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Assessment and comparison of heavy metal concentration in fruit and vegetable samples of market and roadside vendors

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Abstract: Consumption of Fruits and vegetables contaminated with heavy metals can accumulate in different body parts and cause chronic diseases affecting vital organs of the body. Hence, a comparision study was carried out to analyse the presence of heavy metals in fruit and vegetable samples collected from roadside and market vendors. The concentration of heavy metals such as arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), and mercury (Hg) were analysed using inductively coupled plasma-mass spectrometry (ICP-MS). The result showed that the heavy metal concentration of apple samples obtained from the market and roadside are 0.057, 0.070, 0.233, 0.200, 0.053 and 0.077, 0.070, 0.200, 0.300, and 0.073 for As, Cd, Cu, Pb and Hg respectively. For capsicum, the concentrations of market and roadside samples were 0.077, 0.063, 0.200, 0.367, 0.070 (μg/kg) and 0.067, 0.077, 0.200, 0.267 and 0.047 (μg/kg) for As, Cd, Cu, Pb and Hg respectively. The study concluded that the concentration of metals such as As, Pb and Hg were higher in the apple sample obtained from roadside vendors than in the market sample. On the other hand, the concentrations of As, Pb and Hg were higher in the capsicum obtained from the market than from the roadside vendors. Though the heavy metals concentration in fruit and vegetable samples collected from roadside vendors and markets were within the permissible levels recommended by WHO/ FAO, continuous ingestion for a longer period can pose potential side effects.

Introduction:

Food quality and safety is a worldwide issue concerning the public health. Food Safety and Standard Authority of India is a statutory body, plays an important role in providing safe, wholesome and hygienic food to the consumers in order to protect their health. Fruits and vegetables are important food groups must be included in the daily diet of human. Fruits and vegetables are rich sources of fiber, vitamins, minerals and phytochemical components, which have beneficial antioxidant effects. Consumption of fruits and vegetables contaminated with heavy metals such as lead, cadmium, arsenic, chromium, nickel, copper and zinc can significantly put consumers at health risk.

Heavy metals, in general, are not biodegradable, have long biological half-lives, and have the potential for accumulation in different body organs, leading to unwanted side effects (Elbagermi et al., 2012). Heavy metals are deposited on the soil surface, then absorbed by the apoplast of plant roots and further distributed and accumulated into their edible and non-edible parts, posing an imminent danger to the food chain. Heavy metals can also be taken up by vegetables by atmospheric deposition (Gupta *et al.,* 2022). Heavy metal contamination can also occur as a result of the migration of these elements from packaging material and during the processing of food products, for example, use of metal kitchen tools and storing foods in metal containers (Rusin *et al.,* 2021).

Heavy metals can disturb the body's metabolic functions and may accumulate in vital organs of the body such as the liver, heart, kidney and brain disturbing normal biological functioning (Rehman *et al.,* 2018). Heavy metals can be the cause of many chronic diseases whose symptoms are different depending on the level of toxicity of an element, as well as the duration and level of exposure. Kidneys and liver are the main organs especially sensitive to Cd toxicity (Kim *et al.,* 2015). In the human body, Cd most often causes damage to both of these organs, as well as the testicles, lungs and bones. In addition, it causes a carcinogenic effect, initiating cancers of the prostate, kidneys, pancreas and testicles. Chronic exposure to Pb can be associated with an increased risk of developing neurodegenerative diseases (Rusin *et al.,* 2021).

The main aim of the study was to analyze the concentration of different heavy metals in fruit and vegetable samples collected from market and roadside vendors to know the safety level for the consumption by general public.

Material and methods:

The study aims to analyze and compare the heavy metals concentration in apple and capsicum obtained from market and roadside vendors

Collection of samples: Apples and capsicum were sourced from roadside vendors and markets. The market was located interior of the busy road where the chance of fruits and vegetables being exposed to vehicular emission is low. On the other hand, samples obtained from roadside vendors were sold on busy roads with a heavy flow of vehicles, with fruits and vegetables sold in open carts.

Sample preparation: Collected samples were washed in distilled water, cut into small pieces and oven-dried at 45°C to constant weight. Further, dried samples were ground into powder using a pestle and mortar. The weighed sample was burnt in a hot plate by adding a few drops of concentrated nitric acid till the fumes subsided. Then followed with ashing in a muffle furnace at 550°c. The ash solution is prepared by using HCL and water and filtered using Whatman filter paper. The solution is made up to volume using 3N Hydrochloric acid (HCL). The prepared ash solution is stored in small screw-cap containers for further analysis.

Determination of heavy metals: Concentration of different heavy metals such as Arsenic (As), Cadmium (Cd), Copper (Cu), Lead (Pb), and Mercury (Hg) were analysed using inductively coupled plasma-mass spectrometry (ICP-MS) against standard solutions.

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Results and discussion: The present study reported the concentration of heavy metals such as As, Cd, Cu, Pb and Hg in fruit and vegetable samples collected from market and roadside vendors for comparison. The obtained results were compared with standards provided by WHO/FAO.

Table 1: Comparison of heavy metal concentration in market and roadside apple samples

Heavy metals	**Market sample (µg/kg)**	**Roadside sample (µg/kg)**	**WHO/ FAO Max permissible values (µg/kg)**
Arsenic	0.057	0.077	7.1
Cadmium	0.070	0.070	0.2
Copper	0.233	0.200	40
Lead	0.200	0.300	0.3
Mercury	0.053	0.073	1 (PTWI)

[a] Bairagi *et al.,* 2010 & Onwukeme I V *et al*., 2014

Table 2: Comparison of heavy metal concentration in market and roadside capsicum samples

Heavy metals	**Market sample (µg/kg)**	**Roadside sample (µg/kg)**	**WHO/ FAO Max permissible values (µg/kg)**
Arsenic	0.077	0.067	7.1 (12)
Cadmium	0.063	0.077	0.2
Copper	0.200	0.200	40
Lead	0.367	0.267	0.3
Mercury	0.070	0.047	1 (PTWI)*

*PTWI -

Figure 1: Comparison of heavy metal concentration in market and roadside apple samples

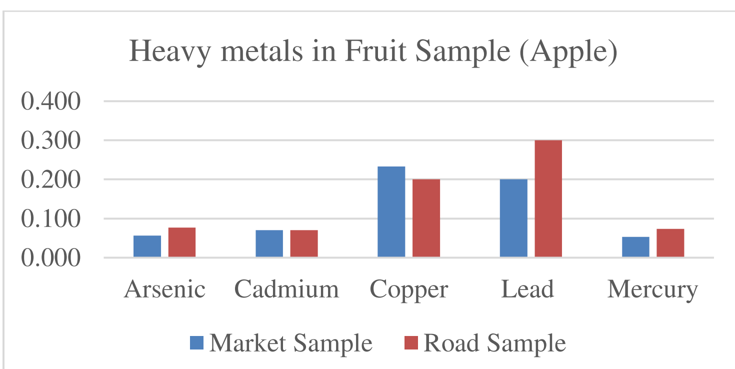

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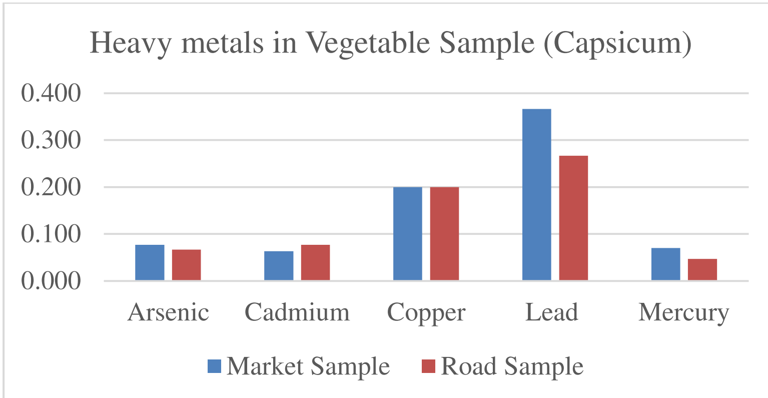
Table 2: Comparison of heavy metal concentration in market and roadside capsicum samples



The mean concentrations of heavy metals in selected samples from market and roadside vendors is presented in Tables 1 and 2. The result showed that the heavy metal content of apple samples obtained from market and roadside are 0.057, 0.070, 0.233, 0.200, 0.053 and 0.077, 0.070, 0.200, 0.300, and 0.073 for As, Cd, Cu, Pb and Hg respectively. Though the concentration is within the acceptable ranges, the concentration of Arsenic, Lead and Mercury for the sample purchased from the roadside vendor is higher than the sample purchased from the market. This can be due to the exposure to vehicular emissions on the roadside.

Heavy metal concentrations of capsicum samples from roadside and market vendors are 0.077, 0.063, 0.200, 0.367, 0.070 mg/kg and 0.067, 0.077, 0.200, 0.267 and 0.047 for As, Cd, Cu, Pb and Hg respectively. The cadmium levels were higher in the roadside sample than the market-purchased sample. On the contrary the Lead, Mercury and Arsenic concentrations of market capsicum were higher than capsicum purchased from roadside vendors. Also, the lead levels in the market capsicum sample are above the permissible limits which can possess major health threat on chronic consumption of capsicum contaminated with lead.

Lead is a non-essential element, can be toxic even at trace levels and is very dangerous for the nervous system (Manea *et al.,* 2020). Lead has toxic effects on organs that include kidneys, liver, lung and spleen that cause different biochemical defects. It exhibits neuropathology when adults are exposed occupationally or accidentally to excessive levels. Also, relationship exists between Pb in the human body and the increase in blood pressure of adults (Ametepey *et al.,* 2018).

Elbagermi *et al.,* 2012 reported that the levels of Pb in all commodities ranged between 0.02 mg/kg in potatoes and 1.824 mg/kg in mangos. The Cd content ranged from 0.01 mg/kg in strawberries to 0.362 mg/kg in mangos. The higher levels of heavy metal contamination found in some fruits and vegetables could be closely related to the pollutants in irrigation water, farm soil, and pesticides or could be due to pollution from traffic on the highways (Igwegbe *et al.,* 1992).

Consuming fruits and vegetables contaminated with heavy metals can result in a various ailments. Vegetables and fruits are the primary routes for heavy metals ingestion that affect humans. Accumulation of heavy metals in the body can produce free radicals, which can cause oxidative stress as well as other cellular damage (Manwani *et al.,* 2022).

Mercury is a naturally occurring metallic element which can be present in foodstuffs by natural causes; elevated levels can also occur due to environmental contamination by industrial or other uses of mercury.

Conclusion:

Consumption of foods contaminated with heavy metals can be harmful to human health and affect different organs like the kidney, liver, heart and lungs. This leads to diseases like liver dysfunction, kidney disease, skin deformity and lung disorders. Accumulation of heavy metals in food also affects the nutrient quality. Hence, in the present study fruit and vegetable samples of the market and roadside fruit and vegetable were compared for the presence of heavy metal concentration. The samples are analysed using inductively coupled plasma-mass spectrometry. The study concluded that the concentrations of heavy metals in fruit and vegetable samples collected from roadside vendors and markets are of different concentrations. Metals such as Arsenic, Cadmium and Lead are higher in apple samples sold by roadside vendors. On the contrary for the capsicum samples, the levels were higher in market samples than in the sample obtained from the roadside vendors. In addition, the capsicum sample obtained from the market has a higher Lead content than the permissible limits by WHO/ FAO. The deposition of heavy metals on food may be due to vehicle emission, environmental pollution, soil contamination and improper irrigation. The heavy metals are not degradable and have a long shelf life. These metals are taken up by the fruits and vegetables through soil and vehicular pollution. Thus care should be taken while growing and purchasing vegetables and fruits to avoid ingestion of heavy metals. Hence it is the need of an hour to address this issue and formulate environmental measures and policies that help minimize the contamination of heavy metals in fruits and vegetables.

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