**Additional Lesson as Time Permits**

**Key Question of the Day**: What other baked goods are made from fermented sourdough?

Bell-Work (Each day the Bell-Work question should be prominently displayed and used to open the lesson)

* Provide students with the weekly Bell-Work sheet (Appendix 1)
* “What other baked goods, aside from bread, are fermented?”

**Learning Objectives**

As a result of this lesson, students will be able to**:**

* Identify other baked products that are fermented.
* Follow a procedure to bake pretzels.
* Use a microscope to observe yeast fermentation of sugar.

**Required Materials for Daily Lesson**

* Lab Data Sheets – Appendix 12 - Lab adapted from *Gourmet Lab: The Scientific Principles Behind your Favorite Foods* by Sarah Reeves Young pg.175-196 - One for each student
* Lab materials per team:
	+ For use prior to fermentation of sugar:
		- ½ package of active dry baking yeast
		- 30 mL of warm water
		- 120 mL of warm water
		- 2.5 mL of sugar
		- 5 mL of table salt
		- 475-550 mL of all purpose flour
		- 2 pieces of filter paper
		- One sheet of aluminum foil
		- Shortening (as needed)
		- Graduated cylinder
		- Balance
		- 100 mL beaker
		- 200 mL beaker
		- Glass stir rod
		- Antibacterial wipes
	+ For use after the fermentation of sugar:
		- Large beaker (over 400 mL)
		- 400 mL of water for boiling
		- Bunsen burner
		- Ring stand
		- Tongs
		- Goggles
		- 10 mL of baking soda
		- 2 pieces of filter paper
	+ For use during microscope analysis
		- Active yeast solution with eyedropper
		- Microscope slide
		- Microscope cover slip
		- Microscope
		- Bottle of 5% sucrose solution, 15% sucrose solution, and 30% sucrose solution
		- Timer or clock
	+ Oven or toaster

**Estimated Instructional Time:** One, 50-minute class period

**Opening –** 5 minutes

* Read the Bell-Work question and solicit responses from the students.
* Possible responses may include:
* Cookies
* Pretzels
* Bagels
* Explain that, “We’ve learned a lot about baking sourdough bread so that we can help the bakery owners find a new bread with a better recipe to use in their bakery. But as bakers, it’s important for us to have knowledge of other products that can be made by following a similar process. There are a number of baked goods that can be made from sourdough starter. They include cakes, biscuits, waffles, or pancakes. Those of you who mentioned pretzels were also right on, and that’s what we’re going to learn about today.”

**Middle –** 40 minutes

* Students will work in their project teams for this lab.
* Teams should develop a hypothesis for the experiment.
	+ Share the following with the class:
		- “We will be using yeast and sugar when making pretzels for this experiment. Yeast is used in pretzels to create air bubbles of carbon dioxide in the dough. The air bubbles allow the dough to double in size and become softer and lighter when baked. Kneading is a process that allows the dough to be pushed, pulled, and pounded to cause the gluten chains to line up and form new chains that are linear as opposed to globular. Boiling the pretzel in baking soda water causes the surface starch to gelatinize into a thin, slimy coating that produces a glossy brown crust when baked. We are trying to determine if the amount of sugar impact the yeast’s speed of fermentation, or, is there a constant rate at which the yeast is able to synthesize sugar? We will be using a microscope to measure this process by counting the number of gas bubbles yeast makes when exposed to different levels of sugar. Make a prediction – how will the rate change or stay the same as we increase the amount of sugar? Use an “If, then, because” statement and explain your answer using what you know about the fermentation process.”
* Once teams have a hypothesis, they may begin the lab.
* **Teacher TIP!** This lab may take longer than one class period depending on the size of the class and how quickly students work. You can make adjustments based on your schedule. If you have more than one Food Science class, one period can start the lab and the other can finish it, or another option is to finish the baking and share the finished product with the students the next day. Also, if students will eat the final product as part of a sensory evaluation, consider using either new and sterilized lab equipment listed above, or modify by using cooking supplies (measuring cups/spoons, pots, stove, etc.). Also, if doing this lab in a kitchen or using cooking supplies, have students convert the measurements of the dry ingredients from metric measurements to cooking measurements (cups, teaspoons, etc.).
* Pre-lab prep:
	+ Make an active yeast solution for the students to use in the microscope observation period. Take half a package of the dry yeast and mix it with 30 mL of warm water. Add the label “Caution: Active Organism Environment” and include a small plastic eyedropper.
	+ Prepare the sugar dropper bottles for the microscope observation. It will save time to prepare these ahead of time, but students can make them if they need practice making solutions of different concentrations..
		- Measure 100 mL of warm water in a glass beaker. Measure 5 mL of sugar. Then, pour the solution evenly among the three plastic dropper bottles, labeling each dropper bottle “5% sugar solution.”
		- Repeat step for a 15% sugar solution by mixing in 15 mL of sugar and labeling the bottles “15% sugar solution.”
		- Repeat step for 30% sugar solution by mixing 30 mL of sugar and labeling the bottles “30% sugar solution.”
		- You will have 9 dropper bottles total. For larger classes, you can double the values to make more dropper bottles of each concentration.
* Procedure for pretzels before fermentation of sugars:
	+ Use an antibacterial wipe to clean the surface of your lab table, since you will be using the surface to create dough. Then, cover the area with waxed paper.
	+ Once this is set up, wash your hands with soap and water.
	+ Begin by taking half a package of the yeast and dissolving the granules in 30 mL of warm water. Mix with glass stir rod.
	+ Using a dry graduated cylinder, measure out 2.5 mL of sugar and place on a piece of filter paper labeled “sugar.”
	+ Using the same dry graduated cylinder, measure out 5 mL of salt and place on a piece of filter paper labeled “salt.”
	+ Measure 120 mL of warm water in a 200 mL glass beaker.
	+ Add 2.5 mL of sugar from the filter paper to the beaker with warm water. Stir to dissolve with glass stir rod.
	+ Add the yeast solution to the 200 mL beaker with the sugar solution along with the 4 mL of salt. Stir well.
	+ Using a large beaker, measure out 475 mL of all-purpose flour.
	+ Add the flour onto the waxed paper on the lab table and create a small mountain.
	+ Poke a hole in the center of the mountain so that it looks like a volcano.
	+ Pour a small amount (about 30 mL) of the sugar solution into the center of the volcano.
	+ Use your hands to push the liquid and dry flower together to start to mix the two together. If liquid runs out of the mountain, use the dry flour to scoop it back in.
	+ Repeat this process until all the liquid is incorporated into the dough. If the dough is too soft, add additional flour. If the dough is too stiff, add additional water at 5 mL at a time.
	+ Once all the flour and liquid are incorporated, use your hands to knead the dough on your lab table. Knead for 10 minutes or until your dough is stiff and elastic.
	+ Grease a piece of aluminum foil with shortening. Place the dough on the foil and turn it until coated with the shortening. Cover the dough with a damp paper towel and let the dough rise on the counter until it has doubled in size. This will take about 30 minutes, during which time you are going to make microscope observations. Make sure you label the foil with your name. Clean your lab area before you move to the microscope observations.
* Procedure for microscope observations:
	+ You will be making a wet mount slide or a microscope slide that has liquid for viewing. Begin by taking your microscope slide. Use a flat glass slide to prepare a wet mount. The slide should be clean and free of dust or other fine particles.
	+ Keeping the slide flat, place two drops of the yeast solution on the center of the slide using the plastic dropper.
	+ Take a coverslip and place the edge of the coverslip on the edge of your liquid on the slide. Slowly lower the coverslip into place. If you do this too quickly, you will have larger air bubbles that will make your observation difficult, so be careful.
	+ Place the coverslip on top of the slide, making sure the edges of the cover slip match up with the edges of the slide. Do not press down on the coverslip.
	+ Grasp the slide/coverslip combination by the outer edges. You should keep the slide as horizontal and steady as possible. Place it on the viewing tray of your microscope.
	+ Start with the lowest degree of magnification on your microscope. Use the coarse adjustment to bring the slide into view, and then the fine adjustment to fine-tune your image. Once you have achieved a clear view, increase the magnification to get a better look at the yeast cells.
	+ Make an observation about the yeast and record it in your Microscope Observation Data Table (Appendix 12). Your observation can be descriptive with words, or a diagram, or a combination of both.
	+ Count the number of bubbles visible in your slide. These should be clearly defined and appear different from the yeast size. Record the number of bubbles in your data table.
	+ Note the time and wait for two minutes. Do not move the slide during this time.
	+ At the conclusion of two minutes, count the total number of bubbles again and record this in your data table. You can then solve for the number of bubbles created during two minutes.
	+ Throw away the coverslip in the trash.
	+ Wash off the yeast and dry your slide with a paper towel.
	+ Repeat steps 4-14 using two drops of yeast solution and three drops of 5% sugar solution from the dropper bottle.
	+ Repeat steps 4-14 using two drops of yeast solution and three drops of 15% sugar solution from the dropper bottle.
	+ Repeat steps 4-14 using two drops of yeast solution and three drops of 30% sugar solution from the dropper bottle.
	+ Clean your lab area and wait for instructions to retrieve your dough.
* Procedure for pretzels after the fermentation of sugars:
	+ Use an antibacterial wipe to clean your work area. You’ll be using the surface to create your dough.
	+ Once you are finished wiping down the table, wash your hands with soap and water.
	+ Break the dough into four equal pieces.
	+ Using your lab table, roll each piece into a long stick about 25 cm long and twist this into a pretzel or knot shape.
	+ Set up a Bunsen burner and ring stand with a wire mesh on the iron ring. Make sure your Bunsen burner gas intake tube is securely connected to the gas nozzle and that the ring is set about 3 inches above the barrel of the burner. Light the burner to create a flame that is no more than 3 inches high.
	+ Measure 10 mL of baking soda and combine with 250 mL of water in a large 400 mL beaker.
	+ Using the tongs, place the beaker on the ring stand. Bring the beaker to a boil.
	+ Use the tongs to drop in one pretzel at a time and wait for them to float (about 1 minute). Remove the pretzel with tongs and place it on your aluminum foil with the shortening.
	+ Once all the pretzels have been boiled, place them in the toaster oven and bake them at 232**°**C or 450**°**F for 12 minutes or until they are golden brown.
	+ Clean your lab area while you are waiting for your pretzels to bake.
* If prepared in a safe manner, conduct a sensory evaluation to determine the texture, flavor, and aroma of the pretzel.
* Give the teams time to complete the data collection from Appendix 12.
* Debrief the lab by discussing the following questions with the class:
	+ Why is it necessary for the dough to be kneaded? What process does this accomplish? What would you expect dough to look like if it had not been kneaded?
		- *Correct response: The dough is kneaded to realign the gluten chains to make the dough smooth and more elastic. If the dough had not been kneaded, it would have turned out lumpy with an inconsistent texture because of the globular gluten concentrations being different throughout the dough.*
	+ Why does the dough need time to rise? What process is occurring during this period? What would you expect the dough to be like if it had not been given time to rise?
		- *Correct response: The dough needs a chance to rise to give the yeast organisms an opportunity to ferment the sugars in the dough and produce the air bubbles that make the bread light and fluffy. Dough that was not given time to rise would be dense with no air bubbles because the yeast would not have time to produce the gas.*
	+ If you wanted to speed up the rising time for the pretzels, how would you alter the procedure?
		- *Correct responses: There are two correct responses for this question. One approach would be to increase the amount of sugar. Based on the student data, higher sugar content produces more bubbles, and therefore should cause the yeast to rise faster. The other answer would be to increase the amount of yeast. By increasing the amount of yeast, there are more microorganisms completing the fermentation reaction, and therefore the yeast should rise faster. A third approach would be to heat the temperature of the rise environment to promote the fermentation process.*
	+ How does this process compare to making sourdough bread?

**Closing** – 5 minutes

* Students will turn in their Exit Slip for that day. They will respond to the following prompt:

“Was your initial hypothesis correct? Restate your hypothesis and identify whether you were correct or incorrect, using data to support your answer.”

* Collect the Exit Slip for the day as students leave the classroom