A Study on the Accumulation Pattern of Cadmium in *Coptis chinensis* Franch

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Abstract

Along with the increasing recognition of traditional Chinese medicine (TCM) in the world, the safety of TCM has also received worldwide attention. The problem of excessive heavy metals in TCM，including coptis chinensis, is frequently reported, which not only affects its safety, but also seriously affects its export. As everyone knows, cadmium(Cd) was a harmful element for the healthy of plants. Though the liquid nutrient solution cultivating methods, The law of cadmium accumulation in Coptis chinensis was studied. Hogland culture medium with 0 and 100μM $Cd(NO_3)_2$ $4H_2O$ was prepared manually. The results show that, accumulation amount of Cd by root (2.017-95.428 mg kg^{-1}) was notable higher than stems and leaves(0.242-11.382 mg kg^{-1}) during the 10 day growth period. When the cadmium content added to the growth medium is compared with the total accumulation of plants and the residual cadmium content in the medium, a large amount of cadmium may be lost through the process of plant volatilization. This is of great significance for Coptis chinensis to tolerate heavy metals and reduce plant enrichment.

Keywords: *Coptis chinensis Franch., Cadmium, Accumulation*

I. Introduction

Recently, the excessive content of heavy metals in officinal has led to worldwide interest. Heavy metals will be absorbed by plants and transmitted to the food chain, and eventually transmitted to humans, causing many health problems[1].*Coptidis rhizoma* are the dry rhizome of the Ranunculaceae plant of Coptis chinensis Franch., Coptis deltoidea C. Y. Cheng et Hsiao, and Coptis teeta Wall., which are commonly referred to as “weilian”, “yalian”, and “yunlian”, especially. *Coptidis rhizoma* is one of the common traditional medicinal materials in China and it is famous and precious. It has a medicinal usage history of more than 2000 years in China. With the increasing recognition of traditional Chinese medicine (TCM) in the world, the safety of TCM has also received worldwide attention. The problem of excessive heavy metals in TCM，including coptidis rhizoma, is frequently reported, which not only affects its safety, but also seriously affects its export[2-3].

Among all heavy metals, cadmium is the most harmful to crops and humans [4-5]. Chinese Pharmacopoeia (2016 Edition) and green trade in imported and exported officinal and preparations. The standard limits the content of Cd in medicinal plants, and stipulates that Cd ≤ 0.3 mg kg^{-1}[6].Cd is produced by some geological and human activities, including microelectronics production, metallurgical industry, mining, waste incinerators and rock fertilizer production [7-8].Cadmium is highly flowability in soil and plant systems and highly enriched in plant tissues [9].The absorption and accumulation of cadmium by plants will not only reduce the output of plants, but also gradually accumulate through the food chain, causing serious adverse effects on human health [10]. Cd was identified as a carcinogen by the US National Department of Toxicology [11-12].So far, the research on Cd in *Coptis chinensis* mainly focuses on the determination of Cd content, but there is no further in-depth research on the accumulation and distribution of Cd in *Coptis chinensis*. Therefore, there is an urgent need to study the accumulation mechanism of Cd in *Coptis chinensis*, so as to provide a theoretical basis for reducing the level of Cd in *Coptis chinensis* in the future.

The purpose of the study is to contribute to clarify the accumulation pattern of Cd in roots, stems and leaves of

Coptis chinensis in Hogland nutrient solution with different concentrations of Cd. On this basis, further understand the accumulation and detoxification mechanism of Cd in *Coptis chinensis*, so as to provide a theoretical basis for reducing the content of Cd in *Coptis chinensis*.

II. Materials and methods

Coptis chinensis collected from the traditional Chinese Medicine Botanical Garden in Enshi. The plants were washed off with running water and used for experiments of heavy metal treatments.The liquid culture nutrient solution is the Hoagland's solution.Wrap around the hydroponic box with black plastic cloth to keep the plant roots away from light, and turn on the air pump to keep the hydroponic box ventilated. Use 0.1 N HCl or 0.1 N NaOH to adjust the pH of nutrient solution every day and keep it at about 5.6. Plants grow under natural light, the day and night temperature is 25℃/20℃, the day and night humidity is 70% / 85%, and the nutrient solution is changed every 3 days.

After 4 weeks of pre culture, Cd was added to the nutrient solution for treatment, 0μM and 100μM.After treatment for 0h, 2d, 4d, 6d, 8d and 10d, samples were taken for analysis, which were abbreviated as different groups respectively.

Plants were collected from all containers every 2 to 10 days for random sampling, and cut into roots, stems and leaves to estimate cadmium content.The cadmium content accumulated in each interval is related to the availability of cadmium in the culture medium and the amount of metal accumulated in the root. After sampling in each interval, the stems and leaves calculated above are added to obtain the total accumulation. The nutrient solution was then analyzed to estimate the residual cadmium content in the culture solution after sampling in each interval.The content of cadmium in roots, stems and leaves was analyzed by atomic absorption spectrometry. Samples were prepared according to Allan (1969)[13].

The specific determination results were statistically analyzed by EXCEL program and SPSS 20.0. Data are reported as mean ± standard deviation. Three independent experiments were conducted for each case. Statistical significance was considered significant when $p \leq 0.05$.

III. Result

The results of Cd treatment of *Coptis chinensis* showed that the concentration of Cd in roots, stems and leaves increased with the extension of treatment time; There are differences in Cd content in different tissues of *Coptis chinensis*. Cd is the highest in roots, followed by rhizomes and leaves (Table 1).

Table 1. Concentrations of Cd in leaf, stem, and root of *Coptis chinensis* Franch. at different treatment time.

Tissues	Cd concentration (mg kg^{-1})					
	0h	2d	4d	6d	8d	10d
Leaf	0.242±0.003c	0.421±0.003c	0.632±0.002c	0.752±0.005c	0.864±0.001c	0.873±0.003c
Stem	0.429±0.007b	4.828±0.053b	7.378±0.026b	9.314±0.017b	11.382±0.021b	13.127±0.038b
Root	2.071±0.031c	42.836±0.214a	54.736±0.132a	73.766±0.128a	87.453±0.108a	95.428±0.103a

Note: Mean±standard deviation (replicates=3). Values with different letters in the same column indicate a significant difference at $p<0.05$.

Coptis chinensis was cultured in Hoagland solution containing a known amount of cadmium. In order to determine the distribution pattern of cadmium, the accumulation of cadmium in plant tissues and the effective residue in culture medium after 10 days of growth were compared. With the extension of growth period, the accumulation increased gradually ($P < 0.01$), while the residual effective Cd content in culture medium decreased gradually ($P <$

0.02), and was almost exhausted on the 10th day. There was a significant difference between the supply of cadmium in the culture medium and the sum of cumulative amount and residual amount, indicating that there was partial Cd loss within 10 days, and the loss was positively correlated with the Cd content in the culture medium ($P < 0.01$) (Table 2).

Table 2. Proportions of Cd in *Coptis chinensis* Franch. was relation to the applicability and wastage during growth.

	mg/whole plants（Cd concentration）				
	2d	4d	6d	8d	10d
T	1.47(13.2)	1.91(17.1)	2.72(24.3)	2.87(25.6)	3.26(29.1)
A	5.85(52.3)	5.24(46.8)	4.01(35.8)	3.18(28.4)	2.17(19.4)
W	3.88(34.5)	4.04(36.1)	4.46(39.9)	5.15(46.0)	5.77(51.5)

11.2 mg Cd was contained in 100 μm
The values in parentheses are percentage content
T= Total cumulative content of plants (mg/whole tissue)
A= applicable quantity of Cd in medium after 10 days of growth
W= Wastage during 10 days of growth (difference between accumulation + applicability and total cadmium content)

IV. Discussion and conclusion

Studies revealed that the concentration of Cd in rhizomes increased, with the extension of Cd treatment time. The bioaccumulation potential of Cd in roots, stems and leaves of *Coptis chinensis* was root > stem > leaf. This is consistent with the results of studying the changes of Cu in Cd treated sunflower seeds by LA-ICP-MS imaging technology[14]. During the treatment with 100 μm cadmium, cadmium gradually decreased within 10 days, and the cadmium residue in the culture medium was negligible. By comparing the total cadmium accumulated in plant tissues with the cadmium content in culture medium, it was found that a large amount of cadmium loss occurred. The percentage of cadmium remaining in the culture medium and cadmium accumulated in plants and the loss of cadmium can be assumed to be released from plants to the atmosphere. This cadmium loss (Table 2) may occur through stomata because the stomatal index of cadmium treated plants increases accordingly[15]. Through the research in this chapter, we further understand the accumulation and detoxification mechanism of Cd in *Coptis chinensis*, so as to provide a theoretical basis for reducing the content of Cd in *Coptis chinensis*.

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