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CONFERENCE PAPER · SEPTEMBER 2015

DOI: 10.13140/RG.2.1.2592.0487

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European Society for Isotope Research – ESIR 2015

Zadar, Croatia

September 20 – 24, 2015

Book of Abstracts

Ruđer Bošković Institute

University of Zadar

ISBN 978-953-7941-08-6

Deuterium and Hydrogen Ratios Determine Proton Spin-Lattice T1-Weighted Magnetic Resonance Images: Clinical Applications in Cancer

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Decreased 1H spectra spin-lattice relaxation-based 3D images of tissue water and fat using whole-body T1-weighted magnetic resonance imaging (MRI) outperform all other radiological diagnostic tools to detect cancer. A relative loss in proton signal can also be seen in egg white when compared to egg yolk using clinically applied axial MRI (Figure 1, 1H detection in water and fat, 1.5 T). We herein report close correlations (R2 = 1; Correlation = -1) between measured deuterium and hydrogen ratios in egg white and yolk (Table 1) via isotope ratio mass spectrometry (2H Content (D; ppm) IRMS) as well as that of MRI Red-Green-Blue (RGB) intensities and luminescence, respectively, using color code analysis by Microsoft Windows Paint HyperText Markup Language (HTML) image analysis (Figure 1; version 6.3, Build 9600).

Table 1. Comparison of measured deuterium and hydrogen ratios in egg white and yolk via isotope ratio mass spectrometry and MRI Red-Green-Blue (RGB) intensities and luminescence via HTML image analysis. Background (1)

	Background (1)	Egg White (2)	Egg Yolk (3)	yolk/white	white/yolk
RGB (MRI)	0	159	201	126.4 %	79.1 %
Luminescence (MRI)	0	152	188	123.7 %	89.9 %
2H content (D; ppm)	0	152	122	80.3 %	124.6 %

Our results demonstrate that MRI is an excellent 2H/1H biomarker imaging tool of compartmentalized tissue water and fat composition. When mitochondria are failing cytoplasmic water and saturated fatty acid pools can potentially decrease MRI proton signals by their increased 2H2O/2H1HO/1H2O ratio resulting in a deuterium enriched lattice. Such lattice yields a relative decrease in 1H-NMR signals and luminescence of primary and metastatic tumor tissues, residing in abdominal and pelvic organs. The brain, on the other hand, is a predilection site for deuterium accumulation due to the blood brain barrier's exclusion of low deuterium-carrying circulating triglycerides as a prelude to myelination and synaptic vesicle turnover. In neurocytes the entire saturated and monounsaturated lipid pool is produced

locally by *de novo* biosynthesis from deuterium rich dietary glucose. Therefore the mechanisms of brain tumors gaining proton signals and luminescence on non-contrast spin-lattice-based fluid-attenuated inversion recovery (FLAIR) images involve the breakdown of the blood brain barrier's fatty acid discriminating function and its resulting effect on gaining access to deuterium depleting fatty acids from circulation. Thus mitochondrial low deuterium fatty oxidation provides the deuterium-depleted signal-yield during water production in brain tumors. Biochemical mechanisms detailed above should help radiologists to metabolically characterize tumors that contrast out by severely altered deuterium depleting mechanisms in comparison with those found in host tissue water and fat pools.

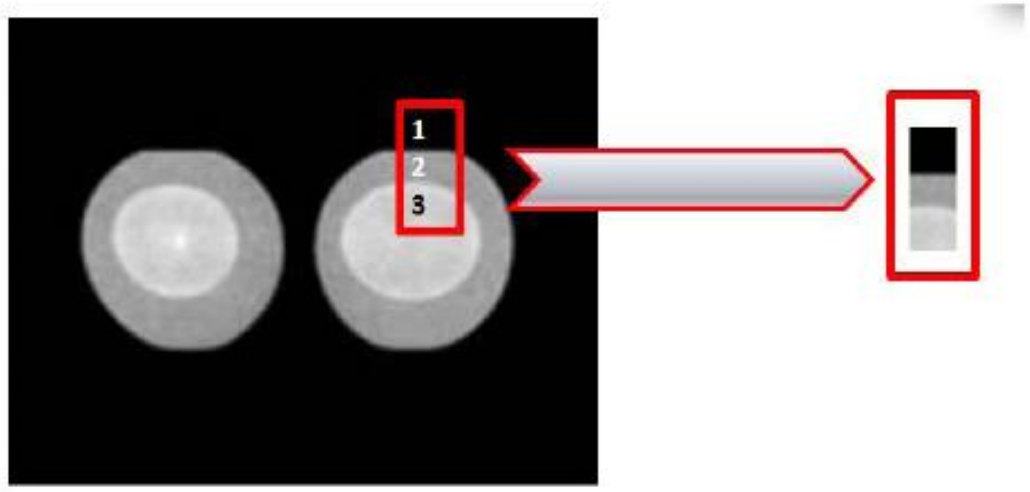

Figure 1. Color code analysis by MS Paint (version 6.3, Build 9600) using sections of MRI images of egg white and yolk for comparison with IRMS deuterium content provided in Table 1. (1: background, 2: egg white, 3: egg yolk)

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Book of Abstracts: ESIR Isotope Workshop XIII
September 20 – 24, 2015 – Zadar, Croatia

ESIR Isotope Workshop XIII
Zadar, Croatia, September 20 – 24, 2015

Editors: Ines Krajcar Bronić, Nada Horvatinčić, Bogomil Obelić

Publisher: Ruđer Bošković Institute, Zagreb, Croatia, 2015

Number of copies: 120

ISBN 978-953-7941-08-6