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From soil to bean: Tracing Cd pathways in cacao trees

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The accumulation of the toxic metal cadmium (Cd) in cacao beans has recently become a subject of intense research after the European Union lowered its limits in chocolate. Large differences (factor 13) in cacao bean Cd concentrations were found between cultivars grown in the field in conditions with comparable soil Cd [1]. Genetics-based techniques may thus offer sustainable strategies for Cd mitigation in cacao. Nonetheless, this reduction potential is yet to be exploited since there is a lack of knowledge on how Cd is transported from soil to the cacao bean. Here, we aimed to compare the mechanisms that control Cd transfer in two genotypes by a combination of Cd stable isotope analyses and X-ray absorption spectroscopy. The latter is providing insights on Cd speciation whilst the isotopic signature of Cd in plants is increasingly used to infer biogeochemical processes in plants. Three replicate trees of a low (**L**) and a high Cd accumulating (**H**) cultivar were selected from a conservatory of cacao cultivars in Trinidad (soil Cd: 0.3 mg Cd kg^{-1}). Cadmium concentrations in leaves and beans of **H** were factors 3.5-4 higher than in **L**. Both cultivars showed a similar partitioning strategy, i.e. Cd concentrations increased in the order: placenta < nib < testa < pod husk < root < young leaf - old leaf < wood. In roots, leaves, and wood tissues of **H**, Cd was mainly bound to carboxyl ligands, while in the bean, Cd was mostly associated with phytate. In contrast, Cd in beans has been reported previously to be primarily bound with O/N-ligands [2]. The first isotope measurements in **H** indicate a significant fractionation between organs. In particular, beans were enriched in light isotopes compared to the leaves. This suggests different pathways and types of ligands for Cd in cacao compared to cereal grains [3]. More isotope data on other tissues are currently measured, and will further unravel the pathways of Cd in the two genotypes.

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