

Research Article

Investigation and Evaluation on Heavy Metal Copper and Cadmium Contaminations of Vegetables Grown in Huanggang City of China

¹Xiaoming Hu, ¹Weibin Jin, ¹Wenjuan Lv, ¹Shuiyuan Cheng and ²Yanyan Jiang

¹Hubei Key Laboratory of Economic Forest Germplasm Improvement and Resources Comprehensive Utilization, Department of Chemistry and Life Science, Huanggang Normal University, Huanggang, 438000, P.R. China

²Department of Agriculture, Yangtze University, Hubei Province, Jinzhou, 434025, China

Abstract: No published data are available on heavy metals concentrations and contaminations of vegetables in Huanggang City, Hubei Province, China. This study focused on characteristics and evaluation on heavy metal (Copper and Cadmium) concentrations and contaminations in vegetables grown in the suburbs of Huanggang. Several important vegetable bases in the suburbs of the city were employed as study areas and 150 representative vegetable samples, including leaf vegetables, melon-fruit vegetables, root-stem vegetables, bean vegetables and melon-fruit vegetables, were collected to determine the contents of heavy metal Copper (Cu) and Cadmium (Cd) using Atomic Absorption Spectrophotometer (Varian, AA240FS, USA). The status of Cu and Cd concentrations and contaminations were analyzed and evaluated according to Chinese Food and Health National Standard. The results indicated that nearly all vegetable in Huanggang City were highly contaminated by Cd. And Cu contamination occurred in leafy vegetables and some melon-fruit vegetables and bean vegetables were not found contaminated by Cu. The contamination degree of Cd was much higher than that of Cu. Vegetable Cd contamination has posed a threat to the people in the city and will hinder the sustainable development of the local vegetable industry. It is strongly recommended that the local government of Huanggang City should pay much more attention to the vegetable Cd contamination in the city. Why heavy metal Cd polluted seriously and how to prevent it in the city need to be further studied.

Keywords: Cd, contamination, Cu, evaluation, vegetable

INTRODUCTION

Vegetables are the extremely important food for people and animals. However, many vegetables are reportedly contaminated by heavy metals, so the international organizations of UNDP, FAO and WHO put vegetables contaminated by heavy metals into the important items of the World Food Pollution Monitoring Plan (Radwan and Salama, 2006). Rapid and unorganized urban and industrial developments have contributed to the elevated levels of heavy metals in the urban environment of developing countries such as China and India (Wang *et al.*, 2005; Tripathi *et al.*, 1997; Khillare *et al.*, 2004). Vegetables take up heavy metals by absorbing them from deposits on the parts of the plants exposed to the air from polluted environments as well as from contaminated soils (Sharma *et al.*, 2008a, b; Jassir *et al.*, 2005; Kachenko and Singh, 2006; Singh and Kumar, 2006). A number of studies have shown heavy metals as important contaminants of the vegetables (Wong *et al.*, 2003;

Singh *et al.*, 2004; Sinha *et al.*, 2006; Sharma *et al.*, 2006, 2007). Vegetables in New Delhi of India were found contaminated by Cu and Cd, the exceeding standard rate of which were 13 and 100%, respectively. In China, problems of vegetable heavy metal contamination has been widely concerned. Thirty percent of the vegetables produced in Beijing Region exceeded standard limits (Zhou *et al.*, 2004). Exceeding standard rate of Cd in Chinese Cabbage produced in Shengyang Suburbs was 58.3%. Cd detection rate and exceeding standard rate of 36 vegetable samples from Tianjin City reached 100 and 58.3%, respectively. Over half of the vegetable samples collected from Nanning City was found Pb contaminated. Sixty percent of vegetable samples from Changsha City and Ningbo City were found Pb and Zn exceeding standard limits (Cao *et al.*, 2010; Liu *et al.*, 2006). In Chongqing City, heavy metal contamination degree was Cd>Pb>Hg (Chongqing, 1996).

Vegetable heavy metal concentrations have been Monitored and evaluated in some developed (Jorhem

Corresponding Author: Shuiyuan Cheng, Hubei Key Laboratory of Economic Forest Germplasm Improvement and Resources Comprehensive Utilization, Department of Chemistry and Life Science, Huanggang Normal University, Huanggang, 438000, P.R. China, Tel.: +86-713-883-3606, Fax: +86-713-883-3606

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and Sundstroem, 1993; Milacic and Kralj, 2003) and developing countries (Parveen *et al.*, 2003), but limited published data on heavy metal Cu and Cd concentrations are available in Huanggang City (a medium-sized and traditional agricultural city, with a population of 7.3 million and a covering area of 17446 km²). This study focused on characteristics and evaluation on heavy metal (Cu and Cd) contaminations of vegetables grown in Suburbs of the city.

MATERIALS AND METHODS

Site description: This study was conducted in Huanggang City (E115°31'~116°04', N30°31'~31°09', eastern Hubei Province, Central China) in 2011. The city belongs to subtropical and continental monsoon climate zone, with an average annual precipitation 1223-1493 mm, a mean annual temperature 15.7-17.1°C, an annual frostless period 237-278 days and an annual sunlight 1913-2161 h. The major soil types are yellow brown soil, red soil, alluvial soil, purple soil and paddy soil. The total vegetable area of the city in 2006 was 106,800 ha, including 29,400 ha leaf vegetables, 11,200 ha melon-fruit vegetables, 22,400 ha root-stem vegetables, 17,800 ha solanaceous fruit vegetables, 11,000 ha bean vegetables and 15,000 ha others (offered by Vegetable Office of Agricultural Bureau of Huanggang City). The crops grown are rice, wheat and peanut in hills and undulating regions and cotton, rape and vegetable in plains. Vegetable production plays an important role in agricultural economy of the city. In recent years, the city witnessed a rapid expansion of vegetable cultivation areas.

Vegetables sampling: One hundred and fifty vegetable samples were collected from four large and key vegetable bases in Suburbs of Huanggang City. The samples included five kinds (leaf vegetables, melon-fruit vegetables, root-stem vegetables, bean vegetables and melon-fruit vegetables) and fifteen varieties and each vegetable variety was collected ten samples. These samples can represent key vegetable varieties grown in the city and even in Central China. The sampling time lasted for five months from May to September 2011.

Cu and Cd determining: Vegetable samples collected from fields were washed several times with tap water and thentree times with deionized water. The cleaned vegetable samples were deactivated for 30 min at 105°C and then dried for 24 h at 65~70°C. Water cotents of Vegetable samples were calculated. The dried Vegetable samples were digested and extracted with concentrated nitric acid and perchloric acid (3:1). Heavy metal Cu and Cd were determined using Atomic Absorption Spectrophotometer (Varian, AA240FS, USA).

Table 1: The evaluation criteria of heavy metal on vegetables

Heavy metal	Limit (mg/kg FW)	Standard number
Cu≤	10	GB15199-94
Cd≤	0.05	GB15201-94

Evaluation criteria and exceeding standard parameters: Chinese Food and Health National Standard (Table 1) was adopted as evaluation criteria to assess the vegetable heavy metal pollution in this study. Exceeding standard rate (Er) and Exceeding standard multiple (Em) were calculated with evaluation Eq. (1) and (2) as follows:

$$Er (\%) = (ni/Ni) \times 100\% \quad (1)$$

$$Em = Pi-Si/Si \quad (2)$$

Er = Exceeding standard rate

ni = Number of vegetable samples of exceeding standard

Ni = Total number of vegetable samples

Em = Exceeding standard multiple

Pi = Heavy metal content determined in vegetable samples

Si = Heavy metal criterion limit

RESULTS AND DISCUSSION

Cu and Cd contents in leafy vegetables and their evaluation: The results showed that heavy metal Cu contents in all leafy vegetables (except for Water spinach) exceeded Chinese Food and Health National Standard (GB14935-96) and Er (Exceeding standard rate) reached 100% and Em (Exceeding standard multiple) 0.37~0.54. The order of Cu contamination degree in leafy vegetables was Brassica oleracea and Pakchoi>Amaranth. Heavy metal Cd contents in all leafy vegetables exceeded significantly Chinese Food and Health National Standard (GB14935-96) and Er reached 100% and Em 2.28 at the most. The investigation results indicated that leafy vegetables produced in Huanggang City were contaminated by Cu and Cd and the contamination degree by Cd was higher than Cu (Table 2).

Cu and Cd contents in root-stem vegetables and their evaluation: Similarly to leafy vegetables, Cd contents in root-stem vegetables exceeded the evaluation criteria of GB14935-96 and Er and Em reached as much as 100 and 2.26%, respectively. Potato was severely contaminated by Cd. Fortunately, root-stem vegetables were not found contaminated by Cu (Table 3).

Cu and Cd contents in bean vegetables and their evaluation: Similarly to root-stem vegetables, bean vegetables were not found contaminated by Cu. However, Cd contents in bean vegetables exceeded the

Table 2: Cu and Cd content in leafy vegetables and its evaluation

Leafy vegetables	Heavy metal	Range (mg/kg FW)	Mean content (mg/kg FW)	*Er (%)	**Em
Brassica oleracea	Cu	11.296-15.384	12.971	100	0.54
	Cd	0.0380-0.061	0.0450	60	0
Amaranth	Cu	10.590-13.68	12.840	100	0.37
	Cd	0.0530-0.127	0.0724	100	1.34
Pakchoi	Cu	11.581-15.32	13.670	100	0.53
	Cd	0.0650-0.165	0.1540	100	2.28
Water spinach	Cu	7.7650-9.864	8.6530	0	0
	Cd	0.0590-0.092	0.0760	100	0.84

*: Exceeding standard rate; **: Exceeding standard multiple

Table 3: Cu or Cd contents in root-stem vegetables and their evaluation

Root-stem vegetables	Heavy metal	Range (mg/kg FW)	Mean content (mg/kg FW)	*Er (%)	**Em
Potato	Cu	2.854-4.613	3.635	0	0
	Cd	0.087-0.164	0.118	100	2.26
Radish	Cu	6.257-8.563	7.612	0	0
	Cd	0.054-0.092	0.086	100	0.84

*: Exceeding standard rate; **: Exceeding standard multiple

Table 4: Cu or Cd contents in bean vegetables and their evaluation

Bean vegetables	Heavy metal	Range (mg/kg FW)	Mean content (mg/kg FW)	*Er (%)	**Em
Cowpea	Cu	4.283-6.865	5.462	0	0
	Cd	0.058-0.106	0.072	100	1.12
Kidney bean	Cu	5.675-7.457	6.431	0	0
	Cd	0.064-0.126	0.083	100	1.52

*: Exceeding standard rate; **: Exceeding standard multiple

Table 5: Cu and Cd contents in melon-fruit vegetables and their evaluation

Melon-fruit vegetables	Heavy metal	Range (mg/kg FW)	Mean content (mg/kg FW)	*Er (%)	**Em
Tomato	Cu	12.268-14.845	13.357	100	0.48
	Cd	0.0690-0.118	0.0820	100	1.36
Pepper	Cu	14.526-17.583	15.946	100	0.76
	Cd	0.0840-0.137	0.0120	100	1.74
Eggplant	Cu	8.156-11.647	9.8510	20	0.16
	Cd	0.0580-0.106	0.0750	100	1.12
Balsam pear	Cu	6.2390-8.273	7.6540	0	0
	Cd	0.0380-0.076	0.0610	60	0.52
Towel gourd	Cu	5.7620-7.891	6.2740	0	0
	Cd	0.0250-0.083	5.2280	40	0.66
Hispid bottle gourd	Cu	3.8640-6.281	4.8620	0	0
	Cd	0.0160-0.046	0.0310	0	0
Cucumber	Cu	20.469-22.671	0.5720	100	1.27
	Cd	0.1050-0.216	0.1480	100	3.32

*: Exceeding standard rate; **: Exceeding standard multiple

the evaluation criteria of GB14935-96, ranging from 0.058 to 0.126 mg/kg FW, Er and Em as much as 100 and 1.52%, respectively, which indicated that bean vegetables in Huanggang City were seriously contaminated by Cd (Table 4).

Cu and Cd contents in melon-fruit vegetables and their evaluation: Cucumber, pepper and tomato in melon-fruit vegetables were highly contaminated by Cd and Cu and the Er and Em reached as much as 100% and 3.32. Cd contents in tomato, Eggplant and Balsam pear exceeded Chinese Food and Health National Standard (GB14935-96). Cu contents in Balsam pear, towel gourd and hispid bottle gourd were in safety range according to the Standard of GB14935-96. Only hispid bottle gourd in melon-fruit vegetables was not contaminated by Cd and Cu (Table 5).

In Huanggang City, Cd contamination occurred in all vegetables and Cu contamination did in nearly all

leafy vegetables and some melon-fruit vegetables. The contamination degree of Cd was higher than that of Cu.

Huanggang City is a medium-sized and traditional agricultural city and weak in terms of industrial foundation. However, why is heavy metal Pb contamination serious and how will it be prevented? This problems need to be further studied.

CONCLUSION

The results indicated that nearly all vegetables in Huanggang City were highly contaminated by Cd and Cu contamination occurred in leafy vegetables and some melon-fruit vegetables Bean vegetables were not found contaminated by Cu. The contamination degree of Cd was much higher than that of Cu. Fortunately; Cu contamination was relatively low in the vegetable in City. Cd contamination in vegetables has posed a threat to the people in the city and will hinder the sustainable

development of the local vegetable industry. Why heavy metal Cd contamination is so serious and how it will be prevented need to be further studied.

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