR is the conversion factor (To convert the concentration of sample from dry weight
159 to fresh weight values, a conversion factor of 0.2 was used based on the moisture content of
160 fresh leaf (80%); IR is the average daily consumption which was considered as 0.3
161 kg/person/day (Thang et al., 2021), 0.17 kg per person per day (Liu et al., 2017) and 0.1 per
162 person/day (Njuguna et al., 2019). BW is the average body weight of consumers, which was
163 estimated 27 kg for children aged 6-9yrs (Nsibambi, 2013) and 70.3kg for adults (Kirunda,
164 2017, Echodu et al., 2019).

165

166 **2.4.2. Target Hazard Quotient**

167 The target hazard quotient (THQ) of each pollutant/heavy metal is an estimate of the non-
168 carcinogenic health risk level (García-Rico and Tejeda-Valenzuela; 2020; Xiong et al. 2020)
169 due to the consumption of wild edible plants. THQ refers to the mean daily dose of metal
170 with reference to its reference dose. According to US EPA, (2011) and Zhang et al. (2018),
171 THQ and HI values >1 indicate a potential adverse cancer effect, while values < 1 denote
172 non-adverse cancer risk in consumers. To estimate the human health risk from consuming
173 heavy metals/pollutants in food, the THQ was calculated using the following formula:

174 $THQ = \frac{EDI}{RfD}$,

175 RfD is the daily intake reference dose (an estimate of the daily dosage to which the
176 consumers may be continuously exposed over a lifetime without experiencing any harmful
177 effects). RfD for Pb = 0.0035 mg/kg/day.

178

179 **3. Results and Discussion**

180 Our findings on metal elements content of selected wild edible plant species (Table1), show
181 that Mg content varied between 10.42±0.15 in *A. gangetica* to 9.48±0.19mg/100g (dw) in *H.*
182 *cannabinus*. These values are higher than the Mg values for *H. cannabinus* reported by
183 Amagloh and Nyarko (2012), which was 508.28 mg/kg. Magnesium concentration in the
184 fresh weight of the wild edible plants was approximately uniform at 0.02mg/g, according to
185 our study. The daily intake of Mg in all the wild edible plants in this study for both adults and
186 children was 2mg (Table 2). This value is lower than the Reference Daily Allowance (RDA)
187 for both children and adults. The assumption is that both adults and children eat at least 100g
188 of fresh vegetables daily. However, these edible plants are not the sole diet of the locals.
189 Thus, other food items consumed contribute towards the realization of the RDA. The RDA
190 values for Mg are (300-600mg) for infants below 6 years, and (280 – 350mg) adults.
191 Magnesium is a cofactor in more than 300 enzyme systems that regulate diverse biochemical
192 reactions in the body, including protein synthesis, muscle and nerve transmission,
193 neuromuscular conduction, signal transduction, blood glucose control, and blood pressure
194 regulation (Faryadi, 2012; Gröber et al., 2015). Magnesium also acts as a cofactor during
195 RNA and DNA synthesis (Glasdam et al., 2016).

196

197 Calcium content varied between 1265.30 ± 14.94 in *S. obtusifolia* to 118.51 ± 5.82 in *I.*
198 *eriocarpa*. Calcium content in fresh weight of vegetables ranges from 2.53 mg/g in *S.*
199 *obtusifolia* to 0.24 in *I. eriocarpa* and *C. ochroleuca* (Table 2). Sudi et al. (2011) reported
200 Ca content of 2.64 ppm , which is lower than the value in our findings. Again, this
201 consumption does not meet children's and adults' daily requirements. The RDA values for Ca
202 are $600\text{--}800 \text{ mg}$ for infants below 6 years, and $800\text{--}1200$ for adults Calcium content in fresh
203 weight ($\text{mg}/100 \text{ g fw}$) of other conventional vegetables for instance cabbages vary from 32.1
204 ± 0.8 to 44.0 ± 1.4 (Masamba & Nguyen, 2008). Calcium salts provide rigidity to the
205 skeleton and calcium ions play a role in many metabolic processes. It is essential for
206 maintaining bones and teeth strong over a lifetime. It also ensures the proper functioning of
207 muscles and nerves and helps blood clot processes (Pravina et al., 2013). Calcium is involved
208 in vascular contraction, vasodilation, muscle functions, nerve transmission, intracellular
209 signaling, and hormonal secretion (Beto, 2015).

210

211 The potassium content varied between $3346.84 \pm 486.86 \text{ mg}/100 \text{ g (dw)}$ in *C. sacrobasis* to
212 $288.37 \pm 1.04 \text{ mg (dw)}$ in *H. surattensis*. Potassium content in fresh weight of vegetables
213 ranges from 6.69 to $0.58 \text{ mg}/100 \text{ g}$. The daily intake of K through eating 100 gm of fresh wild
214 edible plants for adults and children in this study ranged from 58 to 669 mg . This again does
215 not supply the RDA. The RDA values for K are 1600 mg for infants below 6 years and
216 3500 mg for adults (Table 2). Potassium plays an essential role in cell metabolism,
217 participating in energy transduction, hormone secretion, and the regulation of protein and
218 glycogen synthesis (Turck et al., 2016). It also reduces the risk of blood pressure, stroke, and
219 cardiovascular disease (Aaron and Sanders, 2013).

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221 The iron content varied between 11.21 ± 0.08 in *Hibiscus sp.*, and *A. gangetica* to 3.29 ± 0.02 in
222 *S. obtusifolia*. Fe content in fresh weight of the 12 vegetables ranges from 0.02 - 0.01mg/g.
223 The daily intake of Fe through eating 100gm of fresh wild edible plants for adults and
224 children ranged from 1 - 2mg which is below the RDA. The RDA value for Fe was 10mg for
225 infants below three years and adults (Table 3). Iron is an essential mineral for oxygen
226 transport and energy production and is a functional component of hemoglobin and
227 myoglobin. Iron is a crucial part of cytochromes in the electron transport system during the
228 biochemical process of energy production (Alaunyte, 2014).

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230 The zinc content varied between 2.36 ± 0.03 mg/100g (dw) in *C. sacrobasis* to
231 0.52 ± 0.02 mg/100g (dw) in *M. angolensis* (Table 3). Zinc concentration in fresh weight of
232 vegetables ranges was highest in *C. sacrobasis* 0.005mg. The daily intake of Zn in the wild
233 edible plants for adults and children was 0.5mg. The RDA values for Zn are 10mg for infants
234 below three years and adults, respectively. Zinc is an essential component of many enzymes
235 participating in the synthesis and degradation of carbohydrates, lipids, proteins, and nucleic
236 acids, as well as in the metabolism of other micronutrients (Mills, 2013).

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238 The Pb concentration in the twelve vegetables varied from 1.77 ± 0.13 mg/g in *C. ochroleuca*
239 to 0.87 ± 0.02 mg/g in *V. membranacea* (Table 4). These values are higher than 0.005 -
240 0.1ppm reported in a study on vegetables in Jamaica (Antoine, 2017) and the CODEX and
241 EU limits of 0.1mg/kg (CODEX STAN 193-1995; EU-2006). However, the THQ values
242 were less than 1, implying that consumption of wild vegetables does not pose a long-term
243 deleterious effect in children and adults.

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245 **4. Conclusions and Recommendations**

246 Wild edible plants consumed in the Acholi sub-region are rich in inorganic nutrients.
247 However, the amount consumed by the community does not meet the RDA. None of the
248 plants contained detectable levels of Hg or Cd. All the plants contained Pb which was higher
249 than the CODEX and EU limits (0.1ppm). However, the THQ of Pb in all those plants falls
250 below the limit to cause long-term adverse effects. Therefore, consuming these edible plants
251 does not pose a health risk of public concern to the consumer. There is need to promote use
252 of such edible plant through local community sensitization since their consumption can
253 contribute to attaining the RDA which is important for healthy living. Further studies are
254 needed to quantify other inorganic components such as Se, Mn, As, and estimate their
255 bioavailability.

256 **Table 1:** Mean concentration of macro- and micro- nutrients in mg/100g (dw)_± standard deviation

Plant samples	Mg	Ca	Fe	K	Pb	Zn
<i>Acalypha rhomboidea</i>	10.23±0.14 ^{cd}	1170.14±17.0 ^g	8.21±0.04 ^h	2268.2±15.18 ^f	0.99±0.11 ^{ab}	1.38±0.01 ^f
<i>Asystasia gangetica</i>	10.42±0.15 ^d	532.39±25.76 ^e	11.20±0.09 ^j	2180.15±19.20 ^f	1.22±0.07 ^b	1.82±0.01 ^h
<i>Crassocephalum sacrobasis</i>	9.83±0.07 ^{ab}	150.12±1.82 ^a	9.17±0.03 ⁱ	3346.84±486.86 ^g	0.98±0.04 ^{ab}	2.362±0.03 ⁱ
<i>Crotalaria ochroleuca</i>	10.05±0.07 ^{bc}	122.18±10.69 ^a	5.06±0.03 ^c	839.48±39.70 ^{bc}	1.77±0.13 ^c	1.45±0.01 ^g
<i>Heterotis rotundifolia</i>	9.68±0.06 ^a	223.46±9.19 ^b	6.13±0.02 ^f	782.74±4.90 ^{bc}	0.94±0.03 ^{ab}	0.95±0.01 ^d
<i>Hibiscus cannabinus</i>	9.48±0.19 ^a	458.13±20.47 ^d	4.31±0.10 ^c	518.65±2.92 ^{ab}	1.12±0.25 ^b	0.98±0.01 ^d
<i>Hibiscus sp.</i>	9.66±0.11 ^a	576.4±23.85 ^e	11.21±0.08 ^j	532.28±9.77 ^{ab}	0.87±0.22 ^{ab}	0.73±0.01 ^c
<i>Hibiscus surattensis</i>	10.23±0.07 ^{cd}	835.88±10.22 ^f	6.69±0.03 ^g	288.37±1.0 ^a	0.69±0.11 ^a	0.55±0.01 ^d
<i>Ipomoea eriocarpa</i>	9.81±0.13 ^{ab}	118.51±5.82 ^a	4.75±0.04 ^d	1494.4±14.92 ^{de}	1.19±0.20 ^b	0.62±0.02 ^b
<i>Maerua angolensis</i>	10.11±0.20 ^{bcd}	523.73±46.63 ^e	3.82±0.04 ^b	1554.6±13.65 ^e	0.98±0.05 ^{ab}	0.52±0.02 ^a
<i>Senna obtusifolia</i>	9.77±0.02 ^{ab}	1265.3±14.94 ^h	3.29±0.02 ^a	1112.13±4.49 ^{cd}	0.87±0.06 ^{ab}	1.34±0.01 ^f
<i>Vigna membranacea</i>	10.28±0.07 ^{cd}	351.6±11.31 ^c	4.42±0.09 ^c	914.63±19.13 ^{bc}	0.87±0.02 ^{ab}	1.26±0.01 ^e

257 All tabulated mean \pm standard deviation (s.d) values were derived from triplicate sample tests. Turkeys test at 95% confidence level and
258 statistical significance level was taken at $p < 0.05$. The superscript letters a, b, c, d, e, f, g, h, i shown in the table denote significant differences (p
259 < 0.05). Mercury and cadmium were below detectable limits and omitted from the table. A one-way ANOVA revealed that there was a
260 statistically significant difference in mean inorganic components among the twelve wild edible plants: Mg [$F_{(11, 23)} = 17.73, p = 0.00$]; Ca [$F_{(11,$
261 $_{23})=1088.94, p=0.00$], Fe [$F_{(11,23)} = 7064.15, p=0.00$], K [$F_{(11,23)} = 115.42, p=0.00$], Pb [$F_{(11,23)} = 12.48, p=0.00$], and Zn [$F_{(11,23)} = 4400.87,$
262 $p=0.00$].

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277 **Table 2.** Macro-nutrients concentration of mineral nutrients mg/g for dry weight and fresh weight (dw and fw), daily intake (DI)* and percentage
 278 recommended daily allowance (%RDA) for Mg, Ca and K

Sample	Mg				Ca				K			
	dw	fw	DI	%RDA	dw	fw	DI	%RDA	dw	fw	DI	%RDA
<i>Acalypha rhomboidea</i>	0.10	0.02	2.05	0.73	11.70	2.34	234.03	39.00	22.70	4.54	453.64	28.35
<i>Asystasiagangetica</i>	0.104	0.02	2.08	0.74	5.32	1.06	106.48	17.75	21.80	4.36	436.03	27.25
<i>Crassocephalum sacrobasis</i>	0.098	0.02	1.97	0.70	1.50	0.30	30.02	5.00	33.50	6.69	669.37	41.84
<i>Crotalaria ochroleuca</i>	0.101	0.02	2.01	0.72	1.22	0.24	24.44	4.07	8.39	1.68	167.90	10.49
<i>Heterotis rotundifolia</i>	0.097	0.02	1.94	0.69	2.23	0.45	44.69	7.45	7.83	1.57	156.55	9.78
<i>Hibiscus cannabinus</i>	0.095	0.02	1.90	0.68	4.58	0.92	91.63	15.27	5.19	1.04	103.73	6.48
<i>Hibiscus sp.</i>	0.097	0.02	1.93	0.69	5.76	1.15	115.28	19.21	5.32	1.06	106.46	6.65
<i>Hibiscus surattensis</i>	0.102	0.02	2.05	0.73	8.36	1.67	167.18	27.86	2.88	0.58	57.67	3.60
<i>Ipomoea eriocarpa</i>	0.098	0.02	1.96	0.70	1.19	0.24	23.70	3.95	14.90	2.99	298.88	18.68
<i>Maerua angolensis</i>	0.101	0.02	2.02	0.72	5.24	1.05	104.75	17.46	15.60	3.11	310.92	19.43

<i>Senna obtusifolia</i>	0.098	0.02	1.95	0.70	12.65	2.53	253.06	42.18	11.10	2.22	222.43	13.90
<i>Vigna membranacea</i>	0.103	0.02	2.06	0.74	3.57	0.71	71.35	11.59	9.17	1.83	183.33	11.46

RDA (mg/day)

	Mg	Ca	K
Infants 3-6	300-600	600-800	1600
Pregnancy/Lactating mothers	280	1200	3500
Post-menupose/men	350	800	3500

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286 **Table 3.** Micro-nutrients concentration of mineral nutrients mg/g for dry weight (dw) and fresh weight (fw), daily intake (DI)* and percentage
 287 recommended daily allowance (%RDA) for Fe and Zn in dry weight (dw) and fresh weight (fw)

Sample	Fe				Zn			
	dw	fw	DI	%RDA	dw	fw	DI	%RDA
<i>Acalypha rhomboidea</i>	0.08	0.02	1.64	16.41	0.01	0.003	0.28	2.76
<i>Asystasia gangetica</i>	0.11	0.02	2.24	22.40	0.02	0.004	0.36	3.64
<i>Crassocephalum sacrobasis</i>	0.09	0.02	1.83	18.34	0.02	0.005	0.47	4.72
<i>Crotalaria ochroleuca</i>	0.05	0.01	1.01	10.13	0.01	0.003	0.29	2.90
<i>Heterotis rotundifolia</i>	0.06	0.01	1.23	12.26	0.01	0.002	0.19	1.89
<i>Hibiscus cannabinus</i>	0.04	0.01	0.86	8.61	0.01	0.002	0.20	1.96
<i>Hibiscus sp.</i>	0.11	0.02	2.24	22.41	0.01	0.001	0.15	1.46
<i>Hibiscus surattensis</i>	0.07	0.01	1.34	13.38	0.01	0.001	0.11	1.10
<i>Ipomoea eriocarpa</i>	0.05	0.01	0.95	9.50	0.01	0.001	0.12	1.23
<i>Maerua angolensis</i>	0.04	0.01	0.76	7.64	0.01	0.001	0.10	1.04

<i>Senna obtusifolia</i>	0.03	0.01	0.66	6.59	0.01	0.003	0.27	2.68
<i>Vigna membranacea</i>	0.04	0.01	0.89	8.87	0.01	0.002	0.25	2.48

RDA (mg/day)

	Fe	Zn
Infants 3-6	10	10
Pregnancy/Lactating mothers	15	15-22
Post-menupose/men	10	12-15

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295 **Table 4.** Target Hazard Quotient (THQ) values for Lead in the wild edible vegetables

Sample	mg/g(dw)	mg/g(fw)	DI	EDI	Children	THQ	Adult	THQ
<i>Acalypha rhomboidea</i>	0.01	0.002	0.197	0.0004	2.59E-05	0.0065	5.50E-06	0.0014
<i>Asystasia gangetica</i>	0.01	0.002	0.244	0.0006	3.98E-05	0.01	8.50E-06	0.0021
<i>Crassocephalum sacrobasis</i>	0.01	0.002	0.195	0.0004	2.54E-05	0.0063	5.40E-06	0.0014
<i>Crotalaria ochroleuca</i>	0.02	0.004	0.354	0.0013	8.34E-05	0.0208	1.80E-05	0.0045
<i>Heterotis rotundifolia</i>	0.01	0.002	0.188	0.0004	2.36E-05	0.0059	5.10E-06	0.0013
<i>Hibiscus cannabinus</i>	0.01	0.002	0.223	0.0005	3.32E-05	0.0083	7.10E-06	0.0018
<i>Hibiscus sp.</i>	0.01	0.002	0.174	0.0003	2.02E-05	0.005	4.30E-06	0.0011
<i>Hibiscus surattensis</i>	0.01	0.001	0.139	0.0002	1.28E-05	0.0032	2.70E-06	0.0007
<i>Ipomoea eriocarpa</i>	0.01	0.002	0.237	0.0006	3.75E-05	0.0094	8.00E-06	0.002
<i>Maerua angolensis</i>	0.01	0.002	0.195	0.0004	2.54E-05	0.0063	5.40E-06	0.0014
<i>Senna obtusifolia</i>	0.01	0.002	0.174	0.0003	2.02E-05	0.005	4.30E-06	0.0011
<i>Vigna membranacea</i>	0.01	0.002	0.17	0.0003	1.93E-05	0.0048	4.10E-06	0.001

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305

306 **Availability of data and materials**

307 All the data generated during this study are available upon request from the first author.

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322 **Authors' contributions**

323 AN and GMM designed this study; AN collected, analysed samples and wrote the initial draft
324 of the manuscript. GMM and GA were responsible for data interpretation and editing of the
325 manuscript. All authors read and approved the final manuscript.

326

327 **Consent for publication**

328 Not applicable

329

330 **Conflict of interest**

331 The authors declare that they do not have any conflict of interests.

332

333 **Availability of data and materials**

334 No datasets have been deposited in public repositories.

335

336 **Abbreviations**

337 AAS, Atomic Absorption Spectrophotometer;

338 SPSS, statistical package for social sciences;

339 USEPA, United State Environmental Protection Agency;

340 WHO, World Health Organisation

341 AOAC, Association Official Analytical Chernist

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