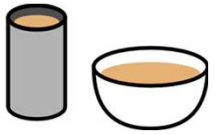

# Oatmeal Texture from Recipe Ratio

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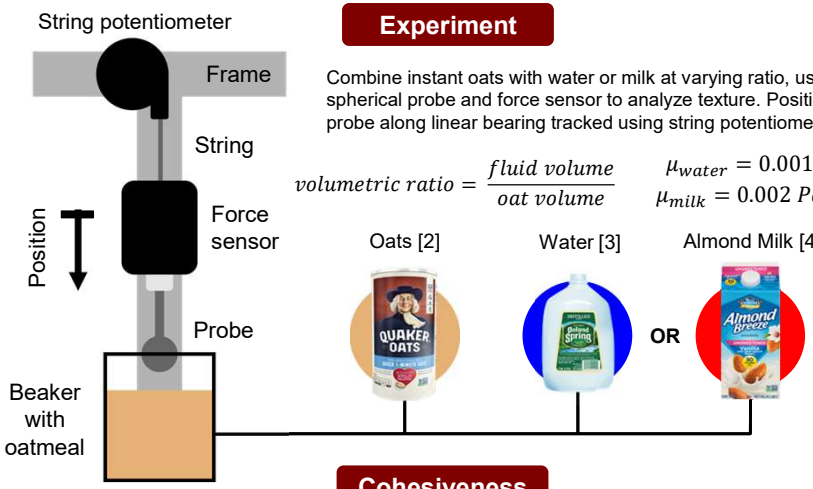
## Abstract

The amount of water or milk relative to oats used to cook oatmeal greatly affects its texture. Knowing the texture that results from a given recipe can be used to inform cooking. To analyze the relationship between recipe and texture, the **viscosity** and **cohesiveness** of oatmeal samples at varying volumetric ratios were measured. Volumetric ratio is defined as the ratio of liquid volume to oat volume. It was found that viscosity decays exponentially with greater fluid volume, asymptotically approaching the viscosity of the fluids used. At any ratio, samples cooked with almond milk were found to be less viscous than those cooked with water on average, 73.1 ± 48 % less at a box-recommended ratio. Furthermore, viscosity decayed faster in almond milk samples with a 6.47 ± 1.9 % smaller exponential constant. Water samples were 28.7 ± 6.4 % more cohesive and did not significantly depend on volumetric ratio.

## Experiment




Combine instant oats with water or milk at varying ratio, using a spherical probe and force sensor to analyze texture. Position of probe along linear bearing tracked using string potentiometer.

$$volumetric\ ratio = \frac{fluid\ volume}{oat\ volume}$$

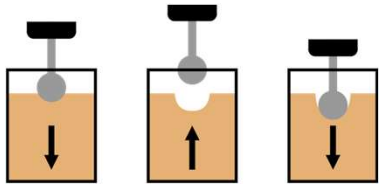
$\mu_{water} = 0.001\ Pa\ s$

$\mu_{milk} = 0.002\ Pa\ s$ [1]

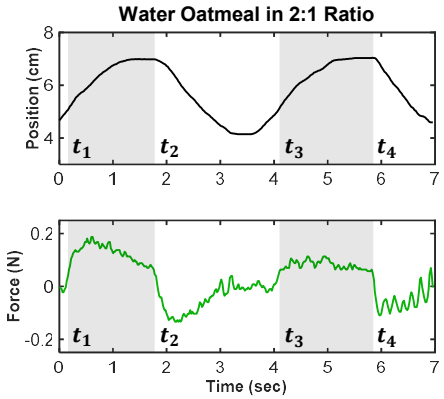
## Cohesiveness

**Cohesiveness (C):** The relative average work between two compressions.

$$C = \frac{\frac{1}{x(t_2) - x(t_1)} \int_{t_1}^{t_2} F\,x(t)\,dt}{\frac{1}{x(t_4) - x(t_3)} \int_{t_3}^{t_4} F\,x(t)\,dt}$$



Compress twice at near constant velocity and peak displacement to evaluate resilience of substance structure.



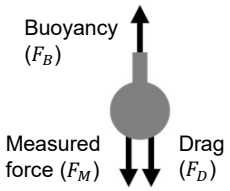

First compression: $t_1 \rightarrow t_2$

Second compression: $t_3 \rightarrow t_4$

## Viscosity

**Viscosity ($\mu$):** Measure of internal friction, higher for thicker fluids.

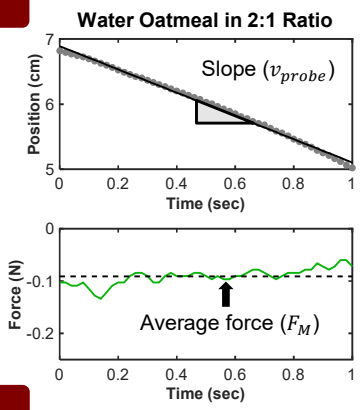
Probe dragged upwards through oatmeal.



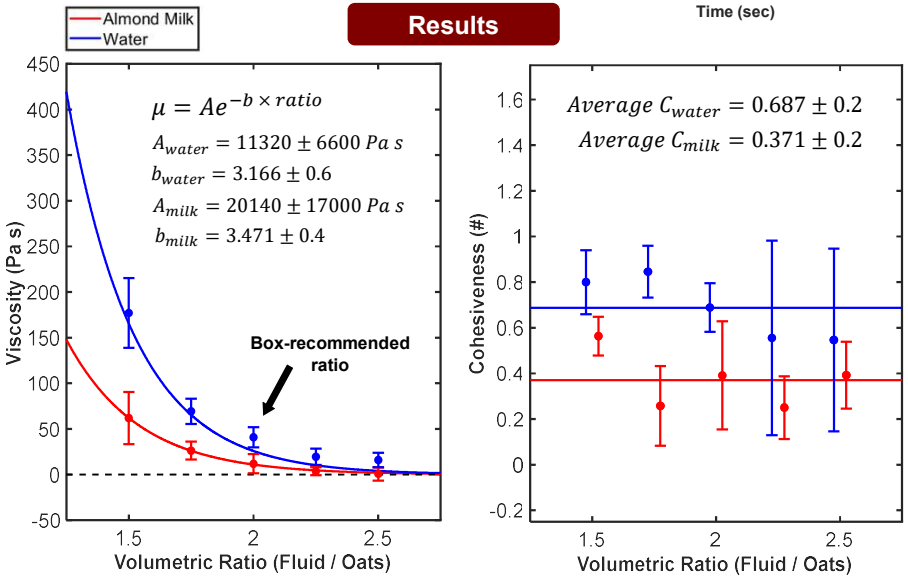

$$F_D = F_B - F_M$$

| | |
|---|---|
| $v_{probe}$ | Probe velocity |
| $R_{probe}$ | Probe radius |
| $\rho_{probe}$ | Probe density |
| $\rho_{oatmeal}$ | Oatmeal density |

$$\mu = \frac{\frac{4}{3}\pi R_{probe}^3 (\rho_{oatmeal} - \rho_{probe}) g - F_M}{6\pi v_{probe} R_{probe}}$$




## Results




ANOVA and t-tests ran on cohesiveness found no significant difference between datapoints at experimented ratios. Water dataset failed the ANOVA test for $\alpha = 0.05$. T-tests between ratios on milk cohesive data showed no significance difference either.

## Conclusions

- Need less milk than water to achieve the same viscosity for a given oat volume
- At box-recommended ratio, using almond milk leads to 73.1 ± 48 % less viscous oatmeal than water
- Viscosity of oatmeal asymptotically approaches that of the fluid its cooked with as ratio increases
- Viscosity decays faster in almond milk samples, with 6.62 ± 1.8 % smaller exponential constant
- Cohesiveness does not significantly depend on volumetric ratio. Samples made with water are on average 28.7 ± 6.4 % more cohesive than those made with almond milk across all tested ratios

## Acknowledgements

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## References

[1] "Food Products - Viscosities." Engineering Toolbox, 2012, https://www.engineeringtoolbox.com/absolute-viscosity-foods-d_1827.html.
[2] "Quick 1-Minute Oats," *Quakeroats.com*. [Online]. Available: https://www.quakeroats.com/products/hot-cereals/quick-oats. [Accessed: 01-Dec-2021].
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