

Lab 6: Milkshakes

Lab sections on Tuesday Oct 23 – Friday Oct 26

You graduate from SPU-27 and to your excitement land a job at a dairy company. Your first assignment is to create a non-melt, low-fat milkshake that is to be sold in grocery stores all over New England. Milkshakes are normally made with ice cream and milk (see the recipe on the next page), but since you need to be able to transport the milkshakes to grocery stores and then store them there at 4°C, you need to come up with a recipe that tastes and feels like a milkshake, but contains no ice cream since it would melt. You thus set out to design a milkshake that has the same consistency as a regular milkshake - there are a lot of factors that contribute to consistency, but one of the main ones is viscosity, which we will focus on here. Since you are practically an expert on thickeners from having taken SPU-27, you decide to put your knowledge to use when designing your recipe.

Equation of the week:

$$\eta = E \times \tau$$

	Description	Units
η	Viscosity	Pa·sec
E	Elastic modulus	Pa
τ	Time constant	sec

Part Ia: Viscosity of regular milkshake

In order to fulfill your assignment and design a non-melt, low-fat milkshake, you first need to determine the viscosity of a regular milkshake so you know what viscosity you are hoping to attain. You thus set out to make a milkshake using the dairy company's tried and true old recipe (below), and you measure the viscosity using a standard test of dropping a ball through the solution and measuring how fast it falls.

Materials:

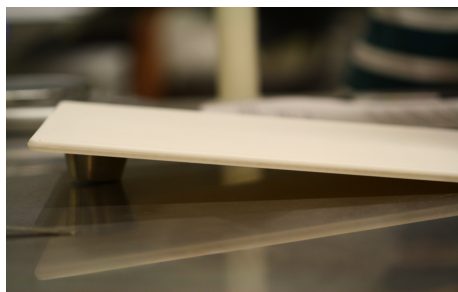
- 2 plastic beakers
- 1 immersion blender
- 1 funnel
- 1 graduated cylinder
- 1 large cutting board
- 1 metal cup
- metal balls
- magnet to fish out balls
- stopwatch/smartphone
- ¼ measuring tsp
- 3 straws
- 3 plastic cups
- 1 large bowl (for ice bath)
- ice

Ingredients (regular milkshake):

- 200 g ice cream
- 100g milk
- flavoring of your choice

Procedure:*For the regular milkshake:*

1. Make a "regular milkshake" according to the recipe above. Use a plastic beaker and the immersion blender to blend the milk and ice cream thoroughly, but not so long that the ice cream melts.
2. Place a metal cup under one side of the cutting board so you create a slanted surface (see picture). This will ensure that you can see the metal ball as it falls through the solution.



3. Pour the milkshake through a funnel into a graduated cylinder. You may have to gently beat the funnel against the rim of the cylinder several times, or use a spoon, to help the solution pass through.
4. Place the graduated cylinder on the slanted cutting board.
5. Choose a metal ball of a size you find appropriate, i.e. whose drop-time is neither

too fast nor too slow.

6. Drop the metal ball from the surface of the milkshake and measure the time it takes for it to reach the bottom. Do this twice, and record your observations on the worksheet.
7. Fish out the metal balls using the magnet before pouring the milkshake into the compost bin.
8. The time it takes for the ball to drop is a measurement of the milkshake's viscosity. The average of the drop-times you measured here will be your benchmark for what you are trying to achieve in designing your non-melt milkshake below.
9. (Optional) Repeat step 1, add your favorite flavoring, and enjoy!

Part Ib: Design a non-melt, low-fat milkshake

In Part Ia, you measured the viscosity of a regular milkshake. You will now create a non-melt, low-fat milkshake using only low-fat milk and xanthan gum. You will then measure the viscosity at different xanthan gum concentrations, and try to emulate the viscosity of the regular milkshake.

- Ingredients (non-melt, low-fat milkshake):
- 300g low-fat milk
- ? g Xanthan gum
- flavoring of your choice

Procedure:*For the non-melt milkshake*

1. Using the immersion blender and a plastic beaker, mix a milkshake with 300 g low-fat milk, xanthan gum, and a flavoring of your choice according to the recipe above. Start using a small amount of xanthan gum – approximately $\frac{1}{4}$ tsp.
2. Measure the viscosity using the same method as above. Record your measurements on the worksheet.
3. Fish out the metal balls using the magnet and pour the solution back into the plastic beaker.
4. Gradually add more xanthan gum in increments of $\frac{1}{4}$ tsp.
5. Repeat steps 2-4 until the viscosity starts to look similar to the viscosity in Part I.
6. Record this value on the worksheet, and plot drop-time as a function of xanthan gum concentration on the provided chart.

Lab 6: Worksheet

Name: _____

TF: _____

Part Ia: Viscosity of regular milk shake

1. Record the drop-times for the regular milkshake here.

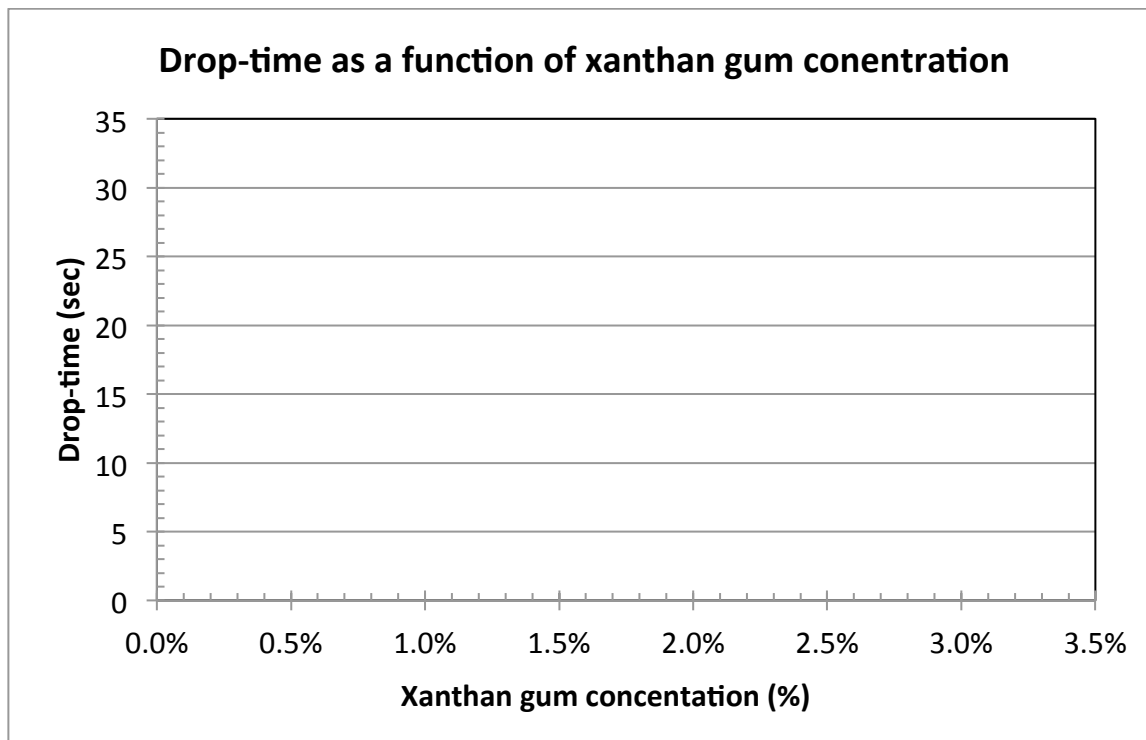
	time ₁ (sec)	time ₂ (sec)	time _{avg} (sec)
100 g milk			

Part Ib: Design a non-melt, low-fat ice cream

2. Record your drop-times for the non-melt, low-fat milkshake here.

Xanthan gum (tsp)	Xanthan gum (g)	Xanthan gum (%)	time ₁ (sec)	time ₂ (sec)	time _{avg} (sec)
$\frac{3}{4}$ tsp					
1 tsp					
1 $\frac{1}{4}$ tsp					
1 $\frac{1}{2}$ tsp					
1 $\frac{3}{4}$ tsp					

3. Plot drop-time as a function of xanthan gum concentration on the chart below.



4. At what xanthan gum concentration do the viscosities of the regular and non-melt milkshakes match? Give your answer in % xanthan gum, and mark this point with a star on the plot above.

5. You now have a first "draft" of a non-melt, low-fat milkshake. Most likely, it still requires some work before it is as delicious as you would like. What are some things you could change to make it more similar to a regular milkshake in taste and mouthfeel? (This would be an example of a great final project!)