Mass Spectrometry Imaging with Single-Cell Resolution: Spatial Distribution of Lipids in Cotton Seeds

Many assays can provide temporal information on metabolic processes; however, providing spatial information proves substantially more difficult. Macromolecules, such as DNA, RNA, and proteins, can be labeled by in situ hybridization, immunohistochemistry, or marker fusions to provide localization information. Thus, we can localize enzymes but usually cannot localize their products, which can be small, mobile, and sometimes ephemeral. Mass spectrometry imaging (MSI) is emerging as a promising method to examine the spatial distribution of smaller molecules (reviewed in Chughtai and Heeren, 2010; Lee et al., 2012). In MSI, the molecules in a sample are vaporized and ionized from a small spot of 10 to 50 μm in diameter (see figure). The components from this spot are then identified by mass spectrometry to show the composition of that area. The sample, which could be the surface of a specimen or a tissue section, is then moved so that the next area can be analyzed; covering the whole area of the sample provides a spatial profile of composition. In matrix-assisted laser desorption/ionization (MALDI) MSI, the addition of a matrix to the sample assists in desorption and allows soft ionization to minimize fragmentation, thus allowing easier identification of biomolecules. MSI has several advantages: It does not require labeling for high-sensitivity identification of known and unknown molecules, and it allows profiling of many metabolites at once. MSI also has several limitations: The resolution is limited by the amount of material that can be detected, and sample preparation, including fixation, matrix application, and sectioning, must carefully preserve the composition and spatial distribution of the molecules in the sample.

Lipids, which are important in signaling and seed development as well as for food and biofuel crops, are amenable to MSI, which has been used to examine lipids in many animal systems. Horn et al. (2012) use MALDI-MSI to examine the distribution of lipids in the seeds of cotton (Gossypium hirsutum). Cotton, an oleseed crop, produces several species of storage lipids (triacylglycerols [TAGs]) and membrane lipids (phosphatidylcholines [PCs]). It also makes the terpenoid gossypol, which acts in plant defense and is toxic to humans. The authors profiled all of these classes of lipids and several others, finding that different species of TAGs show different, nonuniform distributions within the seed. For example, cyclic TAGs were more abundant in the embryonic axis than in the cotyledons. They also validated the use of MALDI-MSI for examining lipid composition, finding that TAG profiles were similar for MALDI-MSI and traditional extraction-based techniques. Although total PC was distributed uniformly through the seed, different species of PCs showed nonuniform distribution; for example, similar to TAGs, cyclic PCs were more abundant in the embryonic axis, and polyunsaturated species were more abundant in the cotyledons. The authors also imaged the distributions of other lipid species, including abundant and minor membrane lipids, some lipids involved in signaling, and gossypol.

This examination of lipid spatial composition provides insights into lipid metabolism in an important oleseed crop, laying a foundation for future improvements, such as changing gossypol concentration, understanding lipid signaling, increasing lipid yield, and engineering lipid composition for food, fuel, and industrial uses.

REFERENCES


Jennifer Mach
Science Editor
jmach@aspb.org

IN BRIEF
Mass Spectrometry Imaging with Single-Cell Resolution: Spatial Distribution of Lipids in Cotton Seeds
Jennifer Mach

Plant Cell; originally published online February 17, 2012;
DOI 10.1105/tpc.112.240210

This information is current as of June 27, 2017

Permissions

eTOCs
Sign up for eTOCs at:
http://www.plantcell.org/cgi/alerts/ctmain

CiteTrack Alerts
Sign up for CiteTrack Alerts at:
http://www.plantcell.org/cgi/alerts/ctmain

Subscription Information
Subscription Information for The Plant Cell and Plant Physiology is available at:
http://www.aspbo.org/publications/subscriptions.cfm

© American Society of Plant Biologists
ADVANCING THE SCIENCE OF PLANT BIOLOGY