Research Article

Estimation of Essential and Toxic Mineral Elements in Edible *Coccinia grandis* L. voigt in Maharashtra

M. Parab, G. Rutuja and S.Singh*

School of Biotechnology and Bioinformatics, D. Y. Patil University,
Navi-Mumbai, Maharashtra, India.

ABSTRACT

Vegetal crop species are vital sources of raw material for pharmaceutical industries and modern-day naturopathic based human therapeutics. Systematic analysis of the macro and micro mineral elements thus facilitates evaluation of nutritional composition and mineral accumulated by edible plants. The main objective of the present study is to quantify the non-essential heavy metals like Ni, Cr, Cu & Pb and essential Minerals like Fe, Mg, K, Na, Ca & P in some edible parts of *Coccinia grandis* using Atomic Absorption Spectrophotometer (AAS). The results were compared with the safety standards established by the World Health Organization (WHO). The micronutrients including Fe, Mn and Cu were found to be in the range of 18 – 1794 ppm, 25 – 350 ppm and 3.18 – 9.81 ppm respectively. The macronutrients were observed to be in range of Ca (70-1550 ppm), Mg (347 - 1612 ppm), K (779 - 1356 ppm), Na (8-165 ppm), and P (0.18- 1.66 ppm) respectively. The quantity of Ni and Pb were found to be in higher ranges than the reported by international regulatory standards of vegetable plants. Thus present study endeavors to unveil the nutritional potential as well as bioaccumulation and biomagnifications of trace toxic heavy metals by this edible vegetable species.

Keywords: *C. grandis*, Atomic Absorption Spectrophotometer, Bioaccumulation, Biomagnification.

INTRODUCTION

Edible vegetal plant species are potent sources of polysaccharides, sugars, vitamins, minerals and organic acids which not only regulate their taste but also befit them with different medicinal properties (Grembecka & Szefer, 2013). The fruits and vegetables contain high amounts of chemically active compounds, such as phenolic compounds (Hui *et al.*, 2006), antioxidants and other biologically active ingredients that bestow medicinally active ingredients. The potency of biological active ingredients in vegetables is observed to directly proportional to *in-situ* availability of edaphic macro and micronutrients (Park *et al.,* 2011).

Bioaccumulation of toxic heavy metals by vegetal crops has become a major challenge for farmers and plant breeders as wells as consumers (Zukowska & Biziuk, 2008). Air, soil, and water pollution contribute to presence of cadmium (Cd), mercury (Hg), Nickel (Ni) and lead (Pb) in foods. The occurrence of heavy metals in the ecosystem is associated with rapid industrial growth, overuse of synthetic agricultural chemicals, or waste-water irrigation (Mapanda *et al.,* 2005). Previous studies have reported that vegetables can take up and accumulate trace minerals and heavy metals in quantities high enough to cause clinical problems to humans (Alam *et al.,* 2003). The consumption of such contaminated food can seriously deplete essential nutrients in the human body causing, or contributing to, a number of diseases (Arora *et al.,* 2008). Therefore it is a critical challenge to determine the concentration of essential elements, heavy and toxic metals among edible vegetal crops to ensure that levels meets the related standards or regulations limiting their concentration in herbal formulations (Maghrabi, 2014).

Coccinia grandis L. voigt (Ivy gourd), member of family *Cucurbitaceae,* is the most important vegetable and medicinal plant, distributed in Asian and African continent. It is a climber and trailer. The fruit, young leaves and shoot tips of ivy gourd are used in Asia for cooking purpose (Muniappan *et al.,* 2009). Every part of this plant is valuable in medicine and various preparations have been mentioned in indigenous system of medicine and unani systems of medicine for skin diseases, bronchial catarrh, leprosy, fever, asthma, infective hepatitis, jaundice and sore throats (Yadav *et al.,* 2010, Mazumdar *et al.,* 2008, Ashwini *et al.,* 2012). Aqueous and ethanolic extracts from the plant have shown analgesic, hypoglycemic principles and hepatoprotective (Munasinghe *et al.,* 2011, Deokate and Khadabadi, 2011). Also the plant is used as one of the natural resources as a supplement of macro- and micro- mineral elements for treatment of deficiencies and malnourishments (Sadou H *et al*. 2007).

The present research study endeavors to quantify the non-essential heavy metals like Ni, Cr, Cu & Pb along with essential minerals like Fe, Mg, K, Na, Ca & P in some edible fruits of *Coccinia grandis* using Atomic Absorption Spectrophotometer (AAS) collected from six different geological and edaphic conditions in West Maharashtra, India. In light of multifarious appliance of whole plant especially the edible parts of *C. grandis* in human therapeutics, the knowledge of the elemental and nutritional quotients amid the land races becomes requisite. In present study for the first time the mineral composition has been evaluated from geologically distinct landvars of *C. grandis* and an attempt has been made to set down a preliminary platform of nutritional composition and bioaccumulation competence of this vegetal crop.

EXPERIMENTAL

Collection of Plant material

Fresh edible fruit samples of *Coccinia grandis* were collected from local markets / fields of 6 different locales in West Maharashtra namely Andheri, Aurangabad, Badlapur, Chiplun, Pune and Palghar. The samples were identified by Blatter herbarium, Mumbai (Herbarium specimen no 16696). The plant samples were thoroughly washed with tap water and rinsed with 70% alcohol and distilled water, blot dried and weighed.

Plant extract and Organic Digestion

The plant extracts were prepared by acid digestion as described by Chatage *et al.* (2012), where 5 grams of plant material was crushed and dissolved in concentrated HNO_3, following which it was subjected to slow heating to facilitate particle dissolution and obtaining a clear solution. On cooling Perchloric acid was added and strongly heated till the volume was reduced to 2- 3 ml. The extract was cooled, diluted with deionized and was stored for further analysis.

Preparation of Standard Solutions

Determination of the metal concentration in the experimental solution was based on the calibration curve plotted for elements like Cu, Ni, Cr, Pb, Ca, Mg, P, Na, Fe, K, Mn at stock solutions of 1000 ppm in de- ionized water respectively. The instrument (AA-301, Thermo fisher Scientific, AAS) was calibrated using calibration blank and threes series of measurement was conducted for each element under analysis (Kanakaraju *et al*., 2007).

STATISTICAL ANALYSIS

The metals concentrations in the samples were characterized by arithmetic mean value, the corresponding standard deviation (SD), average deviation (AD) and ranges for wet weight basis. Statistical analysis was performed using SPSS software and the data were analyzed by an analysis of variance ($p < 0.05$). All measurements were replicated three times.

RESULT AND DISCUSSION

In present research inquisition quantitative analysis employing AAS of fruits of *C. grandis* unveiled presence of essential elements like Na, K, Ca, Mg, Mn, Fe and P, along with considerable concentration of toxic heavy metals like Cr, Pb, Ni and Cu. The repertoire of mineral elements were found to vary widely amid edible fruits of *C. grandis* (Fig. 1, 2) and their concentrations in parts per million (ppm) are as indicated in Table 1. Also the elemental composition appeared to be proportional to the metal concentration in the respective soil (data not shown).

The daily mineral requirements of an adult man (a 70 kg person) are as follows 15 mg Fe, 2.8 mg Mn, 15 mg Zn, 2.5 mg Cu, 0.025 mg Ni, 0.05- 0.2 mg Cr, 0.415 mg Pb and 0.057 mg Cd (Ebrahimzadeh *et al*., 2011). A number of these elements have been reported with high biochemical essence and are involved in upregulating the formation of secondary metabolites which are responsible for pharmacological actions of vegetal species (Tangahu *et al.,* 2011). Trace elements are also essential to all cells and deficiencies of essential metals may cause disease in humans.

The concentration of iron in the Coccinia grandis in present study was recorded in range of 18 ppm (Badlapur) to 1794 (Palghar). The WHO recommended daily dietary limit of iron for human consumption is 10 to 60 mg/day (ATSDR 1994b). Furthermore Iron is actively involved in preventing disorders like anemia and cough associated with angiotensin-converting enzyme (ACE) inhibitors, pallid physique (Khan K. *et al.*, 2011) while hyperaccumulation of Fe can lead to hepatic megaly, cardiac infraction, nephric malfunction (Rathanavel & Arasu, 2013). In addition, Mn and Fe play vital roles in biochemical processes, improvement of impaired glucose tolerance and have indirect role in the management of diabetes mellitus (Choudhury *et al.*, 2007). Also vegetal species from *Cucurbitaceae* are reported as good absorbers of Fe from soil (Khan F. *et. al.,* 2012). Thus wide variation in Fe concentration can be attributed to the *in- situ* geological and edaphic mileu and also the plants from North Maharashtra appear to absorb moderate concentrations of Fe, while some of the geo-edaphic mileu as well the landraces were reported with higher Fe concentrations.

Manganese (Mn) and Magnesium (Mg) are among the most abundant elements in edible fruits of *Cucurbitaceae*. Manganese (Mn) is known to assist the body in metabolizing protein, carbohydrates and used in treating diabetes. Magnesium (Mg) improves insulin sensitivity, protect against diabetes and its complications and reduce blood pressure. The necessary daily intake is 350 mg/day for men and 300 mg/day for women, while the permissible concentration of Mn in vegetal and medicinal plants has not yet been established the WHO (2005) limits (Rathanavel & Arasu, 2013). The concentration of Mn and Mg was found in the range of 25 – 350 ppm and 347 – 1612 ppm in edible wild landraces of *C. grandis*. Thus the landraces from North Maharashtra (i.e. Thane, Badlapur regions) were recorded with higher concentrations of Mg and Mn, whilst very low concentrations of same were recorded in landrace from central Maharashtra (Palghar) (Fig. 1, 2).

Potassium (K) is helpful in reducing hypertension and maintaining cardiac rhythm and Sodium (Na) involves in the production of energy, transport of amino acids and glucose into the body cells (Hashmi *et al.,* 2007). The range of Na and K concentrations was observed to be 779 – 1356 ppm and 8- 165 ppm respectively. Copper (Cu) play important role in treatment of chest wounds and prevent inflammation in arthritis and similar diseases. Highest concentration of Ca was found in the edible wild races from East Maharashtra (Aurangabad) and a range from 70 – 1550 ppm was detected in selected landraces. Previous reports have indicated that Calcium helps to overcome the problems of high blood pressure, heart attack, premenstrual syndrome, colon cancer and keeping the bones strong and reduces the risks of osteoporosis in old age (Rathanavel & Arasu, 2013). Copper (Cu) and Nickel (Ni) are required in trace amounts in human body. The maximum concentration of Cobalt was found as 9.81 ppm in landraces from Central Maharashtra (Thane) and 3.18 ppm from landraces from Aurangabad.

Copper is employed to treat several different types of cancer in humans and anemia but the intake of high amount can cause heart diseases. The health benefits of Ni are optimal growth, healthy skin, bone structure and involved in iron metabolism but it is required in low quantity, otherwise it may cause toxicity (Hashmi *et al.,* 2007). Chromium (Cr) improvises the balancing of blood sugar levels, regulates hunger, reduces cravings, protects DNA and RNA, improves heart function and helps control fat and cholesterol levels in the blood (Rathanavel & Arasu, 2013). The landraces from Palghar was observed to have highest concentration that is 38.88 ppm (Table 1) of Cr.

Lead (Pb) is toxic metal and non-essential element for human body as it causes a rise in blood pressure, kidney damage, miscarriages and subtle abortion, brain damage, declined fertility of men through sperm damage, diminished learning abilities of children and disruption of nervous systems (Cooper *et al.,* 1999). The permissible limit set by FAO/ WHO (1984) in edible plants was 0.43 ppm (Rathanavel & Arasu, 2013). The presence of these heavy metals in almost all the landraces of *C. grandis* analyzed herein thus reflects their natural capacity of sorption of these heavy metals although they were collected from unpolluted natural habitats and therefore can be considered for in-situ metal chelation (Obiajunwa *et al.,* 2002). However further analysis of *C. grandis* prior being employed for phytoremediation is recommended, as the rate of metal sorption may vary in different geotypes as the phenomenon of metal sorption is dependent on extraneous environmental factors , season of collection, age of plant and edaphic conditions.

Vegetables are found all over the world and they have a good potential for human nutrition. The channel of absorption of molecules and ions by plants is selective; plant cells categorize between substances presented to them, accumulating some and excluding others. However, the discrimination process is not perfect, so plants can take up metals in toxic quantities (Sanchez-Castillo *et al*., 1998). The use of sewage sludge for agriculture purposes could also lead to higher uptake of chromium by plants

CONCLUSION

The data obtained in present study will be helpful in understanding preliminary nutritional composition amid different landraces of *C. grandis.* The elemental profile detected in this wild / edible vegetal species shows that many of these fruit contain elements of vital importance in human metabolism and that are needed for growth, development, prevention and treatment of many diseases in reasonable concentration. The trace elements present in this species may play a direct or indirect role in their biological activities. Since the beneficial effects of trace elements are consequently bioavailability, further research is needed to establish the chemical form of trace elements in these plants.

Table 1: Essential mineral elements and Heavy metals evaluated in six *C. grandis* from Maharashtra

Element/ Location	Cu (ppm)	Ni (ppm)	Cr (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)	P (ppm)	Na (ppm)	Fe (ppm)	K (ppm)	Mn (ppm)
Pune	3.53	0	21.55	4.2	1320	452.5	0.15	65	24	779.4	55
Thane	**9.81**	**4.89**	32.46	**32.46**	980	**1612.8**	0.18	145	1452	**1356.4**	**350**
Palghar	4.59	0	**38.88**	9.58	70	603	0.12	**165**	**1794**	1100.16	25
Aurangabad	3.18	3.12	24.27	5.2	**1550**	399.6	**0.23**	8	24	1152	85
Chiplun	4.24	2.7	32.46	9.5	350	585	0.14	50	630	1222.2	240
Badlapur	3.18	0	19.74	16.31	480	347.5	0.21	80	18	852.4	280
SD	2.541	2.088	7.504	10.50	583.5	474.3	0.042	59.29	791.8	221.05	134.78
AM	4.755	1.785	28.22	12.87	791.6	666.7	0.171	85.5	657	1077.1	172.5
AD	1.685	1.785	5.462	7.673	491.6	315.3	0.035	46.33	644	174.12	172.5

Key: SD: Standard deviation, AM: Arithmatic Mean, AD: Average Deviation

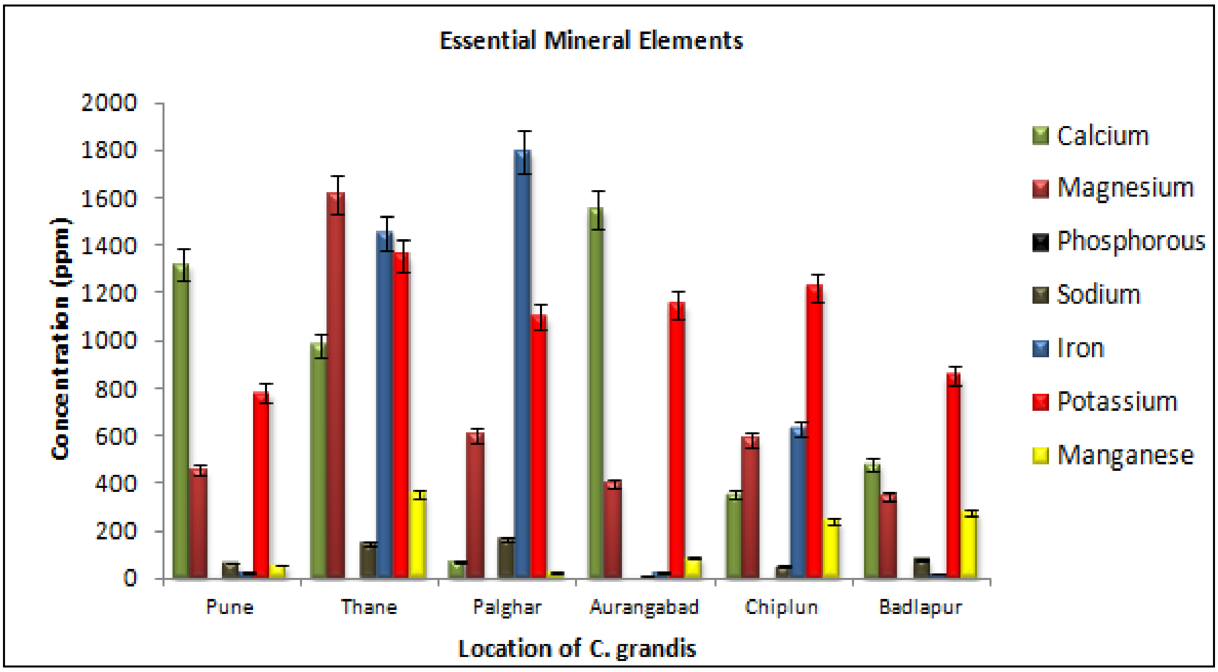

Fig. 1: Composition of Essential mineral elements in six landraces of *C. grandis*

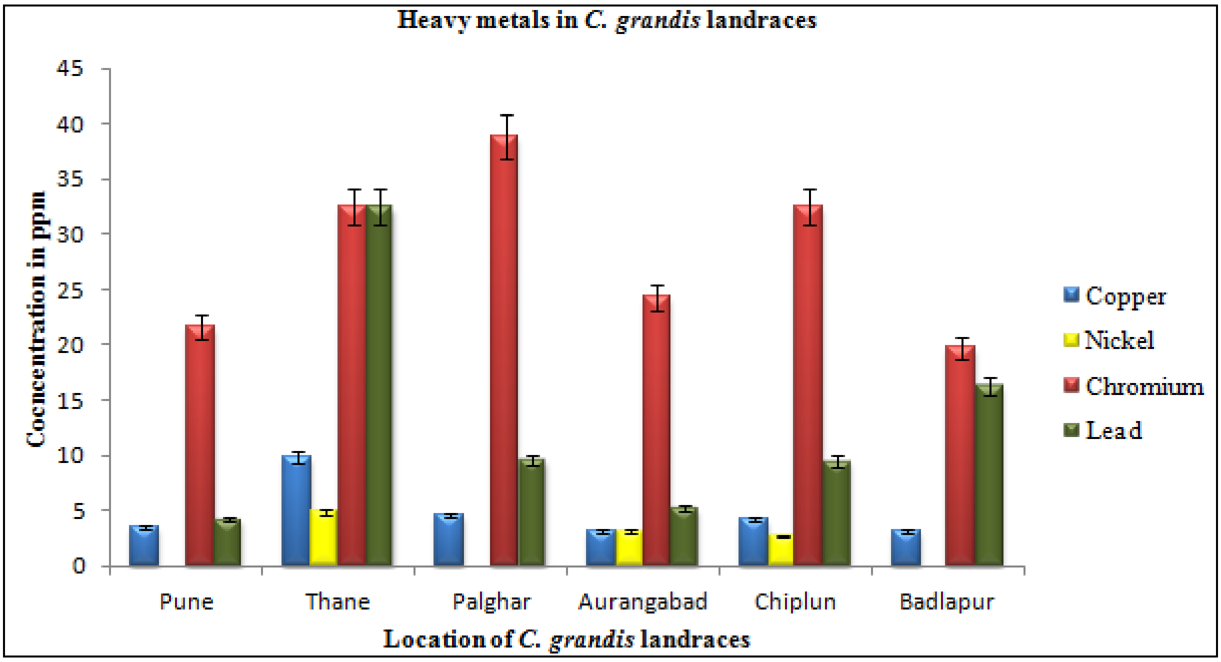

Fig. 2: Concentraion of Heavy metals detected in six landraces of *C. grandis*

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