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Quantitative Characterization and Dietary Exposure Assessment of Toxic Elements in Fruits and Vegetables in Armenia

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Fruits and vegetables are essential components of the human diet and represent an important pathway for exposure to both beneficial and toxic trace elements. While beneficial nutrients can reduce the risk of several chronic disease, chemical hazard such as toxic elements have the potential to pose adverse health effects. From this perspective, an integrated risk and benefit assessment of fruits and vegetable is of high public health priority. Therefore, within the frame of this study, and based on the results of the national residue monitoring program, aimed to characterize the element-specific (Pb, As, Cd, Hg) distribution and assess dietary exposure through consumption of fresh fruits and vegetables in Armenia.

A total of 160 composite samples (10 subsamples each) of 13 commonly consumed fruits and vegetables were investigated, including apricot, apple, plum, cherry, peach, grape, melon, watermelon, cucumber, tomato, eggplant, pepper and potato. Toxic elements (Pb, As, Cd, Hg) were determined using atomic absorption spectroscopy (AAS), and dietary exposure was estimated using nationally representative household consumption data.

Significant ($p<0.05$) differences were observed for Pb, with fruits showing higher contents than vegetables (Table 1). Cd was detected in vegetables, while As and Hg were detected only in some fruit samples. Dietary exposure assessment indicated that Pb and Cd are of public health concern, with margin of exposure (MOE) values below the threshold of 10, whereas Hg and inorganic As (iAs) pose negligible risk (Table 2). Overall, the results highlight element-specific distribution patterns between fruits and vegetables and identify Pb and Cd as priority contaminants from a public health perspective. This work aligns with the One Health framework by emphasizing the importance of integrated food safety surveillance and dietary exposure assessment to protect human health and ensure the safe consumption of plant origin foods.

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Table 1. Toxic element contents in fruits and vegetables

Toxic elements (mg/kg)		**Fruits, n=102**	**Vegetables, n=58** *(including potato)*	**Vegetables, n=36** *(excluding potato)*
Pb	*Mean±SD*	0.0544±0.025	0.0379±0.0137	0.0372 ± 0.0132
	Detection %	85.29% (87/102)	29.30% (17/58)	38.89% (14/36)
Cd	*Mean±SD*	nd	0.0161 ± 0.0048	0.0136 ± 0.0033
	Detection %		34.48% (20/58)	17.24% (10/58)
Hg	*Mean±SD*	0.0133±0.0019	nd	nd
	Detection %	6.86% (7/102)		
As	*Mean±SD*	0.022±0	nd	nd
	Detection %	1.96% (2/102)		

SD - standard deviation, nd - not detected.

Table 2. Toxic elements dietary exposure assessment and risk characterization

Elements	**Total daily intake** (∑EDI, μg/kg/day)	**Reference Point** (μg/kg/day)	**Risk characterization**
Pb	0.175	$BMDL_{10}$=0.63	MOE=3.6 **(concern)**
		$BMDL_{01}$=1.5	MOE=8.6 **(concern)**
Cd	0.049	TWI=2.5	MOE=7.2 **(concern)**
			13.8% of TWI
Hg	0.008	TWI=4	MOE=71 **(no concern)**
			1.4% of TWI
iAs	0.0008	$BMDL_{05}$=0.06	MOE=76 **(no concern)**