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Proanthocyanidin–Aluminum Complexes Improve Aluminum Resistance and Detoxification of *Camellia sinensis*

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Abstract

Aluminum (Al) influences crop yield in acidic soil. The tea plant (*Camellia sinensis*) has high Al tolerance with abundant monomeric catechins in its leaves, especially epigallocatechin gallate (EGCG), and polymeric proanthocyanidins in its roots (rPA). The role of these polyphenols in the Al resistance of tea plants is unclear. In this study, we observed that these polyphenols could form complexes with Al *in vitro*, and complexation capacity was positively influenced by high solution pH (pH 5.8), polyphenol type (rPA and EGCG), and high Al concentration. In the ^{27}Al nuclear magnetic resonance (NMR) experiment, rPA-Al and EGCG-Al complex signals could be detected both *in vitro* and *in vivo*. The rPA-Al and EGCG-Al complexes were detected in roots and old leaves, respectively, of both greenhouse seedlings and tea garden plants. These results indicate that the formation of complexes with tea polyphenols *in vivo* plays a vital role in Al resistance in the tea plant.

Results

1. Complexation Characteristics of Al with Tea Flavan-3-ols *in Vitro*.

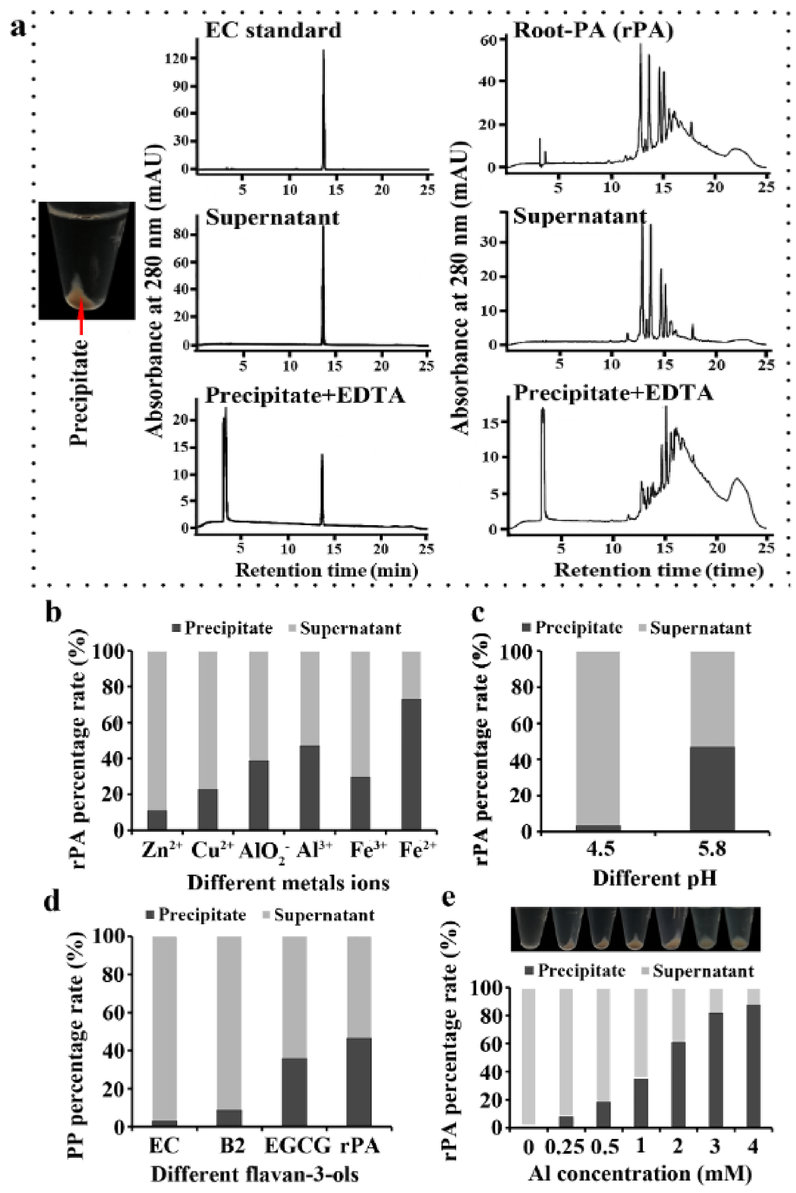

Figure 1. Complexation characteristics of Al with tea flavan-3-ols *in vitro*.

2. Detection of Al complexes by ^{27}Al NMR.

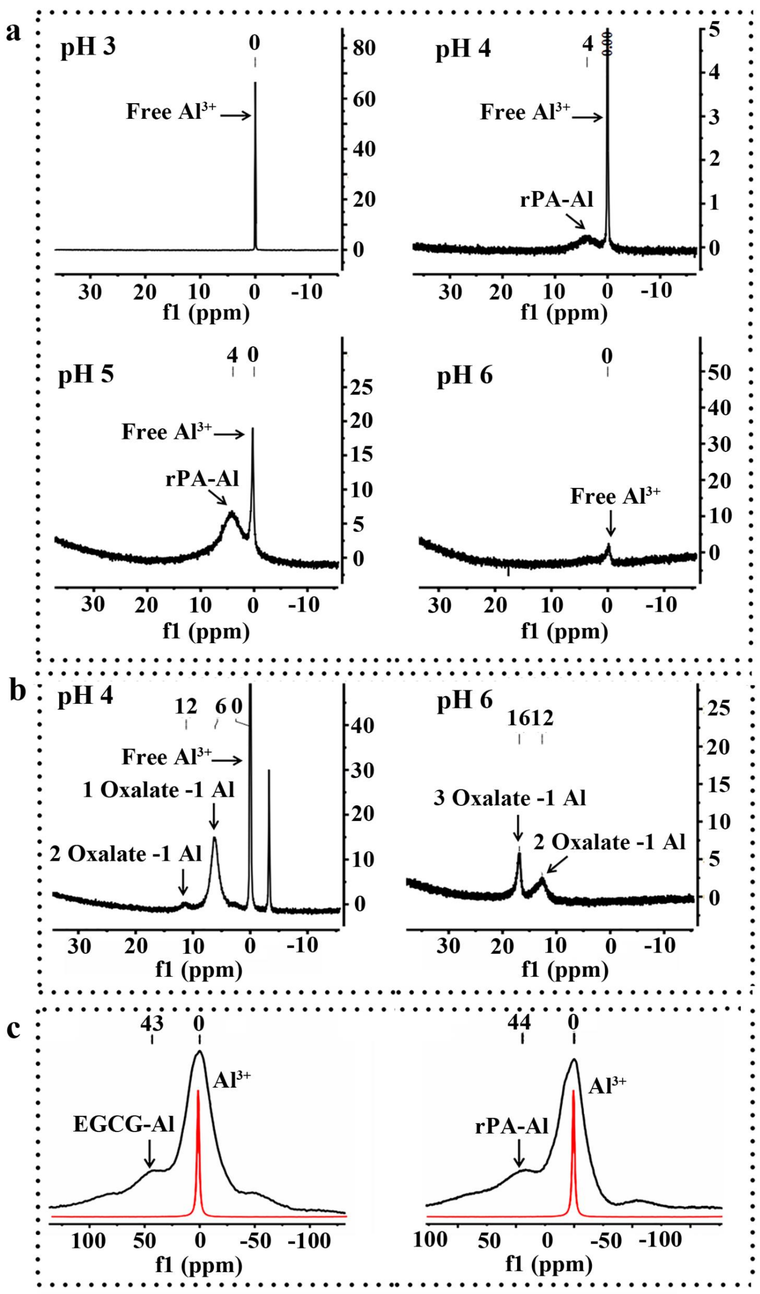

Figure 2. Detection of Al complexes by ^{27}Al NMR.

3. Identification of rPA-Al complexes in tea plants by ^{27}Al NMR.

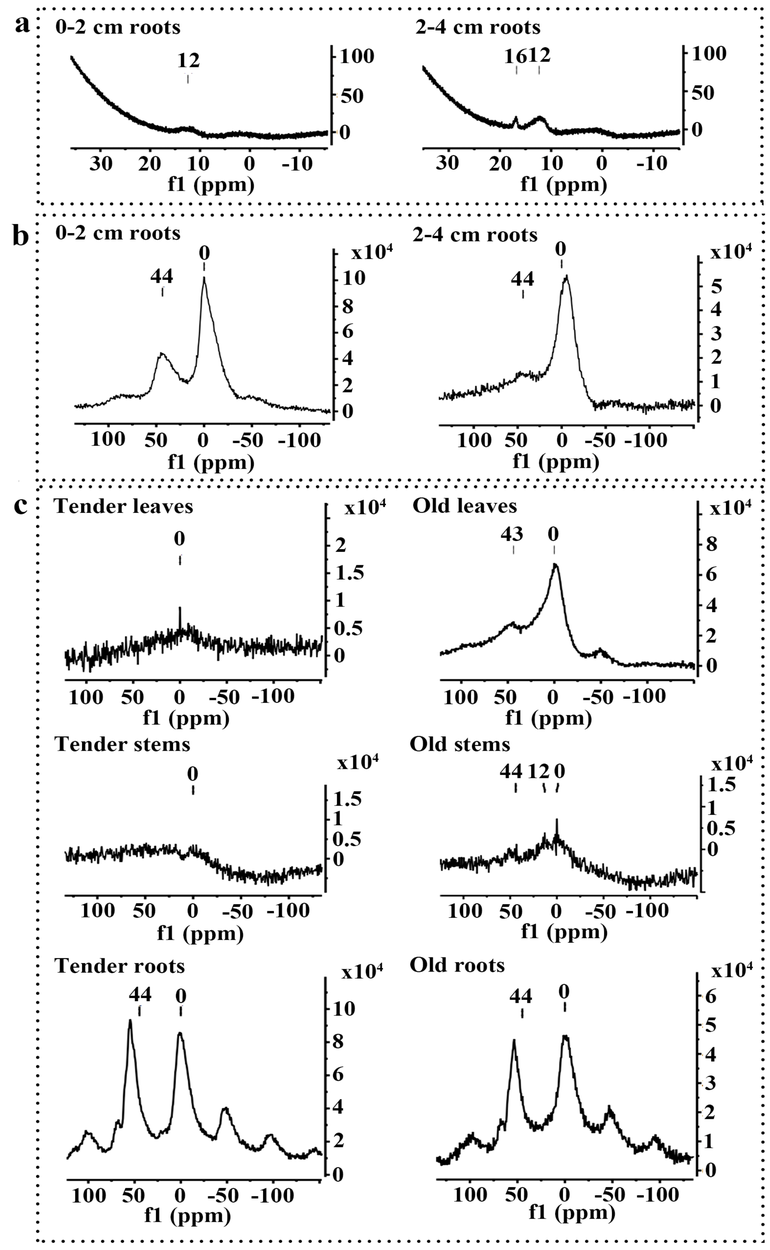

Figure 3. Identification of rPA-Al complexes in tea plants by ^{27}Al NMR.

Conclusion

In conclusion, this study focused on Al resistance mechanisms involving PAs and EGCG in tea plants. The results demonstrated that both PAs and EGCG can combine with considerable amounts of Al to form PA-Al and EGCG-Al complexes in roots and old leaves, respectively, which reduces the mobility and toxicity of Al and results in higher Al tolerance. In addition, in the tender shoots of tea plants for drinking, both free and bound Al were very rarely found. The mechanisms of Al tolerance and accumulation in tea plants are complex and require additional clarification. For instance, the genes and proteins relevant to the absorption and transport of Al, forms of Al, and facilitation of Al for tea plants growth require more research.

4. Distribution and form of aluminum in different tissues and organs of tea plant.

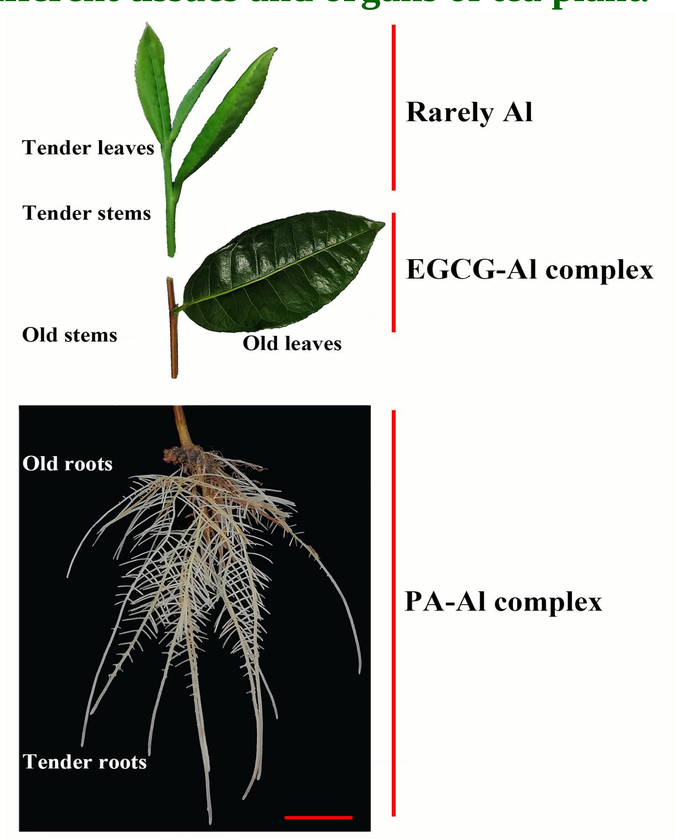

Figure 4. Distribution and form of aluminum in different tissues and organs of tea plant.

Acknowledgments

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