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Transportation of Arsenic (As) & Chromium (Cr) in some Fruits and Vegetables Plants and Variation of Nutritional Profiles due to Contamination

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Abstract

Contamination of Arsenic (As) and Chromium (Cr) are caused by both anthropogenic and manmade sources. These metals are highly reactive, carcinogenic and can cause severe problem with minimum amount of contamination. Agricultural chemicals, industrial wastes and environmental systems are considered significant contributors for these heavy metals transport to food chain despite their existence in natural condition. In this study, freshly prepared heavy metal solutions were used to see the overall transportation to planted vegetables and fruits. Concentrations of Cr and As were assessed in Atomic Absorption Spectrophotometer. Significant level of Chromium (Cr) contamination were found in each of the leafs of vegetable and fruit plants ranges from 5.73 mg/g-23.22 mg/g while comparatively very low level of Arsenic (As) contamination were found in same samples ranges from 0.027 mg/g-1.283 mg/g. Due to presence of metals in leafs the nutritive value also falls and the amount of crude protein drastically decreased and the amount of crude fiber gradually increased and replaced the protein portion.

Keywords: Arsenic • Chromium • Fruits and vegetables • Nutritive value • Contamination

Introduction

Consumption of fruits and vegetables are always crucial for a diversified and healthy diet. Adequate consumption of fruits and vegetables extensively reduce the occurrence of chronic diseases, such as cancer, cardiovascular diseases and other aging-related pathologies [1]. Metal accumulation in vegetables and fruits may pose a direct threat to human health [2,3]. The accumulation of heavy metals and metalloids in agricultural soil is of increasing concern now a day. Potentially harmful metal in soil may come from the bedrock itself and anthropogenic sources like solid or liquid waste deposits, agricultural inputs and fallout of industrial and urban emissions. Among all the heavy metal, Arsenic and chromium (Cr) are widespread environmental contaminants that affect global health due to their toxicity and carcinogenicity [4,5]. These are entering into the terrestrial and aquatic ecosystems, food chain through a combination of natural processes and anthropogenic activities [6]. The contamination of arsenic & chromium in environmental systems, over the past three decades, has received much attention from the scientific community and has been recognized to be a major health concern in several areas of the world [7].

Fruits and vegetable plants can take up heavy metals and accumulate them in their edible and non-edible parts at quantities high enough to cause clinical problems to both animals and human beings. Excessive content of metals beyond Maximum Permissible level (MPL) leads to number of nervous, cardiovascular, renal, neurological impairment as well as bone diseases and several other health disorders [8].

Heavy metal contaminations of surface and groundwater, agricultural soils, fruits, vegetables, and crops are the major concern for public health and ecosystem preservation. Recently, contamination of groundwater by Arsenic (As) has attracted much attention compared to that by other heavy metals [9,10]. The contamination is not only from natural water system but also anthropogenic (human-caused) origin. Surface water is also getting contaminated by As. The As and Cr contamination of surface water occurs in different ways such as by the weathering of minerals [11,12] and by the anthropogenic activities that includes discharge of industrial waste water, applications of sewage sludge and waste water in agriculture, and mining activities. The exposure of As in human is caused by ingesting groundwater and crops contaminated by As. The exposure leads to the problems with cardiovascular diseases, premalignant skin lesions, conjunctivitis, etc. [13].

In Bangladesh, many textile and tannery industries dispose their wastes into nearby rivers, canals and lakes without any treatment, and this type of disposal deteriorates surrounding environment and aquatic ecosystems. The waste water, containing as and other heavy metals, are used for irrigation in adjacent agricultural land. Various industries like textile, dyeing of plastics, metal fabrications, paints, lather, tanning, semiconductor goods, etc. are the major source of As and other heavy metals in the wastewater of Bangladesh [14]. Continuous irrigation from these sources containing wastewater is quite responsible for increased As & Cr concentration in soil. Crops grown in that soil can easily uptake As & Cr, and accumulate in their edible parts [15].

There is an urgent need of local database or risk assessment studies in local fruits and vegetables to assess the potential risk to humans from heavy metal residues because the Bangladesh have varying topographical and environmental conditions under which a considerable number of fruits and vegetable consumption is growing. The knowledge relating to health, diseases and plantation of these plants is acquired usually from the literature of the western countries where the environmental and nutritional conditions are different from those of the Asian countries. Heavy metals are an important source of fruits and vegetables contamination and health hazard. The main threats to human health are associated with exposure to Arsenic, Lead, Chromium and Nickel. Sources of food contamination include environmental and industrial pollution, agricultural practices, food processing and packaging [16]. Absorption of heavy metals through food

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has been shown to have serious consequences on health and thereby economic development associated with a decline in labor productivity as well as the direct costs of treating illnesses such as kidney disease, damage to the nervous system, diminished intellectual capacity, heart disease, gastrointestinal diseases, bone fracture, cancer and death [16].

Materials and Methods

Five types of fruits and vegetables leaf were analyzed in this study. These include Sapodilla, Lemon, Guava, Papaya, Basella alba. Five samples from each type of fruit were selected for the measurement of heavy metals content. The freshly collected sample was washed with deionized water to eliminate visible dirt and removed the water quickly with a blotting paper. Then the sample was cut into small pieces, homogenized and accurate amount was weighed as required for different analysis. Five samples from each fruit and vegetables were selected for measurement. The vegetable samples were washed with distilled water to eliminate air-borne pollutants. The leafy stalks were removed from all samples and these were sliced and dried on a sheet of paper to eliminate excess moisture. Once dried, each sample was weighed and oven-dried at 60°C to constant weight. Each oven-dried sample was ground in a mortar until it could pass through a 60 mesh sieve. The samples were then stored in a clean, dry, stoppered glass container before analysis. Leafs nutritional compositions like moisture, ash, protein, crude fat, crude fiber, and total carbohydrate were analyzed under AOOC method.

Laboratory grade (99.9%) Sodium arsenate and Potassium chromate salts were collected from local suppliers. Freshly prepared 10 ppm of 100ml solutions of Sodium arsenate and Potassium chromate were added to vegetables and fruit plants i.e. Guava, Papaya, Lemon, Sapodilla, Basella daily. Growth and survivability of the plants were observed for two weeks. Leafs of vegetable and fruit plants were collected from third week and addition of arsenic and chromium solutions were continued for next month.

Leaves were then dried and grinded to make it ready for microwave digestion system. Each dried samples of 0.5gm were taken for this operation with adding 5:1:1 concentrated Hydrochloric acid, Perchloric acid and sulfuric acid solutions. Then, the overall contamination of arsenic and chromium were analyzed by Shimadzu AA-7000 atomic absorption spectrophotometer. Variations of nutritional profiles of previously analyzed parameters were also observed.

Results and Discussion

In this study, concentrations of Arsenic and Chromium were determined in the plants of three highly consumed fruits, including Sapodilla(*Manilkara zapota*), Guava (*Psidium guajava*), Lemon (*Citrus limon*) and two vegetables, including Papaya (*Carica papaya*), Basella (*Basella alba*). As fresh fruits, vegetables, and fiber are of significance in the diet because they contain vitamins and mineral salts. They are very important and useful components for the maintenance of a better health and the prevention and management of various diseases. Heavy metals have damaging effects on humans and animals, because of their non-biodegradable nature, long biological half-lives, and potential to accumulate in different body parts as there is inadequate mechanism for their elimination from the body [8]. Accumulation of heavy metals has been reported to exhibit carcinogenic, mutagenic, and teratogenic effects [16, 17]. As, Pb and Cr are the most abundant heavy metals, and their excessive intake is associated with cardiovascular, kidney, skin, nervous, and bone diseases [18,19]. The transportation and concentration levels of As & Cr heavy metals found in the analyzed fruit and vegetable leaf samples are listed along with the change of nutritive value (Table 1).

The experimental results of the present study showed that the concentrations of Chromium in leaf are much higher than the concentrations of Arsenic; although both metal concentrations exceed the permissible limits of WHO and Bangladesh standards. While, highest concentration of Cr 23.22 mg/g was found in Basella leafs and lowest concentration of Cr 5.73 mg/g was found in Sapodilla leafs. While, Arsenic content was high in Sapodilla 1.1283 mg/g and low in lemon 0.027 mg/g plants. Furthermore, all the samples showed considerable level of accumulation of chromium compared to arsenic. It was due the interactions and their selective affinity to these types. Moreover, the growth criteria of all the species was not same and the initial size of the species were different; that's why the concentrations of species showed variations in their result as we examined the level of concentrations in mg/g. However, the overall trend of the accumulation gives similar pattern (Figures 1 and 2)

Arsenic (As) and Chromium (Cr) concentrations, (mg/g)										
	Sapodilla		Lemon		Guava		Papaya		Basella	
Before treatment (Control)	0	0	0	0	0	0	0	0	0	0
After treatment (3 weeks)	1.06	25.93	0.1	9.65	0.03	16.59	0.43	12.07	0.17	12.36
After treatment (4 weeks)	1.28	15.38	0.03	12.97	0.05	9.35	0.22	9.65	0.2	10.55
After treatment (5 weeks)	0.45	5.73	0.22	7.24	0.3	14.17	0.23	10.86	0.6	20.81
After treatment (6 weeks)	0.82	13.27	0.89	9.35	0.51	8.74	0.89	12.07	1.13	23.22

Table 1. Arsenic concentrations of different vegetables and fruits leaf samples in mg/g level.

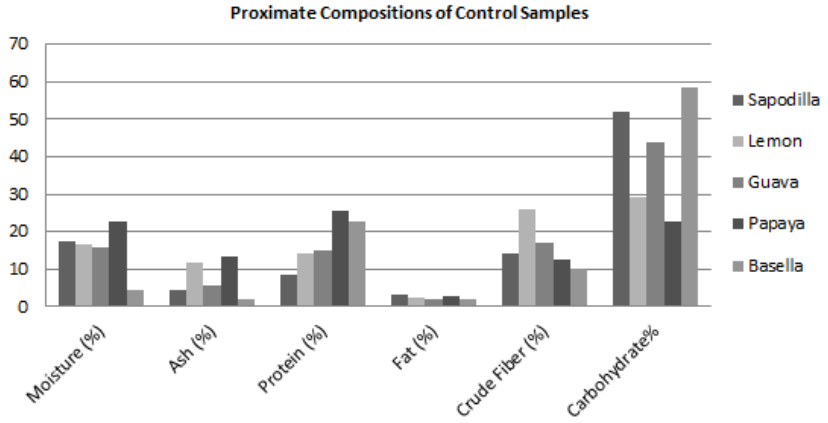

Figure 1. Proximate composition of non-contaminated vegetables and fruits leaf samples.

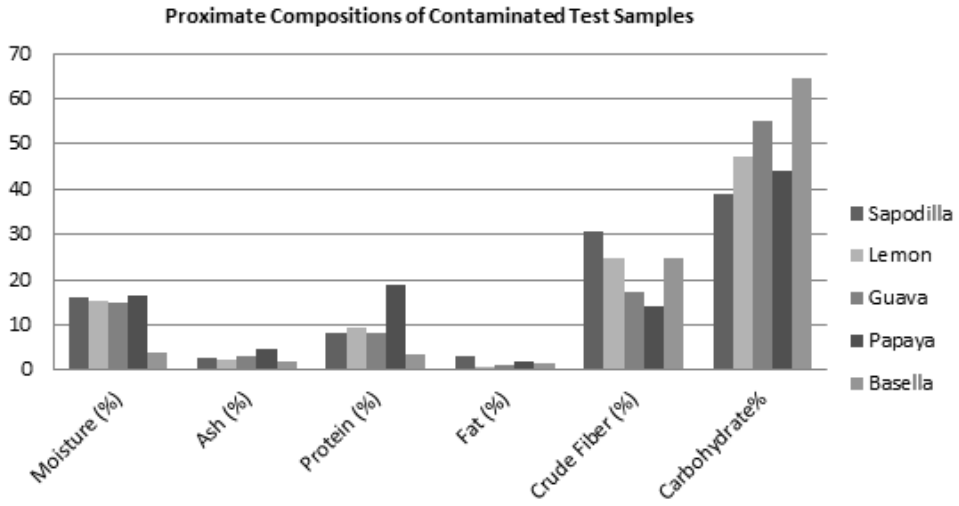

Figure 2. Proximate composition of contaminated vegetables and fruits leaf samples.

Contamination of As and Cr changed the composition of Carbohydrate, protein, and fat in all fruits and vegetable samples. Percentage composition of Protein, Fat and Ash decreased in all test samples compared with non-contaminated test samples. Papaya leafs have the highest percentage of protein in contaminated and non-contaminated samples having 18.89% and 25.55% respectively. Lowest percentage of protein and ash was found in contaminated Basella samples 3.5% & 1.77% respectively. Moisture percentage of all samples has very limited impact on percentage change. Moisture percentage in control and contaminated samples ranges from 3.98 to 22.82%.

Percentage of Crude fiber in Arsenic, Chromium contaminated samples increased compared to non-contaminated control samples, and the highest & lowest percentage was found in contaminated Sapodilla & Papaya leafs was found. These having 30.5% & 14.06% crude fiber in contaminated samples while 14.33% & 12.61% crude fiber found in non-contaminated control Sapodilla & Papaya leafs respectively. It is evident that nutritive composition of Carbohydrate also increased in the contaminated test samples with only exception of Sapodilla leafs. Highest composition of carbohydrate was found 64.48% in contaminated Basella leafs; while lowest percentage of composition was in non-contaminated.

Conclusion

The present study includes the investigation of the levels of Arsenic and Chromium in different fruits and vegetables (Sappodila, Lemon, Guava, Papaya, Basella) located in Chittagong region. The overall prevalence of Arsenic and chromium were higher than the standard tolerance level among most of the experimental plants. It might be due to the absorption system of the plant. Plants are more prone to contaminate by plant-water transportation with heavy metal like arsenic and chromium day by day in Bangladesh. Moreover, heavy metals like Chromium and Arsenic come to the environmental systems due to rapid industrialization and applications without sustainable water management. So, contamination of fruits and vegetables are now rapidly increasing. In this study the level of arsenic and chromium contamination in different fruits and vegetables has reveals the easiest absorption of those heavy metals by the plants. In the leafy vegetables the contamination level is very high then the fruits. Rapid transportation of contaminant like arsenic and chromium in different plant and its drastic impact on the nutritive value of the fruits and vegetable seemed to be alarming. In all test groups, there was a remarkable change in the nutritive composition of plants due to the effect of contamination. In all tested sample there was a prominent change in the nutritional level of the fruits and vegetables. The crude protein normally replaced by crude fiber due to the corrosive effect of the contamination of those heavy metals. Overall, arsenic and chromium contamination of the vegetables is not potentially a wide-spread public health threat if the existing point-sources are traced and ameliorated.

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