The function of plant IDPs (LEA proteins) in stabilizing enzymes during desiccation goes beyond an anti-aggregation activity

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Most of the 51 late embryogenesis abundant (LEA) proteins in Arabidopsis thaliana are predicted to be intrinsically disordered proteins (IDPs). We were able to verify this prediction for 12 recombinantly expressed LEA proteins by CD spectroscopy. In addition, these proteins were partly structured (mainly alpha-helical) after drying. We investigated the ability of six different LEA proteins from three families (Pfam LEA_4, LEA_5 and LEA_6) to prevent the inactivation of enzymes during drying. To test plant enzyme protection in a more realistic experimental system than with e.g. the commonly used rabbit muscle lactate dehydrogenase, we developed a drying assay based on the activity of enzymes in a soluble Arabidopsis protein extract. Using a combination of enzyme activity measurements and FTIR spectroscopy these experiments revealed that all six recombinant LEA proteins protected the soluble Arabidopsis proteome from aggregation in the dry state, while only one LEA protein (LEA7) also partially protected the activity of two enzymes naturally present in these samples. We hypothesize from these data that anti-aggregation (molecular shield) activity is a common property of many IDPs, while the functional stabilization of enzymes during drying may require more specific properties that only a much more limited number of LEA proteins possess. The elucidation of these properties and the establishment of structure-function relationships in these IDPs will be an important goal in our future research.