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Food Chemistry: Experiments for Labs and Kitchens

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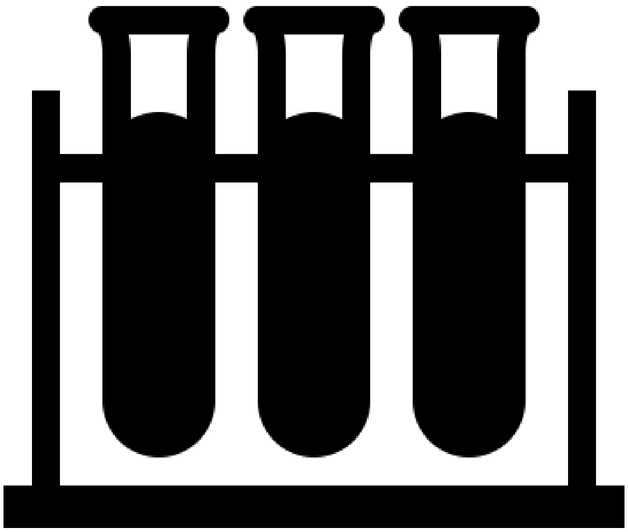

Food Chemistry: Experiments for Labs and Kitchens

First Edition

A manual of kitchen experiments designed to demonstrate the chemical properties of foods and flavors, experienced through the human senses.

Developed and written by

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We share this lab manual with you free of charge in light of the worldwide concerns of the novel coronavirus of 2019, and the COVID-19 disease outbreaks around the world in 2020. Please be warned, this manual is not "complete." There will be typos. There will be errors. Some labs may not work perfectly. But, we hope you may find it useful—especially if your school was closed or you were quarantined/isolated for the sake of slowing the spread of this global virus.

The only thing we ask in return is that you send us a message if you are able to use our experiments. This helps us demonstrate that our work had an effect, which is a key component of an academic career. Dr. Running's email is: crunning@purdue.edu. She can also provide instructors with data for analysis, and with the solution keys.

Many thanks to Ms. Patsy Mellott, whose sponsorship of the Purdue College of Health and Human Sciences Patsy Mellott Teaching Innovation Award made the development of these labs possible.

Introduction

Science should be accessible to all. However, for many people obtaining higher education in sciences is impossible due to the need to conduct and observe experiments. Most traditional courses require a well-equipped laboratory, where chemicals can be mixed and properties or phenomena measured. Consequently, for people who cannot quit their jobs or drop their lives and move to a university town, in order to take traditional courses offered during normal working hours, a degree in science is nearly impossible.

That is unacceptable. Science is for everyone, not just the wealthy and unattached.

One of my biggest pet peeves is the analogy that "chemistry is like cooking—just don't eat it!" This is fundamentally incorrect. Chemistry isn't "like" cooking. Cooking *is* chemistry. Just like a rectangle isn't "like" a square. A square *is* a rectangle. Much of the chemical phenomena that occur on this planet can be observed in our foods and how we manipulate them during preparation, as well as how we experience them during the eating process. Chefs go through the same iterative process of experimentation, observation, and re-experimentation as scientists. The fact that the measured outcomes are human experiences of flavor do not make this some ethereal magic. Flavor is measurable. Certainly, we all differ in our experiences of flavor, but those differences are also measurable. And just as a piece of equipment can be calibrated to provide consistent measurements, so too humans can be calibrated in their assessment of flavor.

Now, to fully "calibrate" humans on specific flavor sensations is actually a lot of work (seriously, there are whole books on this). Most of us aren't trained from a young age to think about defining our flavor experience. Thus, the flavor outcomes we measure in this manual will be relatively simple. Most people can give an assessment of how "sweet" or "bitter" an item is, although sometimes they confuse those terms with whether or not they like the food. Nonetheless, with enough data points (in other words, enough people tasting the food), the outcomes are still observable. We generally shoot for about 60 people in a test. In case you do not have such large classes, we have provided some data that can be used for analysis with this course. We would, however, love for you to add your data to ours. You can do this by opening the links provided in each chapter and entering your responses. This will help us see how consistent our data are, so we know whether the experiments are "working" when conducted without us around to guide them. We'd also love to see your pictures of the experiments, if you are willing to share.

To paraphrase my friend and colleague Dr. John Coupland: In using food to demonstrate science, what we lose in precision is offset by what we gain in relatability. We hope that as you experiment, observe, and relate food to science through the activities in this manual, the experiences engage your mind and make you eager for more.

Dr. Cordelia A Running

Alternate approaches

We have attempted to allow for some adaptations along the way as you conduct these experiments. Food allergies, sensitivities, and avoidances can make some of these experiments unfeasible. When we know whether an alternative product will function in the same way as an original (for example, a soymilk in place of dairy milk) we have indicated that.

We also know that our statistics may be overwhelming to many people. We do encourage you to do some sort of statistical test, as this will help you see what the overall patterns are even if you did not experience a particular flavor shift or preference yourself. People are most certainly different in the ways we sense flavors. Our genetics and experiences both contribute to these differences. Also, sometimes experiments go wrong for unknown reasons. When you are alone or part of a small group conducting that experiment, it is hard to know what happened. By analyzing larger sets of data from more people, you should be able to see what the general trend was, even if your experiment or your own experience of flavor did not match the group's pattern.

A relatively simple way to limit the statistics in this manual would be to only use binomial tests. We already use binomial tests for difference or preference questions (questions where you count the number of responses that said "yes"/"no," or "preferred"/"not preferred"). For questions about flavor intensity or the degree of liking, the sign test can always be used, and you could skip the tests for normality and leave out the paired t-tests. If you wish to leave out the Excel exercises in Chapter 3 completely, we have included a table in the appendix to indicate how many responses need to be greater or smaller in order to decide that responses were not due to chance.

Kitchen Tools and Equipment

We plan to put a complete list of things here eventually. For now, please refer to the tables near the beginning of each experiment.

Computers, Data, and Surveys

We set up this course originally to use Microsoft Excel and surveys administered through Qualtrics software. However, some small adjustments will allow for data collection and analysis without computers or the internet. You can use paper sensory questionnaires and sign tests (skipping Laboratory 3 as necessary) and there is no longer a need for computers in this course.

We have included the sensory questionnaires as an appendix in this manual so that they can be copied and administered as paper ballots (or converted into another survey software of the instructor's choice). Paper ballots are tedious (who wants to sit around with a ruler and measure all those line scales???), but just as effective as digital. We do strongly recommend you attempt to randomize the order in which samples are tasted if you choose to use paper ballots (we do this automatically in our software). Samples that are tasted first tend to be rated strangely compared to samples tasted later.

Binomial tests can be used for all data. The data that are "counts" are already binomial tests, and all comparative tests can be run as "sign tests." With this approach, a computer is not needed. All that you need is a binomial table, which we include in the appendix. Instructions on how to use the table can also be found there.

Food Chemistry: Experiments for Labs and Kitchens

Laboratory 1: Safety and Measurements

Chaylen Andolino
Cordelia A Running, PhD
Last updated 18 March 2020

LABORATORY 1: SAFETY AND MEASUREMENT

A. OVERVIEW

LAB BACKGROUND AND DESCRIPTION

This laboratory is less an experiment and more a plan for you to develop adequate lab habits and skills. With good measurement skills, you will collect more accurate and precise data. With good safety practices, you will live to tell the tale. Hopefully, these concepts are review.

For measurement skills, we will practice making solutions, measuring pH, and measuring color.

LAB GOALS

Required:

- Describe and implement good lab safety practices
- Identify lab/kitchen hazards
- Label and identify food and non-food containers
- Correctly make molar and percent weight solutions
    - Observe how mistakes in this matter
- Measure color from a digital image
- Measure the pH of solutions using litmus paper

Optional:

- Learn how to use:
    - pH meter
    - Refractometer
    - Spectrophotometer

PRE-LABORATORY

Read through the lab, review the lab/kitchen safety guidelines, and answer the following:

1. Do you have any food allergies, sensitivities, or ingredients you do not consume for religious, moral, or personal reasons? If so, what?
    - This is for course planning purposes so that we can ensure everyone has a way to participate in experiments, and so that we can assign groups.
    - You do not need to give a reason why. *However, if you have a severe or potentially life-threatening allergy, please let us know so that we can keep you safe!*
2. What type of shoes should you wear in the kitchen/lab?
3. What should you do if you think there is a gas leak?
4. How much sucrose do you need for 150 mL of a 0.5 M sucrose solution?
5. What software is suggested to identify the color of the items in this lab?

MATERIALS AND EQUIPMENT

These experiments should take about 90-120 minutes.

Equipment and Materials	Amount	Distance lab
Natural red OR blue food color	15 drops	In your packet
Transfer pipette	~3	
Litmus paper	Several papers	
Sucrose (table sugar)	About 100 grams	Procure!
Water and distilled water		
Vinegar OR lemon juice	30 mL	
Baking soda	30 g	
Camera (cell phone camera is fine)	1	
Scale (with gram measurements)	1	
Measuring cups or beakers (at least 250 mL in size, with marks at 150 mL)	4	
PowerPoint software	1	
Device to access to online class survey online, and a partner/helper	1	

**Note for distance students:* *Items in the "procure" section you will need to purchase or obtain for yourself. All other items will be in your course packet.*

B. EXPERIMENTS

EXPERIMENT 1: FOOD VS. NON-FOOD

In homes as well as kitchens, containers for foods should be separate from containers for non-food items. This prevents contamination, which will help keep you and others safe. However, it can also be challenging—both in homes as well as in food laboratories.

In a home, you might have plastic food containers for storing leftover meals—but those same containers may be very convenient for storing things like paint or personal care products. If you do not carefully separate and label these containers, you could accidentally eat something toxic.

In a food laboratory, we use both edible ingredients, as well as reagents and concentrated ingredients that might be toxic. Most science laboratories can simply implement a rule that you never eat or drink in the lab—that does not work for food labs. Thus, we need ways to identify and segregate the food safe and non-food safe materials and containers. One suggestion is to purchase different colors or types of glassware for food items vs. non-food items. These should be stored separately, with large, obvious labels to indicate that some glassware is only for use with food. Another option is to use disposable items for foods, so you know they can only be used once. We will typically use disposable items and kitchen-type glassware (bowls, not beakers) in this lab.

No matter how you decide to keep your food containers and non-food containers separated, you should always label a container when you fill it with something. The label should give: what is in the container (NO ABBREVIATIONS! Spell it out), your initials, and the date (including the year!). For *on campus students*, also include the course number and your lab section.

Also consider how you will know if things are clean, and what you can use to clean food safe vs. non-food safe items. For example, the same sponge should not be used in a bathroom as in the kitchen—and the same towel should not be used to wipe up a floor and then used to dry a bowl for food.

Finally, think about safety when handling hot items. In general, avoid using towels to pick up hot pans. If the towel is even slightly wet, that water can be instantly vaporized into steam—which will burn you. Look for hot pads or oven mitts for handling hot items, keep the pads or mitts dry, and make sure these are never used to wipe up spills.

On campus students:

Investigate your laboratory. Discuss with your instructors the equipment in the lab, as well as the potential safety hazards.

- How do you know the glassware is for food? Non-food?
- What items can you cook or prepare foods in?
    - Where will they be located when you arrive at lab?
    - Where will you clean them after the lab?
    - Where will you put them after they are cleaned?
- What should you use to pick up hot things?
- Where is the eyewash station?
- Where is the shower?

Distance students:

Investigate your kitchen. Observe what types of containers you have available for preparing foods. Develop a plan to ensure those containers are not used for non-food activities. This can be as simple as picking a drawer to store such items in, deciding that all items stored in the kitchen are used only for food, or deciding that if any container is used for non-food purposes you will mark it as no longer food safe. Make sure you discuss with your roommates or family what your plan is, and that everyone agrees. Take notes on:

- How will you safely identify clean, food-safe containers?
- Where will you clean things? What will you clean them with?
- What will you use to pick up hot things? How will you ensure these are dry?

EXPERIMENT 2: GENERAL SAFETY

Wear protective clothing. Always wear closed toed shoes in the lab/kitchen. I know this might be odd in your own kitchen, but you will cook hot things and carry heavy things. Dropping either of those on your toes feels awful.

On campus: **Always wear a lab coat that goes down to about your knees.**
Distance: **Always wear an apron or chef's coat.** Again, this might feel odd in your own kitchen, but the goal is that if you spill or splash something hot, you are not injured.

**Note*: We cannot enforce this for distance students, but we still recommend it.

Wear gloves and protective goggles when using hazardous chemicals (mostly for *on campus students*). Locate these in the lab for future reference (*distance students*: have a plan for where to obtain these if they were necessary or note down where they are if you already have them). Not sure if the chemicals are hazardous? Assume they are, and wear gloves and goggles.

Ensure proper ventilation.

On campus: **Know how to operate the fume hood.** The sash should be at the correct level when you are actively using it. This is marked on the side. Note where the sash should be at the correct level for use. Close the sash when you are finished. Later in the semester, if you use the fume hood, do not leave your samples in the hood. Dispose of them properly!

Distance: **Know how to use your exhaust fan over the stove, check your smoke detector batteries, and have a plan for how to open windows/doors to ventilate smoke if necessary.** If you don't have a smoke detector, you need to have one installed NOW!

Note the location of emergency equipment.

On campus: This includes the eyewash and shower stations, as well as fire extinguishers. Do not attempt to use a fire extinguisher if you have not been trained! You might make things worse.

Distance students: We recommend that you procure a fire extinguisher for your kitchen and learn how to use it.

Keep paths and aisles clear. Do not leave things (like bags or coats) blocking doorways, sinks, paths in and out of the room/lab, or emergency equipment.

Be safe with electricity. Use proper extension cords where necessary, but do not plug one into another. Make sure extension cords for appliances are rated for appliances. Make sure all cords, plugs, and outlets are kept away from water. Check GFCI outlets for proper functioning by pushing the test button (the outlet should no longer work). Push the reset button (the outlet should work again).

Use proper protection when handling hot things. As discussed above, dedicated hot pads and/or oven mitts are better than towels. Always ensure items for handling hot things are dry!

Don't store strong acids and bases together. In other words, the sodium hydroxide and the hydrochloric acid should be kept separate! When acids and bases mix, they can generate a lot of heat, splashing, bubbling, and vapors that can be dangerous and even cause a fire. In your home, drain cleaner is a strong base—so don't store it next to a big bottle of vinegar.

Don't mix cleaning chemicals. If one contains bleach and another ammonia, you will create chlorine gas, which is poisonous. If you do accidentally mix two cleaning chemicals, and you notice a green gas forming, RUN AWAY (and pull the fire alarm)!

Not sure what something is? Don't eat it. In general, if you are not sure what something is, you shouldn't use it at all, let alone eat it. Safety Data Sheets (SDS) are located in the laboratory for *on campus students*—you can look up the chemicals in the lab in those binders for information on their hazards. Alternatively, you can look it up on the internet.

EXPERIMENT 3: MAKING SOLUTIONS

For this experiment, you will use correct and incorrect methods to make 0.5 M and 20% weight/weight solutions of sucrose. Make sure you measure to the bottom of the meniscus when measuring volumes.

1. "0.5 M" solution A:
    a. Label the food safe measuring cup "Molar solution A" and weigh it empty.
    b. Weigh out enough sucrose to make a 150 mL of a 0.5M solution of sucrose.
    c. Measure 150 mL water to a food safe measuring cup and add it to the sucrose. Stir to dissolve and record the new weight.
    d. Subtract the weight of the empty container to get the weight of your solution.
    e. Set aside for step 7.
2. "0.5 M" solution B:
    a. Label the food safe measuring cup "Molar solution B" and weigh it empty.
    b. Weigh out enough sucrose to make a 150 mL of a 0.5M solution of sucrose.
    c. Put the sucrose in the measuring cup and FILL UP to 150 mL. Stir to dissolve and record the new weight.
    d. Subtract the weight of the empty container to get the weight of the solution.
    e. Set aside for step 7.
3. "20% w/w" solution A:
    a. Label the food safe measuring cup "Percent solution A" and weigh it empty.
    b. Weigh out 20 g sucrose and put it into the container.
    c. Add 100 g water to the container. Stir to dissolve and record the new weight.
    d. Subtract the weight of the empty container to get the weight of your solution.
    e. Set aside for step 8.
4. "20% w/w" solution B:
    a. Label the food safe measuring cup "Percent solution B" and weigh it empty.

   b. Weigh out 20 g sucrose and put it into the container.
   c. Add 80 g water to the container. Stir to dissolve and record the new weight.
   d. Subtract the weight of the empty container to get the weight of your solution.
   e. Set aside for step 8.
5. Record the final volume and the final weights of each solution (4 total solutions).
6. Open the online survey. Working with a partner, record your answer in the class survey.
   https://purdue.ca1.qualtrics.com/jfe/form/SV_77J3ZxF0LHVDcVL
7. Taste the percent weight solutions. Which is sweeter? Record your answer in the class survey.
   a. *Optional:* Use the refractometer to measure the amount of dissolved solids in the percent weight solutions. For instructions, see the appendix.

EXPERIMENT 4: MEASURING pH

For this experiment, you will make some solutions of various pH. You will then use these solutions in Experiment 5, measuring their color.

1. Fill three clear containers with 100 mL of distilled water each (about 100 g water).
   a. These do not have to be food safe containers. You will not drink these solutions.
   b. They do need to be the same type of container—if they are slightly different shapes or have slightly different levels of translucency, then the color you measure can reflect that. (You want to measure the difference in colors due to your solutions, not due to your containers!)
2. Record the pH of each container of water with a piece of litmus paper or a pH meter.
   a. If the water in the three containers has different pH readings, your containers were probably not clean! Get new containers or wash these and start again.
   b. *Optional:* Calibrate and use the pH meter to record the different pH values. For instructions, see the appendix.
3. Label one container "Neutral," one "Acid," and one "Base."
4. To the "Acid": add 9 g vinegar or lemon juice, stir to disperse, and record the pH.
5. To the "Base": add 9 g baking soda, stir until fully dissolved, and record the pH.
6. Take a picture of the five pH strips/pH meter readings (three in the initial waters, one in the Acid, and one in the Base). Make sure you label them.

EXPERIMENT 5: MEASURING COLOR

For this experiment, you will add a pH sensitive color to the solutions you made in Experiment 4.

1. Add 5 drops of the food color to each solution you made in experiment 4: Neutral, Acid, and Base.
2. Observe and record how the pH influenced the color.
3. Find a brightly lit countertop and place your 3 solutions next to each other on the counter.
4. Place white paper behind and under the 3 solutions and take a picture. Make sure you can clearly read the labels in the picture.
   a. *Optional:* Use the spectrophotometer to measure the intensity of light of each colored solution.

C. DATA AND RESULTS

Data: Make sure you completed the survey on the sweetness of the sucrose solutions from Experiment 3.

Results: Answer the following:

All students:

a) Which should have been sweeter, the A or B for the 0.5 M solution? For the 20% w/w solution?
b) Which method for making each type of solution is correct?
c) What molecule makes lemon juice acidic? (just name the predominant one)
d) What molecule makes vinegar acidic?
e) What molecule makes baking soda alkaline?
f) Show a picture of your 5 different litmus paper strips/pH meter readings
g) What did lowering the pH do to the color?
h) What did raising the pH do to the color?
i) Show a picture of the 3 solutions with the added color.
j) Using software that can analyze colors (PowerPoint, Mac's Digital Color Meter/Color Picker), obtain and report the Red, Green, and Blue values for the 3 different colored solutions.

On campus students:

k) Where can you find protective eyewear?
l) Where can you find gloves?

Distance students:

k) What will you use to pick up hot things? How will you prevent steam burns?
l) What brand of smoke detector do you have? (Not sure? Submit a picture!) What type of batteries does it take?

Food Chemistry: Experiments for Labs and Kitchens

Laboratory 2: Flavor and Sensory Evaluation

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Last updated 18 March 2020

LABORATORY 2:FLAVOR AND SENSORY EVALUATION

A. OVERVIEW

LAB BACKGROUND AND DESCRIPTION

INFORM THE INSTRUCTOR IF YOU ARE LACTOSE INTOLERANT.

The strongest driver for food choice and purchasing behavior is flavor (see https://www.foodinsight.org/ for their annual Food and Health Survey). The following experiments were designed to illustrate some principles of flavor perception as well as to acquaint you with several types of tests used in ***sensory evaluation.*** The written report will utilize statistical techniques important for determining differences among samples based on data collected through these sensory tests. We will learn how to apply those statistical techniques in Laboratory 3.

Experiment 1: "Sugar" is generally assumed to be sweet. However, there are many different chemical structures classified as sugars. Not all these structures cause sweetness, and certainly not to the extent that sucrose (table sugar; white sugar) is sweet. In this experiment, you (or a willing partner) will taste several sugars and rate their sweetness.

Experiment 2: Flavor is the combination of multiple sensory attributes. Both colors and odors are important factors in recognizing flavors. By blocking vision, the color cues are lost. Many people are then not able to identify specific flavors, especially among similar items like lime and lemon. By blocking odor, much of the truly identifiable characteristics of flavor are lost. This test will demonstrate how losing sight and smell alters a person's ability to identify flavor sensations.

Experiment 3: Many different methods are used to collect data on food product differences and flavor sensations. This experiment will demonstrate several techniques for collecting data. You will interpret these data in the next week's lab using statistics.

LAB GOALS

- Determine differences in sweetness among different sugar types.
- Demonstrate the importance of smell and sight for flavor identification.
- Execute and correctly analyze sensory tests for differences, intensity, and liking.

PRE-LABORATORY

Read through the lab, and briefly answer the following:

1) What sugar to be tested in this lab contains both galactose and glucose, bound together?
2) Name three senses still available to experience foods when the eyes are closed.
3) What is the difference between a hedonic and intensity scale?

MATERIALS AND EQUIPMENT

These experiments should take about 60-90 minutes in total.

Equipment and Materials	Amount	Distance lab
Fructose, Glucose, Tapioca maltodextrin, Sucrose, and Lactose; each will be labeled with a random code (decoding information will be provided after the labs)	~0.5 grams each	In your packet
Single serve coffee creamers There are two flavors, but they have been covered and labeled with random codes so you do not know which is which for the experiments. The decoding information will be provided after the labs.	10 total, 2 each of 5 different numbers	
5 different flavored beverages	Enough for at least 2 sips	Procure!
Water	1 glass	
Cotton swabs	5	
Small serving cups	10	
Device for access to the online class survey, partner	1	

B. EXPERIMENTS

EXPERIMENT 1: ALL SUGARS BIG AND SMALL

1. Obtain the sugars, the cotton swabs, and a cup of water.
2. Access the online questionnaire to complete the sensory ratings.
3. Dip the cotton side of the swab in water, and then roll the damp cotton tip in one of the sugars.
4. Place the sugar-dipped swab in your mouth, along the side of your tongue, and close your mouth.
5. Rate the intensity of the sweetness of sugar through the online survey.
   https://purdue.ca1.qualtrics.com/jfe/form/SV_3lBb1OLatLSfKkd

   The scale you will use is an ***intensity line scale*** that goes from "None" to "Strongest Ever." None means you did not experience any sweetness from the sample. Strongest Ever means this is the strongest sensation of any kind you have ever experienced. The scale online should look similar to this:

6. Repeat with the other sugars, using a new cotton swab each time.

EXPERIMENT 2: FLAVOR IDENTIFICATION

1. Obtain the small serving cups and the five different flavored beverages (beverages should be similar in type; in other words, do not use both carbonated and non-carbonated beverages, or fruit juice and milk). We recommend using: cola, orange soda, grape soda, lemon-lime soda, and cherry cola.

2. Pour about 30 mL of each beverage into individual small serving cups.
    a. Label the cups so that you do not forget which flavor is which, especially if some beverages are the same color. You will enter these labels into the survey later.
3. Find a partner for this experiment.
4. Access the online questionnaire so your partner can record your responses. Please carefully follow the directions to make sure you do not know which sample you are tasting before placing it in your mouth. Your partner will be handing you samples at random for you to taste, all as instructed by the survey.
https://purdue.ca1.qualtrics.com/jfe/form/SV_ePYIdEMFr1n0UHb
    a. You MUST guess a flavor, even if you are not certain.
    b. Have your partner record whether you were correct or incorrect on the flavor. They should NOT tell you whether or not you were correct.
    c. You MUST keep BOTH your eyes and nose closed for this ENTIRE portion of the experiment. DO NOT OPEN YOUR NOSE.
    d. Do not look at which beverage(s) you have already tasted—you want to remain unbiased in your guesses. Once you're done with the tastings, note down how many of the 5 beverages you got correct with your eyes and nose closed.
    e. Have your partner keep track of how many total correct and incorrect responses you make.
5. After you have done this for all 5 beverages with your nose and eyes closed, record how many total beverages you correctly identified with your eyes and nose closed.
6. Repeat the experiment with your nose open (but eyes still closed) again using the survey to record whether you were correct or not.
7. At the end, note down how many of the 5 beverages you got correct with just your eyes closed.
8. Record how many flavors you correctly identified under each condition (nose closed, nose open) in your notebook.

EXPERIMENT 3:

1. Obtain the single serve coffee creamers. You should have two of each number, and you should NOT be able to tell what flavor they are by looking at the package. You will need to take 3 or 4 small sips of each number, so make sure you save enough for all of the tests (two should be plenty).
2. Access the online questionnaire. You can do this experiment on your own.
https://purdue.ca1.qualtrics.com/jfe/form/SV_6DOksJgp21ZykNn
3. The questionnaire will guide you through these tests:
    a. Paired preference test
        i. Use samples 287 and 743.
        ii. Taste each sample. Which do you prefer? You MUST pick one of the two samples.
        iii. Record your response online.
    b. Triangle test
        i. Use samples 743, 554, and 810.
        ii. Two of these samples are the same, and one is different. Taste all three samples (in random order).
        iii. Which samples was the different one? You MUST pick a sample.
        iv. Record your response online.

c. Tetrad test

i. Use samples 743, 554, 810, and 309. Among these samples, there are only two different flavors. You have two samples of each of these two flavors.

ii. Taste all four samples, and group them into two groups of two, based on similarity of flavor.

iii. Record your response online.

d. Intensity category scale

i. Use samples 309 and 287.

ii. Taste a sample and rate its sweetness using the scale provided online.

The scale should look similar to this:

No sensation								Strongest Ever
1	2	3	4	5	6	7	8	9

iii. Record your response online.

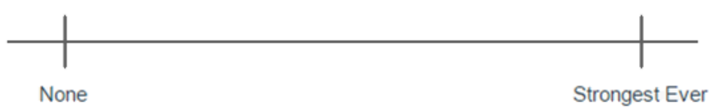
iv. Repeat with the other sample.

e. Intensity line scale

i. Use samples 554 and 810.

ii. Taste a sample and rate its sweetness using the scale provided online.

The scale should look similar to this:



iii. Record your response online.

iv. Repeat with the other sample.

f. Hedonic category scale

i. Use samples 743 and 287.

ii. Taste a sample and rate how much you liked/disliked it using the scale provided online.

The scale should look similar to this:

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neutral	Like slightly	Like moderately	Like very much	Like extremely
1	2	3	4	5	6	7	8	9

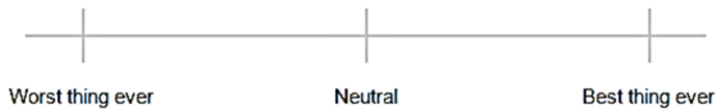
iii. Record your response online.

iv. Repeat with the other sample.

g. Hedonic line scale

i. Use samples 287 and 309.
ii. Taste a sample and rate how much you liked/disliked it using the scale provided online.

The scale should look similar to this:



iii. Record your response online.
iv. Repeat with the other sample.

C. DATA AND RESULTS

Data: Make sure you completed the online surveys for all of the experiments (2-1, 2-2, 2-3)

Results: Download and use the class data to answer the following questions:

You will also need the "decoding" information, which tells you which samples the codes were for the sugars/maltodextrin and creamers.

We will analyze these data further with statistics next week. However, these numbers will be helpful for completing that exercise.

a) What was the average sweetness for each sugar/maltodextrin?
b) What was the median sweetness for each sugar/maltodextrin?
c) How many total guesses would the class have made for each method (nose open vs. closed) of the beverage flavor identification tests?
d) How many total CORRECT responses did the class have with both their eyes and nose closed?
e) How many total CORRECT responses did the class have with their eyes closed and nose open?
f) Paired preference test: How many people selected each flavor?
g) Triangle test: How many people were correct?
h) Tetrad test: How many people sorted the samples correctly?
i) Scales: Give the mean intensity/liking for each flavor using each of the following scales:
    - Intensity category scale
    - Intensity line scale
    - Hedonic category scale
    - Hedonic line scale

Food Chemistry: Experiments for Labs and Kitchens

Laboratory 3: Data analysis and visualization

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LABORATORY 3: DATA ANALYSIS AND VISUALIZATION

A. OVERVIEW

LAB BACKGROUND AND DESCRIPTION

To accurately measure and report the sensations and properties of foods, you need to be able to analyze, interpret, and convey the information gathered during analytical and sensory tests. This lab will apply statistical methods to the data collected in Laboratory 2 so that you can report with more confidence what the outcomes of those experiments were. The goal of these statistical approaches is to be able to distinguish what is an actual, true effect apart from random chance ("*error*").

Many types of statistical tests are available. We have selected the tests in this laboratory because they are common for sensory analysis and will be appropriate to use for the experiments conducted in the rest of this manual. Please note that the methods shown below for comparing numbers are only appropriate for *within-subject designs* (i.e. the same people rating two different items; such as comparing the bitterness of two different brands of coffee). These analyses would not be appropriate for *between-subject designs* (i.e. different groups of people rate the same items; such as comparing males' ratings versus females' ratings for bitterness of just one brand of coffee). Between-subject analyses are very important for many types of experiments but are outside the scope of this manual.

LAB GOALS

- Identify the correct type of statistical analysis to conduct.
- Apply paired t-tests, sign tests, and binomial tests to sensory data.
- Report and interpret appropriate summary statistics.
- Make box and whisker plots to show the spread of data.
- Make graphs showing proportions for preference and difference tests.

PRE-LABORATORY

Read through the lab, and briefly answer the following questions:

1. Does a preference test give counts or numbers?
2. What test do you use to determine if your data are normal? What does a p-value below 0.05 mean for this test?
3. When data are not normal, do you use a paired t-test or a sign test?

When looking at preference data, do you use a one- or two-tailed test?

MATERIALS AND EQUIPMENT

These exercises should take about 120-180 minutes. The exercises describe how to run the analyses and create the charts. You will use these methods to complete the questions for the results this week.

Save the Excel sheets you make during this lab somewhere you can find them later. You will use these exact same methods to calculate your results for the rest of this course. If you save the Excel sheets we create in this lab, you can simply enter the new data at the end of each subsequent lab experiment. This will save you hours of time later.

Equipment/Materials
Data from lab 2
Computer
Microsoft Excel (365, 2016, or later)
Access to the internet

B. EXERCISES

EXERCISE 1: WHAT TYPE OF DATA, AND WHAT TYPE OF TEST?

When planning an experiment, you should decide what type of data you will collect. This will largely be decided by what type of questions you decide to ask. For this exercise, consider the questions asked and data collected as part of Laboratory 2.

1. The types of answers obtained in this course will be actual numbers or counts.
    a. *Interval, Ordinal, or Ratio data (actual numbers)* would be from questions like a line scale, or a category scale with sequentially increasing values.
    b. *Nominal data (counts)* means there are no actual numbers—instead, these are responses you have to count, such as how many yes vs no, correct vs incorrect, selected vs not selected, etc.
2. Consider each experiment and question type in Laboratory 2. Determine what type of data you collected for each. For example:
    a. For the sugar/maltodextrin data, you collected numbers on a line scale. To analyze these data, you will be comparing actual numbers.
    b. For the flavor identification experiment, people could be correct or incorrect in their identification. This is nominal data, which must be counted.

EXERCISE 2:

For this course, we will focus on ***within-subject*** data comparisons. We can do this because in the experiments in this lab manual, all subjects (students) rate all the samples in an experiment. So, you have multiple measurements from the *same person* that you are *comparing across different products*. Follow the steps below to analyze this type of data.

1. Obtain the data for the ratings of the different sugars/maltodextrin from Lab 2, experiment 1.
    a. When you first download the data, you may need to clean up the column headings. You can retitle the columns so that they make more sense to you and have shorter names.

   b. In the case of category scales, you may also need to convert text to numbers (e.g., “Dislike extremely” may become 1 and “Like Extremely” may become 9 on your scale). This all depends on what type of software you used to collect the data. Make sure if you do change the responses to numbers, you write down what the numbers mean.
   c. Each subject should have their own row in the dataset, and each sample should have its own column. For example:

	A	B	C	D	E
1	Subject	Fructose	Glucose	Maltodextrin	Sucrose
2	1	0	21	0	8
3	2	20	3	0	7
4	3	24	93	14	13
5	4	32	14	3	50
6	5	33	52	10	48

FIGURE **ERROR! USE THE HOME TAB TO APPLY HEADING 2,CHAPTER HEADING TO THE TEXT THAT YOU WANT TO APPEAR HERE.**-1: Data table set up for comparing numbers in Excel. Each subject has one row of data.

   d. Remember what type of scale you collected these data on. We used a visual analog scale that ranged from 0 (“None”) to 100 (“Strongest Ever”) for sweetness intensity.

2. We will start with comparing the sweetness of sucrose to the sweetness of lactose. First, we need to calculate the difference between the ratings given by each subject.
   a. Copy and paste your data columns into a new worksheet. This new worksheet is what you will want to save and use the rest of the semester to calculate your results.
   b. Create a new column in the Excel sheet. Title it “Sucrose – Lactose”
   c. Enter a formula into the new column to subtract the value in the lactose column from the value in the sucrose column. Like this:

	A	B	C
1	Sucrose	Lactose	Sucrose-Lactose
2	8	35	=A2-B2
3	7	2	

FIGURE **ERROR! USE THE HOME TAB TO APPLY HEADING 2,CHAPTER HEADING TO THE TEXT THAT YOU WANT TO APPEAR HERE.**-2: Formula for difference column in Excel.

d. Hit Enter. Then, hover your mouse over the bottom right corner of the cell you typed the formula in. A black plus sign appears. Double click, and this will fill your formula down the rest of this column. Like this:

Note: Do not simply subtract the total of the lactose column from the total of the sucrose column—you need the values for EACH subject (one per row) to be able to run the statistical analyses.

	A	B	C
1	Sucrose	Lactose	Sucrose-Lactose
2	8	35	-27
3	7	2	5
4	13	63	-50
5	50	6	44
6	48	4	44
7	6	0	6
8	25	23	2

FIGURE ERROR! USE THE HOME TAB TO APPLY HEADING 2,CHAPTER HEADING TO THE TEXT THAT YOU WANT TO APPEAR HERE.-3: Difference column in Excel.

3. Now that we have the difference values within subject, you need to determine if these different data are ***normally distributed***. Make sure you are testing whether your *differences* are normally distributed, not the original numbers. The normality test determines which type of analyses you can run on the data. We will use the ***Shapiro Wilk test***. You can use statistical software to run this test, or you can use an online calculator. A couple links are given below. In both the links, you simply need to copy/paste your column of data into the field provided. If you are given the option, set ***alpha*** to 0.05.
   a. http://www.statskingdom.com/320ShapiroWilk.html
   b. http://contchart.com/goodness-of-fit.aspx
4. Look at the ***p-value*** for the Shapiro Wilk test.
   a. Is your p-value GREATER than 0.05? Then your data ARE normally distributed.
   b. Is your p-value LESS than 0.05? Then your data are NOT normally distributed.
   c. Make sure you report the p-value for the Shapiro Wilk test with the rest of your results (see below).

Now you will need to select a path based on whether your data are normally distributed.

Normally distributed data:

5. For normally distributed data, use a ***paired t-test*** to evaluate your data.

This test is for comparing numbers given from the same subjects tasting two products (like rating sweetness for two types of muffins). The test will tell you if the ratings for the two products are different, accounting for the variability within your data.

a. In the spreadsheet, set up the following cells:

	Means	SD
Sucrose		
Lactose		
Paired t-test		

FIGURE **ERROR! USE THE HOME TAB TO APPLY HEADING 2,CHAPTER HEADING TO THE TEXT THAT YOU WANT TO APPEAR HERE.**-4: Results table set up for comparing numbers from normal data in Excel.

b. Enter the following formulas in the cells (note: the difference formulas in column C should be in place from step 2c):

	A	B	C	D	E	F	G
1	Sucrose	Lactose	Sucrose-Lactose				
2	8	35	=A2-B2			Means	SD
3	7	2	=A3-B3		Sucrose	=AVERAGE(A:A)	=STDEV.S(A:A)
4	13	63	=A4-B4		Lactose	=AVERAGE(B:B)	=STDEV.S(B:B)
5	50	6	=A5-B5				
6	48	4	=A6-B6		Paired t-test	=T.TEST(A:A,B:B,2,1)	

FIGURE **ERROR! USE THE HOME TAB TO APPLY HEADING 2,CHAPTER HEADING TO THE TEXT THAT YOU WANT TO APPEAR HERE.**-5: Formulas for analyzing normal data comparing numbers in Excel.

c. The formula for the paired t-test (T.TEST) will give you the p-value comparing the data in columns A and B. The "2" tells the program this is a "*two-tailed test*" meaning you want to know if column B is higher *or* lower than column A. The "1" tells the program that you are running a paired test.
   i. A value *LESS than 0.05* for the paired t-test *indicates a difference* between your samples.
   ii. A value *GREATER than 0.05* for the paired t-test *indicates no difference* between your samples.

d. For this class, use this table to report the results of a paired t-test:

Paired t-test (Shapiro Wilk p=0.09)	*Means*	*SD*
Sucrose sweetness	54	28
Lactose sweetness	10	11
Number of subjects	55	
Paired t-test p-value	7E-15	
Result: *Sucrose was sweeter than lactose.*		

Non-normally distributed data:

6. For non-normally distributed data, use a *sign test* to evaluate your data.
   This test will tell you about whether, at a rate greater than chance, people rated one sample as higher than the other. Essentially, you assign a negative, 0, or positive to all of the differences

between samples, and the test tells whether you have significantly more negative or positives values. Hence, the "sign" test.

a. Create a new spreadsheet, and set up the following cells:

	Median	25%	75%	
Sucrose				
Lactose				
Negatives				
Positives				
Zero				
N for test				
Sign test				

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b. Copy your data into the new spreadsheet, as columns A & B (just like in 2-2c above).

c. Enter the following formulas in the cells:

	A	B	C	D	E	F	G	H
1	Sucrose	Lactose	Sucrose-Lactose					
2	8	35	=A2-B2			Median	25%	75%
3	7	2	=A3-B3		Sucrose	=MEDIAN(A:A)	=PERCENTILE.EXC(A:A,0.25)	=PERCENTILE.EXC(A:A,0.75)
4	13	63	=A4-B4		Lactose	=MEDIAN(B:B)	=PERCENTILE.EXC(B:B,0.25)	=PERCENTILE.EXC(B:B,0.75)
5	50	6	=A5-B5					
6	48	4	=A6-B6		Negatives	=COUNTIF(C:C,"<0")		
7	6	0	=A7-B7		Positives	=COUNTIF(C:C,">0")		
8	25	23	=A8-B8		Zero	=COUNTIF(C:C,0)		
9	74	20	=A9-B9		N for test	=F6+F7		
10	50	6	=A10-B10					
11	37	25	=A11-B11		Sign test	=2*BINOM.DIST.RANGE(F9,0.5,MAX(F6:F7),F9)		

FIGURE ERROR! USE THE HOME TAB TO APPLY HEADING 2,CHAPTER HEADING TO THE TEXT THAT YOU WANT TO APPEAR HERE. 7: Formulas for sign test in

d. The formula for the sign test (BINOM.DIST.RANGE) will give you the p-value for whether you have significantly more negative or positive values. The first number in the formula (from F9 in this worksheet) is the total number of *non-zero differences*—in other words, ties do not count in this analysis. The next number is the value for *chance*—in this case, there are only two options, positive or negative (because we are not counting the zeros), so the random chance is 0.5. The third number, given from the "MAX" formula, is the larger of your counts. So, if you had more positive values, this would be the count of positive differences. The final number is the total non-zero differences again. We multiply the answer by two, because this is a ***two-tailed test*** (one sample can be higher *or* lower than the other).

e. The range from 25% to 75% is called the ***semi-interquartile range***. We report this as part of the results when we do a sign test.

f. A p-value *LESS than 0.05* for the sign test indicates that a significant number of people rated *one sample higher than the other*. If you find a significant results, make sure you also report *which* sample was rated higher. To know which was higher, look at your positive and negative counts.
    - If you had more positive counts, that means whatever sample you have in column A was rated higher.

- o If you had more negative counts, that means the sample in column B was rated higher.

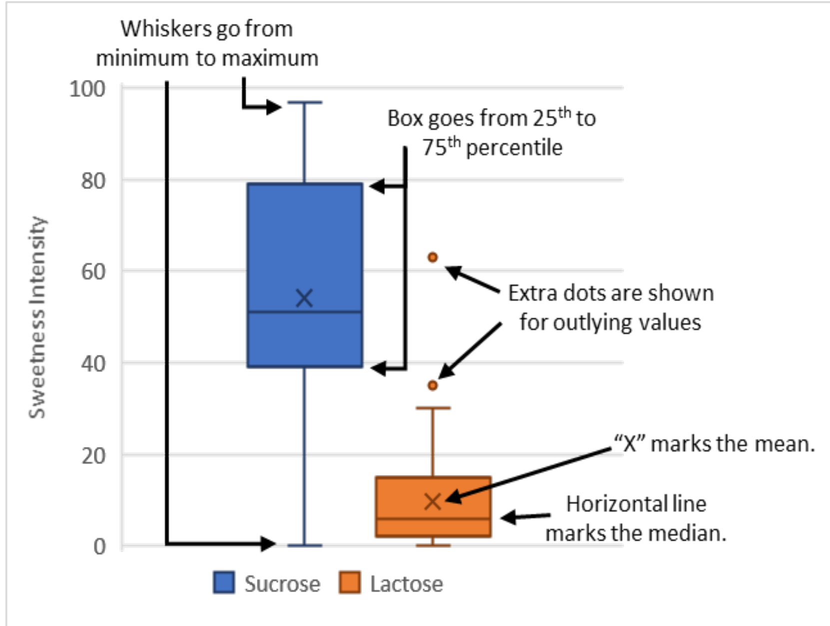
g. A p-value *GREATER than 0.05* for the sign test indicates *no difference* in the ratings between your samples.

h. For this class, use this table to report the results of the sign test:

Sign Test (Shapiro Wilk p=0.01)	*Median*	*25%*	*75%*
Sucrose sweetness	51	39	79
Lactose sweetness	6	2	15
Number of subjects	55		
Sign test p-value	9E-12		
Result: Sucrose was sweeter than lactose.			

EXERCISE 3: GRAPHS FOR COMPARING NUMBERS

We will use *box and whisker plots* to display the data in this course. These are built into Excel 2016 (and later), and we will use the same plot regardless of whether your data are normally or non-normally distributed. Figure 3-8 shows an example. These plots show the minimum and maximum values for a range of data, 25th to 75th percentile, mean, median, and any outliers in the dataset. Other software would allow you to edit this figure (for example, to change the percentiles of the boxes), but the Excel version is adequate for this course.



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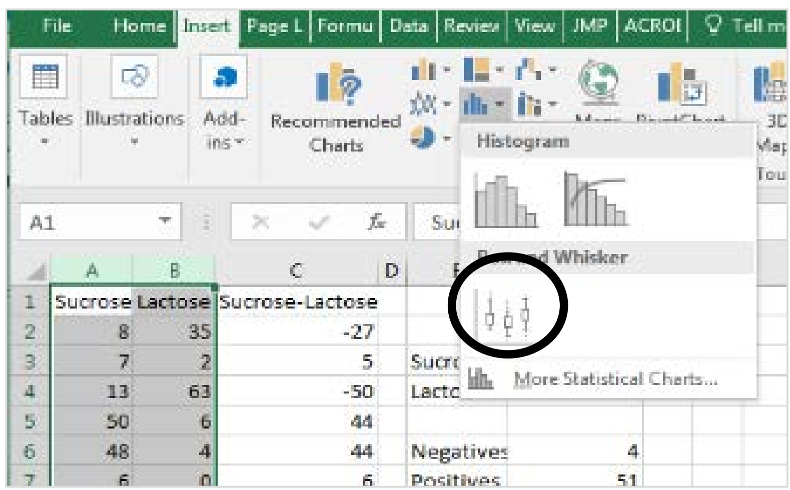
To make a box and whisker plot in Excel 2016, simply select the columns of data you are interested in graphing, and then select the box and whisker plot from the insert chart menu, as shown in Figure 3-9.



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You will need to make some edits from the default options on your chart after inserting it. Some important changes to make the graph more accurate, legible, and descriptive are shown in Figure 3-10.

Make sure you think about how your figure would print in greyscale if someone decides to print your report. For example, in Figure 3-10, we might want to darken the blue or lighten the orange in order to make them easier to tell apart in grey.

Also think about whether individuals who have color blindness can tell your colors apart. Blue and orange or purple and yellow are combinations that make your colors discriminable for most people. Please do not use red and green!

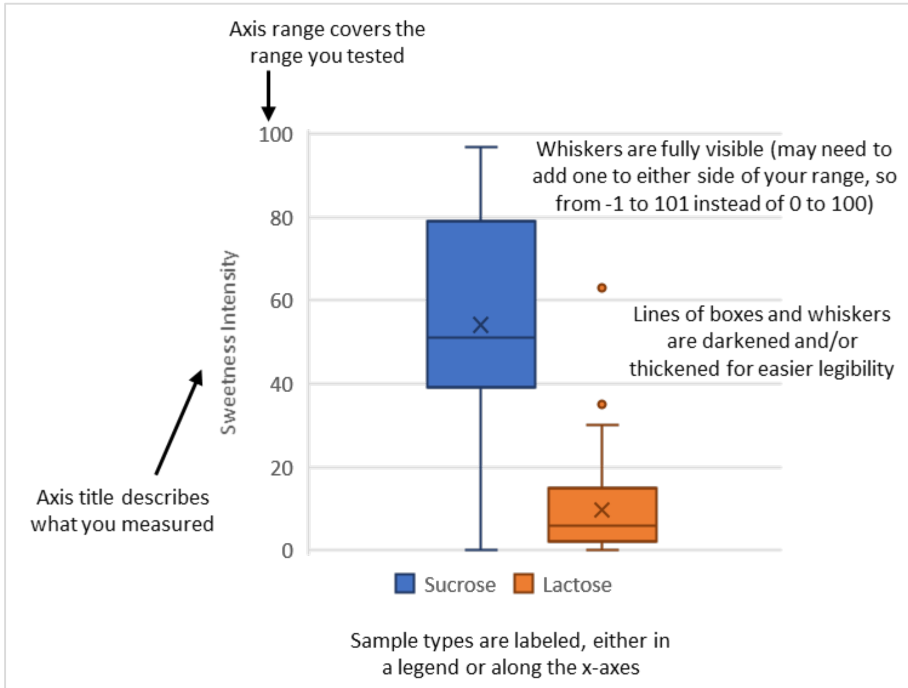


FIGURE **ERROR! USE THE HOME TAB TO APPLY HEADING 2,CHAPTER HEADING TO THE TEXT THAT YOU WANT TO APPEAR HERE.**-10: Important graph components to label and/or correct. Make certain you also include a caption, like this one!

Finally, make sure you insert a figure caption. The caption should be informative, describing what happened in your data, how you tested that (i.e., paired t-test or sign test), and the p-value for the test. For this chart, an example caption would be: "Figure 1: Sucrose was sweeter than lactose (p<0.05, paired t-test)."

EXERCISE 4: COUNTING THINGS

For data where the outcomes are counts, we will analyze whether those counts are likely to be different from chance. For this class, we will only discuss ***binomial data***, where there are only two possible outcomes, such as yes/no, selected/not selected, preferred/not preferred, correct/incorrect. Similar analyses can be applied when there are more than two possible outcomes (i.e. when subjects are given the option of yes/no/maybe instead of just yes/no). However, we will not discuss them for this manual.

1. Set up an Excel sheet like this:

	A	B	C	D	E	F
1	Trials		Correct/Preferred XXX		Difference test	=BINOM.DIST.RANGE(B1,B2,D1,B1)
2	Chance		Correct/Preferred YYY		Preference test	=2*BINOM.DIST.RANGE(B1,B2,MAX(D1:D2),B1)

FIGURE **ERROR! USE THE HOME TAB TO APPLY HEADING 2,CHAPTER HEADING TO THE TEXT THAT YOU WANT TO APPEAR HERE.**-12: Formulas for binomial tests

2. Enter the following formulas into the spreadsheet:

a. The ***difference test*** formula is entered as:

1. =BINOM.DIST.RANGE(Trials, Chance, Successes, Trials)

b. The ***preference test*** formula is entered as:

2. =2*BINOM.DIST.RANGE(Trials, Chance, Highest preferred count, Trials)

3. The "MAX()" formula will look at all the counts you enter for the number of times specific samples were selected as preferred. By using this MAX formula, you can list your samples in any order.

In the preference analysis, we multiply the result by 2 because this type of test can have ***two tails***. In other words, a sample could be selected more often or less often, in addition to having no difference in the number of times it was selected. Thus, we test both "tails" for the statistical test. For difference tests, people can only be correct or incorrect—there is no direction to that correctness. It simply is or is not correct. Thus, there is only one "tail" for the statistical test.

3. Begin analysis of binomial data by determining your total number of trials. This number goes in cell B1.
    a. Often, this will be the number of students in the class.

    For example, for the triangle test in Laboratory 2, the number of trials is the number of students in the class who completed the experiment.

    b. The exception is if students did more than one trial each (for example, if you did two triangle tests each instead of just one). In these cases, we will analyze the data as if those tests were simply additional students. Technically, there are better ways to analyze such "repeated" data (one subject does the same thing more than once), but they are beyond the scope of this course.

    An example of this exception is the flavor identification test from Laboratory 2, where all students did 5 tests each under each condition; so the number of trials for the nose open analysis would be 5 times the number of students who completed the experiment.

4. Next, determine the chance someone could have selected a response/sample by accident. This number goes in cell B2.
    a. For example, if you did a triangle test, the odds of selecting the different sample by accident are 1/3.
    b. For preference data, this would be the chance of selecting a particular sample at random. In a paired preference test, you have two samples, so this is 1/2.
    c. For the flavor identification test in Laboratory 2, you had five flavors. So, what are the odds someone could be correct by chance?
5. Next, count the number of responses in each category. These values go in cells D1 and D2.
    a. For triangle, tetrad, and flavor identification the responses can be correct or incorrect. Enter the correct and incorrect counts into sheet.
        i. For tetrad test data, the responses are correct if the correct pairs are grouped together.

   ii. For triangle test data, if the person selected the different sample they are correct; otherwise, they are incorrect.
   iii. For the flavor identification test from Laboratory 2, you will need to add all of the values to calculate the total of correct responses under each condition (i.e. nose open, nose closed). So if had 3 people, and one was correct 4 times, another person was correct 3 times, and a final person correct 5 times, you would have 4+3+5 = 12 correct responses, leaving 3 incorrect responses.

  b. For preference tests, the categories are your two samples. Label the rows (shown as "XXX" and "YYY" in Figure 3-11) and enter the counts of how often each was preferred.

6. Determine which p-value you should be interpreting (difference or preference).
   a. If the p-value is *LESS than 0.05*, then it is unlikely that your result is due to chance. You can conclude that people *could* tell a difference, or that they *preferred* the most often selected.
   b. If the p-value is *GREATER than 0.05*, then it is likely that your results are due to chance. You must conclude that your subjects *could NOT* tell the difference between the samples, or that they *did NOT prefer* one sample over another.

7. Report your results for preference and difference tests in tables like these:

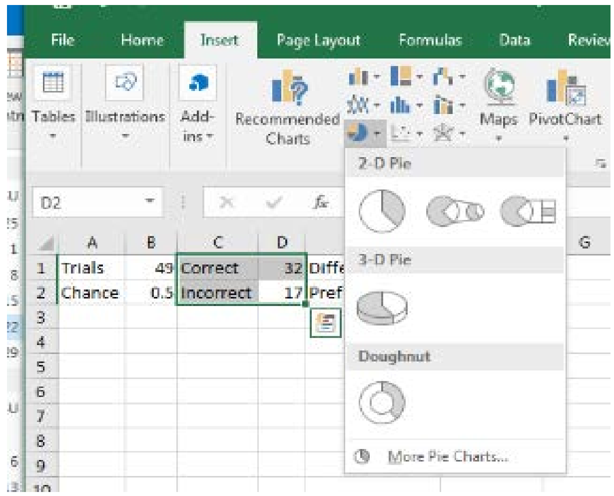
Paired preference test	
Preferred full fat muffin	40
Preferred low fat muffin	15
Total trials	55
Chance	0.5
Binomial test p-value	0.0005
Results: The full fat muffin was preferred over the low fat muffin.	

Triangle test for difference between full and low fat muffins	
Correct	25
Incorrect	48
Total trials	73
Chance	0.333
Binomial test p-value	0.48
Results: Subjects could not correctly identify the full fat muffin.	

EXERCISE 5: GRAPHS FOR COUNTING THINGS

For nominal data, we suggest either a *pie chart* or a *stacked bar/column chart* to display the information. These types of graphs quickly show the relative proportions in each outcome, without misleading the reader about the fact that there were only two possible outcomes.

1. Pie charts:
   a. Select your columns/rows for the correct/incorrect counts or preference counts. Then select pie chart from the insert charts menu, like this:



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   b. You will want to reformat the chart to include the data counts. Make sure there is also a legend to indicate which slice of the pie refers to which outcome. Insert a figure caption.

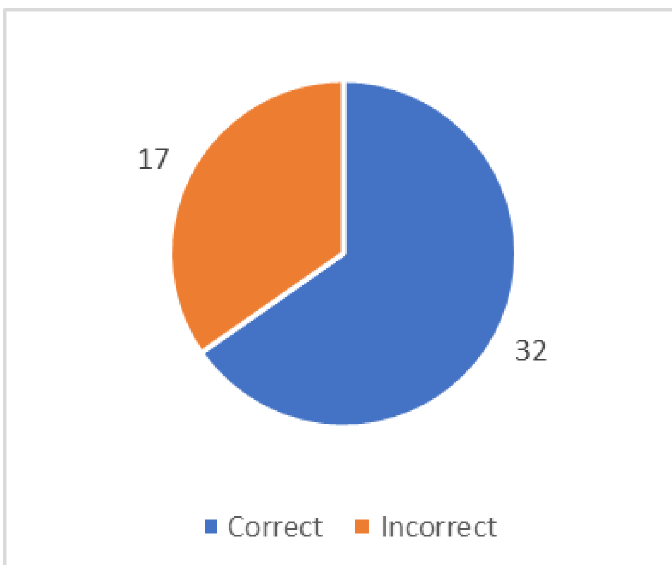

Figure **Error! Use the Home tab to apply Heading 2,Chapter Heading to the text that you want to appear here.**-14: Example of a pie chart. Your caption should include information on what type of test you did and whether the distributions of responses are significantly different from each other.

2. Stacked bar charts:
   a. These charts can be very useful when comparing two testing conditions and their effect on responses. For example, the flavor identification test in Laboratory 2 had two conditions: nose open and nose closed. You still have to analyze the data within each condition separately, but you can display the results side by side in a stacked bar chart.

b. Set up your data as before, but have separate columns for separate conditions, like this:

	Nose open	Nose closed
Correct	32	14
Incorrect	17	35

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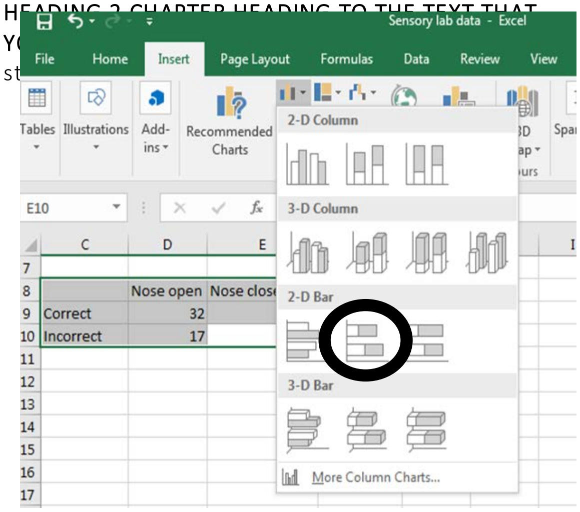
st

c. Select your data, then select a stacked bar chart from the insert charts menu.



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d. As always, ensure the data are displayed correctly, easy to read, and have appropriate labels for axes or other chart elements. Insert a figure caption.

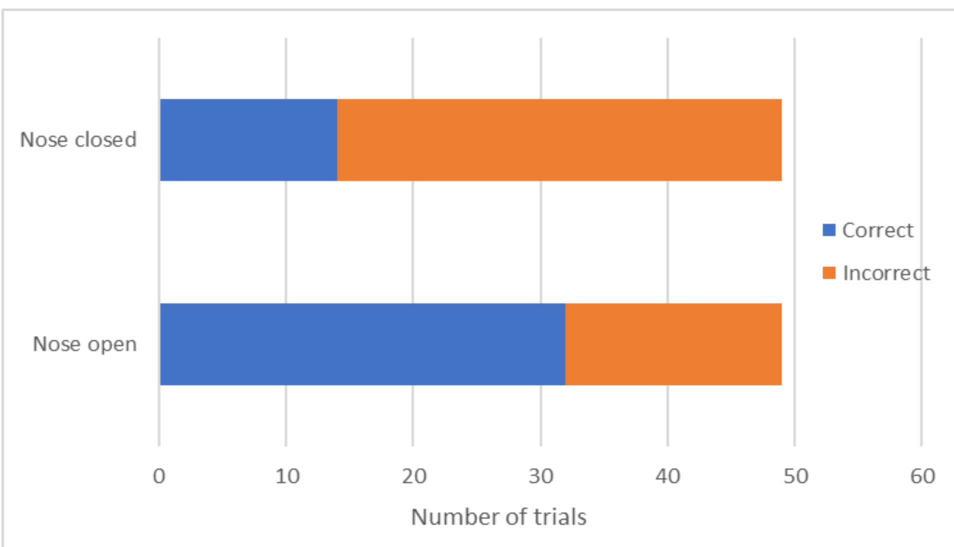

FIGURE **ERROR! USE THE HOME TAB TO APPLY HEADING 2,CHAPTER HEADING TO THE TEXT THAT YOU WANT TO APPEAR HERE.**-17: Example of a stacked bar chart. Your caption should include information on what type of test you did and whether the distributions of responses are significantly different from each other in each condition.

C. DATA AND RESULTS

Data: There are no data to upload/surveys to fill out this week.

Results: The questions below cover the full range of types of questions you can answer using the data analyses presented above. To practice, answer all of the questions. For grading, we look at the questions in bold font (use appropriate statistics, tables, and charts to answer those questions)

Download and use the class data to answer the following questions:

All students:

Use the class data from Laboratory 2 to do the following:

a) Compare sucrose to the others sugars/maltodextrin using statistics.
    a. You should have 4 total comparisons. You will need to analyze whether the differences are normal for EACH comparison, and determine whether to do a paired t-test or a sign test for each comparison. Report the Shapiro Wilk p-value for each comparison.
    b. Run either a paired t-test or sign test for each comparison, as appropriate according to the Shapiro Wilk p-value.
    c. Create a box and whisker plot for each comparison.
    d. From these analyses, were the other sugars/maltodextrin sweeter or less sweet than sucrose?
    e. Which was sweeter, sucrose or fructose?
b) From the flavor identification lab, determine whether people could correct identify the flavors:
    a. With their noses open
    b. With their noses closed
    c. Make a stacked bar chart showing these results.
c) Determine whether the class preferred one coffee creamer over the other.
d) Determine whether people could tell the difference between the coffee creamers:
    a. In a triangle test
    b. In a tetrad test
e) Determine whether one coffee creamer was rated as sweeter than the other:
    a. Using category scales
    b. Using line scales
f) Determine whether one coffee creamer was liked more than the other:
    a. Using category scales
    b. Using line scales

Food Chemistry: Experiments for Labs and Kitchens

Laboratory 4: Water

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Last updated 18 March 2020

LABORATORY 4:WATER

A. OVERVIEW

LAB BACKGROUND AND DESCRIPTION

The ***water activity*** of a food or ingredient is often more directly related to food properties than the actual ***water content*** (the mass or percentage of water in the food). Water activity is loosely defined as the available water for chemical and biological reactions in a product. Technically defined, water activity is equal to the ***equilibrium relative humidity*** of a product (i.e. the humidity at which water will not move into or out of the product). Water will always move from regions of high water activity to regions of low water activity.

Different chemical structures have different affinities for water, and those affinities are the main reason that water content and water activity are not the same. Sugar, for example, binds water quite strongly. Because of this, foods high in sugar tend to have lower water activities than similar low-sugar products. Even different types and sources of sugars can differ in their affinity for water. Similarly, salts bind water differently from each other. Because of this, saturated salt solutions can be used to control the humidity of an environment. We can use these saturated salt solutions to show how ambient humidity alters the movement of water into and out of various foods.

When different portions of a product have different water activities, water will move from the high to the low water activity region. This is why breakfast cereal becomes soggy in milk. To prevent this, foods should either be designed with similar water activities across the portions/segments of the food, or barriers can be used to block moisture migration. Such barriers are typically rich in fat, for example a layer of high fat chocolate coating a high moisture fruit filling. The ***hydrophobic*** (water-hating) nature of fat makes it good at stopping the movement of water.

The ***hydrophobic*** nature of fat compared to the ***hydrophilic*** (water-loving) nature of ingredients like salt and sugar are determined by the ***polarity*** of their structures. Structures are polar when they have electrical charges or partial charges, and non-polar when they are evenly charged across the entire shape. In general, polar solutes will dissolve in polar solvents, and non-polar solutes in non-polar solvents. Yet, most structures are not perfectly polar or non-polar, but somewhere in between. Thus, other factors such as temperature and time can influence how easily a structure is dissolved by a particular solvent.

In this lab, we will observe these properties of water by baking cookies, making coffee, and allowing cookies to sit in environments with different humidity.

LAB GOALS

- Predict moisture migration in foods based on water activity and ambient humidity.
- Explain how to prevent moisture migration.
- Observe how sugar sources with different affinities for water change texture of a cookie.
- Explain how temperature can influence extraction of flavors.

Optional:

Learn how to use: Water activity meter

PRE-LABORATORY

Read through the lab, and briefly answer the following:

1. The two cookie doughs in this lab have the same approximate water content. Where does the water come from in the brown cookie recipe to balance the added water in the white cookie recipe?
2. Research saturated salt (sodium chloride) solutions online.
    - What should the equilibrium relative humidity be for the salt solution?
    - What should the equilibrium relative humidity be for the pure water?
3. Look online to see what flavors may be brought during extraction of coffee beans. How do you think the different methods of coffee extraction in this lab will make the samples taste? Write your thoughts as a hypothesis.

MATERIALS AND EQUIPMENT

These experiments should take about 150 minutes total, but the final experiment requires the cookies to rest for a couple days. On campus students will take cookies home with them.

Equipment and Materials	Amount	Distance lab
None		In your packet
Coffee grounds	20 grams	Procure!
White table sugar	300 grams	
Molasses	20 grams	
Butter, melted and cooled *Non-dairy butter alternative is acceptable*	170 grams (1.5 sticks)	
Vanilla extract	1 teaspoon (~5 grams)	
Egg *Egg substitute is acceptable*	1	
All-purpose flour	165 grams 165 grams	
Baking soda	1 teaspoon (~6 grams)	
Salt (sodium chloride)	10 grams	
Water	45 grams	
Mixing bowls	2 large 2 medium	
Coffee filters	9	
Cups for hot beverages, 8 oz	6	
Mixing spoons or spatulas	2	
Cookie sheet	2	
Small portion cups (*on campus:* with lids), 1 oz	3	
Sandwich size container/Tupperware	3	
Oven (preheated to 375°F)		
Scale (with gram measurements)		
Camera (cell phone camera is fine)		
Device to access to online class survey online		

**Note:* This lab requires you to handle and eat cookies. If you choose not to eat the cookies, please find a willing person to eat the cookies for you. If you cannot physically handle the cookies, please notify your instructor immediately.

B. EXPERIMENTS

EXPERIMENT 1: WATER ACTIVITY OF SUGARS *(THE BATTLE OF THE CRISPY AND CHEWY)*

For this experiment, you will need the white sugar, molasses, butter (or alternative), vanilla extract, egg (or alternative), all-purpose flour, baking soda, salt (about 3 grams), water (2 grams), a scale, 2 cookies sheets, 1 large mixing bowl, and 2 medium mixing bowls. You will be making two types of cookies.

1. Preheat an oven to 375°F (190°C).
2. Take 2 medium mixing bowls, and label them “Brown” and “White.”
3. Melt 170 g (~1.5 sticks) of butter and put it in the large mixing bowl
    a. Make sure the butter is melted, but not hot. If it is too hot, it will cook the egg instantly!
4. To the butter, add 1 egg and 1 tsp (~5 g) vanilla extract.
5. Beat this mixture until the egg is fully mixed into the butter and vanilla.
6. Divide the mixture evenly into the Brown and White bowls
    a. You should have at least 115 g of mixture per bowl. This can vary due to differences in egg weights; just be sure that the amount of mixture in each bowl is <u>*equal*</u> to each other.
7. Add 140 g of white sugar and 20 g of molasses to the Brown bowl. Mix.
8. Add 156 g of white sugar and 4 g of water to the White bowl. Mix.
9. To <u>*each*</u> bowl, Brown and White, add:
    a. 165 g all-purpose flour
    b. 3 g, or ½ teaspoon baking soda
    c. 1 g, or ¼ teaspoon salt
10. Mix both batches of cookie dough until the doughs are consistent.
    a. Make sure you use clean spoons for each batch (you don’t want to accidently mix some of the Brown dough into the White dough).
11. Portion out twelve 25 g dough balls from each type of cookie dough (yes, really weigh them out! Make sure they are precisely 25 g). If you have extra dough, you may save it and cook it later. Arrange the dough balls on <u>*two*</u> cookie sheets like this:

White	Brown	White	Brown
Brown	White	Brown	White
White	Brown	White	Brown

12. Bake the cookies for 4 minutes, then rotate the trays so that the cookies that were in the back are now in the front, and cookie sheets that were on the bottom rack are now on the top.

13. Bake for an additional 4-6 minutes, until cookies are lightly browned (this may be easier to tell on the White cookies), the tops of the cookies look dry, and cracks appear in the surface of the cookies. See figure 4-1.
14. Remove the cookies from oven and allow to cool completely (about 1 hour).

FIGURE **ERROR! USE THE HOME TAB TO APPLY HEADING**

**Note:* You can continue on to Experiment 2 while you wait for the cookies to cool.

15. Take a picture of your cookies.
16. Access the online survey for this lab. Work with a partner, so that your partner can hand you the cookie to evaluate (this helps you to not be biased by the color of the cookie). The survey will lead you and your partner through the tasting steps, which involve feeling the texture of the cookies, chewing the cookies, and indicating which cookie you prefer. Make certain you keep your eyes closed so that you cannot identify which cookie was which from color.

    https://purdue.ca1.qualtrics.com/jfe/form/SV_9MMVz3ZOEh9XBnD

    a. Note: You will need to use 3 of either the white or the brown cookies for experiment 3.

EXPERIMENT 2: WATER EXTRACTIONS *(COFFEE COFFEE COFFEE COFFEE COFFEE)*

For this experiment, you will need coffee grounds, 3 coffee filters, a pot, stove, timer, thermometer, water, and 6 small cups for the different coffees. Note that this experiment may work better with fresher and bolder coffee grounds!

1. Obtain and label 6 foam cups with the following conditions (2 cups for each condition set; “100°C”, “88-93°C”, and “75-80°C”).
2. Take one cup from each condition and set them up with the filter and rubber band (Figure 4-2).

FIGURE 4-2: Put the coffee filter over the cup so that it is loose/dips into the cup. Place the rubber band around the filter/cup so that it stays when you pour the coffee through. Remember to label your cups as instructed, and include the usual sample label information (i.e., “Coffee 100C, Your initials, todays date)

3. Place 6 g of coffee grounds into the “100°C” cup without the filter.
4. Heat approximately 1L (just over 30 oz) of water on the stove to boiling.

   a. Make sure that this reads 100°C (212°F) on the thermometer once boiling. If not, be sure to note the temperature so that you can be conscientious of the thermometer error for your other measurements (if your water is boiling but the thermometer reads 95°C, be sure to measure your other temperatures appropriately; i.e. when you're supposed to have 80°C, water make sure your thermometer reads 75°C).

5. Once boiling, pour approximately the same amount of water (about 6 oz/177mL) into all 3 of the cups without filters (including the "100°C" cup with coffee grounds already inside).
   a. Set a timer for 4 minutes.
   b. After 4 minutes, pour the coffee/water into a cup with a filter attached to the top.
   c. Remove the filter/coffee grounds from the new cup, leaving the brewed coffee below.
6. The cups which have water but no grounds in them need to be monitored for temperature. Once they have reached their goal temperature (88-93°C or 75-80°C), add 6 g coffee, and set a 4 minute timer. After 4 minutes, filter out the coffee grounds by pouring the mixture through a cup with a filter on top, and remove the filter/grounds.
7. Wait for all coffees to be below 65°C, in order to avoid burning your mouth.
8. Open the online survey. Work with a partner; they will hand you samples so that you will not know which sample you are tasting. You will be rating the samples for bitterness and indicating which of a pair of samples you prefer.

   https://purdue.ca1.qualtrics.com/jfe/form/SV_1LnDuQgWE5BVPSt

**Note:* In actual sensory testing, you should never do intensity and preference testing in the same session.

EXPERIMENT 3: COOKIES IN TIME

For this experiment, you will need _either_ 3 white or 3 brown cookies (or cookie halves) from Experiment 1, as well as 2 small portion cups, water, 7 grams salt, and 3 sandwich sized containers. If you are on campus, you will need to take the cookies home with you in a container/plastic zip-top bag to observe later.

1. Label a portion cup "Salt", and add you initials and today's date.
2. In the "Salt" cup, make a solution of 7 grams of salt in 18 grams of water.
3. Label another portion cup "Water" and add 25 grams water to it.
4. Place one cookie in each container/bag (make sure you are using either white or brown cookies)
   a. If you are an *on-campus student*, place a lid on each cup of liquid (so they don't spill), and take these and the cookies.
5. Place the containers of cookies in a secure location where they will not be bumped or moved. Place the cup of liquid inside the container with the cookie (remove the lid). Make sure that the cup of liquid is open to the air inside the container with the cookie.

   **Note:* Do NOT put the cookies *in* the liquid. Just set them inside the container, *next* to a cup of the liquid. The liquid will control the relative humidity inside the container. By sitting in this more or less moist air, the cookie will change over time.

One container will have the pure water solution and cookie, one will have the salt solution and cookie, and one will have just the cookie.

Take a picture of your cookies and the solutions in their containers/bags.

6. Allow the cookies and solutions to sit undisturbed for two days.
7. After two days, open the containers/bags and remove the cookies. Break each cookie in half, noting the texture. Rank and note the cookies from hardest to softest.

**Note:* You will not submit these rankings with your data this week, but you will discuss them in the results.

C. DATA AND RESULTS

Data: Make sure you complete the online questionnaires about the cookies and the coffee.

Results: Download the class data and answer the following questions. You will be graded on your responses to the bolded questions. Make sure you use statistics, and report the results using the tables and charts in Laboratory 3.

All students:

Experiment 1: Brown/White cookies

a) Upload and label an image of your cookies on the baking sheet.
b) Was there a difference in the brown versus white cookie texture?
c) Was one cookie preferred over the other?

Experiment 2: Coffee extractions

d) Which coffee was the more bitter:
  - 88-93°C compared to 100°C coffee?
  - 75-80°C compared to 88-93°C coffee?
  - **75-80°C compared to 100°C coffee?**

e) Which coffee was preferred of:
  - 88-93°C compared to 100°C coffee?
  - 75-80°C compared to 88-93°C coffee?
  - 75-80°C compared to 100°C coffee?

Experiment 3: Cookies and humidity

f) If the water activity of your cookies was 0.84, would you expect your cookies to have lost or gained moisture after equilibrating inside the container with:
  - **The saturated solution?**
  - **The water?**

g) Insert a picture of your cookie set up from experiment 3-5. Make sure you include a caption.
h) How do your expectations from question g compare with what you observed when you touched the cookies after storage with the solutions?
  - If your expectations and reality do not match, what could be an explanation?

i) How could you measure whether your cookies lost or gained water?

Food Chemistry: Experiments for Labs and Kitchens

Laboratory 5: Dispersions

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Last updated 18 March 2020

LABORATORY 5:DISPERSIONS

A. OVERVIEW

LAB BACKGROUND AND DESCRIPTION

Foods are almost never pure chemical compounds. Even rather simple foods, such as lemonade, are ***mixtures***. When mixtures are ***homogeneous***, they are called ***solutions*** (such as sugar in water). When mixtures are not homogeneous, they form a type of ***dispersion***. Stability of dispersions play a big role in sensory and quality perceptions of food items. People tend to dislike and distrust beverages that have sediment on the bottom, for example. In the United States, people traditionally want apple juice to be clear and orange juice to be cloudy. Ranch style salad dressings are expected to be white and opaque, rather than forming two layers where the fats and water phases separate. Achieving these looks requires attention to the details on how the dispersions form and how they can be stabilized over time.

Dispersions can be mixtures of liquids, solids, and gases, but there are always at least two phases that will not completely mix. This lab will focus on ***suspensions*** (a solid dispersed in a liquid) and ***emulsions*** (two liquid phases that are immiscible, usually an oil and water phase). For suspensions, the simplest way to stabilize the solid particles is to thicken the liquid, slowing down the movement and trapping the solid particles so that they do not settle to the bottom of the mixture. When considering emulsions, the difference in ***polarity*** for oil and water will force the two phases to separate. Thickening the ***continuous phase*** of the emulsion can certainly help keep the ***dispersed phase*** from coming together, but better stability of emulsions can be achieved using ***surfactants***: surface active ingredients that have both water-soluble and fat-soluble parts to their chemical structure, such as soaps. Surfactants are able to stabilize the emulsions by binding both the polar and non-polar phases, which helps keep the dispersed phase from coming together as single layer. In this lab, we will demonstrate the function of suspension and emulsion stabilizing ingredients, as well as observe how the fat and water phases of emulsions behave.

LAB GOALS

- Observe behavior of metal flakes suspended in water. Explain how additives are (or aren't) functioning to stabilize the system.
- Observe phase inversion in an emulsion. Explain where the oil phases of the system begin and end, using an oil-soluble color as an indicator.
- Observe the effect of adding emulsifiers to emulsions, as well as how foods such as milk contain emulsifying components. Explain how emulsifiers function.

PRE-LABORATORY

Read the lab, and answer the following, briefly explaining your reasoning for each:
In which fluid from experiment 1 will the metal flakes sink the most? The least?

1. Will the oil soluble color start in the continuous phase or the dispersed phase of the cream at the beginning of experiment 2? At the end of experiment 2?
2. Give an example of a true emulsifier (has both polar and non-polar parts to its structure) and a stabilizer (does not have both polar and non-polar parts).

MATERIALS AND EQUIPMENT

These experiments should take about 120 minutes of hands on time, but one item needs to be prepared the day before (*on campus students* this will be prepared for you ahead of time, *distance students* need to plan ahead).

Equipment and Materials	Amount	Distance lab
Lecithin	0.5 grams (2 packs)	In your packet
Oil or water soluble food color (half the class should use oil, half water)	1 vial	
Metallic food color	1 vial	
Xanthan gum	0.2 grams (2 packs)	
Mono- and/or di-glycerides	0.1 grams (3 packs)	
Transfer pipettes	2 or more	
White vinegar (or lemon juice)	15 g	Procure!
Whole milk	80 g	
Skim milk	80 g	
Non-dairy milk (such as almond milk, coconut milk, soy milk)	80 g	
Vegetable oil (or olive oil)	500 g	
Water	1100 g	
Heavy cream	100 g	
250 mL clear cups or beakers	5	
Small clear cups or test tubes	11	
Blender or mixer **Note:* can be done with a whisk and bowl, but will take longer		
Microscope *(distance* optional—you can actually get a simple microscope online for fairly cheap if desired)		
Slides and coverslips *(distance optional)*	11 of each	
Camera (cell phone camera is preferred for this test)		
Scale (with gram measurements)		

*Note: We give these measurements in grams because you will use that in the lab. For buying these items, volume measurements are often more helpful. Since fat is less dense than water, multiply the gram measurements by 1.1, get at least that many milliliters, and you should have plenty.

If you are unwilling to work with dairy products for any reason, you may either simply observe (on campus students only) or you may elect to test these same experiments using dairy substitutes (distance students). We do not expect these experiments to work the same way with dairy substitutes, but we would love to see your results and compare them to the rest of the class!

B. EXPERIMENTS

**Note:* when taking pictures, make sure you have a label in the image so that you can tell them apart later (you can physically include one with your set up, or edit the image on your phone and add one yourself). The label should indicate the type of sample, as well as the point in the experiment when you took the image (i.e. "Metal flakes in new xanthan gum, 1 hour").

EXPERIMENT 1: SUSPENSIONS OF SOLIDS IN A LIQUID *(OOOOO, SPARKLY!)*

You will need the metallic food color, xanthan gum, 1 pack of mono/diglycerides, blender/mixer/whisk with bowl, water, scale, and the 250 mL clear cups/beakers for this experiment.

Distance students - Day before experiment:

1. Using the mixer/blender/whisk and bowl, disperse 0.2 grams of the xanthan gum in 100 g of water and mix thoroughly until no clumps are visible, at least 30 seconds (more for hand mixing).
2. Pour into a cup/beaker and label it "Rested xanthan gum."
3. Allow it to rest for 24 hours.

On campus students, your instructors will provide you with this pre-dispersed gum solution.

Day of experiment:

1. Using the mixer/blender/whisk and bowl, disperse 0.2 grams of the xanthan gum in 100 g of water and mix thoroughly until no clumps are visible, at least 30 seconds (more for hand mixing).
2. Pour into a cup/beaker and label it "Unrested xanthan gum."
3. Heat 100 g of water to just before boiling.
4. Mix 0.1 g mono/diglycerides into the hot water. Ensure the particles melt and mix in well.
5. Allow the mixture to cool, then blend in the blender/mixer/whisk with bowl for at least 30 seconds (more for hand mixing).
    a. If you are using a blender, adding a hot mixture to the blender can be dangerous. Steam can form and cause the mixing container to explode. Use caution, and make sure the solution is almost to room temperature before blending.
6. Pour the mixture in to a cup/beaker and label it "Mono/Diglycerides."
7. Put 100 g of water into the last cup/beaker, and label it "Water."
8. Shake the metallic food color vigorously to ensure the flakes are dispersed.
9. Add 10 drops of metallic food color to each mixture.
10. Mix each dispersion gently with a clean spoon for 15 seconds.
11. Take a picture of your mixtures just after you stop stirring.
    a. You will probably need to take the pictures individually, as the suspensions may settle while you stir the other mixtures.
12. After stirring each solution, wait 2 minutes, then take another picture (do not stir).
13. Allow the mixtures to rest for an hour (still not stirring), then take another picture (still, do not stir)

EXPERIMENT 2: EXPERIMENT 2: PHASE INVERSIONS (BEAT IT. JUST BEAT IT.)

You will need the cream, a transfer pipette, oil or water-soluble food color, vinegar, a ~250 mL clear cup/beaker, and a mixer (or blender ball in sealed cup, or a whisk and a lot of patience and muscles) for this experiment. Half the class should use the oil-soluble color, and half the water-soluble color.

1. Add 3 drop of the color to 100 g of cream. Mix gently to disperse.
2. Take a picture of the colored cream.
3. Mix the cream on high or whisk vigorously.
    a. The cream will become whipped cream first, then the whipped cream will start to look curdled. Keep mixing.
    b. Eventually, you will observe solid pieces forming in the mixture. Keep mixing.
    c. When all the solid pieces start to come together, you may stop. Use a fork or small slotted spoon to remove the solid butter from the liquid.

    **Note*: This will take a while! The length of time depends in the speed and efficiency of the mixing.

    d. Take a picture of your solid butter and liquid.
4. Take the liquid from the bowl and put it in the 250mL clear container.
5. Add the 15mL vinegar/lemon juice to the liquid.
6. You should see some solids forming the in liquid. Allow these to settle out on the bottom of the container.
7. After the solids have settled, examine the liquid again. Take a picture, tilting the cup/beaker as necessary to see the color of the liquid vs. any color in the solids that settled to the bottom.

EXPERIMENT 3: OIL IN WATER, WATER IN OIL, AND THE MAGIC OF MILK

You will need the oil-soluble food color, a blender, a small bowl, a fork, lecithin, detergent, vegetable oil, water, whole milk, skim milk, non-dairy milk substitute, 11 clear cups/test tubes, microscope and slides/coverslips (*on campus students*), device to access the online survey (for students using a microscope), and a camera for this experiment.

1. Refer to Table 5-1 for the different ingredients for the emulsions.
2. For emulsions 1 – 4, follow these steps:
    a. Put the oil in the blender. Add the additive (where applicable) and food color.
    b. Turn the blender on. Allow ingredients to mix for 30 seconds.
    c. With the blender still on, pour in the water <u>very slowly</u>.

    **Note*: Add just a few drops of water at a time, or this may not work!

    d. Allow the blender to run for at least 30 seconds more.
    e. Stop the blender. Pour the emulsion into a clear cup or test tube (label it!)
        i. If it does not all fit, you may discard the extra.
        ii. Take a picture of the emulsion.
        iii. Clean the blender.
    f. *Students using microscopes*: Put one drop of the emulsion on a microscope slide and place the coverslip on top. Look at the emulsion under the microscope. If possible, hold your cell phone camera up to the eye piece, and take a picture of what you see. If your

camera will not work, draw a picture of what you see, noting where the color is if possible (in the bubbles, or in the continuous phase).

3. For emulsions 5 – 8, follow these steps:
    a. Put the water in the blender. Add the additive (where applicable).
    b. Turn the blender on. Allow ingredients to mix for 30 seconds.
    c. Use the small bowl and fork to mix the food color and oil together.
    d. With the blender still on, pour in the colored oil very slowly.

Note: Add just a few drops of oil at a time, or this may not work!

    e. Allow the blender to run for at least 30 seconds more.
    f. Stop the blender. Pour the emulsion into a clear cup or test tube (label it!)
        i. If it does not all fit, you may discard the extra.
        ii. Take a picture of the emulsion.
        iii. Clean the blender.
    g. *Students using microscopes*: Put one drop of the emulsion on a microscope slide and place the coverslip on top. Look at the emulsion under the microscope. If possible, hold your cell phone camera up to the eye piece, and take a picture of what you see. If your camera will not work, draw a picture of what you see, noting where the color is (in the bubbles, or in the continuous phase).
    h. Upload your images from the microscope to the online survey.
4. For emulsions 9 – 11, follow the instructions for step 3 (emulsions 5 – 8), except use the milk products where the instructions say "water."
    a. *Students using microscopes*: When looking through the microscope, note any unique features when looking at the milk emulsions compared to emulsions 1 and 5.
    b. Make sure to look at the emulsions through the microscope, if you have access to one, and upload images.
5. After finishing all the emulsions, wait 5 minutes.
    a. You are allowing the emulsions to settle.
6. Take a picture that includes all the emulsions in the clear containers (making sure the labels are legible).

Table 5 -1: Emulsion ingredients

Emulsion	Oil (g)	Water (g)	Milk (g)	Food Color (oil soluble)	Additive
1	80	20	--	3 drops	Nothing
2	80	20	--	3 drops	Lecithin, 0.5 g
3	80	20	--	3 drops	Monoglycerides, 0.1 g
4	80	20	--	3 drops	Detergent, 0.5 g
5	20	80	--	3 drops	Nothing
6	20	80	--	3 drops	Lecithin, 0.5 g
7	20	80	--	3 drops	Monoglycerides, 0.1 g
8	20	80	--	3 drops	Detergent, 0.5 g
9	20	--	80, whole milk	3 drops	--
10	20	--	80, skim milk	3 drops	--
11	20	--	80, non-dairy milk	3 drops	--

C. DATA AND RESULTS

Data: There are no data this week but make certain you have all the images from this lab saved (and labeled, so you know which is which!).

Results: Answer the following.

**Note that this lab has many pictures.* You may need to reduce the size of your pictures in order to keep your file size small enough to upload to the course webpage. DO NOT simply shrink them down on the page, as they may become too small to see. You actually have to re-save the images as smaller files. There are many ways to do this—you will need to figure it out! Many phones can do this if you e-mail the images to yourself; the phone will ask you what size of file you wish to send. Make sure you can still see the image clearly after reducing its size.

If you have trouble, we recommend putting all your figures/images (clearly labeled, clearly visible, with captions) on one or two pages. Take a screenshot of those pages (use the PrtScn button on your keyboard, or Shift-Command-4 on a Mac), crop it appropriately, and insert into your file as one or two images. This will substantially reduce the size of your document. Try to keep your file under 10MB for optimal performance of the software.

All students:

Experiment 1: Suspensions

a) Show your pictures of the suspensions immediately after stirring, after 15 minutes, and after 1 hour.
b) Rank the suspensions in order of stability. If you observed no difference between some of the suspensions, say so. Use your images to justify your results.

Experiment 2: Phase inversion

c) Show images of your colored cream and butter, and of your liquid after adding the vinegar.
d) Draw a picture representing the continuous and dispersed phases for the cream and butter. Label the fat and water and indicate where *your color* would be located, noting whether it was oil- or water-soluble.

Experiment 3: Oil in water, water in oil, and the magic of milk

e) Show images of your emulsions:
    - Immediately after blending
    - After resting
f) Rank the milks for how well the oil soluble color dispersed into them. Use your images to justify your results.
g) What is present in each of the following that helps make the oil-soluble color disperse more evenly?
    - Cream
    - Skim milk
    - Whole milk

Food Chemistry: Experiments for Labs and Kitchens

Laboratory 6: Phases and Crystallization

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Last updated 18 March 2020

LABORATORY 6: PHASES AND CRYSTALLIZATION

A. OVERVIEW

LAB BACKGROUND AND DESCRIPTION

Matter generally exists in three states: solid, liquid, and gas. While other states of matter exist (e.g., plasma, supercritical fluid), these three are the most relevant to foods. In solid state, other subclasses of matter are also possible: ***amorphous*** or ***crystalline*** solids. Within amorphous solids, there are ***rubbery*** (more liquid-like) and ***glassy*** (more solid-like) solids. Within crystalline solids, there are different ***lattice*** (types of repeating units) arrangements. These different states and sub-states of matter change the characteristics of a food, as well as how it behaves.

For this laboratory, we will begin by observing the process of water crystallization into ice. Using different types of water, we can observe how ***nucleation sites*** (the tiny spots where crystallization begins) and freezing time influence the growth of ice crystals, and how that changes the properties of the ice. Next, we will observe how thermal energy melts cocoa butter crystals in chocolate, and how the temperature to which the chocolate is heated influences how that cocoa butter recrystallizes. Finally, we will observe how the solid/liquid nature of fat influences sensory characteristics of a high fat food.

LAB GOALS

- Observe ice crystal formation. Explain how the source of water and freezing time influences crystal formation.
- Observe cocoa butter crystal melting and recrystallization. Explain how the heating and cooling process affects the crystals of fat and the subsequent chocolate texture.
- Observe and taste frosting made with different types of fat. Explain how the properties of the fat are (or are not) influencing the analytical and sensory properties of the frosting.

Optional:

- Learn how to use:
    - Texture Analyzer
    - Viscometer

PRE-LABORATORY

Read the lab and answer the following, briefly explaining your reasoning for each:

1. Which water will make the clearest ice?
2. What region of ice will be the clearest (top, middle, bottom)?
3. Which forms of crystal lattice will chocolate cooled in a refrigerator be likely to take: α, β', β?
4. What are the melting points of butter, coconut oil, vegetable oil (soybean oil), and vegetable shortening (Crisco type product)?
    - How does the melting point influence texture in the mouth for frostings made with these fats/oils?

MATERIALS AND EQUIPMENT

These experiments must be done over the course of at least 24 hours, with approximately 2 hours of active sample preparation time.

On campus students will prepare ice samples for testing, but then will be provided with a set of samples to observe. *Distance students* will need to plan to conduct the experiment over 24 hours, at least, to allow for freezing of the ice.

Equipment and Materials	Amount	Distance lab
None		In your packet
Tap water	2 L	Procure!
Distilled water	1 L	
Dark chocolate bar	1, at least 40 grams	
Milk (room temperature)	90 grams	
Butter (room temperature, do not microwave)	60 grams	
Coconut oil	50 grams	
Vegetable oil	50 grams	
Vegetable shortening (like Crisco)	50 grams	
Powdered sugar	720 grams	
Plastic microwavable containers	2	
Plastic wrap or parchment paper	Enough to spread chocolate on	
Foam cups, at least 32 oz in size (about 1 L)	6	
Freezer (must have enough space to store all 3 foam cups, filled with water, upright)	1	
Mixing bowls, at least 500 mL (2 cups) in size	4	
Kitchen thermometer, must go down to 25°C/72°F	1	
Stove, microwave, or kettle for boiling water		
Forks, spatulas, or other stirring utensils	4	
Partner		
Camera (cell phone camera is fine)		
Scale (with gram measurements)		
Device to access to online class survey online		

**Note: Alternative or vegan varieties of milks/butters should work just fine in this lab. Dairy free chocolates should also work, as long as they actually contain chocolate or cocoa butter. Look for these in the ingredient statement: cocoa butter, cacao, cocoa liquor, cocoa solids. Products make from palm kernel oil will not work.*

B. EXPERIMENTS

EXPERIMENT 1: ICE CRYSTALLIZATION *(A BARTENDER'S LAMENT)*

You will need the foam cups (6), distilled water, tap water, a way to boil water, and a camera for this test.

1. Label the foam cups as "Distilled water", "Tap water", and "Boiled tap water".
2. Fill a foam with cup with 750 g of distilled water, and another with 750 g tap water. Then, place these cups into the appropriately labeled "Distilled water" or "Tap water" cup (this way your samples are double-cupped).
3. Heat about 1 L of tap water to boiling. Then pour the boiling water into a foam cup, weighing out 750 g. (Note: the water will be evaporating, so weigh this out quickly). Then place this cup in the "Boiled tap water" cup (this way your sample is double-cupped).
4. Place all three samples into the freezer and allow them to freeze for 24 hours.
    a. **Note:* If you leave the cups for too long, the bottom may break out of the cup, which will allow any unfrozen water to escape. We recommend placing the cups inside another container/foam cup in case this happens.
5. Remove the cups from the freezer and allow them to sit out and thaw for 15 minutes.
6. Remove the ice from each cup.
    a. **Note:* The ice should have melted enough for you to take it out easily by now, but if not, you can peel off the foam, or place the whole cup in a sink with room temperature water to melt the outer layer of ice.
7. Take a picture of each ice block.
    a. Note the clarity of the ice, and any regional differences in clarity of the ice.

EXPERIMENT 2: COCOA BUTTER CRYSTALLIZATION *(A CANDY-MAKER'S LAMENT)*

You will need a chocolate bar, two microwaveable plastic containers, two forks/spatulas, a microwave, plastic wrap or parchment paper, access to the online survey, and a camera. If you have a kitchen thermometer that goes down to 86°F/30°C, it will be very helpful.

1. Label one plastic container "Long time" and the other "Short time".
2. Break the chocolate bar in half, placing one half in each plastic container.
3. Break up the chocolate bar halves into smaller pieces.
    a. Aim for ½ in^2 size pieces.
    b. Make sure the size and number of pieces are similar in both containers.
4. Different brands of chocolate and microwaves will lead to slight differences in the melting of the chocolate. You are aiming to just barely melt one sample of chocolate ("Short time"), which will leave it in the ideal crystal form. The other sample ("Long time") you are trying to melt well past the melting point for the optimal type of crystal in cocoa butter. However, you need to avoid scalding the chocolate. If your chocolate is bubbling, you have gone too far! Follow these guidelines to achieve the two different levels of melted chocolate:
    a. Heat the "Short time" container of chocolate for 20 s.
    b. Stir the chocolate ("stirring" may be more like "pushing" at this stage).
    c. Repeat steps a and b until the chocolate is just barely fully melted. This should take about 4-6 cycles of heating and stirring, and should occur at about 94°F/34°C. Stirring the

chocolate is critical to make sure that you are distributing the heat, and that you can tell when you reach the point where all of the chocolate just melted.

   d. Repeat this process with the "Long time" container. However, after you note this chocolate is fully melted, add 6 more heating/stirring cycles. The goal here is to heat the chocolate past 98°F/37°C, without burning or scalding the chocolate.

   4. **Note:* After the chocolate has melted initially, if you notice hard lumps reforming in the "Long time" chocolate after a heating cycle, you may be burning or scaling the chocolate. Stir it very thoroughly and wait at least 30 seconds before placing it back in the microwave.

5. Scoop the chocolates out of their containers and spread them onto the plastic wrap or parchment paper. Make sure you label them!
6. Place the chocolate in a refrigerator for at least 30 minutes.
7. After 30 minutes, remove the chocolate from the refrigerator. Allow it to rest for 10 minutes.
8. Remove the chocolates from the plastic/paper, if possible. Take a picture of the chocolates after you remove them. Note down if one chocolate held its shape better than the other.
9. Open the online survey to record your responses. Work with a partner and follow the directions to complete the following tasks. These should be completed with your eyes closed. https://purdue.ca1.qualtrics.com/jfe/form/SV_9M0FCZAgeGqHfO5
   a. Touch the chocolates. Which chocolate is harder?
   b. Break the chocolates in half (if they are solid). Which one was easier to break?
10. *Optional:* Use a Texture Analyzer to determine the amount of force needed to cut the chocolates. Refer to the digital appendix.

EXPERIMENT 3: FAT PHASE (A WEDDING CAKE'S LAMENT)

You will need the milk (room temperature), butter (room temperature), coconut oil, vegetable oil, shortening, 4 mixing bowls, 4 mixing utensils (forks, spoons, or spatulas), powdered sugar, a partner, access to the online survey, and a scale for this experiment. You will be making several types of frosting.

1. Mix together 60 grams of butter, 15 grams of milk, and 180 grams of powdered sugar until the frosting is smooth. This may take a few minutes.
2. Mix together 50 grams of coconut oil, 25 grams of milk, and 180 grams of powdered sugar until smooth.
   a. You may need to heat the coconut oil (very slightly) to make it softer.
3. Mix together 50 grams of vegetable oil, 25 grams of milk, and 180 grams of powdered sugar until smooth.
4. Mix together 50 grams of shortening, 25 grams of milk, and 180 grams of powdered sugar until smooth.
5. Open the online survey. Follow the instructions on the survey, working with a partner to taste the samples. The goal is for you to not know and not see (close your eyes) which sample you are tasting when you give the ratings. https://purdue.ca1.qualtrics.com/jfe/form/SV_bEjtWOWefyZpexD
   a. You will be rating the following:
      i. How creamy was the frosting?
      ii. How much did you like the frosting?

6. *Optional:* Use a rheometer or viscometer to measure the viscosity of the frostings. Refer to the digital appendix.

C. DATA AND RESULTS

Data: Make sure you have entered your responses for the chocolate and the frosting ratings.

Results: Answer the following (you will be graded on the bolded questions):

All students:

Experiment 1: Ice crystallization

a) **Show your images of the ice blocks. Make sure these images (figures) are properly labeled.**
b) Explain the differences in the clarity of the ice from different waters, as well as why different regions of the ice cube would have different clarity.

Experiment 2: Cocoa butter crystallization

a) **Show your images of the chocolates after cooling and removing them from the plastic/paper. Make sure these images (figures) are properly labeled.**
b) **Download the class data, use statistics, and report your data using charts to answer**:
    - **Was one chocolate harder than the other?**
    - Was one chocolate easier to break/less "snappy" than the other?
c) Explain why you would expect a difference between these two chocolates in their hardness or how easily they could break.

Experiment 3: Fat phase

a) **Download the class data and use statistics to answer the following:**
    - Which frosting was *creamier*: butter or shortening?
    - Which frosting was *creamier*: butter or coconut oil?
    - **Which frosting was more *liked*: butter or vegetable oil?**
    - Which frosting was more *liked*: butter or coconut oil?

Make sure you report the data as instructed in Lab 3.

**Note:* "Neither" is an acceptable response to these questions, if the statistical analysis indicates there is no difference in the ratings.

Food Chemistry: Experiments for Labs and Kitchens

Laboratory 7: Oxidation

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Last updated 18 March 2020

LABORATORY 7: OXIDATION

A. OVERVIEW

LAB BACKGROUND AND DESCRIPTION

Oxidation–reduction reactions should be familiar from basic chemistry classes. However, often early chemistry courses only introduce these reactions in order to cover the more complex stoichiometry (balancing chemical equations) that is required when oxidation and reduction take place. In this laboratory, we will observe oxidation and reduction in food products, which should demonstrate why controlling these reactions is necessary for stable, appealing foods.

Beta-carotene is a fat-soluble, orange pigment found in carrots and several other plants. When beta-carotene is oxidized, it loses the orange color. *Omega-3 fatty acids* are particularly high in fish oils. These fatty acids are also very susceptible to oxidation. For these fatty acids, oxidation causes a strong rancid odor, as the fats are converted into smaller molecules like aldehydes. Thus, in both cases, minimizing the oxidation of these chemical compounds will aid in promoting a higher quality sensory experience in food.

LAB GOALS

- Observe and explain the oxidation of beta-carotene in the presence of pro- and anti-oxidants.
- Observe, smell, and explain the oxidation of high omega-3 fatty acid oils.

PRE-LABORATORY

Read the lab, and answer the following:

1. Rank the following beta-carotene treatments for how strong of a color you expect to remain by the end of the experiment.
    - Drawer, vegetable oil
    - Oven, vegetable oil
    - Oven, vegetable oil with the penny
    - Oven, vegetable oil with vitamin E
2. Rank the fish oil capsule treatments for how strong of a rancid odor you expect them to have.
    - Window (“sun”)
    - Drawer (“dark”)
    - Drawer with penny (“penny”)
    - Unopened (“capsule”)

MATERIALS AND EQUIPMENT

These experiments should take about 120 minutes of hands on time. You will keep the fish oil capsules for one week after the experiment to then observe and smell them.

Equipment and Materials	Amount	Distance lab
Beta carotene capsules	3	In your packet
Fish oil capsules	5	
Transfer pipette	1	
Vitamin E capsule	2	
Vegetable oil	10 g	Procure!
Coconut oil	10 g	
Flax seed oil (or olive oil for distance students)	10 g	
Copper pennies, clean (or other copper coin) **Note:* you can shine pennies by using hot sauce or vinegar	3	
Filter paper (or coffee filter)	10 in^2	
Small cup or bowl	3	
Parchment or wax paper	To cover baking sheet + extra	
Baking sheet	1	
1 oz portion cups	5	
Sunny window		
Dark drawer or cupboard		
Oven		
Fork		
Scissors		
Refrigerator or freezer		
Camera (cell phone camera is fine)		
Scale (with gram measurements)		
PowerPoint software		
Device to access to online class survey online		

B. EXPERIMENTS

EXPERIMENT 1: BETA-CAROTENE OXIDATION *(BLEACHING TO BLONDE)*

You will need the 3 beta carotene capsules, the 2 vitamin E capsules, vegetable oil, 3 small cups/bowls, a teaspoon, a fork, filter paper, scissors, parchment paper, two pennies, a baking sheet, and a warm oven for this lab. You will be setting up a total of 10 samples.

1. Preheat the oven to 200°F (93°C).
2. Cut the filter paper into equal sized squares, about 1 inch x 1 inch. You will need 10 total squares.
3. Obtain a baking sheet and cover it with parchment paper. Keep another piece of parchment paper to the side (you will place this with a couple of samples in a dark drawer).
4. Place the two shiny pennies onto the parchment paper on the baking sheet.
5. Put about 10 g of vegetable oil into a small cup.
6. Cut the tip of a beta carotene tablet off and squeeze out all of the contents into the vegetable oil. Mix well with a fork.
7. Repeat steps 6-7, but with flax seed oil or coconut oil.
    a. **Note:* You will need to melt the coconut oil.
8. Dip 3 filter papers in carotene/vegetable oil mixture. Dip 2 filter papers each into the carotene/flax seed oil and carotene/coconut oil mixtures.
    a. Flip the papers over once to ensure both sides are soaked in the oil/carotene mixtures.
    b. There should not be any dry or non-pigmented spots on the papers.
    c. Allow any excess oil mixture to drip back into the cup.
9. Place one filter paper of each oil type on the small piece of parchment paper (3 total).
10. Place one filter paper of each oil type on the parchment paper on the baking sheet (3 total).
11. Place the remaining filter paper of the carotene/vegetable oil mixture on top of the penny on the baking sheet (1 total).
12. Cut open two vitamin E tablets and squeeze their contents into the remaining beta carotene and vegetable oil mixture. Mix this well with the fork.
13. Coat 3 final squares of filter paper with the beta carotene/vegetable oil/vitamin E mixture.
14. Place one vitamin E/carotene/vegetable oil paper on the small piece of parchment paper (1 total).
15. Place one vitamin E/carotene/vegetable oil paper on the parchment paper on the baking sheet (1 total).
16. Place the last vitamin E/carotene/vegetable oil paper on top of the second penny on the baking sheet (1 total).
17. Press the papers that are on top of the pennies firmly down, making sure they are in contact with the penny (wash your hands in between touching the two different papers so that you don't get any vitamin E on the non-vitamin E sample).
18. **Take a picture** of the filter papers/your set up. Try to make sure you get all the papers in the same image, and that papers are all well-lit.
    a. Note down where you took the picture, so that you can place them in the same position later. This will help make sure any differences you see in color are not due to lighting changes in the room.
    b. A summary of all the filter papers and oil/carotene mixtures is shown in Table 7-1.

Table 7-1: Set up for filter papers dipped in oil/carotene solutions

Vegetable oil	Flax seed oil	Flax seed oil	Vegetable oil	Vegetable oil on top of penny
Vegetable oil + Vitamin E	Coconut oil	Coconut oil	Vegetable oil + Vitamin E	Vegetable oil + Vitamin E on top of penny
Small parchment paper To dark cupboard		**Parchment paper on baking sheet To 200°F/93°C oven**		

19. Place the small parchment paper of papers in a dark drawer, cupboard, or opaque container.
20. Place the baking sheet in the oven (which was set for 200°F/93°C).
21. Allow the samples to rest in the drawer and warm oven for 1 hour.
22. Remove the sheets from the drawer and oven.
23. **Take a picture** of the filter papers. Again, try to make sure you get all the papers in the same image, and that papers are all well-lit. Take the picture in the same location with the same lighting as the first picture.
24. Use software to measure the color of each filter paper in the image. When you measure the color, select the palest (least orange/yellow) spot on the paper to measure. Note on your image where this spot was that you measured.

EXPERIMENT 2: OMEGA-3 FATTY ACID OXIDATION *(SOMETHING'S FISHY HERE)*

You will need the 5 fish oil capsules, a small container/bowl, small portion cups, a transfer pipette, a sunny window, a freezer, a copper penny, and a dark cupboard for this experiment. *On campus students*, you will set up this experiment this week, and then come back and do the Qualtrics survey next week.

1. Cut open 4 fish oil capsules. Squeeze the oil out into a small bowl/container.
2. Obtain 5 small portion cups. Label them:
    a. Penny
    b. Dark
    c. Cold
    d. Sun
    e. Capsule
3. Use a transfer pipette to put about 5 drops of oil into the cups labeled: Penny, Dark, Cold, and Sun.
4. Add a penny to the cup with oil labeled Penny.
5. Place the last unopened fish oil capsule in the cup labeled Capsule.
6. Place Penny, Dark, and Capsule cups in a dark drawer or cupboard. Place the Sun cup in a sunny window, and the Cold cup in a refrigerator
    a. *On campus students:* Be sure you know exactly where you left your samples, and make sure they are labeled with your names and lab time.
7. Wait one week, and then retrieve all the cups. Cut open the capsule that you had stored in the Capsule cup in the dark.
8. Work with a partner. Open the online survey so you can enter your data. https://purdue.ca1.qualtrics.com/jfe/form/SV_3Ud6sk9ZklJ2hVP

a. The survey will prompt your partner to select the correct sample, and then have you smell it and rate the odor intensity on the next page. Your partner will need to hold the device with the survey while selecting the sample, then hand you the device so you can enter your rating.

C. DATA AND RESULTS

Data: The data you upload this week are from Experiment 2, which will be completed after one week. *On campus students*, this means you will enter your data for this lab during next week's lab section. Refer to the schedule.

Results: As you will receive the data later than typical, the results will also be due later than typical for this lab. Refer to the schedule.

All students (graded on questions in bold)

Experiment 1: Beta-carotene oxidation

a) Show your images of the oil/carotene-soaked papers from the initial set up and after one hour.

b) What are your factors in the beta-carotene experiment?

- **What are the levels of your factors?**

c) Identify the controls in this experiment. Explain what factor they are controlling for.

d) Compare the color change from your controls to the treatments.

e) Which treatment should be a pro-oxidant and which an anti-oxidant: penny or vitamin E?

Experiment 2: Omega-3 fatty acid oxidation

f) Download the class data. Using statistics, compare the intensity of the odor of the oil from the fresh capsule to:

- Odor intensity of fish oil in the window/sun
- Odor intensity of fish oil in the freezer/cold
- **Odor intensity of fish oil with the penny**
- **Odor intensity of fish oil in the drawer/dark**

Make sure you report the data appropriately, with graphs, as instructed in Lab 3.

g) Name a chemical compound that you would expect to smell more of as the fat oxidizes.

Food Chemistry: Experiments for Labs and Kitchens

Laboratory 8: Enzymes and pH

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Last updated 18 March 2020

LABORATORY 8: ENZYMES AND PH

A. OVERVIEW

LAB BACKGROUND AND DESCRIPTION

Enzymes are proteins that promote specific chemical reactions. The enzymes themselves are not used up in the reaction, they just help it take place. This means that the reaction can continue for as long as there is *substrate*—the chemical components that the enzyme is modifying. For example, papain is an enzyme in papayas which causes *proteolysis* (proteins are chopped up into smaller pieces). Thus, papain is used a meat tenderizer, as it cuts the proteins into smaller pieces that feel softer and less chewy. As the papain acts on the proteins in meat, the proteins are cut into smaller and smaller pieces, but the papain is not used up. The reaction will only end if the substrate, protein, is used up, or the papain is *denatured*. Denaturation occurs when enzyme is changed structurally, for example by heating or altering pH, so that it no longer functions.

Hydrogen ions are measured through *pH*, which is: $-\log_{10}[H^+]$, where $[H^+]$ is the concentration of hydrogen ions. A pH value below 7 indicate many hydrogen ions (*acids*), while pH values above 7 indicate very few hydrogen ions and more hydroxide (OH^-) ions (*bases*, or *alkaline* solutions). At pH 7, the concentrations of the H^+ and OH^- ions are equal. Thus, the pH of a mixture can influence the type and charges of ions present, which can cause proteins to become positively, negatively, or neutrally charged. These local changes in charge also add up to influence the protein's overall charge. The *isoelectric point* is the pH at which the protein has an overall charge of zero. In general, this lack of overall charge tends to decrease the *solubility* of the protein, which can cause the protein precipitate out of solution near the protein's isoelectric point.

In this lab, you will observe how both enzymes and pH influence the properties of various food products and mixtures.

LAB GOALS

- Observe and explain how enzymes from fruit and vegetables influence texture, color, and flavor.
- Observe and explain how salivary enzymes influence starch gels.
- Observe and explain what occurs when milk or cream is acidified.

PRE-LABORATORY

Read the lab, do some internet searching, and answer the following:

1. What enzyme in pineapple may influence the setting of gelatin (which is a protein)? Why?
2. After you crush or chop the garlic, will the smell become stronger or weaker over time?
    - What enzyme in garlic could cause this?
3. What enzyme in saliva could cause texture changes in your pudding?
4. What is the isoelectric point of caseins found in milk?

MATERIALS AND EQUIPMENT

These experiments should take about 90-120 minutes of hands on time. The gelatin will need to set up for at least 3 hours.

Equipment and Materials	Amount	Distance lab
pH meter or litmus paper	1 meter or 2 litmus strips	In your packet
Garlic cloves	2	Procure!
Lemon juice	60 g	
Coffee (ground)	30 g	
Plastic zip top bags (small)	4	
Cutting board	1	
Knife	1	
Kitchen mallet (or a hammer/other smashing device)	1	
Fresh pineapple (for vegans: fresh bananas)	45 g	
Canned pineapple (for vegans: cooked bananas)	45 g	
Gelatin mix (such as Jello) (for vegans: tapioca pudding mix)	1	
Hot water	See gelatin package	
Milk**	20 g	
Heavy whipping cream**	20 g	
2 oz portion cups (or similar), with lids for on campus students	4 (2 for distance)	
Bowls	4	
Whisk or other mixing utensil	1	
Plates	1-3	
Pudding, made with starch (instant or individually packaged pre-made pudding; cooked puddings may not work)	2 cups	
Spoons	2	
Blender or fork for smashing pineapple		
Timer		
Refrigerator		
Partner		
Camera (cell phone camera is fine)		
Scale (with gram measurements)		
Device to access to online class survey online		

Most vegan gelatins will not work in this experiment. If you are not willing to work with the gelatin, talk to your instructor about completing a substitute experiment.
Coconut cream and milk may work in this experiment. If you are uncomfortable working with animal products, let your instructor know and we will attempt these.

B. EXPERIMENTS

EXPERIMENT 1: PINEAPPLE ENZYMES (WHY PINEAPPLE MAKES YOUR MOUTH HURT)

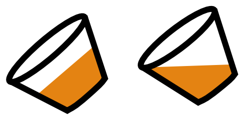
For this experiment, you will need the fresh and canned pineapple, blender or fork, gelatin mix, hot water, 4 bowls, whisks, refrigerator, and a camera. *On campus students*, you will need 3 of the 2 oz cups with lids.

**Note: A vegan version of this experiment can be done using fresh bananas, cooked bananas and tapioca pudding. Inform your instructor and we are happy to accommodate your needs.*

1. Puree (or smash into pulp with fork) both types of pineapple.
   a. Make sure you do not contaminate the canned pineapple with fresh pineapple.
2. Following the direction on the gelatin package, mix the gelatin with hot water.
3. Divide the gelatin mixture evenly into 3 new bowls.
4. Allow mixture to cool for 5 minutes.
5. Add 45 grams fresh pineapple to one bowl of gelatin, mix, and label the bowl "Fresh."
   **On campus students:* Label a 2 oz portion cup "Fresh"
   a. Portion the gelatin out into the cup, and place a lid on it.
   b. Take the gelatin home with you.
6. Add 45 grams canned pineapple to another bowl of gelatin, mix, and label it "Canned."
   **On campus students:* Label a 2 oz portion cup "Canned"
   a. Portion the gelatin out into the cup, and place a lid on it.
   b. Take the gelatin home with you.
7. Leave the final bowl of gelatin plain, and label it "Control."
   **On campus students:* Label a 2 oz portion cup "Control"
   a. Portion the gelatin out into the cup, and place a lid on it.
   b. Take the gelatin home with you.
8. Place the bowls (or 2 oz cups) in a refrigerator. Let them set, without touching them, for at least 3 hours.
   **On campus students*, if you don't have a refrigerator, you can leave these samples at room temperature and they will still set eventually (it may take longer than 3 hours, especially if the room is warm). Just do not eat them if they have not been refrigerated.
9. After at least 3 hours, remove the gelatin from the refrigerator (or its resting place).
10. Poke each gelatin with your finger, and observe its texture.

11. Pick up a cup of gelatin and tilt the cup. The gelatin that has become more liquid should move, while the solid gelatin should not. See example below.

. Solid, gelled



Liquid

Figure 8-1: Left- Solid gelatin will not move when cup is tilted.

9. Right- Liquified gelatin will move when the cup is tilted.

12. Take a picture of how the gelatins look when the cup is tilted, noting whether the gelatin was more solid or liquid, and how well the gelatin held its shape.

EXPERIMENT 2: GARLIC ENZYMES *(IT BURNS!!!!!)*

For this experiment, you will need the garlic cloves, coffee grounds, lemon juice, cutting board, knife, and kitchen mallet (or rock/brick/other heavy item with a flat side; you will use this for smashing the garlic later). You will also need a device to access the internet for the sensory questionnaire.

During this experiment, you will rate the intensity of several items. So that the online survey does not time out, please use the following scale:

0	1	2	3	4	5	6
No odor	Barely detectable odor	Weak odor	Moderate odor	Strong odor	Very strong odor	Strongest odor ever

Write down your intensity ratings as you go along, and enter your ratings into the survey when you are finished with the experiment.

1. Smell the coffee grounds, and record the intensity of the odor using the scale above (“Coffee beginning odor intensity”)
2. Peel the papery layer off the garlic clove, and smell the whole garlic. Record the intensity of the odor using the scale above (“Whole garlic odor intensity”)
3. Cut each garlic clove into three evenly sized pieces.
4. Place one garlic piece into a plastic bag. Label it “Sliced garlic.”
5. Smash another garlic piece with the kitchen mallet (or other smashing device). Place it in a plastic bag, and label it “Smashed garlic.”
6. Smash another garlic piece with the mallet. Dip it in the lemon juice, place it in a plastic bag, and label it “Lemon smashed garlic.”
7. Let the garlic bags sit for 30 minutes. Then, open the bags, smell the garlics, and record the intensity of the odors using the scale above (“Sliced garlic odor,” “Smashed garlic odor,” “Lemon juice smashed garlic odor”
8. Smell the coffee grounds again, and record the intensity of the odor using the scale above. (“Coffee end odor intensity”)
9. Open the online survey and enter your odor intensity ratings (you should have 6 ratings).

   https://purdue.ca1.qualtrics.com/jfe/form/SV_0xQiReOvXa9wcK1

EXPERIMENT 3: SALIVA ENZYMES (DON'T SPIT IN THE FOOD. WE'LL KNOW.)

You will need the packaged puddings (2), a timer, and two spoons for this test.

**Note:* If you are preparing instant pudding, make sure the pudding has set before conducting the experiment. You will want to portion out at least 100 grams into two separate containers.

1. Open a pudding. Take a spoonful of pudding and put it in your mouth. Swish the pudding around for 15 seconds, then spit it back into the pudding cup. Stir.
2. Open the second pudding package. Using the other clean spoon, stir it.
3. Stir both pudding packages over the course of 2 minutes. Observe the thickness of both puddings. Dip the spoons into the puddings, and take pictures of how the pudding flows off the spoon (see figure 8-2).
   a. *Optional:* take a viscosity measurement of each pudding (regular pudding, and spat out pudding mixture). Refer to the digital appendix.

FIGURE 8-2: Example Image of how puddings flow off spoons.

EXPERIMENT 4: MILK PROTEIN ISOELECTRIC POINT *(BEWARE THE CEMENT MIXER…)*

You will need milk, heavy whipping cream, lemon juice, a pH meter or litmus paper, scale, small cups, camera, and two slightly larger cup (2 oz) for this experiment.

1. Measure the pH of the milk, cream, and lemon juice individually.
2. Pour 20g of milk and 20g of lemon juice into the 2 oz cup. Observe what happens.
3. Pour 20g of heavy cream and 20g of lemon juice into the 2 oz cup. Observe what happens.
4. Take pictures of your milk and cream with the lemon juice added.

C. DATA AND RESULTS

Data: Make sure you have entered your responses for the coffee and garlic ratings from Experiment 2.

Results: Answer the following. Bolded questions will be graded.

All students:

Experiment 1: Pineapple enzymes

a) Show pictures of your pineapple gelatins.

b) Canned pineapple is heated treated for safety reasons. What does heating pineapple do to cause a difference in the ability of the gelatin to set?
   - Refer to your pre-lab questions/answers for a hint.

Experiment 2: Garlic enzymes

Download the class data, and use statistics and appropriate data reporting and charts to answer the questions (refer to Lab 3 for help).

c) Was the garlic odor was stronger:
   - Whole (at beginning) or sliced (at end)?
   - Whole (at beginning) or smashed (at end)?
   - Sliced (at end) or smashed (at end)?
   - Smashed (at end) or lemon juice + smashed (at end)?

d) Did the coffee odor intensity change over the experiment?
   - Note: contrary to what you may have heard, the coffee serves no real purpose in this experiment. It does not "reset" your sense of smell. We are simply using it as a control, to see if you generally became less sensitive or more sensitive while working in the room, which would be full of many odors. The best way to "reset" your sense of smell is to smell yourself, by sticking your nose in the crook of your elbow for example.

Experiment 3: Saliva enzymes

e) Show pictures of your puddings.
f) Which pudding was thinner? What enzyme would cause this?
g) How would you make a pudding that could not be thinned by saliva?

Experiment 4: Milk protein isoelectric point

h) Show pictures of your milk and cream with the lemon juice added.
i) Which product curdled more, the milk or cream?

Why should cream and milk respond differently to the lemon juice?

Food Chemistry: Experiments for Labs and Kitchens

Laboratory 9: Colors and other Additives

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Last updated 18 March 2020

LABORATORY 9: COLORS AND OTHER ADDITIVES

A. OVERVIEW

LAB BACKGROUND AND DESCRIPTION

Food additives generally serve one of three purposes: 1) as an aid in the manufacturing process (such as anti-clumping ingredients that help powders pour from one container to another), 2) to keep a food safe or make it last longer by reducing growth of microorganisms, and 3) to optimize flavor, appearance, and texture of the food for consumers. In this laboratory, we will test food additives that are designed for flavor, color, and texture optimization.

LAB GOALS

- Observe and explain how acidulants change fruit browning.
- Test common kitchen alternatives to acids to prevent browning, and determine their effectiveness.
- Observe the effects of a buffering agent/emulsifying salt.
- Observe the stability and intensity of natural versus artificial colors.

PRE-LABORATORY

Read the lab and answer the following:

1. How much water will you need to make a 1% w/w citric acid in water solution, with 1 gram of citric acid?

   Note: Remember Lab 1, where we discussed the correct way to make solutions.
2. Solve the chemical equation from experiment 2 to figure out how much citric acid and sodium bicarbonate you will need to create 6 grams of sodium citrate.

   Note: In the age of computers and the Internet, you really don't need to do this calculation by hand. It is completely acceptable to use a website or program. However, we do expect you to be correct. A website giving you the wrong answer is not an excuse to be wrong.
3. What must be present for fruit, such as apples, to brown? Name the enzyme (the protein that facilitates the browning), the substrate (the compound that turns brown), and the reactant (a third thing that must be present, and that the enzyme uses to turn the substrate brown).
4. Name a possible "natural" source of red food coloring.

MATERIALS AND EQUIPMENT

These experiments should take about 150 minutes of hands on time, if the second experiments are done while the first is resting.

Equipment and Materials	Amount	Distance Lab
Two natural food colors (recommended: Watkin's natural food colors)	5 drops each	In your packet
Citric acid	6 g + more (from calculations)	
Sodium citrate	6 g	
Apple	1	Procure!
Baking soda (sodium bicarbonate)	10 g + more (from calculations)	
Cheddar Cheese block (not pre-shredded!)*	450 g	
Water	~1000 g (1 L)	
Two regular food colors, same colors as natural versions (recommended: McCormick assorted food color)	5 drops each	
Small mixing bowls, microwave safe	3	
Whisk		
Spoons	3	
Heat safe cups or small beakers, clear or white**	12	
PowerPoint or other color measuring software		
Microwave		
Water		
Cutting board		
Knife		
Camera (cell phone camera is fine)		
Scale (with gram measurements)		
Device to access to online class survey online		

*Vegan cheese typically does not melt very well, and thus will not work for this experiment. If this is a concern for you please let your instructor know as soon as possible so your instructor can assign an substitute exercise.

**You can heat the samples using other colored mugs, but you will need to pour the samples into a different cup after heating to observe the color.

B. EXPERIMENTS

EXPERIMENT 1: ACIDULANTS (FRUIT BROWNING: MYTHS AND REALITY)

In this experiment, we will test a common belief that leaving the seeds in an apple (or avocado, or many other fruits prone to browning) will slow down the browning reaction. We will also look at the effects of acid (low pH, from citric acid solution) and removal of oxygen (submersing the apple in water, which reduces access of oxygen to the fruit) on browning.

You will need the apple, cutting board, knife, citric acid, water, camera, access to the internet, and a timer for this experiment.

1. Make a 1% w/w solution of citric acid in water.
    a. Make enough that you can dip an apple slice in the water.
2. Cut the apple into eight pieces (cut it in half, then cut each side in half, then cut each of those quarters in half).
    a. Note: Apples can be shared across groups to cut down waste. Each group only needs one half of an apple.
3. Start the timer as soon as you have cut the apple into the slices.
4. Select 4 slices to use in the rest of the experiment. They should be about the same size and shape.
5. Take 3 apple slices, and cut out the seed portion. Make sure you do not leave any seeds.
6. Take a picture of the 4 apple slices (1 with seeds and 3 without).
7. Dip one seedless apple slice into the citric acid solution.
8. Place another seedless apple slice in a cup of water, making sure it is completely submerged.
9. Let the apples rest for 120 minutes.
    a. You should have: 1 with seeds, 1 without seeds, 1 without seeds that was dipped in citric acid (but is NOT still in the liquid), and 1 without seeds that is submerged in water (IS still in the liquid).
10. After the 120 minutes, remove the slice from the water, and arrange all 4 slices next to each other. Label them, take another picture, and note the time since initial cutting.

EXPERIMENT 2: SODIUM CITRATE (NO ONE LIKES CURDLED CHEESE DIP)

Sodium citrate is a ***buffer***, which helps stabilize again pH changes, but can also help stabilize milk proteins like casein during heating of dairy sauces. To use sodium citrate at home, you can either buy sodium citrate, or you can make it. Sodium citrate is created when sodium bicarbonate reacts with citric acid. The reaction releases carbon dioxide, leaving behind sodium citrate and water. You do this by simply adding both to water. Using the following chemical equation, you can convert between grams and moles in order to determine how much sodium bicarbonate and citric acid you need to add to the water in order to theoretically yield a certain amount of sodium citrate. For our experiment, we want 6 grams. After you turn in your pre-lab, you instructor will provide you with the correct answers so that you can check your results and proceed with the experiment.

Molecular weights:

Na^+ : 23.0g/mol
HCO_3^- : 61.0 g/mol
$C_6H_8O_7$: 192.1 g/mol
$C_6H_5O_7^{3-}$: 189.1 g/mol
H_2O : 18.0 g/mol
CO_2 : 44.0 g/mo

$$3\,NaHCO_3 + C_6H_8O_7 \rightarrow Na_3C_6H_5O_7 + 3\,H_2O + 3\,CO_2$$

Sodium bicarbonate	Citric acid	Sodium citrate	Water	Carbon dioxide

Goal: yield 6 grams total of sodium citrate

You will need baking soda, citric acid, sodium citrate, water, whisks, spoons, and cheese for this experiment. You will make 3 cheese sauces: control, with sodium citrate, and with sodium citrate you create using the baking soda and citric acid.

1. Obtain 3 bowls to mix the cheese in.
   a. Make sure the bowls are big enough to hold 150 g of cheese plus 80 g of liquid, and leave some extra space to allow for a lot of bubbling when you mix the citric acid with the sodium bicarbonate.
2. Weigh out 80 grams of water into <u>each</u> bowl (3 bowls total; 80g of water into each).
3. Add 6 grams sodium citrate to the water in one bowl. Label the bowl "Sodium citrate".
4. Add your calculated amount of baking soda to the water in the next bowl. Then add your calculated amount of citric acid.
   a. It should bubble as the carbon dioxide is released.
   b. Keep stirring until the bubbles completely stop.
   c. Label the bowl "Citric acid/baking soda".
5. Label the final bowl of water "Control".
6. Microwave each bowl separately for 30 seconds. Allow to rest for 30 seconds, then microwave again for 30 seconds.
7. Shred or chop the cheese into small pieces

   10. **Note:* do not use pre-shredded cheese; this type of cheese often has starches or powders added to help prevent it from sticking. Those starches and powders mean the cheese does not melt as nicely into a sauce.
8. Add 150 grams of cheese to each bowl. Stir to combine.
9. Microwave the cheese mixtures for 30 seconds (less if the cheese starts to bubble). Whisk the cheese sauces well. If the cheeses are not completely melted, repeat the microwave and rest cycle (30 seconds each, making sure the sauces do not bubble over, whisking in between cycles of 30 seconds) until melted.
   a. It takes a lot of whisking to mix these sauces well.
   b. If all of your sauces are lumpy, keep whisking and heating. Eventually, the two with sodium citrate (bought and homemade) should become smooth.
10. Take a picture of how all the cheese sauces flow off a spoon (see Figure 8-1 from Lab 8 for example from the pudding and saliva experiment).

11. Stir the sauces again, and open the online survey. Record your responses to the questions, making sure you are not told which sample is which while you are evaluating it. There will be questions about both the appearance and the oral texture of the sauces. If you would rather not eat the cheese, the survey will allow you to skip the question about how the texture of the sauce feels in your mouth.

    https://purdue.ca1.qualtrics.com/jfe/form/SV_bemoKh9x6Pe8SUZ

EXPERIMENT 3: NATURAL AND ARTIFICIAL COLORS *("NATURAL": IT'S COMPLICATED…)*

Natural colors, like the animals, plants, algae, or other organisms they are sourced from, can be altered by heat and pH. Artificial colors were developed to help control those alterations, so that colors for foods are stable regardless of what you do to the food.

For this experiment you will need water, the food colors, citric acid, baking soda, a microwave, heat safe clear or white bottom cups, a camera, and software (PowerPoint or a Mac computer) to analyze the color of your images. We also recommend you look at the ingredient list for your natural food color, as this can be enlightening when thinking about what happens to the colors under certain circumstances.

1. Dissolve 5 grams of citric acid in 245 grams water.
2. Dissolve 10 grams of baking soda in 240 grams water.
3. Add 50 grams of the citric acid solution to 4 different cups. Label them "acid."
4. Add 50 grams of the baking soda solution to 4 different cups. Label them "base."
5. Add 50 grams of plain water to 4 different cups. Label them "neutral."
6. Select two colors (i.e., red and blue). You will need a natural and an artificial version of each color.

Optional: If you have a yellow natural color that says "turmeric" on the ingredient list, we recommend you find a UV light (common "black lights" should work). The yellow pigment from turmeric will fluoresce under UV light, and you can watch this property change as you alter the pH of the solution.

7. Add 5 drops of each type/color to each of the 3 different pH solutions. So, if you have red and blue you should end up with:

Natural Red acid	Natural Red neutral	Natural Red base	Artificial Red acid	Artificial Red neutral	Artificial Red base
Natural Blue acid	Natural Blue neutral	Natural Blue base	Artificial Blue acid	Artificial Blue neutral	Artificial Blue base

8. Take a picture of all your cups, making sure you can see the color and that the samples are lit evenly.
    a. If you cannot get all your samples in the same image, make sure that the different treatments for the same colors are in the same image (so, acid, neutral, base for natural red all in the same photo).
    b. Make sure you make note of where you are taking this image, so that your image after the heating can be taken in the same location.

9. Microwave the samples 3 at a time. Heat at full power for 30 seconds (pause the heating if the solutions start to boil), then rest for 30 seconds. Repeat this cycle until you have heated the cups for 2 minutes total (4 cycles of heating then resting, taking 4 minutes total for each color).
10. Take another picture of all the cups, making sure all the labels are intact.
    a. Make sure that you take your image in the same location as the initial image, so that the lighting is as similar as possible.
11. Use a computer software like PowerPoint measure the colors of each solutions.
    a. Instructions for how to do this through PowerPoint or with a Mac computer are in the appendix or posted to the lab website.
12. Note how much the colors shifted in each source type (natural or artificial), color type (for example, red or blue), and treatments (acid, neutral, base; unheated, heated).

C. DATA AND RESULTS

Data: Make sure you have your responses for cheese sauce. The survey will allow you to skip the oral texture question if you are only willing to stir, not eat, the cheese.

Results: Answer the following. Bolded questions will be graded.

Experiment 1: Acidulants

- **a) Show pictures of your apple slices.**
- b) Does leaving the seeds in the apple directly influence the browning reaction?
- c) What component of the enzymatic browning reaction does immersing the apple slice in water influence?
- **d) Why does acid slow the browning reaction? Explain the answer chemically.**

Experiment 2: Sodium citrate

- e) Download the class data. Use statistics, with proper reporting and visualizations, to answer the following:
  - o Which had better visual appearance:
    - i. Purchased sodium citrate or control?
    - ii. Homemade (citric acid/baking soda) sodium citrate or control?
    - **iii. Homemade (citric acid/baking soda) sodium citrate or purchased sodium citrate?**
  - o Which texture in the mouth was better:
    - **i. Purchased sodium citrate or control?**
    - ii. Homemade (citric acid/baking soda) sodium citrate or control?
    - iii. Homemade (citric acid/baking soda) sodium citrate or purchased sodium citrate?

Experiment 3: Natural and artificial colors

Include your images and use your color data to answer the following:

- **f) Show your images of your colors in acid, base, and neutral, both before and after heating.**
- **g) Overall, were natural or artificial colors more stable:**
  - **o In an acidic environment?**
  - **o In an alkaline (basic) environment?**
  - **o To heating?**
- h) Did the color you used (red, green, yellow, blue, etc) influence the way acid, base, or heat altered the natural colors?

Food Chemistry: Experiments for Labs and Kitchens

Laboratory 10: Sweeteners and Browning

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Last updated 18 March 2020

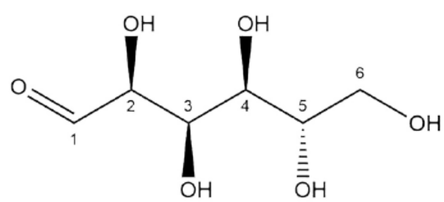
LABORATORY 10: SWEETENERS AND BROWNING

A. OVERVIEW

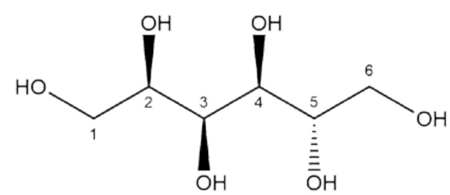
LAB BACKGROUND AND DESCRIPTION

Many sugars are sweet. Typically, “sugar” refers to sucrose, one of the most common sugars in the food supply. But many other “sugar” structures exist. Some of them are also sweet (examples: glucose, fructose), while others are minimally sweet, or not sweet at all (examples: lactose, galactose). Regardless of sweetness, most of the sugar structures common in the food supply will yield energy when eaten. So, when people try to reduce their energy intake in order to lose weight or make their diet healthier, they may target sugars as food ingredients to consume less of.

However, removing the sugar from foods can reduce the sweetness. Alternatives sweeteners with zero calories have been developed, either from synthesized molecules in laboratories (examples: saccharin, aspartame) or isolated from plants (examples: stevia, monk fruit). Sugar alcohols (sugar structures that have hydroxyl groups instead of carbonyls, see figure below) can also be used to supply sweetness with less energy, often less than 50% of the calories you would get from regular sugar.



Glucose (carbonyl on carbon 1)



Sorbitol (hydroxyl group on carbon 1)

However, sugars do more than just add sweetness in foods. Sugars contribute bulk and body to foods, the actual substance making up the mass and volume of a product. Sugars also participate in chemical flavor reactions, attract and bind water, and contribute to the texture of foods.

As a result, replacements for sugars are never perfect substitutes. Some replacements are very potent as sweeteners, and so a very small amount will match the sweetness intensity of the original sugar. However, that means the volume and mass of the sugar is not replaced, just the sweetness. This works fairly well in beverages, as the volume and mass can be replaced with water, but not very well in solid foods. In solid foods, there must be a way to replace the volume as well as the sweetness, otherwise the product will be much smaller, denser, and stranger in texture compared to the original.

Finally, flavor and appearance of sugar substitutes never perfectly match the original. Most sugar substitutes do not brown when they are heated, and many substitutes have other flavors like bitter tastes or cooling sensations in addition to the sweetness.

These properties must be considered when using sugar substitutes, as sugar free and reduced sugar products will behave differently during mixing, heating or processing, and eating.

In this lab, you will test several sugars and sweeteners to observe differences in function and flavor.

LAB GOALS

- Observe and explain function of different sugars and baking substitutes in cookies.
- Experience and describe the flavor of low calorie sweeteners.
- Observe and explain the heat stability of low calorie sweeteners.

PRE-LABORATORY

Read the lab, do some research, and answer the following:

1. What other ingredients are present in:
   **Note:* (just give one example of each, citing your brand and source):
   - Stevia baking substitutes
   - Sucralose baking substitutes
   - Aspartame packets
   - Saccharin packets
2. What are “dextrose” and “maltodextrin”? (you should see these as common ingredients in many of your sweetener products)
3. How much should the following weigh?
   - ¼ cup sucrose
   - ¼ cup honey
   - ¼ cup stevia baking substitute
   - ¼ cup sucralose baking substitute
4. If you portion all cookies to weigh 20g, will you have the same number of cookies from each recipe? Why or why not?
5. Which low calorie sweeteners should be heat stable (resulting in the same sweetness before and after heating)?

MATERIALS AND EQUIPMENT

These experiments should take about 120 minutes total.

Item	Amount	Distance lab
Stevia baking substitute	¼ cup	In your packet
Sucralose baking substitute	¼ cup	
Stevia packets (green)	2 packets	
Sucralose packets (yellow)	2 packets	
Aspartame packets (blue)** *Note: In ~2019, Equal changed its formulation for these blue packets. Check the label to see if yours contains just aspartame, or a mixture of aspartame and acesulfame potassium ("Ace-K")*	2 packets	
Saccharin packets (pink)	2 packets	
Transfer pipettes	10	
Sucrose	¼ cup, plus ~10 g	Procure!
Honey	¼ cup	
All-purpose flour	4 cups (about 600 g)	
Baking powder	1 tsp	
Salt	½ tsp	
Butter	4 sticks (about 460 g)	
Eggs	2 whole, or 120 grams pre-blended egg	
Vanilla extract	1 tbs	
Mixing bowls and utensils	2 (wash them between recipes)	
Parchment paper	To cover 2 cookie sheets	
Cookie sheets	2	
Microwavable mugs	5	
Plastic or foil wrap	To cover all 5 mugs	
Thermometer (accurate to room temperature)	1	
Oven	1	
Camera (cell phone camera is fine)		
Scale (with gram measurements)		
Device to access to online class survey online		

B. EXPERIMENTS

EXPERIMENT 1: SUGAR BAKING SUBSTITUTES *([DON'T] LET THEM EAT CAKE!)*

You will need the sucrose, stevia baking substitute, sucralose baking substitute, honey, all-purpose flour, baking powder, salt, butter, eggs, vanilla extract, mixing bowls/utensils, parchment paper, cookie sheets, camera, kitchen balance (scale), a device to access the online survey, and oven for this experiment.

You will be making 4 different batches of sugar cookies, each using a different sweetener source.

It's vital that you use baking substitutes for stevia and sucralose in this experiment, not just large amounts of packets or other types of sugar substitutes (usually designed for sweetening beverages). You want the type of product specifically designed for baking.

If using whole eggs, beat both eggs together. You want the whites and yolks to be beaten together smoothly, so you get even amounts in each batch of cookies. You will need 30 g of egg per batch of cookies, or 120 g of egg total. Sometimes eggs are smaller than they should be, so weigh your beaten eggs at the beginning to make sure you have enough!

1. Preheat the oven to 375°F (190° C).
2. Make and weigh the yield of each cookie dough type as described below.

Weigh each of your mixing bowls.		
Mix:	¼ cup sweetener ← 1 stick butter (113 g), melted 30 g beaten egg ½ TBS vanilla	4 sweeteners: • Sucrose • Honey • Stevia baking substitute • Sucralose baking substitute
In another bowl, combine:	1 cup flour (150 g) ¼ tsp baking powder 1/8 tsp salt	
Combine the two mixtures together to make the cookie dough. Weigh the bowl with the combined dough. Subtract the original weight of the empty bowl to figure out how much your cookie batch yielded.		

3. Divide the yield of each batch of cookies by 12.
   a. This is how much each cookie should weigh for that type of sweetener.
   b. **Access the online survey and record your calculated cookie weights.**
      - You may do this as a group (i.e., one survey per GROUP, not one per PERSON)

   https://purdue.ca1.qualtrics.com/jfe/form/SV_5tFiiGABNzoNkWN
4. Portion out 6 cookies for each sweetener type by the weight calculated in step 3.
   a. For example, if your cookie batch yielded 240 grams, you would make six 20g cookies.

   b. You will have extra dough. You may bake this later (*on campus students*: make sure all other lab groups have finished baking their cookies before you bake your extras)
5. Cut your parchment paper to fit two cookie sheets. Label the parchment paper so that you know which cookie goes where.
   a. Make sure you will be able to read your labels after you put cookies on the sheet! If the cookies hide all the labels it will be hard to tell them apart.
6. Organize the cookies as shown below.

Sheet 1

Sucrose cookie	Honey cookie	Stevia cookie	Sucralose cookie
Sucralose cookie	Sucrose cookie	Honey cookie	Stevia cookie
Stevia cookie	Sucralose cookie	Sucrose cookie	Honey cookie

Sheet 2

Stevia cookie	Sucralose cookie	Sucrose cookie	Honey cookie
Honey cookie	Stevia cookie	Sucralose cookie	Sucrose cookie
Sucrose cookie	Honey cookie	Stevia cookie	Sucralose cookie

7. Bake the cookies for 6 minutes, then rotate the cookie sheets front to back and top to bottom (so cookies that were on the top rack are now on the bottom rack, and cookies in the rear of the oven are now in the front). Bake for an additional 6-12 minutes, until the sucrose cookies are golden brown around the edges. Other cookies may be more or less brown.
8. Remove cookies from the oven and allow to cool for at least 10 minutes.
9. While cookies are cooling, take a picture of the cookies. Make sure the cookies are labeled in the photo, adding additional labels as necessary.
10. **Access the online survey again for the taste test.** Work with a partner and follow the instructions on the survey to record your liking for the cookies' flavors and textures. https://purdue.ca1.qualtrics.com/jfe/form/SV_b2FLIu5qFhPslSd

EXPERIMENT 2: SWEETENERS AND HEAT STABILITY *(WHY DIET COLA EXPIRES…)*

For this lab you will use 10 grams sugar, as well as the sweetener packets: sucralose (yellow), stevia (green), saccharin (pink), and aspartame/ace-K (blue; some of these may contain only aspartame—that is fine [better, actually!]). You will also need coffee mugs (microwaveable), a thermometer, plastic or foil wrap, tap water, and access to the online surveys.

1. Label the cups "sugar", "sucralose", "stevia", "saccharin", and "aspartame/ace-K". Put 6 oz of water into each cup and then add the appropriate sweetener packet. Measure the temperature of each solution.
2. **Open the online survey.** Work with a partner, following the instructions on the survey. You will be rating the samples for sweetness and bitterness.
   a. *On campus students*: use a transfer pipette to take a small amount of sample from the cup to drink; don't double dip (once you put the pipette in your mouth, don't put it back in a cup!)
   b. This will allow everyone to taste the samples without having to use many different cups.
   https://purdue.ca1.qualtrics.com/jfe/form/SV_9Hu3IYy2xyHpRBP
3. Microwave the cups on high for 2 minutes.
4. Let them sit for 30 seconds, then microwave on high for 30 seconds.
5. Continue this cycle of microwaving and resting until you have heated the samples for a total of 10 minutes (20 cycles of 30 seconds on and 30 seconds off).

6. Cover the samples with wrap to help prevent evaporation. Let the samples rest until they are cooled back to the original temperature you measured. You may put them in a refrigerator to help them cool faster.

When the samples are cool, **open the next online survey.** Again, work with a partner to record the sweetness and bitterness intensity through the online survey (use transfer pipettes to suck up the solutions if you are working in groups). Remember, it's important that you don't know which sample you are tasting!

https://purdue.ca1.qualtrics.com/jfe/form/SV_cNprAhFMPxaqglv

C. DATA AND RESULTS

Data: Make sure you have entered your responses and photos for the cookies and the sweeteners. Note there were FOUR surveys to complete (cookie weights, Cookie sensory data, sweetener solution data before heating, sweetener solution data after heating)

Results: Answer the following. The bolded questions will be graded.

Experiment 1: Sugar and baking substitutes

a) **Draw or show (and cite your source) the structures of:**
   - **Sucrose**
   - The sugars found in honey (do some research)
   - Steviol (a stevia sweetener)
   - **Sucralose**

b) **Appropriately label/caption and include your image of the cookies after baking.**
   - Which browned more, the honey or the sucrose cookies?
   - Explain the structural difference between honey and sucrose sugars that would cause this. **Hint:* It is not because honey is brown already.

c) **Download the class data, and answer the following using appropriate statistics and visualizations:**
   - **Which cookie was rated higher for texture liking:**
     - **Sucrose or sucralose?**
     - Sucrose or honey?
     - Sucrose or stevia?
   - Which cookie was rated as sweeter:
     - Sucrose or sucralose?
     - Sucrose or honey?
     - Sucrose or stevia?
   - Which cookie was rated higher for overall liking:
     - Sucrose or sucralose?
     - Sucrose or honey?
     - Sucrose or stevia?

Experiment 2: Sweeteners and heat stability

d) **Download the class data, and answer the following using appropriate statistics and visualizations:**
   - **Did any of the following change in sweetness after heating?**
     - Sucrose
     - Sucralose
     - Stevia
     - Saccharin
     - **Aspartame**
   - **Did any of the following change in bitterness after heating?**
     - Sucrose
     - Sucralose
     - Stevia
     - Saccharin
     - **Aspartame**

Food Chemistry: Experiments for Labs and Kitchens

Laboratory 11: Molecular Gastronomy

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Last updated 18 March 2020

LABORATORY 11: MOLECULAR GASTRONOMY

A. OVERVIEW

LAB BACKGROUND AND DESCRIPTION

Chefs have always used science in the kitchen, whether they realized it or not. Certainly, much of the development of delicious recipes and flavors is an art form, but the process of learning the techniques, revising them, and gradually changing recipes to create the best food is very similar to the scientific method. Today, however, a movement has arisen specifically harnessing the chemical properties of foods to create new flavors, textures, and techniques in modern cuisine. This new approach to cooking is called ***molecular gastronomy***.

In this lab, we will demonstrate some techniques of molecular gastronomy.

LAB GOALS

- Demonstrate the properties of alginate gels.
- Demonstrate how maltodextrin binds fat to make powders.

PRE-LABORATORY

Read through the lab. Answer the following questions.

1. What is necessary for alginate to gel?
2. Why does acid interfere with alginate gels?
3. Why should you avoid hard water when making the alginate solution?
4. Why should you avoid milk in the alginate solution, but not in the calcium solution?

MATERIALS AND EQUIPMENT

These experiments should take 90-150 minutes.

Item	Amount	Distance lab
Sodium alginate	~5 grams	In your packet
Calcium lactate	~5 grams	
Tapioca maltodextrin	~25 grams	
Transfer pipettes	~5	
Emulsifier (optional)	Less than 1 gram	
Nut butter or nut butter alternative	40 grams	Procure!
Flavors (water or fat soluble)	Select at least 2	
Colors	Select at least 2	
Vegetable, corn, safflower, or other neutral oil	40 grams	
Powdered sugar	10 grams	
Blender		
Molds/ice trays etc.		
Distilled, deionized, or reverse osmosis water		
Food processor, blender, or mixing bowl and whisk		
Kitchen balance		
Camera (cell phone camera is fine)		
Scale (with gram measurements)		
Device to access to online class survey online		

B. EXPERIMENTS

EXPERIMENT 1: NOODLES, CAVIAR, AND SPHERES

You will need the blender, scale, sodium alginate, calcium lactate, colors, pipettes, molds/trays, and flavors for this experiment. Note that if you select a fat soluble flavor, you may need to blend it for some extra time to get it to disperse evenly in the liquid. Alternatively, you could add an emulsifier like monoglycerides or lecithin (note: if you choose to do this, make sure you use an appropriate concentration (like 0.1%) – you need very little of these types of emulsifiers in foods).

For flavors, you can either use extracts (such as vanilla extract) or actual flavoring (such as cake batter flavor), which can be found in some craft stores, online, or at cake supply shops. You could also try soaking and or/heating herbs and spices in oils or water to extract the flavor yourself. Adding sugar or salt (depending on whether you are aiming for savory or sweet items) will also improve the flavor. For *on campus students*, several options will be provided. As for *distance students*, feel free to experiment!

<u>“Reverse spherification” method</u>: This method is used for larger spheres, with liquid inside a film-like pouch. The alginate makes a layer on the outside of the calcium solution, but the inside will stay liquid. We recommend you do this one first because it requires freezing the samples.

1. Make a 0.75% w/w sodium alginate in distilled water solution. Make sure the powder is fully dissolved by using a blender.
    - Allow the solution to rest after blending. You will want to make sure there are as few bubbles as possible before you attempt the spheres.
    - You can flavor this solution if you want. It will form a layer on the outside of your calcium solution, so it may be nice to at least add a little sugar (for sweet flavors) or salt (for savory flavors). If you don’t flavor it at all, there will just be a tasteless film on the outside of your final item.
2. Make a 2% w/w calcium lactate in distilled water solution. Flavor and color this solution.
    - You could also use milk instead of distilled water, and you would need to add less calcium lactate (milk contains a lot of calcium).
3. Pour the flavored calcium lactate solution into molds, and freeze it.
    - You can use liquid nitrogen or dry ice to speed up the freezing process. If you do so, use caution when handling these dangerously cold materials. On class students should let their TA handle the actual liquid nitrogen/dry ice. Off campus students, please seek out training before you attempt to use these things! The danger of frost bite is very real from even very short times working with these cold items.
    - You may work on the “Direct spherification” method while you wait for your items to freeze, if you are using a regular freezer.
4. Take the frozen lumps of flavored calcium lactate solutions and drop them into the sodium alginate solution.
5. Allow your calcium lactate “spheres” to sit for at least 30 seconds, stirring the alginate gently while you wait. Then remove them from the alginate solution. The longer the spheres sit, the thicker the layer of alginate will be.
6. Taste your creations, and try other flavors as you wish.
7. **Take a picture of your reverse spheres.**

“Direct spherification” method: This method is used for noodle and caviar type shapes. The alginate is originally a thick liquid, but when dropped into the calcium water it instantly forms a gel. If you remove and eat the gel quickly, the inside will still be relatively liquid. If you wait, the gel will become solid as the calcium diffuses into the alginate.

8. Make a 1% w/w sodium alginate in distilled water solution. Flavor and color this solution as you desire. Make sure all the powders and liquids are fully dissolved by using a blender.
9. Make a 1% w/w calcium lactate in distilled water solution.
10. To make “caviar”: Use a pipette to drop small balls of the alginate solution into the calcium lactate solution. Retrieve the small spheres, and taste them. You can rinse them if you find they have an odd taste on the outside (calcium has a taste, so rinsing off the calcium solution can improve the flavor).
11. To make “noodles”: Use the pipette to quickly squirt a stream of the alginate solution into the calcium lactate solution. Retrieve the noodles and taste them.
12. **Take a picture of your caviar and noodles.**

EXPERIMENT 2: POWDERED FAT

For this experiment, you will need the tapioca maltodextrin, a nut butter (or alternative), safflower oil, scale, and a food processor/blender/mixing bowl with whisk.

1. To make a powdered flavor, you will need a mixture of 60% fat (nut butter or safflower oil with flavoring) and 40% maltodextrin. So, for example, you could blend:
   12 grams nut butter + 8 grams tapioca maltodextrin to yield 20 grams of powdered nut butter
2. To mix the powders, you can use a food processor, blender, or just a bowl with a whisk. Which tool works best may depend on how much you want to make (you’ll likely have to make a larger batch for the food processor to work well).
3. Make a powdered nut butter/nut butter alternative.
   - If you are in a lab with someone with a nut allergy, you must use the alternative for their safety.
4. **Take a picture of your powder.**

C. DATA AND RESULTS

Data: There are no data to upload this week, but make certain you have taken the pictures you will need in your results.

Results: Answer the following. Bolded questions will be graded.

All students:

Experiment 1: Noodles, caviar, and spheres

a) **Show the images of your reverse spheres, caviar, and noodles.**
b) Why do we use distilled/deionized/reverse osmosis water in this lab?
c) **Draw a picture of the chemical structure of alginate, and how it interacts with calcium (make sure it is clear in your drawing what is alginate and what is calcium).**
d) If you wanted a softer/weaker alginate gel with calcium, what structural feature of alginate would you look for when talking to a food ingredient company?
e) Why would very acidic flavors not work well for this type of product?

Experiment 2: Powdered fat

f) **Show the image of your powdered fat.**
g) **Draw the structure of maltodextrin. Make certain to indicate approximately how many sugars would be linked together in this structure.**

Appendix A: Instructor Notes

LABORATORY 1:

INSTRUCTOR DUTIES FOR LAB

- Ensure materials are available for students, including packet for distance if appropriate
- Review student allergies/food avoidances per pre-lab. Assign students to groups based on this.
    - Ideally put students with the same issues in the same group, so that they can have projects assigned based on these issues.

LABORATORY 2:

INSTRUCTOR DUTIES FOR LAB

- Ensure you verify all students tasting samples are able to consume sugars, lactose, and milk.
- Here is the decoding for the samples:

Sugars/maltodextrin from week 2 lab Fructose- 492 Glucose- 207 Tapioca maltodextrin- 731 Sucrose-995 **Lactose-384* make sure lactose intolerant students avoid this sample**
Creamers: Coffee mate French Vanilla: 287, 810, 554 Coffee mate Italian Sweet Cream: 743, 309

Coffee mate ingredient list: Water, Sugar, Vegetable Oil (High Oleic Soybean and/or High Oleic Canola), and Less than 2% of Micellar Casein (a Milk Derivative)**, Mono- and Diglycerides, Dipotassium Phosphate, Natural and Artificial Flavors, Cellulose Gel, Cellulose Gum, Carrageenan, sucralose. **Not a Source of Lactose.

CONTAINS MILK

LABORATORY 3:

INSTRUCTOR DUTIES FOR LAB

- Ensure students know where/when to meet if using a computer lab
- Set up times to work with distance students; can use skype or a meeting set up via the internet.

LABORATORY 4:

INSTRUCTOR DUTIES FOR LAB

- Check whether students have gluten, dairy, or egg allergies, or if they do not consume caffeine/coffee

LABORATORY 5:

INSTRUCTOR DUTIES

- Check whether any student cannot or will not consume dairy products.
    - Substitutes for dairy may not work in this lab
    - Distance students may elect to use dairy substitutes, but they should be warned the experiments will not function as expected. If they elect to try substitutes, though, please observe their results, and if they do not function the same as dairy, have them observe the results of other groups.
- Check for allergies to soy, for the lecithin. Sunflower may be used instead.
- Prepare "rested xanthan gum" for all on campus lab groups.

LABORATORY 6:

INSTRUCTOR DUTIES

- Check whether any students are allergic to dairy, soy, or peanuts. Check the labels of the chocolates carefully for these ingredients
- Vegan and non-dairy versions of the milk and butter are fine for the frosting experiment. Note that non-dairy/vegan butter alternatives may not behave the same as regular butter.

LABORATORY 7:

INSTRUCTOR DUTIES

- Check whether any student has a fish allergy
    - Substitutes for dairy may not work in this lab
    - Distance students may elect to use dairy substitutes, but they should be warned the experiments will not function as expected. If they elect to try substitutes, though, please observe their results, and if they do not function the same as dairy, have them observe the results of other groups.
- Check for allergies to soy, for the lecithin. Sunflower may be used instead.
- Prepare "rested xanthan gum" for all on campus lab groups.

LABORATORY 8:

INSTRUCTOR DUTIES

- Samples of the gelatins will need to be sent home with students. Plan ahead for that.
- Check whether any student has a pineapple allergy or is vegan. Note that they do not have to eat any of the animal products or dairy in this lab, just look at and/or touch them.
    - Another option for vegan students would be fresh/cooked banana, and tapioca puddings/pearls. Have the student prepare the cooked tapioca pudding/pearls, then add the fresh vs. cooked banana.
    - Coconut based dairy substitutes could potentially work in this lab. Students who are unwilling/unable to handle animal products could attempt that and document their results to compare with their classmates.

LABORATORY 9:

INSTRUCTOR DUTIES

- Determine if anyone is vegan or has a dairy allergy, and needs a substitute exercise for the cheese experiment (Experiment 2). Note that they have the opportunity to just stir, and not eat, the cheese sauce if they choose. If they prefer not to work with the cheese at all, make sure they let you know so that you can assign an alternative activity. One example would be researching and writing a short summary of how vegan cheese is made.
- At the beginning of the lab (or after all pre-labs have been submitted), tell the students that they will need 4.5 grams of citric acid and 5.9 grams of sodium bicarbonate. This is a pre-lab question, but we do want them to use correct amounts for the experiment!
- Make sure the students know they should pause the microwaves if the solutions in Experiment 3 begin to boil over.

LABORATORY 10:

INSTRUCTOR DUTIES

- Read the labels on all packets/baking substitutes. Note down if any sweeteners not discussed here are used. Many of the blue packets changed formulation in 2019, containing a mix of aspartame and acesulfame potassium. The acesulfame potassium is more heat stable, so the differences after heating may be less obvious.
- Check if any students are allergic to any ingredients in the sugar cookies.
- Vegan substitutes for butter/eggs are acceptable in this lab.
- Gluten free flours may not work quite as well in this lab, at least for showing the cookies do not spread as much with the substitutes, but the browning show at least still be different among the sugars/substitutes if gluten free flour is used.
- Make sure students know to stop microwaving, letting the solution rest a few seconds, if their solutions are boiling very rapidly. You do not want them to boil away all the water.

LABORATORY 11:

INSTRUCTOR DUTIES

- Ask about allergens and avoid any flavors/ingredients that include those allergens. Recommend using sunflower seed “butter” and maybe cookie “butter” as the butters to use in class, to avoid any nut allergies.
- Make certain that students are using food grade/food approved glassware. They will often use beakers or flasks in this lab—make sure they are the food ones, and not used for other chemicals.
- If using liquid nitrogen, make certain you have proper attire and cold gloves. Do not let the students use the liquid nitrogen directly. Make certain you have done formal training on how to handle the liquid nitrogen, if you are using it. Dry ice is an alternative for fast freezing if liquid nitrogen is unavailable in food grade. The same rules apply for using caution and ensuring ultra-cold training has been conducted before you use it.
-

Appendix B: Binomial table

Binomial Table:
The number of people who have to select a sample in order for you to believe they can tell a difference, or have a preference (For p<0.05)

Total people tested	*For difference test*				*For preference test*
	Chance: 1/2	Chance: 1/3	Chance: 1/5	Chance: 1/6	Chance: 1/2
7	7	5	4	4	7
8	7	6	5	4	8
9	8	6	5	4	8
10	9	7	5	5	9
11	9	7	6	5	10
12	10	8	6	5	10
13	10	8	6	6	11
14	11	9	6	6	12
15	12	9	7	6	12
16	12	9	7	6	13
17	13	10	7	7	13
18	13	10	8	7	14
19	14	11	8	7	15
20	15	11	8	7	15
21	15	12	8	7	16
22	16	12	9	8	17
23	16	12	9	8	17
24	17	13	9	8	18
25	18	13	9	8	18
30	20	15	11	10	21
35	23	17	12	11	24
40	26	19	13	12	27
45	29	21	15	13	30
50	32	23	16	14	33
55	35	25	17	15	36
60	37	27	18	16	39

Appendix C: Paper sensory questionnaires

Lab 01-3: Solution sweetness 2020 public share

"Student" refers to the individual who will be tasting samples.

"Partner" is the person who will be handing the Student the samples to taste.

Partner: Have the student close their eyes, and then hit next. You will record their responses to the sugar solutions on the next screen.

Partner: The Student's eyes should be closed.
Hand the molar solutions to them to taste in random order. Do not let them see which solution they are tasting.
Have the Student taste each solution, and record which solution the Student thought was SWEETER.

- O Molar solution A was sweeter (1)
- O Molar solution B was sweeter (2)

Partner: The Student's eyes should be closed.
Hand the molar solutions to them to taste in random order. Do not let them see which solution they are tasting.
Have the Student taste each solution, and record which solution the Student thought was SWEETER.

- O Percent solution A (1)
- O Percent solution B (2)

Lab 02-1: Sensory Sugars - 2020 public

Rate the sweetness of each type of sugar. Taste them in random order.

492 ()	None	Strongest Ever
207 ()	None	Strongest Ever
731 ()	None	Strongest Ever
995 ()	None	Strongest Ever
384 ()	None	Strongest Ever

Lab 02-3: Sensory Creamers - 2020 Public

Taste all samples in random order.

Paired preference: Which sample did you prefer?

- O 287
- O 743

Triangle test: Which sample was different from the other two?

- O 743
- O 554
- O 810

Tetrad test:
You have four samples. Two are one flavor, and two are another flavor.
Taste all the samples, the sort them into two groups of two based on similarity.

These two samples are the same flavor	These two samples are the same flavor
______ 743	______ 743
______554	______ 554
______ 810	______ 810
______ 309	______ 309

Intensity category scale:
Rate the sweetness of each sample
1 = None, 9 = Strongest ever

Sample 309	Sample 287
O 9 - Strongest ever	O 9 - Strongest ever
O 8	O 8
O 7	O 7
O 6	O 6
O 5	O 5
O 4	O 4
O 3	O 3
O 2	O 2
O 1 - None	O 1 - None

Intensity line scale:
Rate the sweetness of the following samples, from None to Strongest ever

554	
810	

Hedonic category scale:
Taste each sample. Rate how much you liked/disliked it.

Sample 743	Sample 287
O Like Extremely	O Like Extremely
O Like very much	O Like very much
O Like moderately	O Like moderately
O Like slightly	O Like slightly
O Neutral	O Neutral
O Dislike slightly	O Dislike slightly
O Dislike moderately	O Dislike moderately
O Dislike very much	O Dislike very much
O Dislike extremely	O Dislike extremely

Hedonic line scale:
Taste the samples below, and rate how much you liked/disliked them.

287	Worst thing ever — Neutral — Best thing ever
309	Worst thing ever — Neutral — Best thing ever

End of Block: Hedonic line scale

Lab 04-1: Water Cookies 2020 public

"Student" refers to the individual who will be tasting samples.

"Partner" is the person who will be handing the Student the samples to touch and taste.

Note: if the Student is willing to feel the texture of the cookies, but not eat them, that is ok. You will be able to indicate that in the survey.

Partner-- Do not show the Student which cookie you are giving them!

Partner: Have the Student close their eyes.
Randomly select a cookie, and hand it to the Student.
Repeat for other cookies.

Partner: Instruct the Student to break the cookie in half, and note the texture of the cookie (hard or soft)
Take the cookie back, hide it from the Student, and then give this device to the student so they can rate the cookie.

White Cookie texture		
	Soft	Hard
Brown Cookie texture		
	Soft	Hard

Partner: Again, have the Student close their eyes. Then hand them the cookies in random order. You can use the halves of the cookies the student felt for texture in the previous part of this test.

Have them taste both cookies (again, in the order below), and indicate which they preferred (without opening their eyes!).

Select the cookie that the Student preferred.

- O White
- O Brown
- O Student was not willing or able to eat the cookies.

Lab 04-2: Water Coffee 2020 public

"Student" refers to the individual who will be tasting samples.

"Partner" is the person who will be handing the Student the samples to touch and taste.

Partner-- Do not show the Student which coffee sample you are giving them!

Partner: Have the Student close their eyes.
Select a coffee at random, and hand it to the Student.
Repeat for all coffees.

Partner: Instruct the Student taste the coffee.
Take the coffee back, hide the label from the Student, and then give this device to the student so they can rate the coffee's bitterness

75 C coffee Bitterness	None	Strongest Ever
88 C coffee Bitterness	None	Strongest Ever
100 C coffee Bitterness	None	Strongest Ever

Partner: Again, have the Student close their eyes.
Then hand them the two of the coffees, in random order.

Have them taste both coffees and indicate which they preferred (without looking at which sample was which).
Record the coffee the student preferred from each pair.

The pairs are:
75 C and 100 C
88 C and 100 C
75 C and 88 C

Lab 06-2: Phases/Crystals Chocolate - 2020 public

"Student" refers to the individual who will be tasting samples.

"Partner" is the person who will be handing the Student the samples to touch and taste.

Note: if the Student is willing to feel the texture of the chocolates, but not eat them, that is ok. You will be able to indicate that in the survey.

Give this device to the Partner for instructions. Have the Student close their eyes.

Partner: Instruct the Student to touch the chocolates, handing them to the student in random order. Ask the student which chocolate was harder, and record their response.

- O Short heating time chocolate (1)
- O Long heating time chocolate (2)

Partner: Now have the chocolates tot he Student again, in random order. Have the student taste the chocolates, and record which they preferred.If the student was unwilling or unable to taste the chocolate, indicate so below.

- O Short heating time chocolate (1)
- O Long heating time chocolate (2)
- O Student did not taste the chocolates. (3)

Lab 06-3: Phases/Crystals Frostings - 2020 public

"Student" refers to the individual who will be tasting samples.
"Partner" is the person who will be handing the Student the samples to touch and taste.
Partner: Have the Student taste each frosting (in random order). Tell them to think about how creamy it is, and how much they liked or disliked it. Have the student record these ratings.

Frosting 1:____

Creaminess ()	None — Strongest Ever
Dislike/Like ()	Worst thing ever — Neutral — Best thing ever

Frosting 2:____

Creaminess ()	None — Strongest Ever
Dislike/Like ()	Worst thing ever — Neutral — Best thing ever

Frosting 3:____

Creaminess ()	None — Strongest Ever
Dislike/Like ()	Worst thing ever — Neutral — Best thing ever

Frosting 4:____

Creaminess ()	None — Strongest Ever
Dislike/Like ()	Worst thing ever — Neutral — Best thing ever

Lab 07-2 Fish oil stink - 2020 public

"Student" refers to the individual who will be smelling samples.
"Partner" is the person who will be handing the Student the samples to evaluate.

Give this device to the Partner. Make sure the Student cannot see the instructions regarding which sample they are smelling.

Partner: Have the student close their eyes. Hand each fish oil sample to the Student in random order, and have them rate the rancid/fishy smell.

Student: Rate the intensity of the rancid, fishy odor from the oil.

Penny sample: Rancid, Fishy smell ()	None ... Strongest Ever
Dark sample: Rancid, Fishy smell ()	None ... Strongest Ever
Cold sample: Rancid, Fishy smell ()	None ... Strongest Ever
Sun sample Rancid, Fishy smell ()	None ... Strongest Ever
Capsule sample: Rancid, Fishy smell ()	None ... Strongest Ever

Lab 08-2 garlic odor intensity - 2020 public

Rate the intensity of the odors you smelled during this lab.
The items with the asterisks (*) are the ones you smelled at the end of the experiment, 30 minutes after you sliced/smashed the garlic.

Odor intensity

Coffee beginning ()	None	Strongest Ever
Whole garlic ()	None	Strongest Ever
Sliced garlic* ()	None	Strongest Ever
Smashed garlic* ()	None	Strongest Ever
Lemon juice smashed garlic* ()	None	Strongest Ever
Coffee end* ()	None	Strongest Ever

Lab 09-2: Additives Sodium Citrate 2020 public

"Student" refers to the individual who will be tasting/looking at samples.

"Partner" is the person who will be handing the Student the cheese sauces to view and taste.

Partner, please make certain the Student cannot tell from the cups/bowls which sauce is which (hide the labels from the Student)

Partner: Hand the student the sauces below in random order. Have them stir the sauces with a spoon. Ask them which sample had the better visual appearance, and fill in their answer below.

- O Homemade sodium citrate (citric acid/baking soda) cheese sauce (1)
- O Sodium citrate (purchased) cheese sauce (2)

Partner: Hand the student the sauces below in random order. Have them stir the sauces with a spoon. Ask them which sample had the better visual appearance, and fill in their answer below.

- O Control cheese sauce (1)
- O Sodium citrate (purchased) cheese sauce (2)

Partner: Hand the student the sauces below in random order. Have them stir the sauces with a spoon. Ask them which sample had the better visual appearance, and fill in their answer below.

- O Homemade sodium citrate (citric acid/baking soda) cheese sauce (1)
- O Sodium citrate (purchased) cheese sauce (2)

Partner: Hand the student the sauces below in random order. Have them taste the sauces and tell them to think about the sauce's texture. Ask them which sample had the better oral texture, and fill in their answer below.

- O Homemade sodium citrate (citric acid/baking soda) cheese sauce (1)
- O Control cheese sauce (2)

Partner: Hand the student the sauces below in random order. Have them taste the sauces and tell them to think about the sauce's texture. Ask them which sample had the better oral texture, and fill in their answer below.

- O Control cheese sauce (1)
- O Sodium citrate (purchased) cheese sauce (2)

Partner: Hand the student the sauces below in random order. Have them taste the sauces and tell them to think about the sauce's texture. Ask them which sample had the better oral texture, and fill in their answer below.

- O Homemade sodium citrate (citric acid/baking soda) cheese sauce (1)
- O Sodium citrate (purchased) cheese sauce (2)

Lab 10-1: Cookie weights Baking Substitutes (as a group) 2020 public

---

What is the calculated cookie weight for cookies made from the SUCROSE (regular white sugar) dough? (batch weight / 12 = cookie weight)

____

What is the calculated cookie weight for cookies made from the SUCRALOSE (Splenda) dough? (batch weight / 12 = cookie weight)

____

What is the calculated cookie weight for cookies made from the HONEY dough? (batch weight / 12 = cookie weight)

____

What is the calculated cookie weight for cookies made from the STEVIA dough? (batch weight / 12 = cookie weight)

____

Lab 10-1: Cookie Sensory Baking Substitutes (each person fills this out) 2020 public

"Student" refers to the individual who will be tasting/rating samples. They may choose to only feel the cookie, not eat it, if they wish. Rate the following for all cookies, in random order (Have a partner keep track of which cookie is which.

Student: Break the cookie in half using your hands. Then rate how much you like the texture of this cookie.

Sucrose cookie

Texture ()	Worst thing ever	Neutral	Best thing ever
Student, now taste the cookie.			
Sweetness ()	None		Strongest Ever
Student: Now rate how much you liked the cookie.			
Liking ()	Worst thing ever	Neutral	Best thing ever

Honey cookie

Texture ()	Worst thing ever	Neutral	Best thing ever
Student, now taste the cookie.			
Sweetness ()	None		Strongest Ever
Student: Now rate how much you liked the cookie.			
Liking ()	Worst thing ever	Neutral	Best thing ever

Stevia cookie

Texture ()	Worst thing ever — Neutral — Best thing ever

Student, now taste the cookie.

Sweetness ()	None — Strongest Ever

Student: Now rate how much you liked the cookie.

Liking ()	Worst thing ever — Neutral — Best thing ever

Sucralose cookie

Texture ()	Worst thing ever — Neutral — Best thing ever

Student, now taste the cookie.

Sweetness ()	None — Strongest Ever

Student: Now rate how much you liked the cookie.

Liking ()	Worst thing ever — Neutral — Best thing ever

Lab 10-2: BEFORE microwaving sweeteners 2020 public

"Student" refers to the individual who will be tasting samples.
"Partner" is the person who will be handing the Student the samples to taste.

Partner, in random order, hand the Student a sample of the solution and let them try it. Have them rate it for sweetness and bitterness. Make sure you hide the sample's name on this page from the Student.

Sucrose	Bitterness ()	None — Strongest Ever
	Sweetness ()	None — Strongest Ever
Sucralose	Bitterness ()	None — Strongest Ever
	Sweetness ()	None — Strongest Ever
Stevia	Bitterness ()	None — Strongest Ever
	Sweetness ()	None — Strongest Ever
Saccharin	Bitterness ()	None — Strongest Ever
	Sweetness ()	None — Strongest Ever
Aspartame	Bitterness ()	None — Strongest Ever
	Sweetness ()	None — Strongest Ever

Lab 10-2: AFTER microwaving sweeteners 2020 public

Student" refers to the individual who will be tasting samples.
"Partner" is the person who will be handing the Student the samples to taste.

Partner, in random order, hand the Student a sample of the solution and let them try it. Have them rate it for sweetness and bitterness. Make sure you hide the sample’s name on this page from the Student.

Sucrose	Bitterness ()	None — Strongest Ever
	Sweetness ()	None — Strongest Ever
Sucralose	Bitterness ()	None — Strongest Ever
	Sweetness ()	None — Strongest Ever
Stevia	Bitterness ()	None — Strongest Ever
	Sweetness ()	None — Strongest Ever
Saccharin	Bitterness ()	None — Strongest Ever
	Sweetness ()	None — Strongest Ever
Aspartame	Bitterness ()	None — Strongest Ever
	Sweetness ()	None — Strongest Ever