Targeted Fat Characterization with MQC Pathways

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Introduction

Characterizing lipid is medically very important in the treatment and monitoring of a number of diseases, such as liver damage associated with alcohol abuse, hepatitis C, and diabetes.[1,2] Fat quantification is also essential for research programs examining the mechanisms and the physiological response to obesity. However, fats are difficult to characterize in vivo for a number of reasons. First, the spectrum of even a simple lipid is extremely complicated, with many peaks crowded into a narrow region. Second, inhomogeneous broadening makes it difficult if not impossible to distinguish these lines in vivo. To address this, we present a sequence that can distinguish saturated from unsaturated lipids, making a first step towards their chemical characterization. Furthermore, the sequence can be used to create edited spectra which can serve as fingerprints for lipids that are indistinguishable by conventional means.

Methods

The presented sequence creates diverging pathways to separate water protons, protons on saturated carbons (present in all fats), and protons on unsaturated carbons (present only in unsaturated fats). With an appropriate choice of gradients and timings, we can simultaneously acquire separate images for each of these components, as verified by our studies on phantoms. It accomplishes this by interleaving a standard single quantum pathway for spins on water molecules, a standard multiple quantum pathway for spins on saturated carbons, and a zero quantum to double quantum pathway for spins on unsaturated carbons. This last pathway, similar to that exploited by the Sel-MQC and HOT methods, is only available to mixed spin coherences and efficiently isolates unsaturated lipid signal.[3,4]

In essence, the imaging application amounts to a coarse chemical shift imaging that takes no longer to acquire than a standard proton density image. However, because the pathway for protons in unsaturated lipid involves a (conventional) zero quantum coherence, the same sequence can be used to acquire edited spectroscopy which will have narrow lines and simplified spectra in vivo. The water is also naturally suppressed, since conventional zero quantum transitions are not available to it, making this a feasible approach for in vivo spectroscopy.

Results and Discussion

The method has already been shown to distinguish unsaturated oils whose chemical shift spectra are nearly superimposable using standard acquisitions, such as PRESS. (Figure 1) The spectra acquired with the proposed sequence are highly edited and of much higher resolution than that attainable by conventional techniques, making them far more legible. We will present further characterization of the peaks observed by this method, as well as details on the pathways followed by each type of spin. Experimental results from the full three window sequence, which can be used to image the distribution of water, saturated lipid, and unsaturated lipid in a sample, will also be presented.

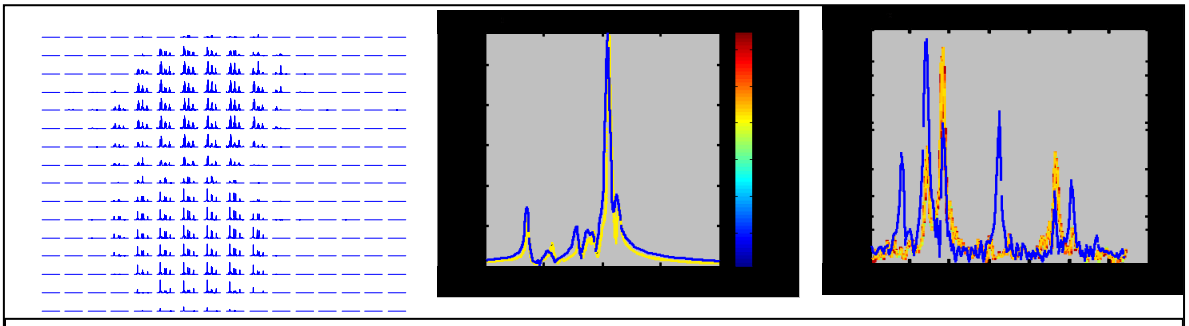

Figure 1: (a) A chemical shift image of cod liver oil (above) and an unsaturated cooking oil (below) using the presented sequence. The CSI spectra show only zero quantum peaks between protons on saturated carbons and their neighbors. This both improves resolution and simplifies the spectrum, making these two unsaturated fats distinguishable. (b) PRESS spectra from the two vials are nearly superimposable, but the edited zero quantum spectra (c) are distinct.

References

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