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RESEARCH ARTICLE

Assessing the concentration and potential health risk of heavy metals in China's main deciduous fruits

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Abstract

To assess levels of contamination and human health risk, we analyzed the concentrations of the heavy metals lead (Pb), cadmium (Cd), chromium (Cr), and nickel (Ni) in China's main deciduous fruits — apple, pear, peach, grape, and jujube. The concentration order of the heavy metals was Ni>Cr>Pb>Cd. In 97.5% of the samples, heavy metal concentrations were within the maximum permissible limits. Among the fruits studied, the heavy metal concentrations in jujube and peach proved to be the highest, and those in grape proved to be the lowest. Only 2.2% of the samples were polluted by Ni, only 0.4% of the samples were polluted by Pb, and no samples were polluted by Cd or Cr. Compared with the other fruits, the combined heavy metal pollution was significantly higher (P<0.05) in peach and significantly lower (P<0.05) in grape. For the combined heavy metal pollution, 96.9% of the samples were at safe level, 2.32% at warning level, 0.65% at light level, and 0.13% at moderate level. In the fruits studied, the contribution of heavy metals to the daily intake rates (DIR) followed the order of Ni>Cr>Pb>Cd. The highest DIR came from apple, while the lowest DIR came from grape. For each of the heavy metals, the total DIR from five studied fruits corresponded to no more than 1.1% of the tolerable daily intake, indicating that no significant adverse health effects are expected from the heavy metals and the fruits studied. The target hazard quotients and the total target hazard quotients demonstrated that none of the analyzed heavy metals may pose risk to consumers through the fruits studied. The highest risk was posed by apple, followed in decreasing order by peach and pear, jujube, and grape. We suggest that the main deciduous fruits (apple, pear, peach, grape, and jujube) of China's

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main producing areas are safe to eat.

Keywords: deciduous fruits, heavy metals, health risk assessment, China

1. Introduction

Heavy metals such as lead (Pb), cadmium (Cd), chromium (Cr), and nickel (Ni) generally refer to metals and metalloids having densities greater than 5 g cm^{-3} (Oves *et al.* 2012). Barring occupational exposures, the main route of human exposure to heavy metals is through dietary intake (Sharma and Tripathi 2008). Once the heavy metals are dispersed into water, soil and air, they can accumulate in the crops (Hao *et al.* 2009; Hernández-Martínez and Navarro-Blasco 2012). Heavy metal pollution of food items is one of the most important aspects of food quality assurance (Wang *et al.* 2005; Radwan and Salama 2006; Khan *et al.* 2008). Fruits can accumulate high levels of heavy metals in their edible parts (Roba *et al.* 2016). Heavy metal pollution in fruits is arisen by many ways, such as irrigation water, industrial emissions, the harvesting process, storage and/or at the point of sale (Huang *et al.* 2014).

Heavy metals are harmful because of their non-biodegradable nature, long biological half-lives, and potential to accumulate in body (Arora *et al.* 2008). Prolonged consumption of unsafe concentrations of heavy metals through foodstuffs may lead to the chronic accumulation of heavy metals in the kidney and liver of humans, causing disruption of numerous biochemical processes, and leading to cardiovascular, nervous, kidney and bone diseases (Järup 2003; Sharma *et al.* 2009). Some heavy metals such as Cd, Cr, and Pb, are nonessential and can cause negative human health effects (Järup 2003; Ferré-Huguet *et al.* 2008; Martí-Cid *et al.* 2008a; Martorell *et al.* 2011). Other heavy metals, such as Ni, are micronutrients for human beings, but excessive intake may affect health (Powers *et al.* 2003). The consumption of foodstuff polluted with heavy metals may lead to accumulation of these contaminants in different tissues, causing both chronic and acute health outcomes (Järup 2003). It is therefore reasonable to hypothesize that the intake of fruits containing heavy metals is a potential health risk to consumers.

Fruits contain carbohydrates, proteins, vitamins, minerals, and fibers required for human health (Cherfi *et al.* 2014). They are important components of human diet both in terms of consumed quantities and nutritional value (Roba *et al.* 2016). In China, apple (*Malus spp*. Mill.), pear (*Pyrus spp*.), peach (*Prunus persica* L.), grape (*Vitis* L.), and jujube (*Ziziphus jujube* Mill.) are the most important deciduous fruits, accounting for 55% of the total fruit output and more than 80% of the total deciduous fruit output (CAYEC 2014). Although some studies have reported the heavy metal pollution and its health risk in fruits cultivated in China (Xiao *et al.* 2010; Sheng *et al.* 2014), as far as we know, there are few studies focusing on China's main deciduous fruits and their main producing areas. This study aimed to investigate the concentrations and pollution of the heavy metals Pb, Cd, Cr, and Ni in the above-mentioned deciduous fruits cultivated in China's main producing areas, and to assess the possible human health risk associated with consumption of these fruits by calculating the daily intake rates (DIR) and the target hazard quotients (THQ). The results of our study may provide some insight into heavy metal pollution for main deciduous fruits in China, and serve as a basis for comparison with other countries and other fruits.

2. Materials and methods

2.1. Sampling and preparation

A total of 775 deciduous fruit samples (Table 1) were collected at harvest time in 2014 from the main producing areas of China, including Liaoning, Shaanxi, Shandong, Hebei, Xinjiang, Jiangsu, Henan, and Anhui (Fig. 1). Production from these provinces account for 62.2, 57.6, 63.2, 57.8, and 74.9 of Chinese total output of apple, pear, peach, grape,

Table 1 Number of fruit samples from different provinces of China

Fruits	Anhui	Hebei	Henan	Jiangsu	Liaoning	Shandong	Shaanxi	Xinjiang	Total
Apple		42			55	60	55		212
Pear		50		10	49	25	15	46	195
Peach	10	25	20	10	20	32	20		137
Grape		20		15	15	22	10	55	137
Jujube		20				24	20	30	94
Total	10	157	20	35	139	163	120	131	775