Comparison of 2- and 3-Point Dixon Muscle Fat Content with Chemical Analysis

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Introduction. Fat quantification based on 2- and 3-point Dixon techniques is a promising measure for clinical trials e.g. in muscular dystrophies, where normal muscle is replaced by fatty and connective tissue [1,2]. Good correspondence of Dixon techniques with single-voxel proton MR spectroscopy and histology has been reported [3,4]. However, it is unclear which chemical components are exactly accounted for by MT-determined fat fractions. In this work, fat content in several meat samples is determined by an extended 2-point Dixon (2PD) [5,6] and a 3-point Dixon (3PD) [7] technique and compared to a chemical analysis (CA) of triglyceride and fatty acid content of the samples. The results are of interest for the interpretation of previous and future quantitative MR measurements of muscle fat content.

Methods. *MRI:* All experiments were performed on a clinical 3T scanner using a wrist coil, with 1mm in plane resolution with 3mm slice thickness. For 2PD imaging, a gradient echo sequence with two different echo times for in-phase and opposed-phase imaging was acquired (3D, TR = 20ms, TE_1 = 2.45ms, TE_2 = 3.68ms, flip angle = 15°). 3PD imaging was based on a turbo spin-echo sequence (2D, TR = 5s, TE = 15ms). Regions of interest (ROI) were drawn 1cm from the border across 10 slices. Water (w) and fat (f) images and the relative fat fraction f / (f + w) were calculated based on the in-phase and opposed-phase images. *Chemical analysis (CA):* The sample was hydrolyzed with hydrochloric acid to break the tissue down to its components and release the fat. After filtration, the filter residue including the fat was washed, dried and extracted with petroleum ether. The solvent was evaporated, and the fat content was determined by weighing. This method measures triglycerides and free fatty acids, while phosphatides are cleaved by the hydrochloric acid. *Evaluation:* Linear regression was performed using a least squares approach, and Pearson's correlation coefficient (R^2) was calculated between 2PD and 3PD fat content and CA.

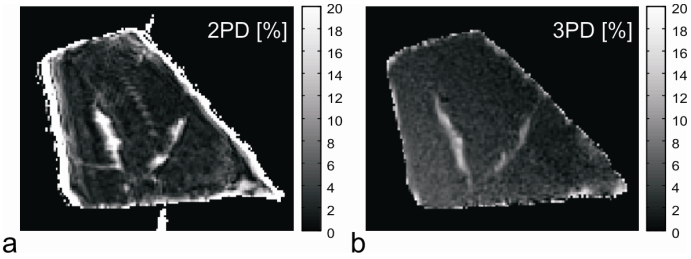

Fig. 1: Exemplary 2PD and 3PD fat content maps of a meat sample.

Sample No.	2PD [%]		3PD [%]		CA [%]
	Mean	SD	Mean	SD	Mean
1	3.6	3.0	3.3	1.6	0.5
2	16.6	20.9	12.9	12.5	15.6
3	7.7	9.6	5.9	5.4	6.5
4	19.8	23.9	22.3	25.6	25.1
5	19.1	25.0	12.5	14.0	22.6

Tab. 1: 2-point Dixon (2PD) and 3-point Dixon (3PD) fat content of five meat samples measured at 3T compared with chemical determination (CA) of triglyceride and fatty acid content of the same samples.

Results & Discussion. Exemplary 2PD and 3PD fat content maps of a meat sample are shown in Fig. 1. The mean fat content from Dixon imaging in the ROIs and the triglyceride and free fatty acid content from chemical analysis are given in Tab. 1. The high standard deviations in 2PD and 3PD originate from sample inhomogeneity across the ROI. Linear regression and correlation between 2PD, 3PD and CA is shown in Fig. 2. Strong correlations are observed for both MR methods: R^2 = 0.97 for 2PD and R^2 = 0.84 (R^2 = 0.98 without sample 5) for 3PD. Dixon methods do not reach fat contents below 3% due to remaining relaxation between echoes. Apart from this effect, 2PD seems to underestimate the chemically determined fat content by about 5%, while 3PD shows very good correspondence except for sample 5.

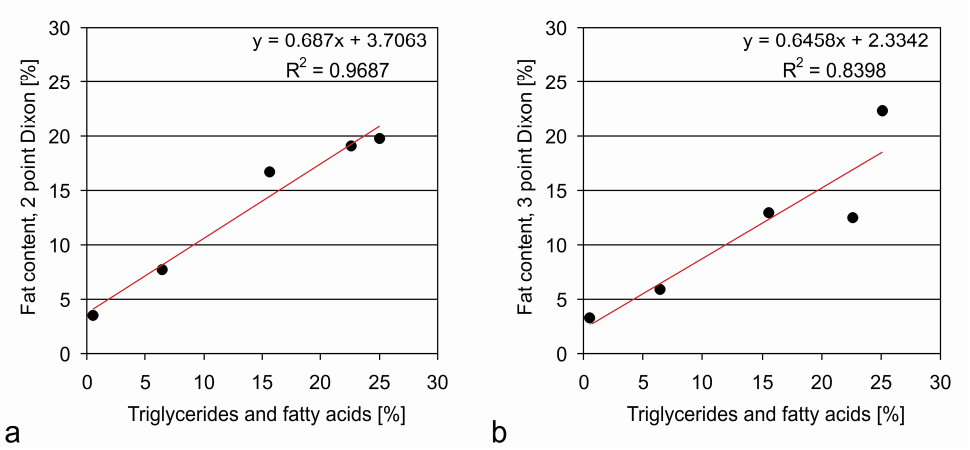

Fig. 2: Measured data points and linear regression (red line) of (a) 2-point Dixon (2PD) and (b) 3-point Dixon (3PD) fat content of five meat samples as a function of chemically determined triglyceride and fatty acid content of the same samples.

Conclusion. The comparison of 2PD and 3PD MR imaging with chemical analysis suggests that these techniques are able to quantify triglycerides and fatty acids. This finding may help to interpret the outcome of future quantitative MR studies in the field of neuromuscular diseases.

References. [1] Gloor et al., JMRI 2011; 33:203-210; [2] Wren et al., AJR 2008; 190:W8-W12; [3] Hussain et al., Radiology 2005; 237:1048-1055; [4] Kim et al., MRM 2008; 59:521–527. [5] Dixon Radiology 1984;153:189-194; [6] Skinner et al. MRM 1997; 37: 628-630; [7] Glover et al. MRM 1991; 18:371-383.