

MRI Fat Quantification Phantom

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Abstract

An MRI phantom is needed for calibration of the client's MRI-based fat quantification technique. Physiological fat concentrations were simulated by various oil/water emulsions (3%, 4%, 7%, and 15% oil). Standardized steps for emulsion creation were documented, and a structure was built to house emulsions. Preliminary testing suggests the current emulsion design will be an accurate platform for fat concentration simulation. Future testing will investigate and quantify signal properties; additional emulsion concentrations will be developed.

Introduction

Fatty Liver Disease

- Fat accumulation causes progressive liver disease

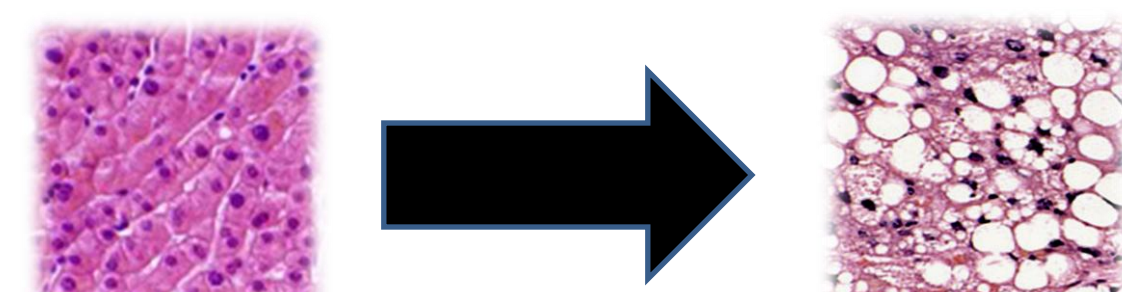


Figure 1: Normal hepatocytes (left)¹ can accumulate fat vesicles through steatosis (right)².

Detection can help prevent disease progression

- IDEAL allows fat deposit quantification through MRI
- Technique developed by Dr. Scott Reeder

Need calibration phantom for IDEAL

- Intended to calibrate IDEAL on various scanners
- Multiple readings must be consistent

Acknowledgements:

The authors would like to thank Catherine Hines for her generous support of time and lab resources during the emulsion making process as well as MRI testing. The authors would also like to thank Gary Frank for his expert advice regarding the creation of MRI phantoms.

References:

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- Wikimedia: Human Liver. June 2, 2006. http://upload.wikimedia.org/wikipedia/commons/f/fc/Human_liver.jpg (accessed October 30, 2009).
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Final Prototype Design

- Design consists of two distinct features:
 - Emulsions: Simulating fatty tissue in the liver
 - Mechanical: provides structure, spatial consistency and compartmentalizes emulsions

Emulsions



Mechanical Structure

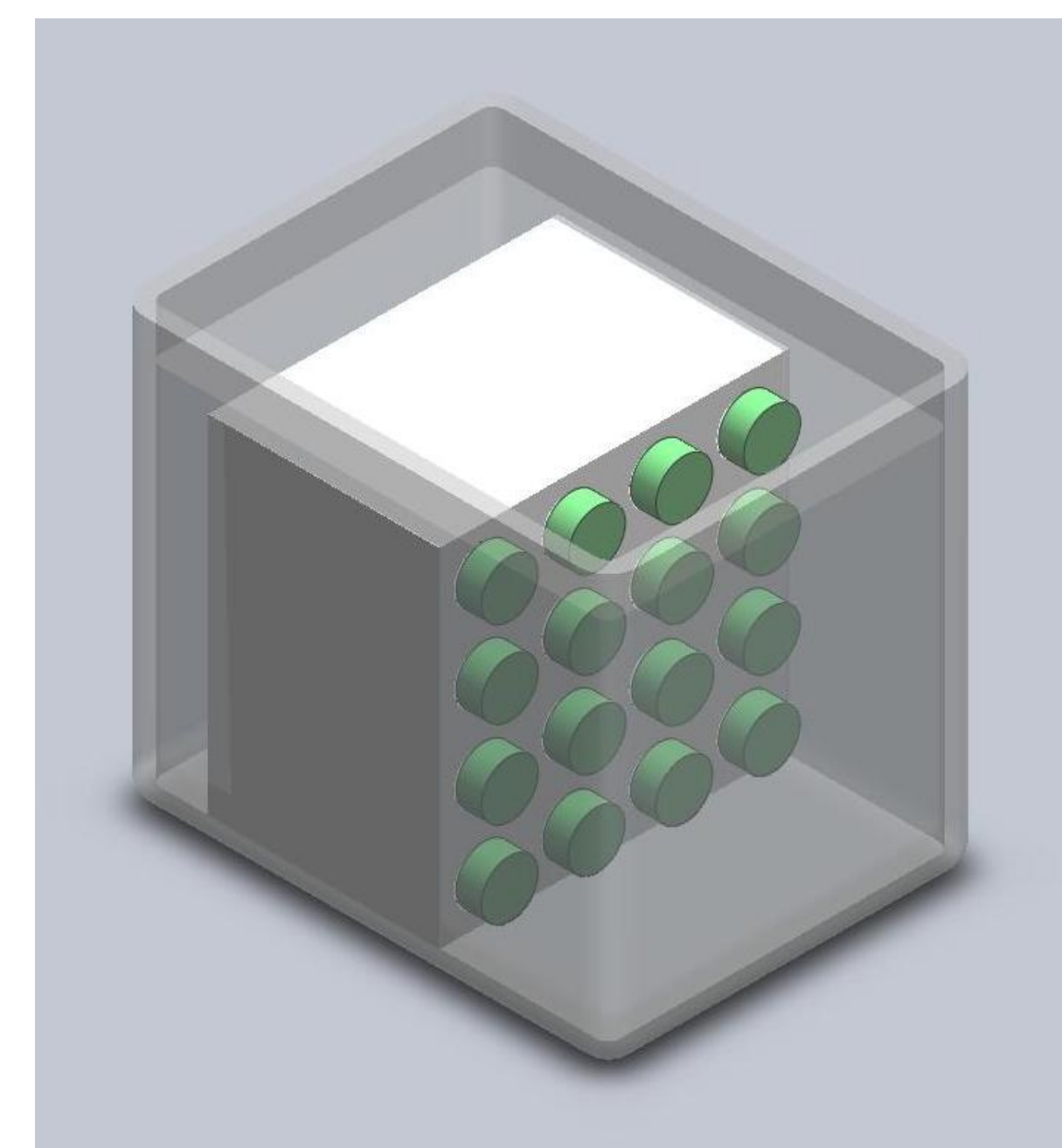


Figure 2: Picture of vial holder with six vials.

- Outer Case
 - Polypropylene box filled with water
- Vial Holder
 - Ultra high molecular weight polyethylene holds vials under water parallel to the main magnetic field
- Vials
 - High quality glass contains oil/water emulsions

Testing Procedure

- MRI Scanning (1.5 T Research Scanner)
 - Emulsions scanned and processed with IDEAL
 - Figure 3, 4 and 5
 - Outer 2 pixels discarded to avoid noise
- Density Testing
 - Emulsions sliced into small disks
 - Densities assessed between and within each disk
 - Figures 6 and 7

Measured	Expected	Measured	Expected
0.40	15	5.00	7.56
105.2	100	3.10	3.76
104.2	100	2.60	4.82
10.20	18.56	1.04	0.00

Figure 3: IDEAL image of emulsions and controls. Actual and expected values fat concentrations.

Results

- Built vial holder
- Created 4 emulsions
- Quantified emulsions with IDEAL
 - Soap and formalin have negligible effects on signal (Figure 4)
 - Pure water was measured as 1.4% fat concentration (Figure 4)
 - Pure oil was measured as 104.5 % fat concentration (Figure 4)
 - Gelatin concentration affects readings non-linearly (Figure 5)
- Densities of emulsions were measured
 - Deviation of density was greatest at the top of the vial (Figure 6)
 - Density decreases with height (Figure 6)
 - Density changes across horizontal planes were insignificant (Figure 7)

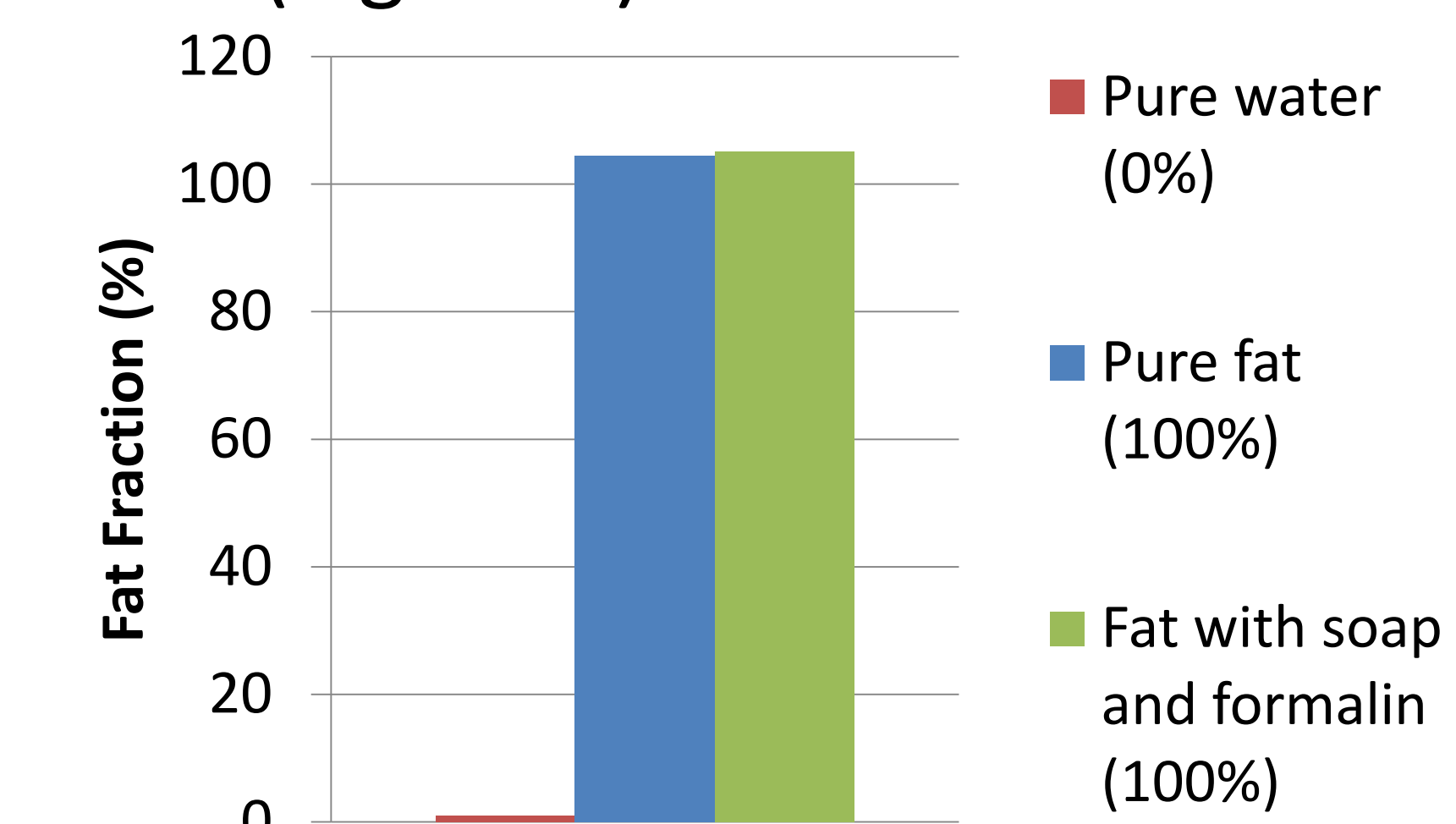


Figure 4: Measured fat fractions of pure water, pure safflower oil, and oil with soap and formalin

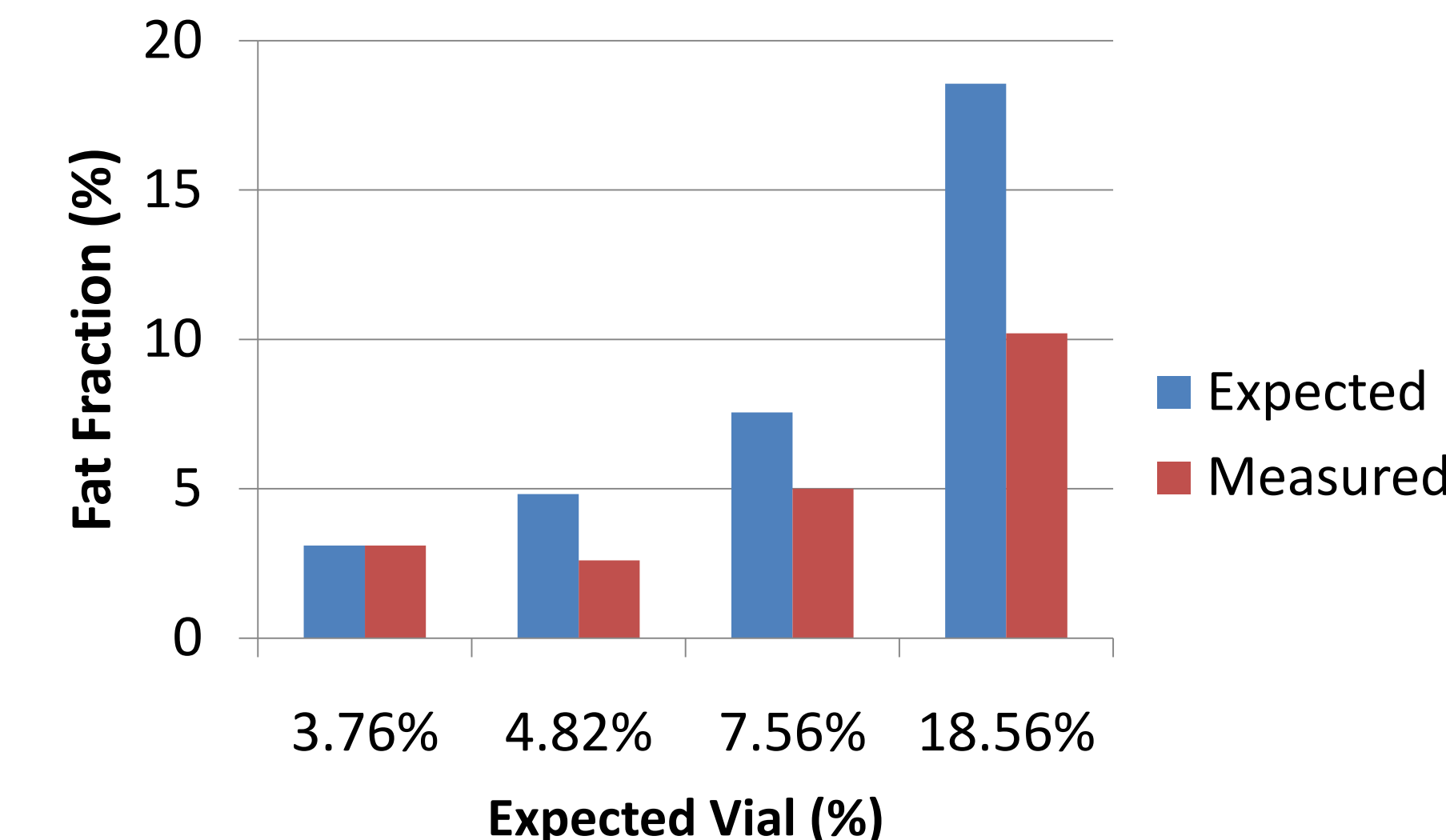


Figure 5: Expected versus measured emulsion fat fractions. Each emulsion contains different amounts of gelatin.

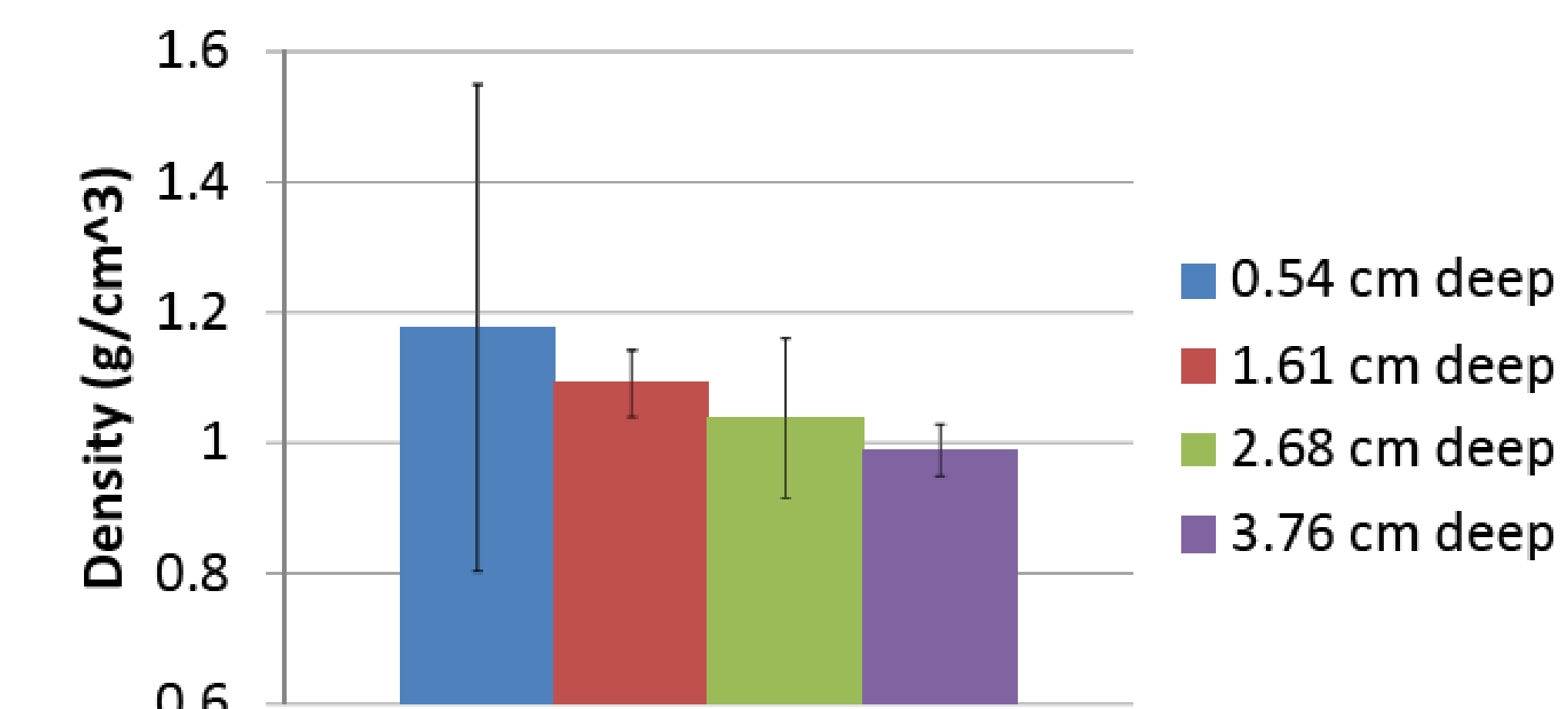


Figure 6: Density of an emulsion throughout its bulk at varying depths; Error given in \pm standard deviation.

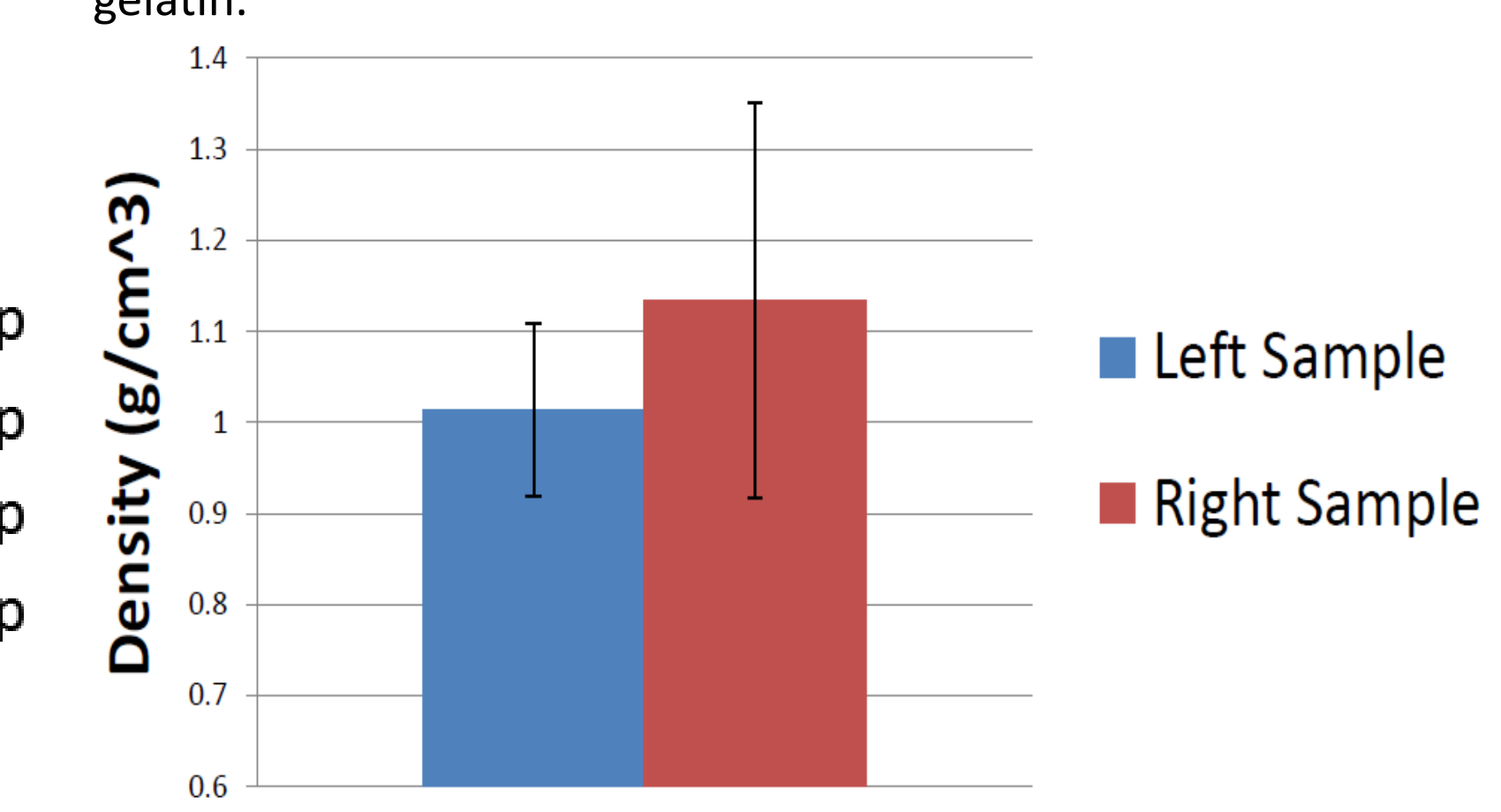


Figure 7: Density of an emulsion throughout its bulk across its width; Error given in \pm standard deviation.

Future Work

- Vial Completion
 - Make remaining emulsions
 - Ensure emulsion homogeneity
- Further Testing
 - Submerge in doped water
 - Ensure repeatability between scans