Cadmium contamination of vegetables commonly sold in vegetable markets in Khartoum State, Sudan

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Abstract

The contamination of vegetables by cadmium is a major chemical hazard to human public health. The fumes emitted from the exhaust pipes of vehicles operated by gasoline are considered a major source of heavy metals polluting the Atmosphere. This study focus on the determination of cadmium level in some vegetable varieties commonly sold in vegetables markets in Khartoum state, Sudan. The following samples, Okra, Jews' mallow, Snake cucumber, Tomatoes, Purslane, Eggplant, Potatoes and water crest were collected from three locations in Khartoum State. Samples were cut, air-dried at room temperature and consequently powdered. Samples were analyzed for cadmium content using Atomic Absorption Spectrophotometer (AASP). Results revealed that, cadmium concentration was very high for all tested vegetables and exceeded the recommendation (0.1mg/kg) of the CODEX (2010), FDA (2006), EU, FSANZ (2011). The highest cadmium values (4.90 ±0.14 mg /kg) were recorded in tomatoes sold at Omdurman, then (3.07 0±.12mg/kg) in Jew's mallow (leafy vegetable) in Nile street, followed by (2.450±.17mg/kg) in water cress and (2.30 ±0.18 mg/kg) in purslane found at Omdurman. Although, the lowest cadmium concentration (0.03 ±0.09mg/kg) was detected in cucumber, but exceeded the standard level (0.1mg/kg). This study concluded that, the levels of cadmium concentration in vegetable commonly sold in Khartoum State are high which imposes adverse risk to public health.

Keywords: Vegetables, Cadmium concentration, Khartoum State

1. Introduction

Cadmium (Cd) is considered as a major environmental concern to the agricultural system over the years. Cadmium ranks seventh among the top toxins (Nazar et al., 2012) and classified as human carcinogenic group 1 (Dinis and Fiuaz, 2011). Man- made cadmium (Cd) emissions can be transported between environment media and the food chain. Food is the primary source of cadmium exposure where chronic cadmium exposure has been reported to be associated with chronic kidney disease, osteoporosis, diabetes cardiovascular disease, liver and lung diseases, and cancer (ATSDR, 1999).

Human exposure to cadmium occurs chiefly through inhalation or ingestion of food containing cadmium which is the main venue for the human body. Vegetables are regarded as a common part of the human diet; they contain essential nutrients such as; carbohydrate, proteins, vitamins and trace elements, which are vital to human existence as a result of their role in metabolism, vegetables richness in fibers having anti oxidative effects as well as buffering agents for acidic substances obtained during the digestion process. However, a wide range of concentration of heavy metals are the most hazardous pollutants. The problem of environmental pollution by heavy

metals has attracted much attention in recent years. Automobiles using gasoline as fuel are a major source of heavy metals in the atmosphere. Heavy metals, being non-degradable, become an integral part of the habitats after been released into the environment (Elhouri, 2016). Lead and cadmium are the major metals pollutants of the environments are released from burning fuel where vehicular exhaust accounts for more than 50% of the total pollution (Sharma and Prasad, 2010). This study investigated the contamination of vegetables with cadmium element in three arrears of Khartoum state, Omdurman, shops in the main street and the Nile street.

2. Materials and methods

2.1. Collection of samples

All vegetables samples were collected from three different locations in Khartoum state (Omdurman, shops in the main street, and the Nile Street). The gathered samples represent eight varieties of vegetables (Tomatoes, Watercress, Purslane, Jew's mallow, Eggplant, Snake cucumber, Okra and Potatoes).

2.2. Preparation of samples

At first, samples were cut and air-dried for at room temperature, then ground to powder, packed in polyethylene bags, and then stored at room temperature.

2.3. Determination of Cadmium

Analysis of samples were done by Atomic Absorption Spectrophotometer (AAS) (Perkin Elemer, 1994).

2.4. Statistical Analysis

Data were analyzed as complete randomized design with three replicates using Statistical Analysis system program SAS (1997). Means were separated using Duncan's Multiple Range Test and the differences were accepted at $P \leq 0.5$

3. Results and discussion

Cadmium is one of the most toxic heavy metal elements in the environment due to its high mobility and toxicity (Ye et al., 2003) and its susceptibility to transport across the food chain (Hiroyuki et al., 2002). It is found in soil, air, and water, especially in congested areas with factories, and wide use of fertilizers containing cadmium. Pesticides are one of the main sources of cadmium contamination, as well (Wu et al., 2004).

3.1. The concentration of Cadmium in some vegetables sold in Omdurman

The cadmium concentration in some samples of vegetables is shown in Table 1. The highest cadmium concentration was recorded for tomatoes (4.900±.14mg/kg) where the lowest was in potatoes (0.50 ±0.11mg/kg), while other samples ranked as intermediate position ($P \leq 0.05$). Cadmium concentration in some samples of tested vegetables exceeded the standard level of (0.1mg/kg) as recommended by CODEX (2010), FDA (2006), EU, FSANZ (2011).

Munisamy et al. (2013) reported that the cadmium concentration in all vegetables samples were within permissible limit of 1.5 mg/kg except samples cultivated in different distances away from the roadside (2.90mg/kg and 1.63mg/kg). Saeed (2005) found that the maximum levels of cadmium (1.8 mg/kg) were in water cress collected from the farm, but in roadside market was (0.845 mg/kg) in tomatoes, then (0.0575mg/kg) in Okra in the roadside farm and (0.0412mg/kg) in the roadside market. So, those results were lower than the obtained result by Jacob and Samuel (2012) for the tomato (3.2mg/kg). Elhouri (2016) stated that leafy vegetables such as mallow and water cress are good absorber of heavy metals. Radwan and Salama (2006) detected cadmium and other heavy metals in Egyptians fruits and vegetables where cadmium levels were found about 0.01mg/kg in tomatoes, 0.15mg/kg in cucumber and 0.02mg/kg in potato.

3.2. Concentration of cadmium in some vegetables in the main street in Khartoum state

The concentration of cadmium in the main street of Khartoum are presented in Table 2. The highest value (1.65±0.17mg/kg) of cadmium was found in purslane followed by water cress (1.38±0.13mg/kg) and Jew's mallow (1.7±0.15mg/kg) which means that leafy vegetables had high level of cadmium, however, the lowest level (0.33±0.19 mg/kg) was observed in eggplant which exceeded the allowed level of 0.1mg/kg by CODEX (2010), FDA (2006), EU, FSANZ (2011). Chunhabundit (2016) reported that, the leafy vegetables may have considerably higher cadmium levels. Toxic elements including cadmium are higher in leafy vegetables than in root vegetables, in general. A recent report in 2013 for vegetables collected from local markets, big supermarkets and grocery stores in Bangkok revealed that potatoes had highest cadmium concentration. Guerra et al. (2010) stated that cadmium concentration was as follows; in okra (0.12mg/kg), potatoes (0.09mg/kg) in water cress (0.10mg/kg) and in eggplant (0.04mg/kg). Islam and Hoque (2014) found that cadmium concentration in vegetables ranged from (0.009 to 1.0 mg/kg) but in tomatoes it was 0.05mg/kg. Dafa Elseed (2007) reported that cadmium concentration in snake cucumber at roadside farm and in roadside market was (0.45 and 0.28 mg/kg respectively, but cadmium concentration in tomatoes from open market and in watercress in roadside farm was (0.25 and 0.60mg/kg) respectively. In Pakistan, Parveen et al., (2003) reported that cadmium concentration in tomatoes, cucumber and potatoes were 0.33, 0.36 and 0.08 mg/kg, respectively. Gadomaska et al., (2016) stated that cadmium concentration was (0.00119mg/kg -1) DM in Eggplant. Cadmium is considered a multi-target mineral within the body and the deposition of this mineral increases in the liver and kidneys, which leads to the occurrence of hepatotoxicity and nephrotoxicity as well as a decrease in the content of glutathione, the enzyme that attacks free radicals causing increase in the amount of free radicals in plasma, liver and brain. In addition, cadmium was found cause a decrease in hemoglobin and hematocrit (EL-Demerdash et al., 2004). Likewise, there was an increase in glucose, urea, creatinine, white blood cells. A decrease in protein, hemoglobin, red blood cells, number and lack of movement of sperms (Nemmiche et al., 2007).

3.3. Concentration of Cadmium in some vegetables in the Nile street in Khartoum state

The data in Table 3 shows the cadmium concentration in samples of vegetables collected form Nile street in Khartoum exceeded the standard level recommended by CODEX (2010), FDA (2006), EU, FSANZ (2011). Cadmium concentration was significantly higher in Jew's mallow (3.07±0.12mg/kg) followed by Purslane (1.50 ± 0.13mg/kg), water cress (1.35± 0.18mg/kg), tomatoes (1.12 ±0.11mg/kg), eggplant (0.90± 0.15mg/kg), okra (0.35±0.08 mg/kg) and (0.30 ± 0.09mg/kg) in cucumbers. Zhou (2016), reported the range of cadmium concentrations in vegetables was 0.003–0.195mg/kg and in tomatoes it was 0.028mg/kg, but the maximum concentration of cadmium in all vegetables varieties tested exceeded the recommended values. Therefore, the concentrations of cadmium in leafy vegetables were significantly higher (2.39mg/kg) than the other five vegetables varieties, the lowest concentrations of cadmium, (0.004mg/kg) in species of vegetables were in cucumber. Dafa Elseed et al. (2006) found cadmium around 3.7, 3.3 and 2.8 (mg/kg) in tomatoes in the roadside farm, roadside market and open market as well as in watercress and 4.3, 3.7, 1.5 (mg/kg) in roadside farm, roadside market, and open market, respectively. In snake cucumber, it was 1.7 (mg/kg) in both roadside farm, roadside market, but in open market it was 1.5 (mg/kg). Dospatliev et al., (2012) reported that cadmium in eggplant about 0.24 (mg/kg) in potatoes 0.82 (mg/kg) and 0.35 (mg/kg) in okra. Sharma et al., (2010) concluded cadmium in okra 0.53 (mg/kg). According to Stancic et al., (2016) maximum concentration of cadmium in wet vegetables was 0.20 (mg/kg) whereas in leaf vegetables, stem vegetables, root vegetables, and potatoes it was 0.050 (mg/kg). Food is the main source of human exposure to cadmium, in addition to air and water. The body absorbs half of the amount from food, which ranges from 2-40 parts per kilo. This element is stored in the liver and the kidneys and eliminated slowly and in the event of an increase in its concentration in the body. Higher cadmium levels cause damage to the kidneys. Breathing cadmium in high concentration causes serious lung damage, as well as liver damage, osteoporosis, lung cancer and may lead to death Chen and Zhang (2004). Few animal studies indicated that younger animals absorb more cadmium than older animals and are more likely than adults to develop osteoporosis and weakening of their strength as a result of exposure to cadmium. Also, there is some information extracted from the studies that Conducted on animals indicates extremely high rates of cadmium exposure may cause a decrease in body weight and affect the skeleton Osteospermum in young people (ATSDR, 2012).

Table 1. Concentration of Cadmium in some vegetables in Elsoog Elshaabi Omdurman

English name	Scientific name	Cadmium mg/kg	Standard mg/kg	Increase%
Okra	*Abelmoschus escutentus*	0.70^{f}±0.15	0.1	85.7%
Jew's mallow	*Corochorus oliterios*	1.78^{c}±0.19	0.1	94.3%
Snake cucumber	*Cucumis memo*	1.60^{d}±0.18	0.1	93.7%
Tomatoes	*Lycopersium esculentus*	4.90^{a}±0.14	0.1	97.9%
Purslane	*Portulaca oleracae*	2.30^{b}±0.13	0.1	95.6%
Eggplant	*Solanum melongena*	1.10^{e}±0.11	0.1	90.9%
Potatoes	*Solanum tuberosum*	0.50^{f}±0.17	0.1	80%
Water cress	*Erua sativa*	2.45^{b}±0.12	0.1	95.9%

*Mean ±SD. Having different superscript letters on columns are significantly different (P ≤ 0.05).

* Standard: CODEX (2010), FDA (2006), EU, FSANZ (2011).

Table 2. Concentration of Cadmium in some vegetables in the main street in Khartoum state

English name	Scientific name	Cadmium mg/kg	Standard mg/kg	Increase%
Okra	*Abelmoschus escutentus*	0.60^{d}±0.12	0.1	83.3%
Jew's mallow	*Corochorus oliterios*	1.17^{c}±0.18	0.1	94.4%
Snake cucumber	*Cucumis memo*	0.57^{de}±0.16	0.1	82.4%
Tomatoes	*Lycopersium esculentus*	0.45^{f}±0.11	0.1	77.7%
Purslane	*Portulaca oleracae*	1.65^{a}±0.19	0.1	93.9%
Eggplant	*Solanum melongena*	0.33^{g}±0.14	0.1	69.9%
Potatoes	*Solanum tuberosum*	0.55^{e}±0.15	0.1	81.8%
Water cress	*Erua sativa*	1.38^{b}±0.17	0.1	92.7%

*Mean ±SD. Having different superscript letters on columns are significantly different (P ≤ 0.05).

* Standard: CODEX (2010), FDA (2006), EU, FSANZ (2011).

Table 3. Concentration of Cadmium in some vegetables in the main street in Khartoum state

English name	Scientific name	Cadmium mg/kg	Standard mg/kg	Increase%
Okra	*Abelmoschus escutentus*	0.35^{f}±0.13	0.1	71.4%
Jew's mallow	*Corochorus oliterios*	3.07^{a}±0.14	0.1	96.7%
Snake cucumber	*Cucumis memo*	0.30^{f}±0.15	0.1	66.6%
Tomatoes	*Lycopersium esculentus*	1.12^{c}±0.12	0.1	91.1%
Purslane	*Portulaca oleracae*	1.50^{b}±0.11	0.1	93.3%
Eggplant	*Solanum melongena*	0.90^{d}±0.09	0.1	88.8%
Potatoes	*Solanum tuberosum*	0.82^{e}±0.16	0.1	87.8%
Water cress	*Erua sativa*	1.35^{bc}±0.18	0.1	92.6%

*Mean ±SD. Having different superscript letters on columns are significantly different (P ≤ 0.05).

* Standard: CODEX (2010), FDA (2006), EU, FSANZ (2011).

Conclusion

The level of cadmium in vegetables from polluted areas is very high. Farm sale, market sale, road sale are source of contamination and may pose significant public health risk to the local communities. The high consumption of vegetables is the most important source of dietary cadmium exposure. Cadmium contents in contaminated vegetables samples from Khartoum state is still in a position to cause health hazard to the consumers. The results of monitoring cadmium levels showed that cadmium exposure was likely related to the adverse health condition of the public.

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