Estimating Relative Levels of Linolenic Acid with Magnetic Resonance Spectroscopy of Fat Allylic Protons at 3 T

Iain Marchi[1] and Atiyah Yahya[1,2]
1. Department of Oncology, University of Alberta, Edmonton, Alberta, Canada
2. Department of Medical Physics, Cross Cancer Institute, Edmonton, Alberta, Canada

ABSTRACT

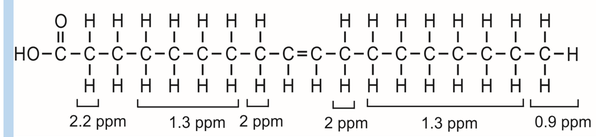
Purpose: To exploit differences in J-coupling evolution of the ≈ 2 ppm fat allylic protons (neighbor the two ends of the double bond chain) to estimate relative linolenic acid content at 3 T. Oleic (mono-unsaturated), linoleic (di-unsaturated) and linolenic acid (tri-unsaturated) are the three primary unsaturated components of edible oils.
Methods: A 3 T Philips MRI scanner was used with a Point RESolved Spectroscopy (PRESS) sequence (first echo time, TE_1, 17 ms) to measure the response of fat allylic protons from oleic, linoleic and linolenic acid. TE values ranged between 40 ms and 300 ms in steps of 10 ms. A TE that resulted in relatively low yield for oleic and linoleic acid but a significantly higher output for linolenic acid was identified. Measurements were obtained with the identified TE and with a TE of 70 ms (resolves allylic resonance from that of the ≈ 2.2 ppm resonance) from oils of varying linolenic acid content (linseed, walnut, canola, soybean and peanut oil).
Results: A TE of 220 ms was found to be effective for identifying the presence of linolenic acid. J-coupling evolution resulted in inverted allylic signal for all three constituents. The allylic resonance areas obtained with a TE of 220 ms normalized to that acquired with a TE of 70 ms were -0.07, -0.22 and -2.8 for oleic, linoleic and linolenic acid, respectively. The higher signal yield for linolenic acid is likely a result of more J-coupling evolution rewinding due to weaker coupling. A correlation was found between linolenic acid contribution to total unsaturation and allylic signal area obtained with a TE of 220 ms normalized to that from a TE of 70 ms ($R^2 = 0.99$).
Conclusion: Allylic fat proton signal obtained with PRESS with a TE of 220 ms can provide an indirect means of estimating relative linolenic levels at 3 T.

INTRODUCTION

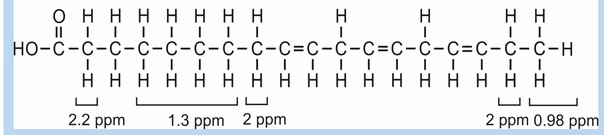
- Magnetic Resonance Spectroscopy (MRS) provides a non-invasive means of assessing fat composition[1].
- Fatty tissue in the body, like edible oils, consist of saturated and unsaturated fatty acids. The latter consists of oleic (mono-unsaturated), linoleic (di-unsaturated) and linolenic (tri-unsaturated) acid.
- In unsaturated fatty acids, there are two allylic proton groups (≈ 2 ppm) that neighbour the two ends of the double bond chain.
- In linolenic acid, the allylic group neighbours the methyl group (unlike in oleic and linoleic acid) resulting in differing J-coupling evolution[2].

Purpose: *To demonstrate that the J-coupling evolution of the allylic protons can be exploited to provide an indirect means of assessing relative linolenic acid content at 3 T..*

Oleic acid



Linolenic acid



METHODS AND MATERIALS

- A 3 T Philips MRI scanner was employed.
- A Point RESolved Spectroscopy (PRESS) sequence (first echo time, TE_1, 17 ms) was used to measure the response of fat allylic protons from oleic, linoleic and linolenic acid. TE values ranged between 40 ms and 300 ms in steps of 10 ms.
- A TE that resulted in relatively low yield for oleic and linoleic acid but a significantly higher output for linolenic acid was identified.
- Measurements were obtained with the identified TE and with a TE of 70 ms (resolves allylic resonance from that of the ≈2.2 ppm resonance) from oils of varying linolenic acid content (linseed, walnut, canola, soybean and peanut oil).

Oil	% saturated	% Oleic	% Linoleic	% Linolenic
Peanut	19.5	60.8	19.7	negligible
Canola	9.2	60.7	20	10.1
Soybean	16.6	21.7	53.4	8.3
Walnut	10.2	20.4	53.2	16.2
Linseed	10.7	24.4	8.3	56.6

RESULTS AND DISCUSSION

- Figure 1 shows the allylic resonance (right of the dashed line) acquired from oleic, linoleic and linolenic acid..
- A PRESS TE of 70 ms resolves the allylic resonance from that of the ≈ 2.2 ppm protons (left of the dashed line).
- A TE of 220 ms yields relatively low allylic signal area for oleic acid (-0.07 times that obtained with a TE of 70 ms) and linoleic acid (-0.22 times that with a TE of 70 ms) but yields significantly higher signal for linolenic acid (-2.8 times that with a TE of 70 ms).
- Figure 2 displays example spectra obtained with a TE of 220 ms from linseed, walnut and peanut oil (linoleic acid contribution to total unsaturation 63.4%, 18% and 0%, respectively).
- The signal yield is lower with decreasing linolenic acid content.
- Normalizing the allylic signal area to that obtained with a TE of 70 ms from each oil yields a linear correlation with linolenic acid content (Figure 3)
- Allylic fat proton signal obtained with PRESS with a TE of 220 ms can provide an indirect means of estimating relative linolenic levels at 3 T.

Figure 1

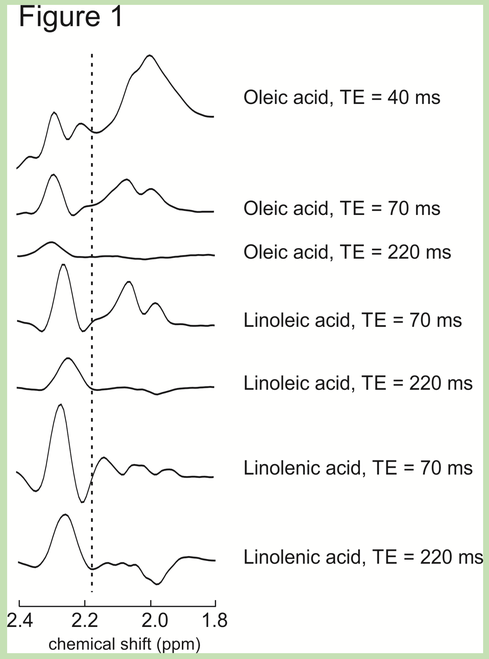


Figure 2

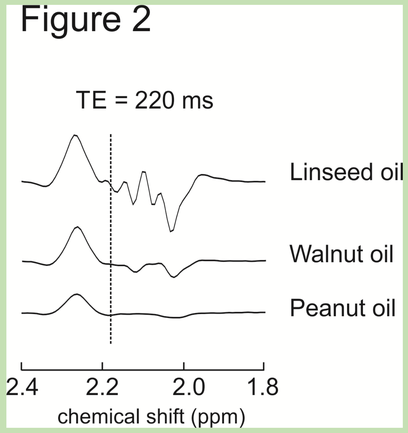
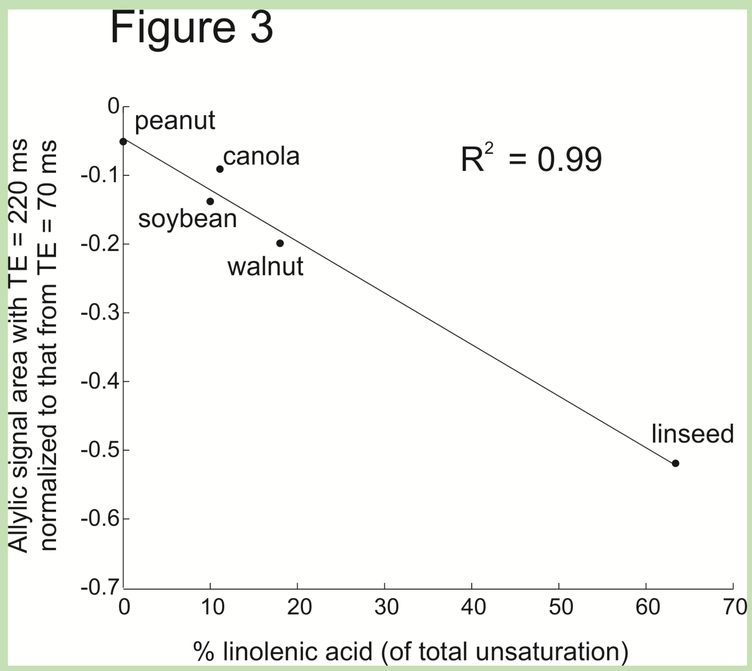


Figure 3



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Contact: Dr. A. Yahya, Medical Physics, Cross Cancer Institute, Edmonton, AB, Canada, ayahya@ualberta.ca