Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)
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New milestone in plant magnetic resonance imaging

Press Release

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Gatersleben, 25.09.2024 **Magnetic resonance imaging (MRI) is a versatile technique in the biomedical field, but its application to the study of plant metabolism *in vivo* remains challenging. A research team led by Dr. L. Borisjuk (IPK Leibniz Institute) and Prof. P.M. Jakob (Würzburg University) reports the establishment of chemical exchange saturation transfer (CEST) for plant MRI. This method enables noninvasive access to the metabolism of sugars and amino acids in complex sink organs (seeds, fruits, taproots, and tubers) of major crops (maize, barley, pea, potato, sugar beet, and sugarcane). Recently, the results were published in the journal "Science Advances".**

The "omics" technologies - genomics, transcriptomics, proteomics, and metabolomics - are at the forefront of discovery in modern plant science and systems biology. In contrast to the more "static" genome, the metabolome and the products measured within it are dynamic and regulated spatially and temporally. In the biomedical field, one of the most powerful technological platforms allowing for *in vivo* metabolic diagnostic and functional studies is nuclear magnetic resonance (NMR) imaging or magnetic resonance imaging (MRI). In plant science, a similar perspective has been desired but not explored.

The interdisciplinary research group "Assimilate Allocation and NMR" at the IPK is investigating the potential of NMR imaging in plant science. Establishing the new NMR platform, made financially feasible by the European Regional Development Fund (ERDF) and the Investment Bank of Saxony-Anhalt, provides a crucial foundation for this endeavour.

Common H NMR imaging of biological tissue, for example, relies on signals primarily originating from water or lipid protons. As the concentration of metabolite protons is at least three orders of magnitude lower than that of water, the *in vivo* detection of metabolites requires effective suppression of the water signal.

Chemical exchange saturation transfer (CEST), an approach used in the biomedical field, could offer a solution. In CEST, magnetisation is transferred from other molecules to water molecules so that the saturation effect (i.e., signal reduction) that was originally on the targeted species can be observed on water instead. "In that way, CEST enables the detection of various metabolites based on their ability to exchange protons with water, thereby providing an additional MRI contrast", says Simon Mayer, first author of the study and researcher at IPK Leibniz Institute. "Because of its high signal detection sensitivity and low susceptibility to magnetic field inhomogeneities, CEST analyses heterogeneous botanical samples inaccessible to conventional magnetic resonance spectroscopy."

The results are encouraging. "Our studies demonstrate that CEST is a powerful MRI approach that facilitates *in vivo* metabolic analysis in plants, allowing microscopic resolution and dynamic assessment of sugar and amino acid distribution despite the magnetic heterogeneity of the samples. Its application to various crops demonstrates that CEST is a species-, variety-, and organ-agnostic approach to noninvasively visualising metabolites without the need for prior labelling or sample processing", explains Dr. Ljudmilla Borisjuk, head of IPK's research group "Assimilate Allocation and NMR".

The research team showed metabolite dynamics in growing seeds, which is impossible using conventional techniques. Breeders highly seek knowledge of the spatiotemporal dynamics of sugars and amino acids in sink organs. Their distribution influences mass transport and metabolism in many ways; this knowledge ultimately flows into crop improvement.

The CEST offers unprecedented opportunities for monitoring dynamic changes in metabolites in living plants. It is particularly important for a deeper understanding of trait formation and supporting breeding research by *in vivo* testing metabolic responses to genetic engineering and/or developmental alterations.

“Visualisation of metabolite dynamics in living plants is a desired tool to bridge structural and metabolic interactions in plant responses to ever-changing environments. Thus, introducing CEST, which visualises internal tissue structure and metabolite dynamics while avoiding tracers using only one technological platform, MRI, is an important milestone toward this goal.”

Original publication:

Mayer *et al.* (2024): Metabolic imaging in living plants: A promising field for chemical exchange saturation transfer (CEST) MRI. Science Advances. DOI: 10.1126/sciadv.adq4424

Photo (for free use):

Non-invasive CEST MRI of sugars (left) and amino acids (right) distribution in fruit of kiwi (*Actinidia deliciosa)*