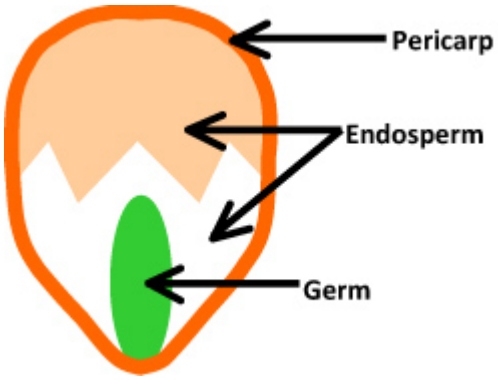
Lab #23: Analyzing the “Pop” in Popcorn

Background Information:

In this experiment, you will use the ideal gas law, (PV = nRT) to determine the pressure inside the kernel when it pops.

Corn is a common foodstuff, native to the Americas, which appears in many forms: corn on the cob, corn off the cob, creamed corn, and popcorn. This variety is known as **sweet corn**. It’s almost as American as apple pie.If you’re barbequing with friends and family in the summer, chances are it’s on the menu. Or maybe you’re celebrating Thanksgiving with a plump turkey and all the fixings – mashed potatoes, dressing, cranberries, and a nice big serving bowl filled with sweet corn. When most people think of corn, it’s sweet corn that comes to mind. But the fact is, of the 97.2 million acres of corn planted in the United States last year, sweet corn made up less than 1 percent of the total crop.



The rest was **field corn**. When driving through rural Minnesota, Wiconsin or any other Corn Belt state, it’s usually field corn you see out your window. Although field corn kernels start out soft like sweet corn, it’s not harvested until the kernels are dry. Field corn is used to feed livestock, make the renewable fuel ethanol and thousands of other bio-based products like carpet, make-up or aspirin.There is also field corn that is fed to livestock and colored corn that is hung on our doors in autumn. Each variety of corn contains a different amount of water, sugars and starches. Sweet corn is harvested when the kernels are soft and sweet, making it ideal for eating. If you grab an ear of field corn and try to take a bite, you’ll probably break your teeth. It’s hard and dry (and only tastes good to cows, chickens, pigs, turkeys and some wild animals). U.S. corn farmers harvested 10.8 billion bushels of field corn last year. In contrast, 158.7 million bushels of sweet corn was harvested throughout the entire United States. While sweet corn satisfies our taste buds, field corn improves our lives in many other ways. One bushel of field corn weighs 56 pounds, and if it isn’t used directly for livestock feed, it is likely to be exported or made into ethanol that is used to fuel some cars. Each bushel produces 2.8 gallons of ethanol, 18 pounds of dried distillers grains (a high protein livestock feed), 14 pounds of corn gluten pellets, 1.8 pounds of corn oil and 17 pounds of carbon dioxide (used in dry ice, the beverage industry, water treatment facilities and other applications

Popcorn is a favorite snack. Popping popcorn involves heating the corn until the vapor pressure of water inside the kernel is great enough to cause it to burst, turning the kernel inside out and releasing the trapped water vapor. Cooking oil surrounds and softens the kernel shell and provides a medium through which heat can be transferred from the glass flask to the popcorn. When a popcorn kernel is heated, the trapped water in the endosperm turns into steam, building up pressure inside the pericarp. This pressurized, super-heated steam transforms the soft starch in the endosperm into a gelatinous material. Popcorn pericarp is much stronger than that of all other corn kernels and is able to retain this pressurized steam up to 9.2 atm (135 psi).

Above that pressure, the pericarp ruptures, releasing the steam and gelatinous starch that solidifies upon cooling. The resulting popped kernel is 40 to 50 times its original size.

People often wonder what is the ideal percentage of water in popcorn kernels for best popping. Popcorn is harvested in the fall when the kernels' moisture content is between 16 and 20%. The kernels are then stored in bins where they are dried by forced air until reaching an optimum moisture level of 14%. If the moisture content drops below that value, the size of the popped kernels is smaller and the number of kernels that pop decreases.

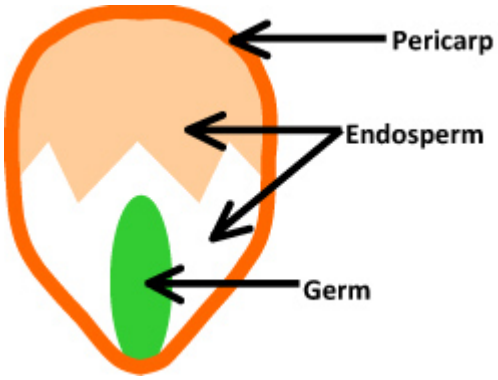


Figure 1 Corn kernel.

Purpose:

- Determine the percent of water in popcorn.
- Determine the moles of water in popcorn.
- Use the ideal gas law to determine the pressure inside the kernel when it pops

Safety:

1. Wear protective goggles throughout the laboratory.
2. Do not eat the popcorn popped in lab. It may be contaminated with chemicals from other laboratory investigations.
3. Thoroughly wash your hands before leaving the laboratory.

Procedure:

Find the mass of popcorn

1. Calculate the mass of 16 popcorn kernels. **Record**

Find the volume of popcorn

1. Using the water displacement method, find the volume of the 16 kernels using the 25-mL graduated cylinder. **Record**
2. Use paper towels to dry the kernels before proceeding.

Find the mass of water in popcorn

1. Record the atmospheric pressure of the day.
2. Add one pipette of cooking oil and the 16 kernels of popcorn to a clean, dry 125-mL Erlenmeyer flask.
3. Determine the mass of the flask, oil and un-popped popcorn.
4. Cover the flask with wire mesh. You want to prevent popcorn from flying out of the flask while allowing heat to escape.
5. Place beaker on hot plate.

6. Remove from heat when all of the kernels have popped. **Do not burn the popcorn!! If you do, you will have to start over.**
7. If there is water vapor on the inside of the flask, dry it.
8. Let the flask cool completely. Then, carefully remove the flask. Remove the wire mesh.
9. Determine the mass of the flask, oil and popped popcorn.
10. Throw popped popcorn in a trashcan. Wash Erlenmeyer flask in soapy water, rinse, and dry.
11. Wash your hands thoroughly.

Safety Precautions

• Hot olive oil can cause serious burns (we're using olive oil because the smell of hot vegetable oil is unpleasant to Mr. Mott). Hand it with care.
• Do NOT eat the popcorn from the flask. You would be consuming chemicals that have been placed in the flask during other experiments!!

Data: Place the following information in the right hand column of your procedure section:

Include appropriate labels.

Mass of weighing cup - _____
Mass of popcorn and weighing cup - _____
Mass of popcorn - _____

Volume of popcorn - _____
Volume of popcorn in L (dm^3) - _____

Atmospheric Pressure of Classroom: _____

Mass of flask, oil, and un-popped popcorn - _____
Mass of flask, oil and popped popcorn - _____
Mass of water in the popcorn - _____
Molecular mass of water _____

Percent Water in kernel of popcorn: _____

Moles of Water in kernel of popcorn: _____

Pressure required to pop kernel of popcorn: _____

The following statements should be written in your journal

Lab Title:

Date:

Purpose: What is the purpose of this lab?

Pre-Lab Questions:

1. How is popcorn different from sweet corn?
2. How does popcorn 'pop'?
3. What is the purpose of the cooking oil in this lab?

Hypothesis:
Will the pressure inside the kernel be greater than or less than the atmospheric pressure in the classroom? Explain your prediction.

Data:
Write your data (WITH UNITS) in your journal

Post-Lab Questions:

Answer the following in your lab notebook. **REWRITE THE QUESTIONS AND SHOW ALL WORK AND UNITS**

1. What is the percent of water in the popcorn?

2. How many moles of water were in the popcorn?

3. Using the ideal gas law, determine the pressure of steam (water vapor) inside the kernel at the time of 'pop'. Assume that the popcorn pops at the boiling point of the cooking oil (225^{o}C).

4. We made two assumptions that might cause errors in our calculations of the popcorn pressure. Examine the numbers you used to calculate the pressure in question #3. List two measurements that you did not measure directly, but instead either measured indirectly or assumed. Which one do you think contributed to error most? Why?

5. Compare the pressure required to "pop" corn with atmospheric pressure. Explain how this difference allows popcorn to pop.

6. Explain, in detail (at least one paragraph) how this lab relates to our study of States of Matter. Consider the list of topics in the Powerpoint for the Independent Research paper.