

**Tolerance mechanism of *Trichoderma asperellum* to Pb²⁺: response changes of
related active ingredients under Pb²⁺ stress**

Huiqing Sun^{a,b,c}, Lingran Wu^{a,b,c}, Yali Hao^{a,b,c}, Chunyu Liu^{a,b,c}, Lichao Pan^{a,b,c},
Zhenyuan Zhu^{a,b,c,*},

*^aState Key Laboratory of Food Nutrition and Safety, Tianjin University of Science and
Technology, Tianjin 300457, PR China*

*^bKey Laboratory of Food Nutrition and Safety, Ministry of Education, Tianjin
University of Science and Technology, Tianjin 300457, PR China*

*^cCollege of Food Science and Biotechnology, Tianjin University of Science and
Technology, Tianjin 300457, PR China*

**Corresponding author: Tel.: +86 2260912390, Fax: +86 2260912390.*

E-mail address: zhyuanzhu@tust.edu.cn. (Z.Y. Zhu).

List of supplementary materials:

Table S1 Significance analysis on removal ratio of Pb^{2+} with fermentation time in different initial concentration of Pb^{2+}

Table S2 Significance analysis on polysaccharides content in mycelia under Pb^{2+} stress

Table S3 Significance analysis on soluble proteins content in mycelia under Pb^{2+} stress

Table S4 Significance analysis on thiol compounds in fermentation broth under Pb^{2+} stress

Table S5 Significance analysis on thiol compounds in mycelia under Pb^{2+} stress

Table S6 Significance analysis on oxalic acid content in fermentation broth under Pb^{2+} stress

Table S7 Significance analysis on oxalic acid content in mycelia under Pb^{2+} stress

Table S8 Significance analysis on formic acid content in fermentation broth under Pb^{2+} stress

Table S9 Significance analysis on formic acid content in mycelia under Pb^{2+} stress

Table S10 Significance analysis on malic acid content in fermentation broth under Pb^{2+} stress

Table S11 Significance analysis on malic acid content in mycelia under Pb^{2+} stress

Table S1 Significance analysis on removal ratio of Pb²⁺ with fermentation time in different initial concentration of Pb²⁺

Initial concentration of Pb ²⁺ (mg/L)	Fermentation time (h)							
	24	26	28	32	36	48	72	96
10	Aa	Bb	Cc	Cc	Cc	Cc	Cc	Cc
25	Aa	Bb	Cc	Dd	Dd	Dd	Dd	Dd
50	Aa	Bb	Cc	Dd	Ee	Ff	Ff	Ff
100	Aa	Bb	Cc	Dd	Ee	Ff	Gg	Gg
200	Aa	Bb	Cc	Dd	Ee	Ff	Gg	Hh
400	Aa	Bb	Cc	Dd	Ee	Ff	Gg	Hh

Note: The different uppercase letters and lowercase letters in the same line showed that the difference between the groups was extremely significant ($P < 0.01$) and significant ($P < 0.05$), respectively. The same lowercase letters indicated that the difference between the groups was not significant ($P > 0.05$). Same as followed.

Table S2 Significance analysis on polysaccharides content in mycelia under Pb²⁺ stress

Initial concentration of Pb ²⁺ (mg/L)	Fermentation time (h)						
	26	28	32	36	48	72	96
0	Aa	Bb	Cc	Dd	Ee	Ee	Ee
50	Aa	Bb	Cc	Dd	Ee	Ee	Ee
100	Aa	Bb	Cc	Dd	EFef	Ff	Ee
200	Aa	Bb	Cc	Dd	Ff	EFef	Ee
400	Aa	Bb	Cc	Dd	Ff	Ee	DEde

Table S3 Significance analysis on soluble proteins content in mycelia under Pb²⁺ stress

Initial concentration of Pb ²⁺ (mg/L)	Fermentation time (h)						
	26	28	32	36	48	72	96
0	Dd	Cc	Cc	Bb	Aa	Aa	Aa
50	Dd	Cc	Cc	Bb	Aa	Aa	Aa
100	Cc	Bb	Bb	Aa	Aa	Aa	Aa
200	Cc	Bb	Bb	Aa	Aa	Aa	Aa
400	Cc	Bb	Bb	Aa	Aa	Aa	Aa

Table S4 Significance analysis on thiol compounds in fermentation broth under Pb²⁺ stress

Initial concentration of Pb ²⁺ (mg/L)	Fermentation time (h)						
	26	28	32	36	48	72	96
0	Aa	Bb	Ef	De	Dd	Cc	Cc
50	Aa	Bb	Dd	Cc	Cc	Bb	Bb
100	Aa	Dd	Ff	Ee	Ee	Cc	Bb
200	Aa	Cc	Ff	Ee	Dd	Cc	Bb
400	Aa	Bb	Ee	Dd	Cc	Bb	Aa

Table S5 Significance analysis on thiol compounds in mycelia under Pb²⁺ stress

Initial concentration of Pb ²⁺ (mg/L)	Fermentation time (h)						
	26	28	32	36	48	72	96
0	Aa	Bb	Cc	Cc	Dd	Dd	Bb
50	Aa	Bb	Cc	Cc	Dd	Ee	Cc
100	Aa	Bb	Cc	Dd	Ff	Ff	Ee
200	Aa	Bb	Cc	Dd	Ee	Ff	Gg
400	Aa	Bb	Cc	Ee	Ff	Ff	Dd

Table S6 Significance analysis on oxalic acid content in fermentation broth underPb²⁺ stress

Initial concentration of Pb ²⁺ (mg/L)	Fermentation time (h)						
	26	28	32	36	48	72	96
0	Cc	Cc	Aa	Aa	Aa	Aa	Aa
50	Bb	Cc	Bb	Aa	Aa	Aa	Aa
100	Bb	Ee	Dd	Cc	Aa	Aa	Aa
200	Aa	Ee	Dd	Cc	Bb	Aa	Aa
400	Aa	Ee	Ee	Dd	Dd	Cc	Bb

Table S7 Significance analysis on oxalic acid content in mycelia under Pb²⁺ stress

Initial concentration of Pb ²⁺ (mg/L)	Fermentation time (h)						
	26	28	32	36	48	72	96
0	Bb	Dd	Dd	Ee	Dd	Cc	Aa
50	Bb	Dd	Ee	Ee	Ee	Cc	Aa
100	Aa	Dd	Ee	Dd	Cc	Cc	Bb
200	Aa	Bb	Ee	Dd	Cc	Cc	Aa
400	Aa	Ee	Ff	Ee	Dd	Cc	Bb

Table S8 Significance analysis on formic acid content in fermentation broth underPb²⁺ stress

Initial concentration of Pb ²⁺ (mg/L)	Fermentation time (h)						
	26	28	32	36	48	72	96
0	Dd	Cc	Bb	Aa	Ee	Dd	Dd
50	Dd	Bb	Bb	Aa	Cc	Dd	Cc
100	Ee	Bb	Aa	Aa	Aa	Dd	Cc
200	Dd	Cc	Aa	Aa	Bb	Cc	Dd
400	Cc	Aa	Aa	Aa	Aa	Bb	Bb

Table S9 Significance analysis on formic acid content in mycelia under Pb²⁺ stress

Initial concentration of Pb ²⁺ (mg/L)	Fermentation time (h)						
	26	28	32	36	48	72	96
0	Aa	Bb	Cc	Dd	Ee	Dd	Bb
50	Aa	Bb	Dd	Ee	Ff	Ee	Cc
100	Aa	Bb	Cc	Dd	Ee	Ee	Dd
200	Aa	Bb	Bb	Cc	Dd	Ee	Bb
400	Aa	Aa	Aa	Bb	Cc	Cc	Aa

Table S10 Significance analysis on malic acid content in fermentation broth underPb²⁺ stress

Initial concentration of Pb ²⁺ (mg/L)	Fermentation time (h)						
	26	28	32	36	48	72	96
0	Aa	Dd	Ff	Gg	Ee	Cc	Bb
50	Aa	Bb	Dd	Ee	Cc	Cc	Cc
100	Bb	Aa	Aa	Bb	Cc	Dd	Bb
200	De	Cd	Bc	ABbc	Aab	Aa	Aa
400	Dd	Cc	Bb	Aa	Aa	Aa	Aa

Table S11 Significance analysis on malic acid content in mycelia under Pb²⁺ stress

Initial concentration of Pb ²⁺ (mg/L)	Fermentation time (h)						
	26	28	32	36	48	72	96
0	Aa	Cc	Gg	Fe	Ee	Dd	Bb
50	Aa	Dd	Fe	Ee	Cc	Cc	Bb
100	Aa	Bb	Ef	Dde	CDcd	Cc	Cc
200	Aa	Cc	Cc	Cc	Bb	Bb	Bb
400	Aa	Dd	Dd	Cc	Bb	Aa	Aa