



## Comparative analysis of heavy metal contamination in some common tubers and vegetables of Kerala

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### ABSTRACT

Leafy vegetables and tubers contaminated by heavy metals will cause potential health risk to human beings. An analysis was carried out to study the heavy metal contamination in tubers and leafy vegetables at Kottayam district, Kerala. The results indicated that higher levels of lead were recorded in all of the samples analyzed when compared to the WHO permissible limits (0.1 mg/kg) for tubers and leafy vegetables, except in *Colocasia esculenta* (L.) Schott., collected from Erattupetta market. Cadmium content was higher in both the tubers and leafy vegetables collected from Changanacherry market. Therefore, regular assessment of the accumulation of heavy metals in leafy vegetables and tubers is the need of the era.

**Key words:** Accumulation, Cadmium vegetables, Flame atomic absorption spectrophotometer, Health risk, Heavy metals, Lead, Tubers.

### INTRODUCTION

Heavy metals are very toxic to human beings and plants and their mobile nature can move from bottom to top in plants and animals. Also the consumption of food items with heavy metal contamination is highly toxic to human beings. Some metals have importance in plant breeding or crop improvement. For example, Vijayata *et al.* (2017) studied that the genomic regions which were detected to be associated with high iron and zinc could be candidate for further fine mapping, gene identification and MAS in breeding. Also, Radmila Trajkovic *et al.* (2012) studied the influence of lead acetate and actinomycetes on germination and growth of vetch plant. Venkatesh *et al.* (2018) studied the response of zinc application on growth, zinc content and grain yield of rice genotypes and correlation between zinc content and yield attributes of rice genotypes. In their study the high and low seed zinc content genotypes showed negative correlation with yield and yield attributes. However, shoot zinc content was positively correlated with yield.

Several anthropogenic activities become the source of accumulation of heavy metals in air, soil and water. Industrialization, urbanization, soil contamination through mining, agronomic practices such as artificial fertilizers and metal based pesticides etc. will cause the increase in the heavy metal circulation through the soil (Uwah *et al.*, 2011, Usman and Ayodele, 2002, Ndiokwere and Ezech, 1990). For most of the toxic metals, mankind has become the key agent in the global atmospheric cycle of trace metals and metalloids.

Soil and vegetable samples are contaminated by toxic heavy metals and Fe concentration in soil variable in tomato and chilli and are crossed permissible limits (Smriti *et al.*, 2017). Ashiq *et al.* (2013) found that the concentration of cadmium, lead and nickel were higher in the upper surface of tube well and surface irrigated soils at all the four depths (0-15, 15-30, 30-45 and 45-60 cm), respectively and decrease in the lower surface. In relation with aquatic system, researchers found that based on the critical pollution index value (1491.5), river Yamuna is highly polluted due to anthropogenic activities (Richa *et al.*, 2017). The studies on *Telfairia occidentalis* Hook. F. is believed to contain heavy metals and cause potential health risk to the consumers (Oguntibeju *et al.*, 2013).

The consumption of leafy vegetables and tubers as food offer rapid and least means of providing adequate vitamins supplies minerals and fiber. Tubers are the most efficient carbohydrate producers. Heavy metal contamination of vegetables cannot be underestimated, as these foodstuffs are important components of human diet. Vegetables are rich sources of macro and micronutrients, vitamins, minerals, and fibers, and also have beneficial antioxidative effects (Agrawal *et al.*, 2007). Tubers constitute the daily part of every human diet. Also, vegetables are very important source of our daily diet rich in carbohydrates, proteins and vitamins but unfortunately contain the accumulation and translocation of heavy metals (Sobukola, 2010). Asaolu *et al.*, (2012) studied the proximate analysis and mineral composition of some Nigerian leafy vegetables and found that leafy

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vegetables contain high levels of crude protein with low fat content and crude fibres.

Akan *et al.*, (2013) analyzed the heavy metal accumulation in freshly harvested vegetables from four locations of Nigeria. They realized that the leaves of vegetables contain high concentrations of heavy metals and anions than its roots and stems. Simul *et al.*, (2017), estimated the concentration of globally alarming the heavy metals (Zn, Al, Cd, Pb, Cu, Ni, Fe, Mn, Cr, Co) in Meghna River, Bangladesh. A very strong positive correlation was recorded between Fe vs Al (0.992), Mn vs Cu (0.948), Fe vs Mn (0.939), Zn vs Al (0.929), Fe vs Zn (0.920) in water. Murat *et al.*, (2014) investigated the heavy metal accumulation in the leaves, stem and root of the invasive submerged Macrophyte *Myriophyllum spicatum*. According to the factor data of bioconcentration, the order of heavy metal accumulation in the plant was As > Cr > Pb > Hg > Cd.

Alexander and Ubandoma (2014) investigated the levels of heavy metals in *Amaranthus caudatus* and *Hibiscus sabdariffa* in two farms, A and B. The order of the metal contamination in the vegetables were Fe > Cu > Zn in farm A and Cu > Fe > Zn in farm B. Aydinalp and Marinova (2003) studied that the presence of heavy metals in some agricultural soils. So, there is chance to enter these metals in the cultivated plants. Zheng *et al.*, (2007) investigated that the inhabitants around Huludao zinc plant showed high health risk through the consumption of contaminated vegetables by the transfer of Hg, Pb, Cd, Zn, Cu from soil.

Based on persistent nature and cumulative behaviour as well as the probability of potential toxicity effects of vegetables and tubers, there is need to test and analyze these food items to ensure the levels of these trace elements meet the agreed international requirements. Knowledge of the contamination of tubers and vegetables with heavy metals from the areas of Kottayam has not yet been established. Desta *et al.*, (2017) explained about the need of regular monitoring of irrigation water, otherwise it

will create the presence of heavy metals in water. The present study was undertaken with the aim to compare and investigate the concentration of some specific heavy metals (Pb, Cd) found in some selected tubers and vegetables from most polluted areas of Kottayam District.

## MATERIALS AND METHODS

**Study area:** The study was conducted at designated sampling points representative of the markets from Kottayam, District of Kerala state. Kottayam lies between latitude 9°15' and 10° 21' and longitude 76° 22' and 77° 25'. The present study was carried out in three most polluted areas of Kottayam District. Three sampling sites chosen for the includes Changanacherry, Mukkoottuthara and Erattupetta (Table 1).

**Collection of samples:** The samples of various tubers and leafy vegetables were collected from from different market places of Kottayam District (Changanacherry -S1, Mukkoottuthara -S2 and Erattupetta-S3). The tubers include Elephant yam (*Amorphophallus campanulatus* Roxb.) belongs to the family Araceae. *Colocasia* (*Colocasia esculenta* L.Schott.) is a genus of 25 or more species of flowering plant in the family Araceae.

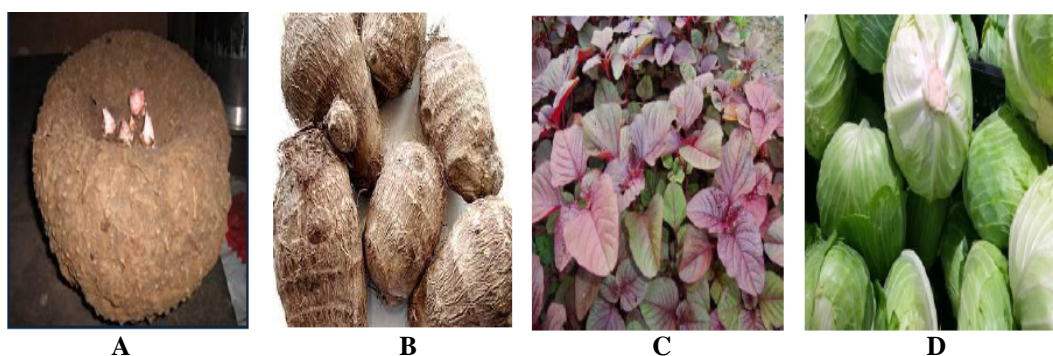
Leafy vegetables include cabbage (*Brassica oleracea* L. var. *capitata*) is a member of the genus Brassica and the mustard family, Brassicaceae and *Amaranthus* called edible amaranth (*Amaranthus tricolor* L.) belongs to



Fig 1: Site map of selected areas for the study.

Table 1: Heavy metal analysis in tubers and vegetables.

Tubers			
Tubers	Markets	Conc. of Lead (mg/kg)	Conc. of Cd (mg/kg)
<i>Colocasia esculenta</i>	Changanacherry (CC)	0.124	0.545
	Erattupetta (CE)	0.087	0.012
	Mukkoottuthara (CM)	0.150	0.010
<i>AmorphophallusCampanulatus</i>	Changanacherry (AC)	0.182	0.254
	Erattupetta (AE)	0.173	0.018
	Mukkoottuthara (AM)	0.101	0.014
<b>Leafy vegetables</b>			
<i>Amaranthus tricolor</i>	Changanacherry (AC)	0.115	0.746
	Erattupetta (AE)	0.222	0.023
	Mukkoottuthara (AM)	0.275	0.028
<i>Brassica oleracea</i>	Changanacherry (BC)	0.780	0.914
	Erattupetta (BE)	0.207	0.016
	Mukkoottuthara (BM)	0.192	0.013



**Fig 2:** Tubers and Leafy Vegetables.

**A)** *Amorphophallus campanulatus* Roxb., **B)** *Colocasia esculenta* (L.) Schott., **C)** *Amaranthus tricolor* L., **D)** *Brassica oleracea* L. var. capitata.

Amaranthaceae family (Fig 2). All samples from different markets are collected and stored in clean polythene bags and brought to the laboratory for analyses.

**Preparation and treatment of sample:** The collected samples were washed with distilled water to remove the dust particles and were cut into small pieces using a clean knife, the pieces of vegetables were dried in an oven at 100°C for three days. After drying the samples were ground into a fine powder using a commercial blender and stored in polyethylene bags until used for acid digestion. The powdered samples were subjected to analysis for their heavy metal content.

**Acid digestion and metal determination of samples:** One gram of powdered plant samples were weighed and placed separately in a small beaker. Added 10 ml concentrated  $\text{HNO}_3$  to each sample. Placed beaker in a stand and undisturbed overnight. Heated the beaker carefully on a hot plate until the production of red  $\text{NO}_2$  fumes has ceased and digestion become completed as was shown by a light coloured, clear solution. The samples were not permitted to dry during digestion. Cooled the beaker and added a small amount of 70% perchloric acid ( $\text{HClO}_4$ ) usually 2-4 ml. Heated again and allowed to evaporate to a small volume.

The extract was filtered through whatman no: 42 filter paper. Transferred the sample to a 50 ml standard flask and diluted to a volume with distilled water and used for analysis. Standards for the samples were also prepared in all cases for calibrations. Chemical analysis of heavy metal of both tubers and leafy vegetable samples carried out in the Atomic Absorption Spectrophotometric (AAS) method British (Pharmacopoeia, 2005).

The concentrations of heavy metals in every sample were determined three times, and the results were expressed as the mean concentration of heavy metal in the given sample (Singh *et al.*, 2005). Concentration of the metal in both the tubers and leafy vegetables were computed as mg metal per kg dry samples ( $\text{mg/kg}^{-1}$ ).

**Statistical analysis:** All analysis was performed in triplicates. Results were expressed by mean of  $\pm$  SD. Statistical significance was established using one way analysis of variance (ANOVA), means were separated according to Duncan's multiple range analysis ( $p < 0.05$ ).

## RESULTS AND DISCUSSION

Globally everyone is potentially vulnerable to the toxic effects of heavy metals. Many toxic heavy metals are ubiquitous in our environment. The accumulation of metals has been described as their content or concentration in different tubers and leafy vegetables on the basis of their amount per unit dry weight of tissues ( $\text{mg/kg}$  dry weight). The rate of accumulation of Pb and Cd are given in Table 2 and 3. The observed concentrations of Pb and Cd in the tubers and leafy vegetables were compared with the recommended limit as established by the WHO to assess the levels of food contamination.

The results obtained from the analysis revealed the levels of the heavy metals in vegetables and tubers were in excess levels when compared with the standard for maximum acceptable limits of WHO standards for heavy metals in food. The results indicated that higher levels of Pb were recorded in all of the samples analyzed when compared to the WHO permissible limits ( $0.1 \text{ mg/kg}$ ) for tubers and leafy vegetables, except in *Colocasia esculenta* collected from S3. In most of the samples, levels of Cd were found to be within safe limits of the WHO standard ( $0.1 \text{ mg/kg}$ ) but exceed high in both tubers and leafy vegetables from S1.

Lead is the main cause for concern in this work because it is highly toxic at minute concentration and can be harmful to man who may consume the affected tubers and leafy vegetables. Concentration of Pb in tubers ranged between from 0.087 from 0.182. Pb being a serious cumulative body poison enters into the body system through air, water and food and cannot be removed by washing tubers and leafy vegetables. In case of tubers high accumulation of lead is found in *Amorphophallus campanulatus* from S1 (0.182) (Fig 1). In most of the tuber samples concentration

of Pb was high, except in one case *Colocasia esculenta* collected from S3. In case of leafy vegetables the highest levels of Pb were observed in *Brassica oleracea* L.var.*capitata* from S1 (0.780) followed by *Amaranthus tricolor* L., which ranged between (0.115-0.275). (Fig 3). The results showed that the levels of Pb in all leafy vegetable samples were high ranges from (0.115-0.780).

Cadmium is a non-essential element in foods and natural waters and it accumulates primarily in the kidneys and liver (Divrikli *et al.*, 2003). Regarding Cd accumulation, tubers and leafy vegetables collected from S3 and S2 showed normal levels of accumulation. But the Cd values were higher for both the tubers and leafy vegetable samples of S1. In tubers highest value was reported in *Colocasia esculenta* (0.545) as compared to *Amorphophallus campanulatus* (0.245). Not only tubers but leafy vegetables of S1 reported much higher levels of accumulation of Cd. Highest value was analyzed in *Brassica oleracea* L.var.*capitata* (0.914) followed by *Amaranthus tricolor* L., (0.746) (Fig 4).

The obtained results showed that the amounts of Pb and Cd in the leafy vegetables were higher as compared to tubers. It was found that heavy metals accumulated more in leafy vegetables than those in other parts because these leaves considered as entry points of heavy metals from air (Muhammad *et al.*, 2008). It is clearly evident from the present findings that leafy vegetables are accumulated of

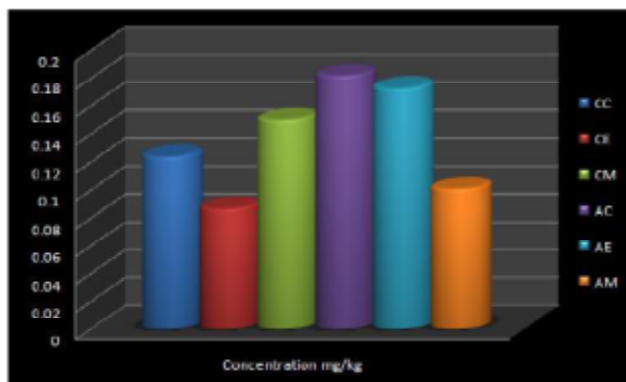


Fig 3: Rate of lead accumulation in tubers.

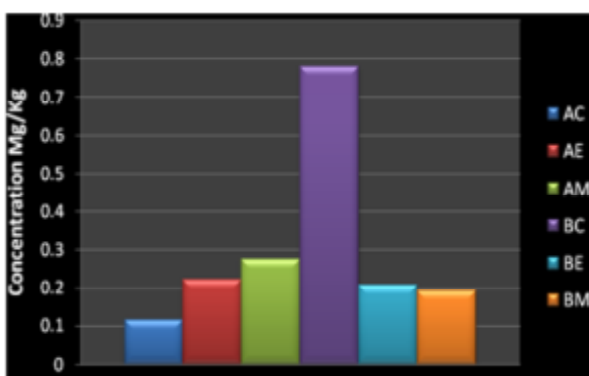


Fig 4: Rate of lead accumulation in leafy vegetables.

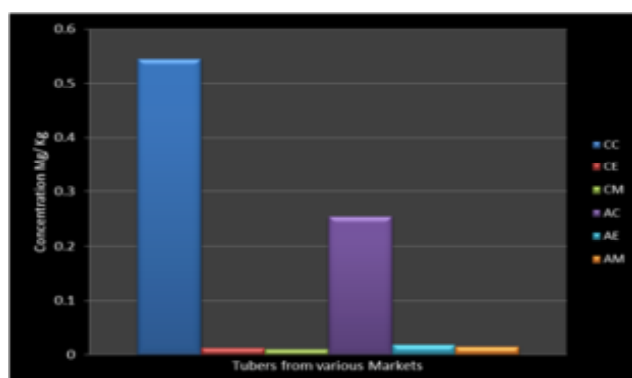


Fig 5: Rate of cadmium accumulation in tubers.

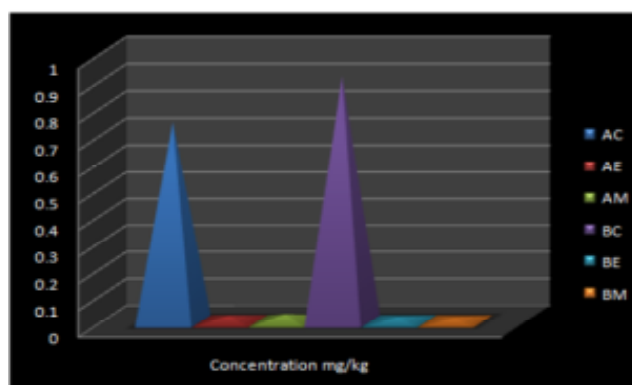


Fig 6: Rate of cadmium accumulation in leafy vegetables.

most of the non-essential heavy metals such as lead and cadmium. People especially those live within the Changanacherry area have a risk of Pb and Cd toxicity.

When compared to the samples of other two places, the samples of S1 showed the high contamination. The reasonable explanation is mainly attributed to these results are heavy traffic and they include the major industries and factories in Kottayam District leading to enforced heavy metals accumulation in the vegetables and tubers. There is no doubt, leafy vegetables and tubers obtained from neighbourhood of major highways can contain significant traces of Pb and Cd due to air borne metal particulates derived from vehicle emissions and other sources (Penny Farmer (2005).

Given the importance that the concentrations of Pb and Cd have for the quality of vegetables and tubers and their health safety, it is important to determine their concentrations. Cd content in S3 and S2 is safe in comparison to the suggested international food standard levels. However, for the Pb level, a special caution would need to be considered, since the Pb level in all samples in this study was higher than the international food standard levels. The consequence of trace metals in foods such as vegetables and tubers have been a considerable interest because of their toxicity effects which are important in the food diet of human beings (Asaolu *et al.*, 1995).

## CONCLUSION

In conclusion, the results reported here confirm that the tubers and leafy vegetables collected from chosen market sites in the Kottayam area contained heavy metal contents more than the safe limits prescribed by the WHO especially Pb. Cd values were within the safe limits except in S1. The samples collected from S1 had more concentration of heavy metals than those collected from other two markets. Secondly samples collected from S3 showed high heavy metal concentration than sample collected from S2. Thus it was determined that samples collected from S1 showed more contamination. Comparatively leafy vegetables contain more accumulation of heavy metal content as compared to tubers. The concentration of heavy metals especially Pb were significantly higher in tubers and vegetables than the WHO maximum acceptable limit for food and may cause serious health issues in human beings and also cause various diseases and disorders. Because of the high consumption of fruits

and vegetables in the diet, it is very urgent to monitor the concentration of heavy metals.

It is therefore suggested that regular monitoring of heavy metals in tubers and leafy vegetables should be performed and alternative options should be carried out in order to prevent excessive accumulation of these heavy metals in the human food chain and ultimately cause risk to human health. Replication of such type of study should be performed where excessive vegetables are produced and consumed.

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## COMPETING INTERESTS

The authors declare that they have no competing interests.

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