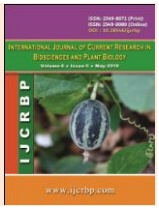
EXCELLENT PUBLISHERS

International Journal of Current Research in
Biosciences and Plant Biology

Volume **6** • Number **5** (May-2019) • ISSN: 2349-8080 (Online)

Journal homepage: www.ijcrbp.com



Original Research Article **doi:** https://doi.org/10.20546/ijcrbp.2019.605.003

A study of potentially toxic elements in potato and cabbage grown in different regions of Uttar Pradesh

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Article Info

Date of Acceptance:
18 April 2019

Date of Publication:
06 May 2019

Keywords

Climate change
Heavy metal
Toxicity

ABSTRACT

The study of heavy metals like lead, mercury, arsenic, zinc and copper has carried out in two different vegetable (cabbage and potatoes) of Uttar Pradesh (UP). The results of analysis revealed that all cabbage samples met Public Health Regulation Standards regarding investigated metals. However, potatoes from nine investigated locations exceeded the Maximum Permissible Concentrations (MPC) allocated for lead and met the standards considering other investigated elements. In the view of obtained results, pointing out lead as major problem regarding heavy metal pollution of investigated vegetables.

Introduction

The environmental persistence of metals, additionally associated with their considerable use in modern society, resulted in accumulation of significant levels of these contaminants in the environment. They are being absorbed by plants to different extent depending on their source, soil and climatic factors, plant genotype and agrotechnical conditions, entering thereby the human food chain (McLaughlin et al. 1999). Some of them are essential for plant growth and /or different human metabolic processes in small amounts, resulting in adverse health effects at high levels of consumption while others show major toxic effects at the lowest rates of exposure.

The aim of our study was to determine contents of lead, total mercury, arsenic, cadmium, zinc and copper in samples of cabbage and potato, the most consumed vegetables in Uttar Pradesh, and to estimate dietary intake of investigated elements through potato and cabbage consumption. In the framework of our research we also assessed the impact of high temperature time operations on the quality of crops grown in that area several years after the western, regarding their content of investigated elements. Pb, Hg, As and Cd were chosen as target contaminants of the investigation because they are known to be the most important to consider in terms of food-chain contamination. The main sources of toxic metal emission to the environment are different anthropogenic

activities such as industrial, agricultural and urban activities. Main sources of lead in the soil are atmospheric depositions from combustion of gasoline containing Pb additives (Andersson 1979). Mercury is usually added to soils in fertilizers and manure (Hutton 1983). Largest emissions of cadmium to the soil are by waste disposal, but also to the lesser degree through coal combustion, iron and steel production, phosphate fertilizers etc (Page 1972). Its concentrations in foodstuff vary widely, and considering food crops, the highest levels of that metal are found in leafy vegetables and rooty crops (Langdon 2003).

The greatest accumulation of arsenic occurs in the areas exposed to industrial effluents and especially in areas next to smelters and mine spoils (Palinkaš 1993). Earlier, the heavy metal and other related to biomonitoring studies has been carried out by various workers in the Uttar Pradesh but this study is first time carried out in the whole UP.

Materials and methods

Sample collection and preparation

Potato and white cabbage samples were collected in 20 different locations in UP; ten locations (samples 1 –10) are located in East UP. Other ten locations (samples 11 – 20) are situated in the West part of the UP. From each location two heads of cabbage and 2x1 kg of potato were collected. In cabbage samples all damaged outer leaves were removed and the rest of the sample was chopped and homogenized. Potatoes were washed several times with tap water, followed by distilled water, and after the excess water was wiped off using filter-paper, potatoes were peeled, chopped with disposable plastic knife to small pieces and mixed thoroughly. After high temperature, samples were first air dried for several days and then dried in an electric furnace at 105°C to constant weight. For further analysis samples were stored in polyethylene bottles at 4°C. Moisture was determined in fresh samples by drying them to constant weight at 105° C in an electric furnace.

Determination of toxic and potentially toxic elements

In order to determine Zn, Cu, Pb, Cd, As and total Hg amounts in investigated vegetables, 1g ±0.0001 of homogenized, dry samples were weight into the vessels and wet digested using HNO_3 conc. and 30% H_2O_2 in an microwave unit.(MLS-1200 Mega Microwave Digestion System). After digestion process, clear solutions were transferred to 50 ml volumetric flasks and diluted with deionized water. Mercury and arsenic were determined by atomic absorption spectophotometry - AAS (Pye Unicam SP9 Atomic Absorption Spectrophotometer), using hydride technique at 193.7 nm (As) and 253.7 nm (Hg). Content of all other investigated elements were determined by inductively coupled plasma atomic emission spectroscopy - ICP-AES (Liberty 200 Inductively Coupled Plasma Atomic Emission Spectrometer). The analytical wavelengths of the elements of interest were as following: 228.802 (Cd), 220.353 (Pb), 324.754 (Cu) and 213.856 (Zn). All measurements were carried out in duplicates.

Results and discussion

Amounts of toxic and potentially toxic elements detected in investigated vegetables are shown in Table 1, and are characterized by a large variability within investigated groups. Arsenic was not detected in any of investigated samples, while measurable levels of mercury were only found in the part of investigated potato samples.

Zinc and copper contents in investigated vegetables

Zinc and copper levels were investigated in this context since too high intake of those, otherwise essential metals can show adverse health effects. The range of zinc contents were 1.7 – 3.4 mg/kg fresh weight (FW) (mean 2.5 mg/kg FW) in cabbage grown Western region and 0.97 – 4.27 mg/kg FW (mean 2.00 mg/kg FW) in samples from western affected locations. Although obtained results point to on an average higher Zn levels in samples from western region, performing statistical analysis showed that those differences were not statistically significant. Zinc levels found in potato samples were higher compared to those of cabbage and they ranged from 3.42 – 14.11 mg/kg FW in Western region and 2.64 – 8.34 mg/kg FW affected areas. The differences between the two groups of samples were statistically insignificant as well.

Table 1. Content of toxic and potentially toxic elements in investigated samples.

Sampling site	Cabbage (mg/kg FW)						Potato (mg/kg FW)					
	Cu	Zn	Cd	Pb	Total Hg	As	Cu	Zn	Cd	Pb	Total Hg	As
Eastern areas of Uttar Pradesh												
Bahraich	0.24	0.97	0.012	0.006	* /	/	1.55	4.33	0.020	0.10	0.003	/
Gonda	0.17	1.45	0.006	0.012	/	/	1.60	8.34	0.039	0.06	0.007	/
Allahabad	0.23	1.80	0.008	0.023	/	/	1.59	5.10	0.059	0.14	/	/
Gorakhpur	0.62	4.27	0.009	0.114	/	/	1.95	2.64	0.012	0.14	/	/
Deoria	0.31	1.60	0.005	0.039	/	/	1.90	3.94	0.008	0.11	/	/
Azamgarh	0.38	2.19	0.007	0.012	/	/	2.98	6.45	0.012	0.27	0.040	/
Varanasi	0.38	2.35	0.007	0.020	/	/	1.87	4.57	0.010	0.08	0.025	/
Jaunpur	0.33	2.33	0.006	/	/	/	1.85	3.96	0.027	0.14	0.030	/
Sultanpur	0.25	1.59	0.007	0.018	/	/	1.71	4.05	0.022	0.06	0.010	/
Faizabad	0.17	1.45	0.006	/	/	/	2.46	4.04	0.005	0.11	0.017	/
Western area of Uttar Pradesh												
Saharanpur	0.30	3.40	0.007	0.027	/	/	1.02	3.42	0.010	0.07	0.004	/
Moradabad	0.40	2.91	0.017	0.021	/	/	1.67	5.85	0.063	0.06	0.017	/
Bareilly	0.38	3.03	0.027	0.011	/	/	2.57	4.69	0.040	0.03	0.008	/
Lakhimpur	0.31	2.44	0.007	0.014	/	/	2.00	14.11	0.057	0.08	0.005	/
Muzaffarnagar	0.39	2.03	0.014	0.026	/	/	1.71	8.57	0.031	0.04	0.015	/
Meerut	0.35	2.37	0.010	0.002	/	/	1.75	4.86	0.058	0.04	0.002	/
Philibhit	0.32	2.42	0.020	0.284	/	/	1.39	4.39	0.021	0.38	/	/
Etawah	0.26	2.21	0.006	/	/	/	1.26	4.34	0.008	0.01	0.024	/
Aligarh	0.38	2.46	0.015	0.110	/	/	1.58	5.12	0.041	0.11	0.019	/
Mathura	0.30	1.70	0.010	0.005	/	/	1.76	3.90	0.020	0.17	0.007	/

* / - concentrations are below the limit of detection of applied method (LD_{As}= 0.5µg/l, LD_{Hg}= 0.5µg/l, LD_{Pb}=2µg/l). Levels of investigated toxic elements that were below the limits of the detection of applied methods, were considered to be zeros for the sake of statistical analysis.

Obtained copper levels were rather uniformed ranging from 1.02 – 2.57 mg /kg FW (western region) and 1.55 – 2.98 mg/kg FW (western region) in potatoes while levels found in cabbage were somewhat lower ranging from 0.26 – 0.40 mg/kg FW in western areas and 0.17 – 0.62 mg/kg FW in western region. No significant differences were found between two investigated groups of samples regarding their Cu and Zn content.

Cadmium, total mercury and lead contents in investigated vegetables

The potatoes were found to contain higher levels of Cd compared to cabbage, especially potato samples from locations 3 ,12, 14 and 16, but they still didn't exceed MPC (0,1 mg/kg fresh weight) allocated by Indian law, and therefore all samples can be considered as sanitary safe regarding values obtained for Cd content. Revealed mercury levels were also characterized by large variability of results within groups. The highest mercury contents were found in potatoes from locations 6, 7, 8 and 18 (0.024 – 0.04 mg/kg FW) but obtained values were still lower than MPC for mercury. The mean contents of lead were higher in potato samples from western affected areas (0.12 mg/kg FW) related to control group (0.068 mg/kg FW) while obtained values in cabbage samples were almost the same for samples from both investigated groups (0.024 mg/kg FW – western region and 0.022 mg/kg FW–western regions). It has been noted that both, cabbage and potato samples from one location in out of western region (location 17) showed rather high lead content (0.284 mg/kg FW in cabbage and 0.380 mg/kg FW in potato), so Q-test for rejecting of data was performed. It indicated that samples of issue don't belong to their respective groups so they were excluded from further statistical analysis. Those aberrations point to the probable local lead contamination.

Although recovered results seem very alarming considering increased lead levels in as many as nine out of twenty investigated locations, it is important to say that emphasizing the lead as the main toxicological problem considering sanitary safety of investigated samples, is partially due to drastically changes of MPCs for heavy metals in food in UP. At the same time new MPCs allocated for mercury and cadmium allowed higher contents of those metals in fresh vegetables compared to the previous regulations. Estimation of dietary intakes of investigated toxic and potentially toxic elements through potato and cabbage consumption in UP. In order to estimate the hazard effects of toxic and potentially toxic elements present in food on human health, it is of great importance to precisely estimate their daily intake through food consumption. Most frequently, it is being done by conducting total diet studies that cover all foodstuffs consumed by an average person. Since results considering lead concentrations obtained in potato samples seem rather alarming in the view of the new regulations, we thought that it would be interesting to compare average lead dietary intake in UP to intakes in some other countries. Due to already mentioned high potato and cabbage consumption in UP, we also estimated the significance of cabbage and potato in participating in daily intake of investigated elements. Data are shown in Table 2.

Table 2. Estimation of toxic and potentially toxic element intake through cabbage and potato consumption in Uttar Pradesh.

Parameters	**POTATO**				
	Pb	**Cd**	**total Hg**	**Zn**	**Cu**
Average (mg/kg FW)	0.096	0.028	0.011	5.334	1.809
Average potato consumption	42.51 kg /person/year				
Estimated weekly (daily) intake through potato consumption - on 70 kg body weight basis	0.078 mg	0.023 mg	0.009 mg	(0.621 mg)	(0.210 mg)
PTWI (PMTDI) for 70 kg person	1.75 mg	0.49 mg	0.35 mg	(70 mg)	(35 mg)
Estimated intake as percentage of PTWI (PMTDI)	4.45%	4.69%	2.86%	(0.88%)	(0.6%)
TDI in UP – weekly (daily) intake*- on 70 kg body weight basis	0.701 mg	0.1214 mg	0.019 mg	8.1 mg	0.6 mg
Estimated intake as percentage of Croatian TDI	11.13%	18.95%	47.36%	7.67 %	35 %
Parameters	**CABBAGE**				
	Pb	**Cd**	**total Hg**	**Zn**	**Cu**
Average (mg/kg FW)	0.024	0.0103	0	2.249	0.324
Average cabbage consumption	11,73 kg/person/year				
Estimated intake weekly (daily) through cabbage consumption	0.005mg	0.002 mg	0	(0.072 mg)	(0.01 mg)
PTWI (PMTDI)	1.75 mg	0.49 mg	0.35 mg	(70 mg)	(35 mg)
Estimated intake as percentage of PTWI (PMTDI)	0.29%	0.41%	0%	(0.10%)	(0.03%)
TDI in Croatia - weekly (daily) intake*- on 70 kg body weight basis	0.701 mg	0.1214 mg	0.019mg	(8.1 mg)	(0.6 mg)
Estimated intake as percentage of TDI	0.71%	1.65%	0%	0.89%	1.67%
Parameters	**TOTAL**				
Estimated intake weekly (daily) through cabbage and potato consumption	0.083	0.025	0.009	(0.693mg)	(0.22mg)
Estimated intake as percentage of PTWI (PMTDI)	4.74%	5.10%	2.86%	(0.98%)	(0.63%)
Estimated intake as percentage of TDI	11.84%	20.59%	47.60%	8.56%	36.67%

*TDIs for Pb and Cd [13]; TDI for Hg [14]; TDIs for Cu and Zn [17].

It is obvious, from presented data, that cabbage and potato consumption significantly contributes to daily dietary intake of investigated elements covering from 8.73% (Zn) to 31.57% (Hg) of estimated daily dietary intakes for investigated metals in UP. Comparing obtained Zn and Cu levels to Recommended Dietary Allowances (RDAs) for Zn (ranging from 8 -11 mg/day) and for copper (900 µg/day) [16] and to PTMDIs (Table 2) allocated for those metals, it is obvious that in the case of investigated cabbage and potato samples, they cannot be considered as contaminants, but only as nutrients present in investigated vegetables that considering their average daily consumption can cover up to 10 % of RDA for Zn and up to 25% of RDA estimated for Cu. The information considering the percentage of total mercury intake through potato consumption was rather surprising since usually sea food is considered to be the richest source of this metal.

Conclusion

In this work we conducted the evaluation of sanitary safety of cabbage and potato samples, grown by individual producers in different locations in UP. Revealed levels of toxic and potentially toxic metals (Pb, Cd, Hg, As, Cu and Zn) were compared to other sources. Our investigation also showed that important agricultural areas in UP and studies of constant foodstuff monitoring are necessary in order to evaluate the impact of applying new regulations and to retain the constant insight on the situation with dietary intakes of toxic and potentially toxic elements in Uttar Pradesh.

Conflict of interest statement

Authors declare that they have no conflict of interest.

Acknowledgement

We are thankful to the Director of CytoGene Research & Development, providing necessary laboratory facilities.

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How to cite this article:
Archana, D., Uma Shankar, 2019. A study of potentially toxic elements in potato and cabbage grown in different regions of Uttar Pradesh. Int. J. Curr. Res. Biosci. Plant Biol. 6(5), 17-22.
doi: https://doi.org/10.20546/ijcrbp.2019.605.003