Comprehensive Characterization of Environmental Cadmium Toxicity on Rice, Mouse and Human Urine by Mass Spectrometry-Based Omics Analysis

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INTRODUCTION

Cadmium (Cd) is a toxic environmental pollutant that has detrimental effects on plants, animals and human-beings. Mass spectrometry (MS)-based omics analysis has been widely applied in providing massive information associated with environmental pollution.

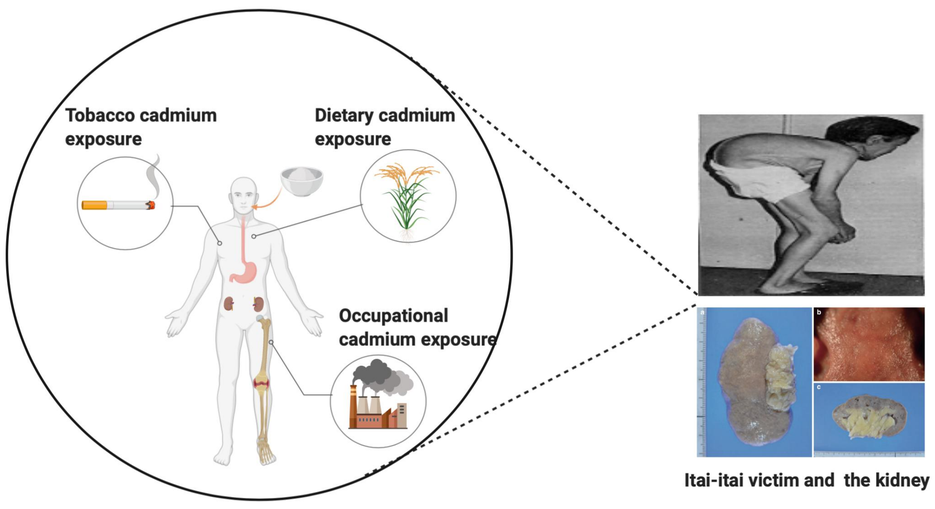

Figure 1. Cadmium pollution and *itai-itai* victim

EXPERIMENTAL SECTION

Study 1: Mass spectrometry-based metabolomics investigation on two different indica rice grains (Oryza sativa L.) under cadmium stress

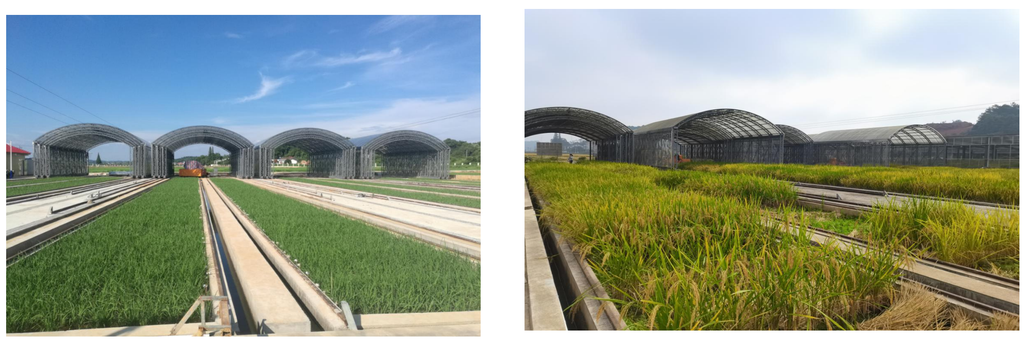

Figure 2. Field experiment for the selection of low-camium-accumulating rice variety

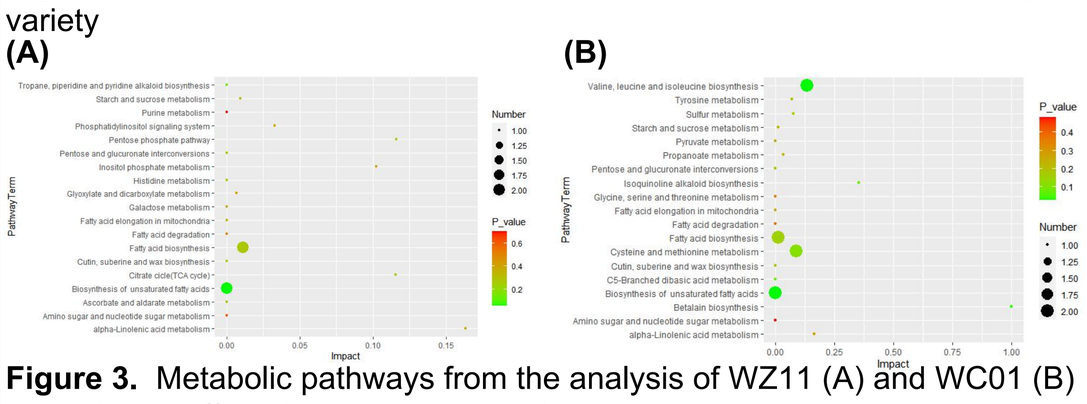

Figure 3. Metabolic pathways from the analysis of WZ11 (A) and WC01 (B) under three different cadmium concentration exposures.

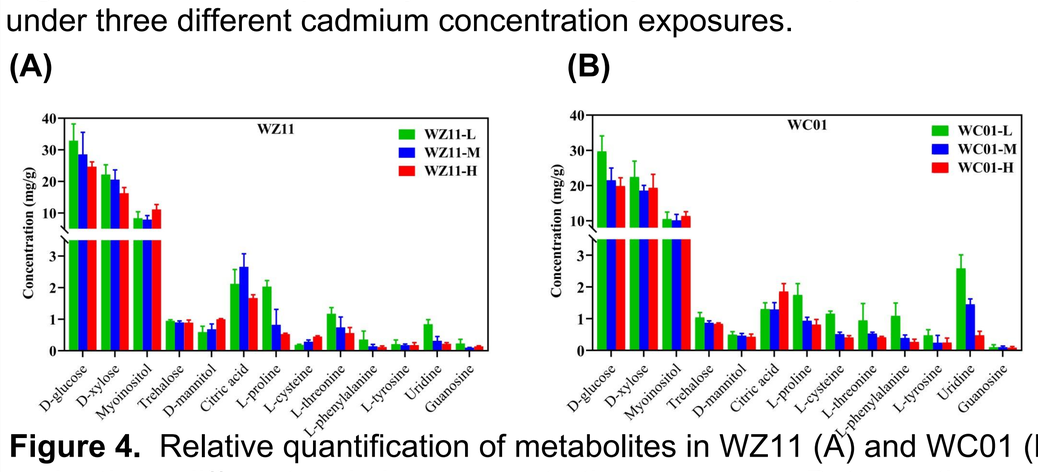

Figure 4. Relative quantification of metabolites in WZ11 (A) and WC01 (B) under three different cadmium concentration exposures. Data are the mean ± SD of n = 3.

Study 2: Integration of omics analysis and atmospheric pressure MALDI mass spectrometry imaging reveals the cadmium toxicity on female ICR mouse

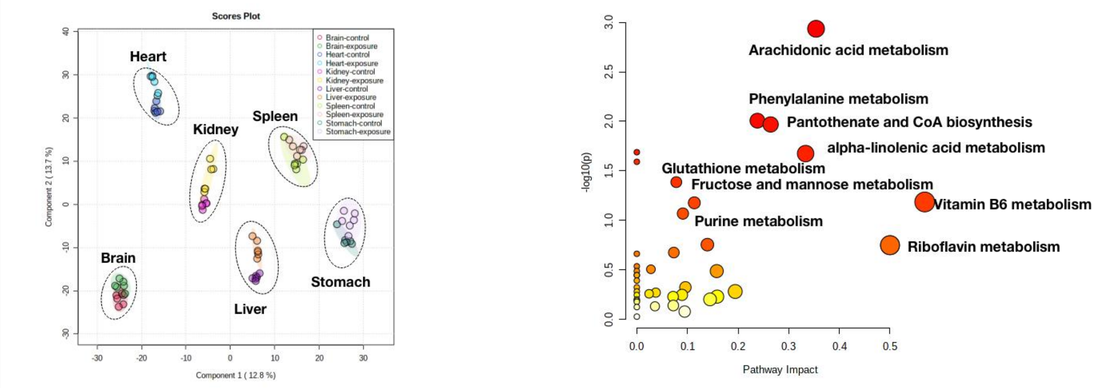

Figure 5. PLS-DA score plots (A) and Metabolic pathways (B) of biomarkers in mice tissues under cadmium exposure by metabolomics analysis.

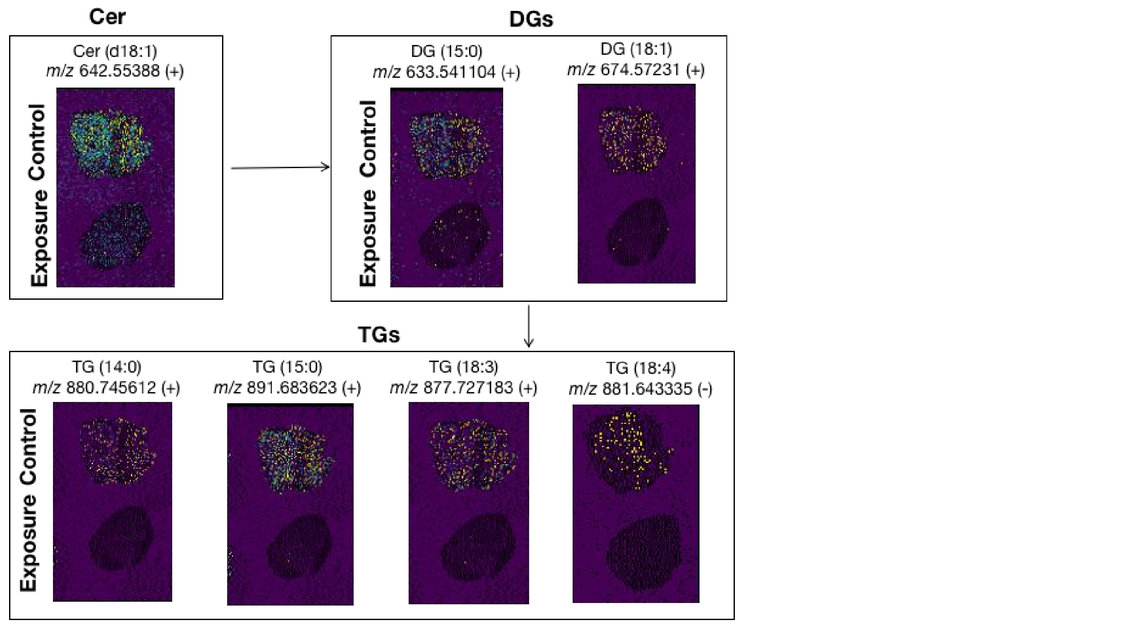

Figure 6. AP-MALDI mass spectrometry imaging of representative lipids from mice liver tissues under cadmium exposure.

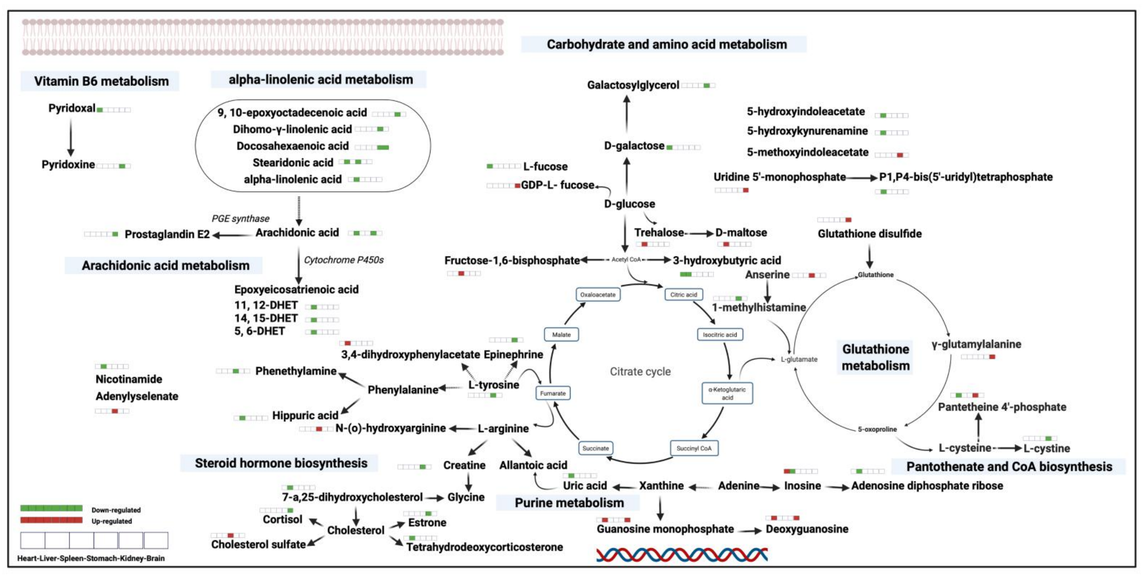

Figure 7. Proposed metabolic pathway of mice tissues under cadmium exposure by metabolomics analysis.

Study 3: Urinary metabolic characterization with nephrotoxicity for residents under cadmium exposure

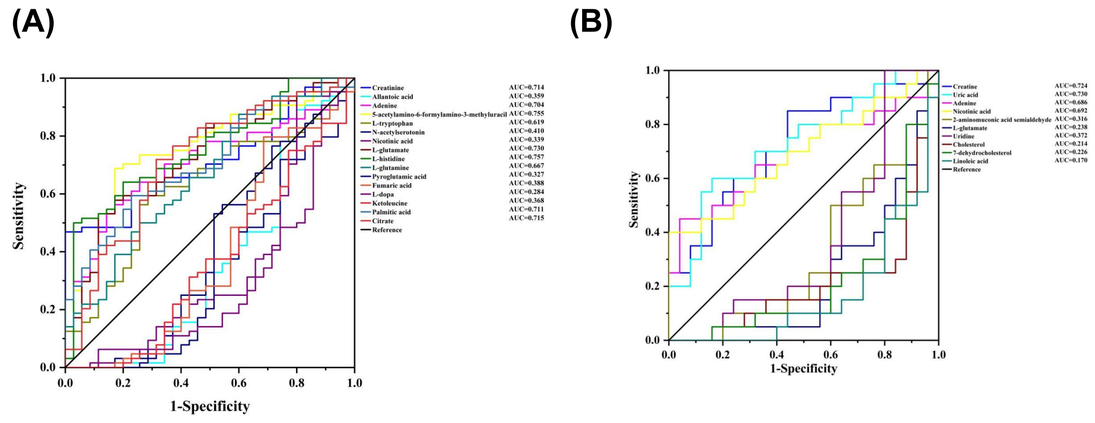

Figure 8. ROC curve analysis of urine from (A) female and (B) male residents in high-polluted, low-polluted and control areas under cadmium exposure.

CONCLUSIONS

- Two contrasting indica rice grains under cadmium stress were subjected to mass spectrometry-based metabolomics analysis for the first time.
- The systematic metabolomics study on female ICR mice tissues including liver, kidney, heart, stomach, brain as well as spleen under cadmium exposure was firstly conducted and lipidomic characterizations on female ICR mice liver, kidney and heart were further constructed step by step.
- To deeply understand its toxicological mechanisms, several representative lipids on the mouse liver were visualized by AP-MALDI MSI.
- A mass spectrometry-based metabolomics investigation on urine from a cohort of 144 volunteers was conducted to explore sex-specific metabolic alteration and to screen biomarkers related to cadmium-induced nephrotoxicity.
- These insights could enhance knowledge in cadmium toxicity of public health and guide risk assessment in the future

REFERENCES

1. Zeng, T.; Fang, B.; Huang, F.; Dai, L.; Tang, Z.; Tian, J.; Cao, G.; Meng, X.; Liu, Y.; Lei, B.; Lu, M.; Cai, Z. *Food Chemistry*, **2021**, 343, 128472.

2. Zeng, T.; Guo, W.; Jiang, L.; Luo, Q.; Shi, Z.; Lei, B.; Zhang, J.; Cai, Z. *Science of the Total Environment*, **2021**, 801, 149803.

3. Zeng, T.; Liang, Y.; Chen, J.; Cao, G.; Yang, Z.; Zhao, X.; Tian, J.; Xin, X.; Lei, B.; Cai, Z. *Environment International*, **2021**, 154, 106646.

ACKNOWLEDGMENTS

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