Can metabolic mri be useful to image tomato metabolism?

Guilhem Pagès, Catherine Deborde, Martine Lemaire-Chamley, Moing A Lemaire-Chamley, J.-M. Bonny

CAN METABOLIC MRI BE USEFUL TO IMAGE TOMATO METABOLISM?

Pagés G.*[a,b], Deborde C.[c,d], Lemaire-Chamley M.[d], Moing A.[c,d], Bonny J.-M.[a,b]

[a] *INRAE, UR QuaPA, F-63122 Saint-Genès-Champanelle, France*
[b] *INRAE, PROBE research infrastructure, AgroResonance facility, F-63122 Saint-Genès-Champanelle, France*
[c] *Metabolome Bordeaux, INRAE, MetaboHUB, PHENOME, Centre INRAE de Nouvelle-Aquitaine Bordeaux, F-33140 Villenave d'Ornon, France* *doi: 10.15454/1.5572412770331912E12*
[d] *INRAE, Univ. Bordeaux, UMR BFP, F-33140 Villenave d'Ornon, France*

* guilhem.pages@inrae.fr

Fruit development allows seed maturation and dispersion. For tomato fruit, seeds are maturating while they are inside the fruit locular cavities, embedded in a jelly-like tissue called locular tissue.[1] Surprisingly, seed maturation continues while the seeds are no longer connected to vascular tissues, i.e. to metabolite supply. To better understand this particular developmental process, it is crucial to determine the metabolite spatial profiles near the seeds, i.e. inside the locular tissue. In this context, the non-invasive character as well as the versatility of MRI makes this analytical tool promising to investigate this question.

For this purpose, we investigated two metabolic MRI contrasts. The first one records one NMR spectrum per voxel leading to a complete characterization of the metabolites present inside the voxel. This approach is named Magnetic Resonance Spectroscopy Imaging (MRSI). The second contrast images the chemical exchange between exchangeable protons on specific moieties like hydroxyl, amine or amide and water. This latter is referred to as chemical exchange using saturation transfer (CEST) imaging. Unlike MRSI that gives a complete metabolite profile, CEST image is specific of one chemical exchangeable moiety which may come from several metabolites. The aim of this work was to evaluate the interest of both metabolic MRI contrasts to study tomato metabolism.

The figure below illustrates the main results for both contrasts obtained for the same fruit slice.[2] For MRSI, the NMR spectrum quality, e.g. linewidths or water suppression efficiency, was inequivalent from one pixel to the other leading to non-exploitable data. These variations were explained by a significant magnetic field heterogeneity within the slice. For CEST images, we focused on frequency ranges from 0.4 to 1.6 and 2.4 to 3.6 ppm from the water frequency leading to an image contrasted for hydroxyl and amino moieties, respectively. Knowing the quantification of tomato major metabolites,[1] these images were contrasted for glucose/fructose and glutamate/glutamine, respectively. A clear difference in the metabolite spatial repartition was observed between glucose/fructose, mostly present in the locular tissue, and glutamate/glutamine, mostly located inside the columella. These differences in the tissue localisation matched what was previously found using tissue dissection.[1] In conclusion, for tomato fruit, CEST MRI is more informative than MRSI regarding metabolite repartition.

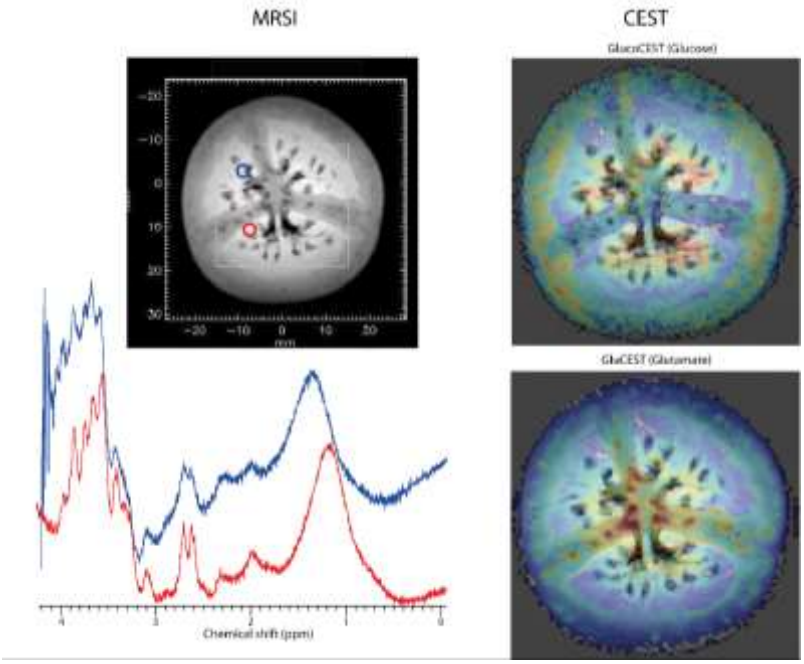

Figure 1 : Illustration of the results obtained from both metabolic MRI contrasts. (left) Two NMR spectra obtained from the locular tissue and localized in two different compartments of the tomato (localization displayed on the top image). (right) CEST maps obtained on the same fruit. The images are contrasted for (top) sugars and (bottom) glutamine and glutamate.

Funding:
This work was partially supported by the IB2019_GelSeed project of the INRAE BAP division and MetaboHUB (ANR-11-INBS0010).

References

[1] Lemaire-Chamley M., Mounet F., Deborde C., Maucourt M., Jacob D. & Moing A., *Metabolites*, 9, 93, 2019.
[2] Pagés G., Deborde C., Lemaire-Chamley M., Moing A. & Bonny J.-M., *Anal. Bioanal. Chem.*, 413, 1251, 2021.