Food Science

Meredith Schneider, RD, LD

pH & Acids/Bases

- Can demonstrate the effects of acids and bases on the color of food and pH of water

Ingredients: broccoli, microwave dish, pH probe, 1 tsp of baking soda, 2 tsp of cream of tartar, 4 two-quart pans, wax paper

1. Wash broccoli and divide into 5 pieces.
2. Place 1 liter of cold tap water in each pan.
3. Test pH of water with pH probe. Record results.
4. Bring each pot of water to a boil.
5. Treat each of the 6 pieces differently according to following instructions:
    a. Add one piece of broccoli to pot of boiling water. Boil uncovered for 3 minutes. After cooking, measure pH of water with probe.
    b. Add one piece of broccoli to pot of boiling water. Boil covered for 10 minutes. After cooking, measure pH of water with probe.
    c. Add ½ tsp baking soda to water; stir well. Bring to a boil. Add broccoli to boiling soda water. Boil for 15 minutes. After cooking, measure pH of water with probe.
    d. Add 1 tsp of cream of tartar to water; stir well. Bring to a boil. Add broccoli to boiling water. Boil for 15 minutes. After cooking, measure the pH of water with probe.
    e. Place broccoli in microwave dish. Add water to cover bottom ½ inch. Cover with wax paper. Microwave on full power for 2 ½ to 3 minutes. After cooking, measure pH of water with probe.
6. Record results and evaluate color of juice, color of vegetable, and pH before and after cooking.

Acid: baking soda
Base: cream of tartar

*Acid will lower pH (to about 3); base will keep it at basic pH (around 9)

Food Safety and Microbiology

- Biological hazards & microorganisms: bacteria, viruses, parasites, fungi, molds, yeast, toxins
    - Bacteria: pathogenic organisms that use nutrients found in foods and are potentially dangerous; can be toxic and produce toxins that cause diseases
    - 2 very dangerous bacteria*: salmonella & Clostridium botulinum*
    - FATTOM: food, acidity (4.6-7.0), time (2 hours in temperature danger zone), temperature (40°-140°F), oxygen, moisture
        - Contribute to bacterial growth

- Food infection: an illness resulting from ingestion of food containing large numbers of living bacteria or other microorganisms
- Food intoxication: an illness resulting from ingestion of food containing a toxin

Solutions, Colloids, Gels, Foams, Emulsions

- Adding a solute (ex. Salt or sugar) to a mixture will lower the freezing point; adding too much slows the freezing process.
- Adding a solute can elevate the boiling point.
- 3 parts of an emulsion:
    - Dispersed or discontinuous phase, which is usually oil
    - Dispersion or continuous phase, which is most likely water-based
    - Emulsifier, which is a stabilizing compound that helps keep one phase dispersed in the other (ex. Lecithin, mono- or diglycerides, gelatin, gluten, ground paprika, dried mustard)
- Food emulsions: salad dressings, milk, mayonnaise, gravies, pudding, cheese sauces
- Temporary emulsions: least viscous and least type of emulsion that separate on standing when left alone (ex. Oil and vinegar salad dressing)
- Semipermanent emulsions: emulsions with a stabilizer added so it does not separate as easily (ex. French and Italian salad dressings)
- Permanent emulsions: very viscous and very stable to the point that they do not separate (ex. Mayonnaise, milk)

Emulsions Experiment

Ingredients: 1 tsp sugar, ¼ tsp paprika, ½ tsp dry mustard, ¼ tsp salt, ¼ tsp pepper, ¼ cup vinegar, ½ cup canola oil, 1 garlic clove, crushed

1. Secure ingredients, two timers, two jars with lids
2. Make French dressing using all ingredients above and divide in half. Place all ingredients in covered jar. Shake and divide into half into two jars.
3. Begin timing version 1 to determine the time required to start to separate, and then finally to complete separation.
4. To the second version, add ½ tsp dry parsley and ½ tsp celery seed. Shake well.
5. Start timing on version 2 as soon as parsley and celery seed are added and shaking completed.
6. Record data.
7. Evaluate dressings for color, mouthfeel, flavor and stability of product.

Have students identify continuous and discontinuous phases, function of emulsifier and how it affected the mixtures in the experiment.

Fermentation: the conversion of carbohydrates to carbon dioxide and alcohol by yeast or bacteria

Experiment: Influence of Liberation of Carbon Dioxide by Yeast
Supplies: Secure eight 250 mL beakers, one 100 ml beaker with graduated markings, centigrade thermometer, glass stirring rod, 100 mL graduated cylinder, eight 10 ml disposable pipettes with graduated markings and pipette bulb, timer, water bottle filled with distilled water, one 500 ml beaker for washing, one 7g package of yeast

1. Secure supplies.
2. Turn on the oven to 350°F, bring it to temperature, and then turn it off.
3. Label the 8 beakers with masking tape with numbers 1-8.
4. In a 100 ml beaker, add 80 ml of water that is 42°C. Measure the water with a 100 ml graduated cylinder.
5. Add one package of dry yeast to the beaker containing 80 ml of water that is 42°C. Stir with glass stirring rod. Wash the stirring rod with distilled water in water bottle over a 500 ml beaker.
6. Let the yeast stand for a few minutes to allow yeast to hydrate.
7. To each of the numbered beakers (1-8), add the following items as specified below:

Graduated Cylinder #	Amt of Water	Temp of Water	Substance	Vol. at Beginning	Vol. After 30 min.	Vol. After 1 Hour
1	118 ml	42°C	None			
2	118 ml	42°C	2 g sugar			
3	118 ml	42°C	2 g sugar + 3g salt			
4	118 ml	42°C	2 g sugar + 6 g salt			
5	118 ml	42°C	25 g sugar + 3g salt			
6	118 ml	0°C	6 g sugar			
7	118 ml	42°C	6 g sugar			
8	118 ml	92°C	6 g sugar			

8. Transfer 10 ml of yeast solution to each of the 8 graduated cylinders using a pipette and bulb.
9. Place beakers in oven on rack, with oven door open. This will create a warm environment for the yeast to ferment. Start timer.
10. Observe fermentation of beakers at beginning, in 30 min, and at end of 1 hour. Use table for data collection.

Have students compare yield of carbon dioxide in beakers 2,3,4 and compare to yield in beaker 1. Compare yield of CO2 in beakers 3 and 5. Account for difference. Have students account for effects of temperature, time, and substance.

Leavening Agents

- The presence of a leavener causes a flour mixture to rise. There are 3 types of leaveners:
  - Physical: air and steam
  - Biological leaveners: yeast and bacteria
  - Chemical leaveners: baking powder and baking soda
- Baking soda must have an acid ingredient added to the flour mixture in order to yield carbon dioxide. When using baking powder, an acid does not need to be added to the mixture.
- Air as a leavening agent: incorporating air into a flour mixture helps the dough rise (added by mixing, creaming of fat and sugar, sifting dry ingredients, using whipped egg whites)
- Steam as a leavening agent: water incorporated into flour mixtures produces steam when heated and expands to 1,600 times its original volume.

Experiment: Leavening of Bread by Steam- Popovers

1. Secure mixer on a stand, oven thermometer, popover pan, graduated cylinder, 237 ml Pyrex cup, mixing bowl, sifter, sharp knife, hot pads, wire cooling rack.
2. Secure ingredients for popovers: 3 large eggs, 46 g margarine stick, 237 ml reconstituted non fat dry milk, 1.5 g salt, 129 g instant flour, Pam
3. Preheat oven 365°F on Bake
4. Spray pan with Pam
5. Melt margarine in microwave.
6. Sift 129 g instant flour and 1.5 g salt
7. Place eggs in mixer and beat slightly. Add 237 ml reconstituted non fat dry milk and melted butter.
8. While mixer is beating on slow speed, gradually add flour/salt. Mix for 30 seconds.
9. Pour batter into cups to ¼ inch of top.
10. Place in oven and check in 50 minutes. DO NOT bother while cooking.
11. Remove when popovers are dark brown and crisp. Make slit in side to release steam.
12. Remove popovers from pan and place on wire rack.

Questions:

1. What is the main leavener in popovers?
2. What is the ratio of liquid to flour?
3. Why did the popovers rise?
4. State ways air may be incorporated into a batter or dough.

Food Additives

- Purposes:
  - Improve the appeal of foods by improving their flavor, smell, texture, color
  - Extend storage life
  - Maximize performance
  - Protect nutrient value
- Common food additives and functions:
  - Acetic acid: pH control, preservative
  - Ascorbic acid (Vitamin C): nutrient, antioxidant, preservative
  - Aspartame: sweetener, low calorie
  - Cellulose: emulsifier, stabilizer and thickener
  - Citric acid: preservative, antioxidant, pH control agent
  - Gelatin: stabilizer, thickener, texturizer

Heat Transfer Experiment

1. Secure containers of similar size made of glass, stainless steel and pottery/ceramic materials. Each should have a lid. Also secure oven thermometer, graduated cylinder, timer.
2. Heat oven to 400°F.
3. Add same amount of water to each container (approximately 2/3 full).
4. Check and record temperature of water in each container.
5. Place one container with water in center of oven rack, close door, and allow to heat for 10 minutes.
6. Pull rack ½ way out of oven and immediately insert thermometer into water and read. Make sure thermometer does not touch container.
7. Record highest temperature.
8. Remove from oven, close door, and allow oven to return to temperature.
9. Repeat with other containers.

Material of Container	Before temperature	Temperature after 10 minutes in oven
Glass		
Aluminum		
Pottery		

Questions:

1. Which pan heated water the fastest? Aluminum
2. How does heat reach the baking utensil in oven? Convection
3. How is heat transferred from hot air to utensil? Conduction
4. How is the transfer of heat affected by each kind of material? Conductors

Gelatinization, Paste, Retrogradation, Syneresis

- Gelatinization: the increase in volume, viscosity, and translucency of starch granules when they are heated in a liquid

- Retrogradation: the seepage of water out of an aging gel because of the contraction of the gel (bonds tighten between the amylose molecules)
    - Also known as syneresis or weeping

Experiment for Comparison of Starches

1. Secure the following ingredients: 2 T cornstarch, 2 T flour, 1 ½ T tapioca Equipment needed includes 3 sauce pans, 6 custard cups, timer, graduated cylinder, thermometer.
   In all experiments, measure the temperature when starch paste was completed.
2. Measure and place 237 ml tap water in small heavy aluminum saucepan.
3. Add the 2 T cornstarch stirring constantly. Stir until smooth.
4. Place over direct heat; stir continuously; turn heat to low and cook for 5 minutes. Cornstarch must reach near boiling temperature for thickening to occur. Measure temperature when solution is thickened.
5. Divide the starch solution between 2 custard cups. Freeze 1 of the custard cups that will be thawed and evaluated later.
6. For experiment 2, follow same steps for cornstarch but replace the cornstarch with 2 T (14 g) flour.
7. Divide the starch solution between 2 custard cups. Freeze 1 cup that will be thawed and evaluated later.
8. For experiment 3, weigh 1 ½ T (14.3 g) tapioca and place in 237 ml of water. Let it stand and soak for 15 minutes. Use timer.
9. After soaking period, place the saucepan on the direct heat.
10. Continuously stir as the solution reaches boiling. Once boiling is reached, remove immediately from the heat.
11. Divide the solution between the 2 custard cups. Place once custard cup in freezer until frozen. It will be thawed and evaluated later in the lab.
12. Turn the cooked starch upside down on a small dish for evaluation.
13. Rate transparency from 1= most transparent to 10= most opaque; 1= thickest and 10= thinnest.
14. Fill out chart.

Thickening Agent	Pasting Temperature	Thickness	Transparency of Cooked Mixture	Consistency Following Freezing and Thawing
Cornstarch				
Flour				
Tapioca				

Questions:

1. Why is the gel made with flour slightly softer than the gel made with cornstarch? Cornstarch has more amylose which makes a more solid gel.
2. Which starch gels showed syneresis? The most? The least? Tapioca=most, flour= least
3. Describe the difference between the cooked and frozen starch gels.

4. Which frozen gel exhibited the best texture?
5. Why was the tapioca soaked? It softens the amylopectin
6. What should be the process for cooking a cherry pie that has tapioca as the thickening agent? Cross-linked starch to prevent syneresis.

Eggs and Egg Foams

- Factors affecting the stability of an egg foam:
    - Beating technique, temperature, type of bowl, careful separation of yolks and whites, whether or not sugar, acid, fluid or salt have been added

Experiment: Effect of Stage of Beating on Quality of Egg White Foam

1. Secure 4 eggs, 6 T sugar, baking sheet, parchment paper, 5 timers, ½ cup measuring cup, 4 glass funnels, 4 graduated cylinders, electric hand beater, 4 small pyrex bowls, spatula, egg separator, 2 measuring cups
2. There are 4 variations of foams with different amounts of sugar in this experiment. Use 1 egg white for each variation.

    Variation 1: Add 2 T sugar to one egg white. Beat until peaks have a slightly rounded top.

    Variation 2: Beat the egg white to foamy stage, then add 2 T sugar and continue to beat until peaks have slightly rounded top.

    Variation 3: Beat egg white until stiff peaks are formed; add 2 T sugar and beat until sugar has been incorporated.

    Variation 4: Beat egg white until stiff peaks are formed. DO NOT ADD SUGAR.
3. Time the beating time for each foam.
4. Measure the total volume of each foam before separating to measure leakage.
5. Immediately after each variation is made, place ½ cup of foam in a mound on a baking sheet line with parchment paper that is labeled as to variation.
6. Measure another ½ cup foam and place it in a glass funnel that is place on top of a graduated cylinder to check for leakage. Time the beginning of each foam place in a funnel separately.
7. At this point, all 4 variations should be draining with timing being monitored.
8. Place the baking sheet with the 4 labeled foams in the oven to bake for 5-7 minutes at 375°F until a golden brown.
9. Remove from oven and allow to cool for 20 minutes.

    Read drainage in graduated cylinders and record leakage.

    Record results in chart below.

Variation	Beating Time	Evaluation of peak and foam	Leakage (ml)
1			
2			
3			
4			

What constituents in egg white contribute to its foam-forming ability? Protein

Compare beating times, volume, leakage, and baked meringues.
How did the addition of sugar affect the egg white beaten to the stiff peak stage?
Makes it more stable
What did the absence of sugar have upon the beaten egg white when it was baked?
More air, less brown
What appears to be the optimum stage for adding sugar to beaten egg white?
Beginning

Milk Proteins

- Coagulate: to clot or become semi-sold. In milk, denatured proteins often separate from the liquid by coagulation.
    - Lowering the pH in the milk or adding heat denatures proteins; adding an acid can drop the pH.

Teachers: you can create an experiment to show milk coagulation using heat and an acid. Heat milk in a saucepan on a stove and have students evaluate the scum and coagulation of the milk. You can add vinegar or lemon juice to milk and measure the pH before and after adding the acid. Have students observe the consistency/coagulation of milk.

Forming a cream foam: factors affecting this are temperature, amount of fat, acid, sugar

- Foams that are colder and are higher in fat/sugar will form a more stable foam
- Acid will interfere with the stability of a foam

Teachers: you can create an experiment in which students whip cream and evaluate the stability of the foam formed

- Use different creams with different fat percentages, at different temperatures, add acid to one and you can compare the foams to commercial whipped topping

*Lab experiments from NTR 107L Food Science Laboratory Workbook by Margaret E. Briley, PhD, RD, LD