Investigation of Iron In Edible Parts of Vegetables From Selected Content

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Abstract

Vegetables are rich sources of vitamins, minerals and fibers, and have beneficial antioxidative effects. Ingestion of vegetables containing heavy metals is one of the main routes through which these elements enter the human body and can cause an array of diseases. In this study the concentrations of iron in the most frequently consumed vegetables (water spinach, roselle, spinach and field mustard) in Hinthada District were investigated. The vegetable samples were collected from two different vegetable farms at Gaung Say Kyun as site 1 (S-1) and Ta Loke Htaw village as site 2 (S-2). Atomic absorption spectrophotometry was used to estimate the levels of iron content in various vegetables. The concentration of heavy metals (iron [Fe]) in the investigated water spinach from S-1 and S-2 were (172.3120 mg/kg) and (164.1281 mg/kg). The iron (Fe) concentrations of roselle from S-1 and S-2 were found to be (42.2220 and 18.6990) mg/kg. The content of iron in spinach from S-1 were 270.1330 mg/kg. The concentrations of iron in field mustard from S-1 and S-2 were 212.1800 mg/kg and 120.6380 mg/kg. The concentration of iron (Fe) in all vegetable samples from S-1 is greater than S-2. The concentration of Fe in the different vegetable samples under this study was found within the permissible limit according to FAO/WHO (2011).

Keywords: Heavy metals, water spinach, roselle, spinach, field mustard

Introduction

Iron (Fe) cause harmful effects in plants, animals and humans as results of long-term or acute exposure. Therefore, Iron (Fe) tend to resist oxidation. Iron (Fe) occur naturally in the ecosystem with large variations in concentrations. In modern times, anthropogenic sources of iron (Fe), i.e. pollutions from the activities of humans, have introduced some of these iron into the ecosystem. The presence of iron in the environment is of great ecological significance due to their toxicity at certain concentrations, translocation through food chains and non-biodegradability which is responsible for their accumulation in the biosphere (Kumar *et al.*, 2009). Iron (Fe) is believed to be the tenth most abundant element in the universe. Iron (Fe) is also the most abundant (by mass, 34.6 %) element making up the earth, the concentration of iron in the various layers of the earth ranges from high at the inner core to about 5% in the outer crust. Most of this various iron oxides, such as the minerals haematite, magnetite and taconite. The earth's core is believed to consist largely of a metallic iron (Fe) nickel alloy. Iron (Fe) is the essential to almost living things, from micro-organisms to humans. Iron (III)-O-arsenite, pentahydrate may be hazardous to the environment, special attention should be given to plants, air and water. It is strongly advised not to let the chemical enter into the environment because it persists in the environment. Vegetables are in important part of the human being because they are a source of nutrients (Njagi, 2013). Human body needs appropriate concentrations of various minerals, the normal function and sustain life. Vegetables can take up and accumulate iron (Fe) in quantities high enough to cause clinical problems to human (Alam and Tanaka, 2003). Fruit and vegetables consumption is the primary pathway of human exposure to iron. Iron(Fe) are persistent in the environment and are subject to bioaccumulation in food-chains. They are easily accumulated in the edible parts of leafy vegetables, as compared to grain or crops (Mapanda *et al.*,2005).

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Iron (Fe) is a mineral. Most of the iron (Fe) in the body is found in the hemoglobin of red blood cells and in the myoglobin of muscle cells. Iron (Fe) is needed for transporting oxygen and carbon dioxide. It also has other important roles in the body. Iron (Fe) can be found in foods like meat, fish, tofu, beans, spinach, cereal and other foods. Iron (Fe) is most commonly used for preventing and treating anemia caused by low iron levels. It is also used for anemia caused by abnormal heavy bleeding during menstrual periods (menorrhagia), pregnancy, or kidney problems.

Iron (Fe) is the most people when it is taken by mouth in appropriate amounts. It can cause side effects such as stomach upset and pain, constipation or diarrhea, nausea, and vomiting. Taking iron (Fe) supplements with food seems to reduce some of these side effects. However, food can also reduce how well the body can absorb iron. Iron (Fe) should be taken on an empty stomach if possible. If it causes too many side effects, it can be taken with food. Iron (Fe) are widely distributed in the environment, soil, plants and animals. These are essential for plants and animals in trace amount. Iron (Fe) absorption from plants and translocation to edible plant parts is a potential risk for the food chain and has to be evaluated based on plant metal availability and plant efficiency for metal uptake and translocation (Ashraf *et al*., 2014).

Although most minerals soils are rich in iron, the expression of iron (Fe) toxicity symptoms in leaf tissues occurs only under flooded conditions, which involves the microbial reduction of insoluble Fe^{3+} and Fe^{2+}. Iron (Fe) toxicity in tobacco, canola, and soybean are accompanied with reduction of plant photosynthesis and yield and the increase in oxidative stress and ascorbate peroxidase activity. The appearance of iron (Fe) toxicity in plants is related to high Fe^{2+} uptakes by roots and its transportation to leaves and via transpiration stream. The Fe^{2+} excess cause free radical production that impairs cellular structure irreversibly and damages membranes, DNA and proteins. Iron toxicity is not common, but some plants do secrete acids from the roots, which lowers soil pH. These plants can take up too much iron, leading to toxicity (Asati *et al.*, 2016).

Iron (Fe) are found naturally in the earth. In humans, iron (Fe) poisoning is generally treated by the administration of chelating agents. Some elements otherwise regarded as toxic iron are essential, in small quantities, for human health (Abdullahi, 2013). Iron(Fe) enter plant, animal and human tissues via air inhalation, diet, and manual handling. Water sources (groundwater, lakes, streams and rivers) can be polluted by iron (Fe) leaching from industrial and consumer waste; acid rain can exacerbate this process by releasing iron trapped in soils (Olivier, 2018). Free iron (Fe) enters cells and concentrates in the mitochondria. This disrupts oxidative phosphorylation, catalyzes lipid peroxidation, forms free radicals, and ultimately leads to cell death. When cellular injury occurs, metabolic acidosis is common (Some *et al*., 2018). Vegetables constitute an important part of the human diet since they contain carbohydrates, proteins, as well as vitamins, minerals and trace elements. Iron (Fe) contamination of vegetables may occur due to irrigation with contaminated water and emissions of iron from the industries and vehicles may be deposited on the vegetable surfaces during production, transport and marketing, the addition of fertilizers and metal based pesticides on vegetable farm. Four vegetable samples (water spinach, roselle, spinach and field mustard) which are widely consumed by local people from Hinthada District were selected and analyzed to assess the level of heavy metal contamination. The aim of this research work is to investigate the concentrations of some iron (Fe) in edible parts of vegetables cultivated on selected farms in Hinthada District.

Materials and Methods

Sample Collection

Four kinds of vegetables (water spinach, roselle, spinach and field mustard) were collected from two different vegetable farms in Hinthada District, Gaung Say Kyun (Site 1) and Ta Loke Htaw village (Site 2) during the harvesting period. Google map of sampling sites are shown in Figures 1and 2. Photographs of vegetables are shown in Figures 3 a-b.

Sample Preparation

At the end of the cultivation season, samples were taken from editable parts of the plants under study to determine the levels of iron (Fe) concentration in each sample. Vegetable samples were washed with distilled water to eliminate suspended particles. The leafy stalks were removed from all samples and these were sliced and dried on a sheet of paper to eliminate excess moisture; and then carefully dried in oven at 80°C for 48 h. Prepared vegetable samples are shown in Figure 4. Sample (5g) were burnt to ashes in a muffle furnace for 4 h at 500 °C. The ash samples were suspended in 20 mL of aqua regia (HCl: HNO_3, 3:1 v/v). The samples were digested on a hot plate and filtered. Following this, the volume of the filtrate was made up to 50 mL. Finally, the filtrate was analyzed for heavy metal of iron (Fe) content using atomic absorption spectroscopy.

Determination of Iron (Fe) Content in Four Kinds of Vegetables by Atomic Absorption Spectroscopic Technique

The concentrations of iron (Fe) in each sample solution (water spinach, roselle, spinach and field mustard) were determined. The wavelengths were set up at 194, 229, 283 and 372 nm for the determination of iron, using their specific hollow cathode lamps (HVG-1, Shimadzu) of the Atomic Absorption Spectrophotometer. The results are presented in Tables 1-2 and Figure 6.

Figure 1. Google map of Gaung Say Kyun

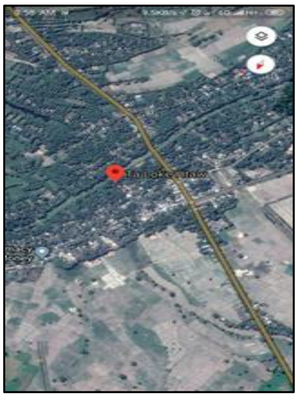

Figure 2. Google map of Ta Loke Htaw village

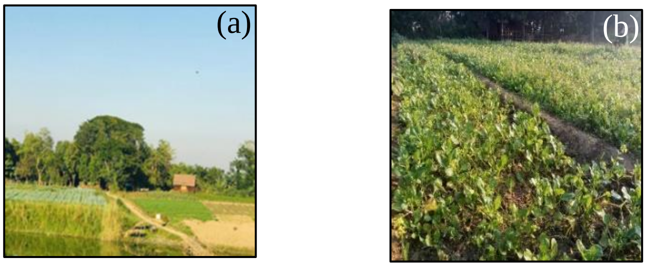

Figure 3. Photographs of vegetable farm at (a) Gaung-Say Kyun (S-1) (b) Ta Loke Htaw village (S-2)

Water spinach Roselle Spinach Field mustard

Figure 4. Photographs of four kinds of vegetables

Water spinach Roselle Spinach Field mustard

Figure 5. Photographs of vegetable samples

Results and Discussion

Vegetables constitute an important part of the human diet since they contain carbohydrates, proteins, as well as vitamins, minerals and trace elements. Iron (Fe) contamination of vegetables may occur due to irrigation with contaminated water and emissions of iron from the industries and vehicles may be deposited on the vegetable surfaces during production, transport and marketing, the addition of fertilizers and metal based pesticides on vegetable farm. Four vegetable samples (water spinach, roselle, spinach and field mustard) which are widely consumed by local people from Hinthada District were selected and analyzed to assess the level of heavy metal contamination. Hinthada Township is situated along the Ayeyarwady river. In the north- eastern part of the town, alluvial islands are found. Gaung Say Kyun is the one of the alluvial islands nearest to Hinthada. The whole island had flooded in rainy season. In winter, mostly crops are cultivated on this island. The sampling locations were chosen from large vegetable farm lands at Gaung Say Kyun as site 1 (S-1) and Ta Loke Htaw village as site 2 (S-2). In Gaung Say Kyun, the farm was irrigated with river water. The vegetable farm in Ta Loke Htaw village was irrigated with tube well water.

Iron (Fe) Distribution in Four Kinds of Vegetables from Gaung Say Kyun

In this study the concentration of some heavy metal iron (Fe) content in four selected vegetables (water spinach, roselle, spinach and field mustard) from farm land in Gaung Say Kyun were investigated. The concentrations of the iron (Fe) in the edible parts of the selected vegetables from Gaung Say Kyun are presented in Table 1.

Table 1. Iron (Fe) Content of Four Kinds of Vegetables from Farm land at Gaung Say Kyun, (S-2)

Sample	Concentration of Fe (mg/kg)
Water spinach	172.3120
Roselle	42.2220
Spinach	270.1330
Field mustard	212.1800
MPL (FAO/WHO, 2011)	425.5000

MPL= Maximum Permissible Limit

The highest concentration of iron (Fe) was found in all the vegetable samples among other analyzed heavy metals. These probably were because iron (Fe) was the essential elements for vegetables growth and were readily accumulated in roots and transported to aerial part; while Pb, Cd, and As were the toxic elements and were not required for vegetables growth, they were stored in roots, and transport to aerial parts of the plant was limited (Liu, 2007). The range of iron (Fe) concentration in selected vegetables were (42.2220 - 301.5950 mg/kg). In general, the mean concentrations of Fe accumulated by these vegetables were below FAO/WHO (2011) recommended limits for vegetables. The results are shown in Table 1 and Figure 6.

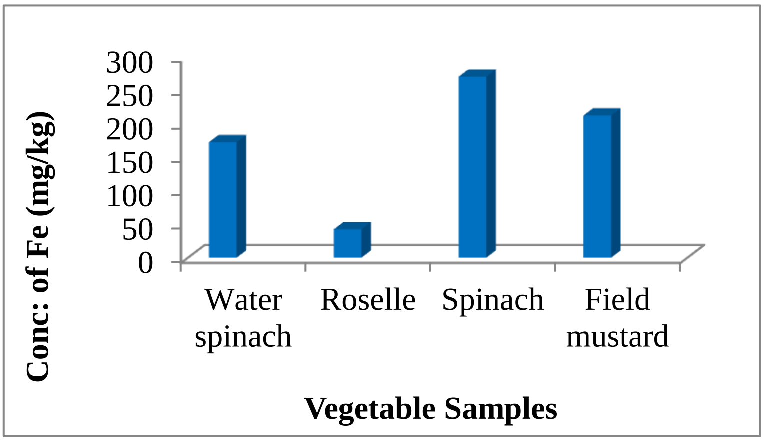

Figure 6. Iron (Fe) content of four kinds of vegetables from farm land at Gaung Say Kyun

Iron (Fe) Distribution in Four Kinds of Vegetables from Ta Loke Htaw Village

The concentration of some iron (Fe) in four selected vegetables (water spinach, roselle, spinach and field mustard) from farm land in Ta Loke Htaw village were investigated. The concentrations of the iron (Fe) in the edible parts of the selected vegetables from Ta Loke Htaw are presented in Table 3.

Iron (Fe) was found to have the highest concentration in all the vegetable samples, since it is one of the essential micronutrients know to play important role in plant growth. The maximum concentration of iron (Fe) was found in spinach (201.7299 mg/kg) and the minimum in roselle (18.6990 mg/kg). The FAO/WHO (2011) maximum limit for Fe concentration in vegetables is (425 mg/kg). The results are shown in Table 3 and Figure 7. According to these results, no analyzed vegetables with excessive levels of irons (Fe) were found in this farm. Iron (Fe) content in each vegetable sample from Ta Loke Htaw compared with maximum permissible limit of FAO/WHO (2011).

Table 2. Iron (Fe) Content of Four Kinds of Vegetables from Farm land at Ta Loke Htaw Village, (S-2)

Sample	Concentration of Fe (mg/kg)
Water spinach	164.1281
Roselle	18.699
Spinach	201.7299
Field mustard	120.6380
MPL (FAO/WHO, 2011)	425.5000

MPL = Maximum Permissible Limit

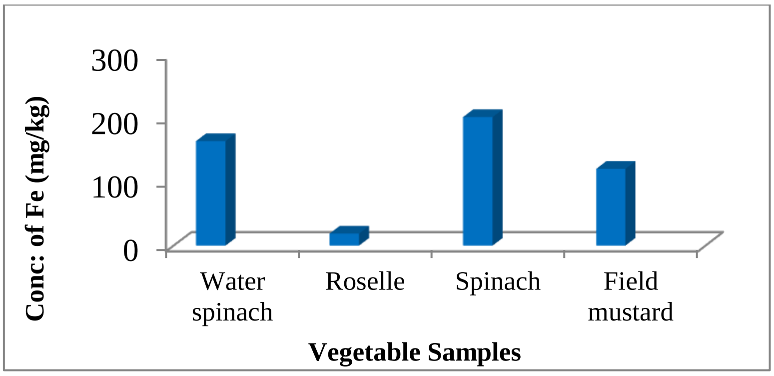

Figure 7. Iron content of selected vegetables from farm land at Ta Loke Htaw village, Hinthada District

Iron (Fe) Distribution in Four Kinds of Vegetables from Two Different Sampling Sites (S-1 and S-2)

Comparing the two sampling sites, the concentration of iron (Fe) in all vegetable samples from S-1 is greater than S-2. Iron (Fe) was found in all vegetable samples because it is one of the micronutrients for plant growth. The concentration of iron (Fe) in all vegetable samples from S-1 is greater than S-2. It is because S-1 is one of the alluvial island and existing physical condition may support the nutrients for plants. The contents of iron (Fe) in collected vegetables from S-1 and S-2 are shown in Table 3.22 and Figure 9.

In this research, it was found that all the metals investigated under this study were found in water spinach collected from both sites. According to these observations, it may be predicted that among all the vegetables, water spinach can absorb the metals from soil more than the others. This is because plants may uptake essential and nonessential elements from soils in response to electrochemical potential gradient of the plasma membrane in the root cells or by diffusion of elements in the soil. The level of iron (Fe) accumulation differs between species and there are different defenses strategies to plant avoid iron (Fe) contamination (Hossain *et al*.,2012).

Although the results showed the presence of iron (Fe) in most of the vegetable samples in both study area, all of the resultant data were within the safe limit for consumers.

Table 3. Iron (Fe) Content of Four Kinds of Vegetables from Different Farm lands in Hinthada District

Sample	**Concentration of Fe (mg/kg)**	
	S-1	**S-2**
Water spinach	172.3120	164.1281
Roselle	42.220	18.6990
Spinach	270.1330	201.7299
Field mustard	212.1800	120.6380

S-1 = Site-1 (Gaung Say Kyun) , S-2 = Site-2 (Ta Loke Htaw village)

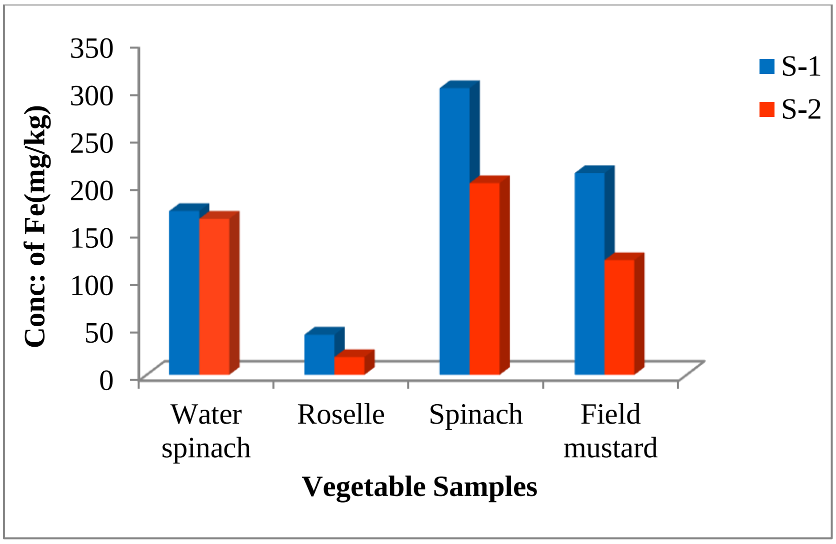

Figure 8. Iron (Fe) content in four kinds of vegetables from different farm lands in Hinthada District

Conclusion

Iron (Fe) are considered as one of the most significant environmental concerns because of their toxicity and accumulation in the tissues in living organisms which even at low levels can endanger human health. Considering high importance role of these iron in public health, their contents in edible vegetables cultivated in Hinthada District was investigated in this study. Four vegetable samples (water spinach, roselle, spinach and field mustard) which are widely consumed by local people from Hinthada District were selected and analyzed to assess the level of iron (Fe) contamination. In this study the concentration of iron (Fe) in four selected vegetables from farm lands in Gaung Say Kyun and Ta Loke Htaw village were investigated.

The concentration of iron (Fe) in spinach was the highest among the others. The least content was observed in roselle. The highest concentration of iron (Fe) was found in all the vegetable samples among other analyzed heavy metals. The observed range in the concentrations of iron (Fe) was (42.2220 - 301.5950 mg/kg).

From the investigation of the concentration of iron (Fe) in four selected vegetables from farm land in Ta Loke Htaw village (S-2), it was observed that the range of iron (Fe) concentration in selected vegetables were (42.220-270.1330 mg/kg). The concentration of iron (Fe) in spinach was the highest among the others. Iron (Fe) was found to have the highest concentration in all the vegetable samples. The range of iron (Fe) concentration in selected vegetables from S-2 was (42.220-270.1330 mg/kg).

Comparing the two sampling sites, the concentrations of iron (Fe) in all selected vegetables from farm lands in S-1 were higher than S-2. Iron (Fe) was found in all vegetable samples because it is one of the micronutrients for plant growth. The concentration of iron (Fe) in all vegetable samples from S-1 is greater than S-2. It may be closely related to the situation of sampling site, since S-1 is one of the alluvial island and existing physical condition may support the nutrients for plants.

In this research, it was also found that among all the vegetables, spinach can absorb the metals from soil more than the others. This may be due to the fact that vegetable species differ widely in their ability to take up and accumulate iron (Fe), according to the plant species and tissues.

The results of analysis and their comparison with standard values showed that the average concentration of iron (Fe) in the studied vegetables did not exceed the permissible limit of (FAO/WHO, 2011) and therefore, they had acceptable conditions for human consumption.

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