# Experiments In Food Science

## Laboratory Manual, Volume 2

**Contents**



### What is Food Science?

This laboratory manual has two purposes. The first purpose is to describe what food science is and what food scientists do. The second purpose is to describe fun laboratory experiments that that demonstrate practical applications of food science.

Food science is all of the science involved in taking agricultural food products from the farmer's gate to the grocery store, restaurant, or dinner table. Food scientists work with all sectors of agriculture. Food science includes both basic and applied biology, microbiology, chemistry, math, business, engineering, physics, and other disciplines. A food scientist's goal is to make safe, high quality food products that are profitable to all segments of agriculture.

Those who earn a bachelor of science in food science have starting salaries of $45,000 to $60,000 per year and work for some of the largest food manufacturing companies in the country. Food science students can also compete in national competitions dealing with food, such as Dairy Judging, Meats Judging, New Product Development, and the Research Chef's Association. These events offer participants networking and learning opportunities for future career growth.

Some food science majors pursue careers in veterinary medicine or other healthcare fields. They complete the food safety option in the food science curriculum, which allows them to work towards an undergraduate degree while completing the prerequisites for veterinary school. The veterinary school acceptance rate for food science majors is very competitive compared to the acceptance rate for all pre-vet disciplines.

But food science graduates who do not pursue professional degrees in healthcare also have great job opportunities and often advance rapidly. They can work for regulatory agencies, ingredient and equipment manufacturers, research firms, suppliers, or other companies; all offer great opportunities for food science graduates.

Laboratory exercises in this manual demonstrate principles behind lipid extraction, jelly making, temperature and taste, freezing, iron extraction, food states (liquids, gels, etc.), emulsions, and pickling. These laboratory experiments demonstrate some simple scientific principles that apply to food manufacturing and show the characteristics of some common foods.

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## Experiment 1: Invisible Lipids

### *Purpose*

This experiment demonstrates the presence of lipids in common foods.

### *Materials*

- 5 grams potato chips (broken into small pieces)
- 5 grams semi-sweet chocolate chips (crushed between two pieces of foil with a rubber mallet)
- 5 grams sunflower seeds (crushed between two pieces of foil with a rubber mallet)
- 60 milliliters ethanol
- Three 150 milliliter beakers
- Three 100-mm petri dishes or weigh boats
- Balance
- Gloves
- Aluminum foil

### *Procedure*

*** Please do not consume any of the food products.***

1. Label each of three beakers with the three types of food. Weigh and record the weight of each beaker.
2. Weigh and transfer each food sample to labeled beakers. Record the weight of the beakers with the food samples.
3. Add 10 milliliters of ethanol to each beaker and swirl for 1 minute. Be sure to perform this step in a well-ventilated area or under a hood.
4. Carefully decant the ethanol from each beaker into a labeled petri dish or weigh boat. Make sure the food samples remain in the beaker.
5. Add 10 more milliliters of ethanol to the beakers, swirl for 1 minute, and decant the ethanol into the petri dishes as before.
6. Allow ethanol in the petri dish to dry overnight in a well-ventilated area or under a hood. Look in the petri dish to see the lipid that was extracted.
7. Allow the beakers with the food samples to dry overnight.
8. Weigh the beakers with the dry food samples. Record the weights.

### *Notes*

Lipids are soluble in organic solvents. In this experiment, ethanol is used to extract lipids from food. When extraction is complete, the lipids become visible. Two types of lipids should show up in the petri dish: saturated and unsaturated lipids. Saturated fatty acids have all single bonds, have a maximum number of hydrogen associated with the carbon atoms, and are solid at room temperature. In contrast, unsaturated fatty acids are liquid at room temperature and have double bonds between the carbon atoms. Fatty acids that have more than one double bond are known as polyunsaturated fatty acids.

### *Reference*

http://www.ift.org/Knowledge-Center/Learn-About-Food-Science/K12-Outreach/Food-Science-Experiments/~/media/Knowledge%20Center/Learn%20Food%20Science/Experiments/TeacherGuideLIPIDS.ashx

**Extraction Of Lipids**

| Food | Weight of beaker (grams) | Weight of beaker with food (grams) | Weight of food sample (grams) | Weight of beaker with dried food overnight (grams) | Weight lost from food (grams)[1] | Percent lipid extracted[2] |
|---|---|---|---|---|---|---|
| Potato chips | | | 5 | | | |
| Chocolate chips | | | 5 | | | |
| Sunflower seeds | | | 5 | | | |

[1](Weight of beaker with food) – (Weight of beaker with dried food) = Weight lost from food

[2](Weight lost from food / weight of food) x 100 = percent lipid extracted

**Description Of Fats**

| Food | Color | Texture | Odor | Viscosity |
|---|---|---|---|---|
| Potato chips | | | | |
| Chocolate chips | | | | |
| Sunflower seeds | | | | |

## Experiment 2: Jelly Making

### *Purpose*

This experiment demonstrates the importance of pectin in jelly making. It also shows how the amount of sugar used affects the jelly.

### *Materials*

- Commercial pectin (like Sure-Jell)
- Concentrated apple juice
- Balance
- Sugar
- Graduated cylinder
- 600 mL beakers
- Stirring rod or wooden spoon
- Hot plate
- Heavy gloves

### *Procedure*

**Treatment 1 (control)**

1. Place 117 ml apple juice in a 1000 mL beaker. Gradually add 10.5 grams pectin, stirring to mix it.
2. Place the beaker on a hot plate and stir constantly over high heat to a full boil.
3. Add 79 grams of sugar. Return the mixture to a full, rolling boil. Boil hard for 1 minute, stirring constantly. Be sure to adjust the heat source so that the liquid does not boil up the sides of the beaker. **CAUTION!** This mixture can boil over very quickly if it's not carefully watched.
4. Remove the hot beaker from the heat source. Place the hot beaker on a heatproof pad and allow the jelly to cool. Use a spoon to skim off the foam on the top.
5. If the sample gelled, loosen the pectin from the beaker with knife and then invert the beaker to slide the gel onto a paper plate. Observe the consistency of the gel and its ability to hold a shape.

**Treatment 2 (low sugar)**

1. Repeat steps as in control, but use 39 grams of sugar instead of 79 grams.
2. Record your results.

**Treatment 3 (high sugar)**

1. Repeat steps as in control, but use 159 grams of sugar instead of 79 grams.
2. Record your results.

**Treatment 4 (low pectin)**

1. Repeat steps as in control, but use 5 grams of pectin instead of 10.5 grams.
2. Record your results.

### *Notes*

Jellies are made from the strained juice of fruits. Jellies should be crystal clear and hold their shape but soft enough to spread. The main ingredients to make jelly are

- pectin, which is a carbohydrate found in fruits (some fruits have more pectin than others, so commercial pectin is available)
- an acid, like lemon juice or citric acid
- sugar, and
- juice (almost any juice will make jelly).

To make jelly, pectin and lemon juice are added to fruit juice. The solution is then heated, making pectin water-soluble. When sugar is added, the pectin precipitates out, forming insoluble fibers. Lemon juice lowers the pH and aids in the gelling process. The insoluble fibers produce a mesh-like structure that traps the fruit juice, much like a sponge absorbs water.

This enables the mixture to form a gel. Too little sugar will result in a runny, liquid jelly; too much sugar will produce a jelly that has some firmness but will not hold its shape. Sugar also contributes to flavor and acts as a preservative.

### *Reference*

http://www.accessexcellence.org/AE/AEPC/IFT/unit_one.php

**Jelly Consistency**

| Experiment | Jelly | Consistency |
|---|---|---|
| Control | Regular formula | |
| Treatment 1 | Low sugar | |
| Treatment 2 | High sugar | |
| Treatment 3 | Low pectin | |

## Experiment 3:
## Effect of Temperature on Taste

### *Purpose*
This experiment demonstrates how temperature influences taste.

### *Materials*
- 15 grams non-iodized salt (sodium chloride, NaCl)
- 15 grams food-grade citric acid
- 15 grams granulated sugar
- Water
- Nine 150-mL beakers (three for each chemical compound)
- Weigh boats
- Hot plates
- Thermometers
- Ice bath
- Scale

### *Procedure*
1. Label three beakers “NaCl.” Assign a temperature to each beaker and label them accordingly. Label one beaker “4 °C,” one “20 °C,” and one “40 °C.”
2. Add 5 grams of NaCl (salt) and 95 grams of water to each beaker.
3. Repeat steps 1 and 2 for sugar and citric acid. When you finish, there should be three treatments (NaCl, citric acid, and sugar), and each treatment should have three assigned temperatures.
4. Leave the three beakers labeled 20 °C at room temperature.
5. Place the three beakers labeled 40 °C on hot plates. Place thermometers in the beakers.
6. Place the three beakers labeled 4 °C in an ice bath. Place thermometers in the beakers.
7. Monitor the temperatures of the solutions. When the desired temperature is reached, carefully taste the solutions. Record your observations in the table provided.

### *Notes*
For many years, scientists have observed that temperature affects perceived taste of foods.  The taste buds in our tongue contain receptors that are sensitive to temperature and specifically recognize sweet, bitter, sour and salty.  When warmer food comes in contact with these receptors, a stronger electrical signal is generated in our tongue. This signal is sent to our brains, intensifying the flavor of the food and causing us to recognize the taste. Certain desserts, such as ice cream, are sweeter when they are warm. Likewise, beer tastes less bitter when it is chilled. Have you ever noticed that soups taste saltier when cold?  As the temperature of the food increases, our ability to distinguish sweetness also increases.

### *Reference*

http://suite101.com/article/colorful-flavors-how-color-and-other-influences-can-affect-taste-a405081

http://ukangela.blogspot.com/2010/04/how-temperature-of-food-affects-our.html


**Flavor Observations**

| Contents of Beaker | 4 °C | 20 °C | 40 °C |
|---|---|---|---|
| 5 grams NaCl, 95 grams water | | | |
| 5 grams citric acid, 95 grams water | | | |
| 5 grams sugar, 95 grams water | | | |

# Experiment 4: Supercooling of Water

## *Purpose*

This experiment demonstrates how water can remain liquid below its normal freezing point of 0 °C.

## *Method 1*

**Materials**

- 20 mL bottled distilled water
- Ice cubes
- 2 Tablespoons salt
- Large glass bowl
- Thermometer
- Clear plastic cup

**Procedure**

1. Pour 20 mL distilled water into a clean, clear plastic cup.
2. Place the cup in the center of the glass bowl. Cover the cup with plastic wrap.
3. Add ice cubes inside the bowl until the level of the ice is above the level of the water in the cup.
4. Sprinkle 2 tablespoons of salt over the ice cubes. Uncover the cup. Insert a thermometer.
5. Monitor the temperature of the water. When the temperature reaches -1 to -3 °C, carefully remove the cup from the ice.
6. Make the water freeze by pouring it over a piece of ice or by dropping a small piece of ice into the cup.

**Reference**

http://www.sciencebuddies.org/science-fair-projects/project_ideas/Phys_p033.shtml

http://chemistry.about.com/od/chemistryhowtoguide/a/how-to-supercool-water.htm

## *Method 2* (Mini supercooling of water)

**Materials**

- Bottled distilled water
- Wide mouth beaker or bowl (glass)
- Plastic wrap
- Ice cubes
- Pipette

**Procedure**

1. Cover the top of the beaker or bowl with plastic wrap.
2. Using a pipette, place several drops of distilled water on the plastic wrap. Make sure the drops are spaced apart from each other.
3. Place the beaker or bowl in a freezer for 5 minutes.
4. Remove the beaker or bowl from the freezer and note that some drops are opaque, and others are translucent. The opaque drops are frozen, while the translucent drops are liquid.
5. Touch the translucent drops with an ice cube and watch them freeze instantaneously.

**Reference**

http://www.exploratorium.edu/cooking/candy/activity-drops.html

## *Notes*

Supercooling is cooling a liquid below its normal freezing point without crystallization. Water's normal freezing point is 0 °C (32 °F). When water is cooled to its freezing point, ice crystals begin to form and grow in the water. Impurities in the water can trigger ice crystal formation, preventing the water from becoming supercooled. A sample of pure water (free of impurities), cooled slowly, can produce supercooled liquid water. However, when ice touches supercooled water, it catalyzes the crystallization of the liquid, and the water instantly freezes.

## Experiment 5: Iron Extraction

### *Purpose*

The purpose of this experiment is to demonstrate the presence of iron in breakfast cereals.

### *Materials*

- 150 grams breakfast cereal
  (Total cereal works best.)
- Plastic bag with zip top or twist tie
- Warm water
- Beakers
- Large magnetic stir bar (70 mm)
- Stir bar retriever rod
- Scale
- Magnetic stir plate

### *Procedure*

* **Please do not consume any of the food products.***

1. Place cereal into the plastic bag, close the bag, and carefully crush cereal into a fine powder. Transfer crushed cereal into a beaker. Place stir bar in beaker.
2. Add enough warm water to cover the crushed cereal completely. Stir contents until the mixture is brown and soupy. Allow mixture to stand for 30 minutes.
3. Remove stir bar with a stir rod.
4. You should notice a fine gray powder of iron attached to the stir rod. Wipe the powder on a white napkin to see the iron better.

### *Notes*

Many breakfast cereals are fortified with food-grade iron particles (metallic iron) as a mineral supplement. The body must have iron for to function properly. Iron is digested in the stomach and absorbed in the small intestine. Iron is present in muscle tissue and some enzymes, and approximately 60 to 70 percent of the human body's iron is found in hemoglobin. If all of the body's iron were extracted, there would be enough iron to make only two small nails.

### *Reference*

http://www.ift.org/knowledge-center/learn-about-food-science/k12-outreach/~/media/Knowledge%20Center/Learn%20Food%20Science/Food%20Science%20Activity%20Guide/activityguide.ashx
http://www.stevespanglerscience.com/experiment/nails-for-breakfast

## Experiment 6: Reverse Spherification

### *Purpose*

This experiment demonstrates the process used to create edible, liquid-filled spheres.

### *Materials*

- 2 grams sodium alginate
- ½ teaspoon calcium lactate (or calcium chloride)
- 6 cups water (distilled or bottled)
- 1 ½ cups fresh or frozen berries
- 2 Tablespoons sugar
- 2 medium bowls
- Measuring spoon
- Slotted spoon
- Blender
- Balance

### *Procedure*

***Please do not eat any of the food products.***

1. Combine berries, sugar, and calcium lactate in the bowl of a blender. Puree the mixture.
2. In a separate bowl, mix the sodium alginate in 2 cups of water until the sodium alginate is completely dissolved. Refrigerate for 15 minutes.
3. Remove sodium alginate bath from the refrigerator.
4. Using a measuring spoon, carefully transfer several spoonfuls of the berry puree into the sodium alginate bath. Spherification should occur immediately. Allow the spheres to sit in sodium alginate bath 2-3 minutes.
5. Pour the remaining water into a clean rinsing bowl. Transfer the spheres to the rinsing bowl using a slotted spoon.
6. Remove spheres carefully from rinsing bowl, as they are fragile.

### *Notes*

Spherification is a cooking technique in which a liquid is dropped into a solution to create spheres with a thin gel membrane filled with the original liquid. Reverse spherification occurs because of the interaction between a calcium source and sodium alginate. Calcium ions cause alginate polymers to become cross-linked, forming a gel. These spheres have a thicker outer membrane, and the jellification stops when the sphere is removed from the alginate bath and rinsed with water. Jellification occurs only on the surface, as alginate fails to penetrate the sphere. Thanks to these characteristics, reverse spheres are long lasting, can be manipulated more easily and used in more ways.

### *Reference*

http://www.molecule-r.com/en/content/54-raspberry-ravioles
http://www.molecularrecipes.com/spherification/

## Experiment 7: Pickling

### *Purpose*

This experiment demonstrates the effect of pickling on preservation of food.

### *Warnings*

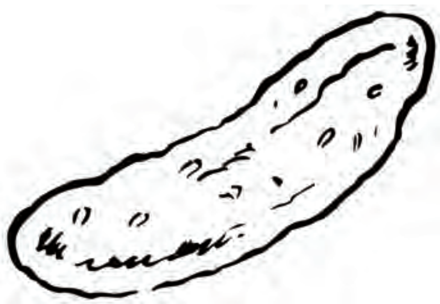
- Never alter the amounts of vinegar, food, or water in a pickling recipe. Do not use vinegars with unknown acidity. Use only well-tested recipes.
- Do not prepare any part of this experiment using copper, brass, iron, or galvanized cookware or utensils; doing so can result in toxic compounds and undesirable colors or flavors.

### *Materials*

- 4 lbs pickling cucumbers (preferably no longer than 4-5 inches)
- 1.42 L vinegar, 5% acidity
- 2.72 lbs sugar
- 38.2 g pickling/canning salt
- 7.6 g pickling spice (may be bound in cheesecloth)
- Knife
- Cutting board
- 2 large saucepots
- 7-8 pint jars with lids and rings
- Large canner with rack and lid
- Jar lifter or oven mitts
- Scale
- Weigh boats
- Ladle or measuring cup
- Tongs
- Thermometer

### *Procedure*

1. Wash jars, lids, and rings. Rinse thoroughly to remove detergent residue. Put jars in canner and boil. Remove jars and set them on a towel.
2. Keep lids and rings in simmering water (180 °F) until needed.
3. Wash cucumbers and remove the ends. Slice cucumbers into ¼ inch rounds.
4. Pack sliced cucumbers into jars, leaving enough space for pickling solution.
5. In a saucepot, combine vinegar, sugar, pickling salt, and pickling spice. Heat over medium heat and bring to a boil.
6. When pickling solution begins to boil, quickly ladle hot solution over cucumbers, leaving ¼ inch of headspace. If pickling spice has been tied in cheesecloth, remove spice pouch before adding solution to jars.
7. Wipe the rim of each jar with a clean, damp cloth. Center heated lid on jar and screw ring down evenly and firmly until you feel resistance.
8. After all jars have been filled and capped, place jars in canner. Water level should be one to two inches above the top of the jars. Place lid on canner and bring water to a steady boil. Boil according to your elevation. If you are at an elevation of 1,000 ft. or below, jars should process for 15 minutes; if you are at 1,001 ft. to 6,000 ft., jars should process for 20 minutes.
9. After processing, remove jars with jar lifter and allow them to cool. When jars are cool, test each jar by pressing the center of the lid. The lid should remain firm and not spring back. (If it does, immediately refrigerate or reprocess with a new lid for the full length of time).



### *Notes*

Pickling is an ancient form of preservation that consists of using an acidic medium, such as vinegar, to lower the pH of a food. Pickled foods should have a pH of 4.6 or below to prevent the growth of microorganisms such as *Clostridium botulinum*, a deadly spore-forming bacterium. Heat processing, such as canning, also helps destroy any microorganisms capable of growing at a pH lower than 4.6.

Heat-treating pickles deactivates enzymes in the cucumbers, helping them retain good color, flavor, and texture. The pickles produced in this experiment are considered fresh-pack or quick-process pickles because they have not been brined like traditional pickles. Pickles will last up to a year if properly processed and stored.

### *Reference*

Recommended processing times in a water bath canner and recipe have been adapted from *Making Pickled Products*, 2011 by Julie Garden-Robinson, Ph. D., North Dakota State University Extension Service (NDSU) in cooperation with Joan Hegerfield-Baker, M.S., South Dakota Cooperative Extension Service.

## Experiment 8: Emulsions

### *Purpose*

This experiment demonstrates how to make mayonnaise, a common food emulsion.

### *Materials*

***For best results, all ingredients should be at 50 °F.***

- 320.4 grams soybean oil
- 27.6 grams water
- 6 grams sugar
- 8 grams apple cider vinegar
- 4.6 grams distilled vinegar
- 24 grams egg yolk
- 4 grams corn syrup
- 2 grams salt
- 2.57 grams mustard
- 0.2 grams garlic powder
- Food processor
- 250 mL beaker
- Balance

### *Procedure*

1. Combine water, sugar, salt, corn syrup, mustard, garlic powder, and vinegars in a food processor bowl. Blend well.
2. Blend egg yolks into mixture until it becomes frothy.
3. While the processor is blending, add soybean oil a little at a time, making sure to incorporate all of the oil into the mixture each time. Do not stop blending, or your emulsion could fail! Blend until all the oil has been incorporated and the mixture is smooth and creamy.

### *Notes*

Emulsifiers are molecules that have two different ends: one that likes water (hydrophilic), and the other that dislikes water and likes oil (hydrophobic). An emulsion is a stable mixture of oil and water that does not separate. Many products are emulsions, including salad dressings, ice creams, and milk. In mayonnaise, egg yolks act as an emulsifier because they contain lecithin and many proteins that have amino acids simultaneously capable of attracting and repelling water.

### *Reference*

http://www.scienceprojectideas.co.uk/making-emulsion.html



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**Publication 2772**
Extension Service of Mississippi State University, cooperating with U.S. Department of Agriculture. Published in furtherance of Acts of Congress, May 8 and June 30, 1914. DR. GARY JACKSON, Director
(POD 6-13)