

Experiments in Food Science: Laboratory Manual, Volume 2

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 demonstrate practical applications of food science.

Food science is the science behind 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 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 can expect starting salaries ranging from \$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 focused on food, such as dairy judging, meats judging, new product development, and the Research Chefs 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 toward 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.

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, and more), emulsions, and pickling. These laboratory experiments demonstrate some simple scientific principles that apply to food manufacturing and show the characteristics of some common foods.

Experiment 1: Invisible Lipids

Purpose

This experiment illustrates the presence of lipids in common foods.

Materials

- 5 g of potato chips (broken into small pieces)
- 5 g of semi-sweet chocolate chips (crushed between two pieces of foil with a rubber mallet)
- 5 g of sunflower seeds (crushed between two pieces of foil with a rubber mallet)
- 60 ml of ethanol
- 3 150-ml beakers
- 3 100-mm petri dishes or weigh boats
- Balance
- Gloves
- Aluminum foil

Procedure

Please do not consume any of the food products.

1. Label each of the three beakers with the corresponding type of food. Weigh and record the weight of each beaker.
2. Weigh and transfer each food sample to labeled beakers. Record the combined weight of the beakers and 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 the corresponding labeled petri dish or weigh boat. Make sure the food samples remain in the beaker.

- Add 10 more milliliters of ethanol to the beakers, swirl for 1 minute, and decant the ethanol into the petri dishes as before.
- 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.
- Allow the beakers with the food samples to dry overnight.
- Weigh the beakers with the dry food samples. Record the weights.

ethanol evaporates, 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.

Notes

Lipids are soluble in organic solvents. In this experiment, ethanol is used to extract lipids from food. When the

Reference

Institute of Food Technologists.

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) × 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 and how the amount of sugar used affects the jelly.

Materials

- Commercial pectin (like Sure-Jell)
- Concentrated apple juice
- Balance
- Sugar
- Graduated cylinder
- 1000-ml beakers
- Stirring rod or wooden spoon
- Hot plate
- Heavy gloves

Procedure

Treatment 1 (control)

1. Place 117 milliliters of apple juice in a 1000-ml beaker. Gradually add 10.5 grams of 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 a 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)

3. Repeat steps as in control, but use 159 grams of sugar instead of 79 grams.
4. 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. Using too little sugar results in runny jelly, while too much sugar creates a firm jelly that cannot hold its shape. Sugar also contributes to flavor and acts as a preservative.

Jelly consistency.

Jelly Experiment	Consistency
Treatment 1 (Regular formula)	
Treatment 2 (Low sugar)	
Treatment 3 (High sugar)	
Treatment 4 (Low pectin)	

Experiment 3: Effect of Temperature on Taste

Purpose

This experiment demonstrates how temperature affects taste perception.

Materials

- 15 g of non-iodized salt (sodium chloride, NaCl)
- 15 g of food-grade citric acid
- 15 g of granulated sugar
- Water
- 9 150-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. After completing this step, there should be three treatments (NaCl, citric acid, and sugar), each with three assigned temperatures.

Flavor observations.

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

4. Leave the three beakers labeled 20°C at room temperature.
5. Place the three beakers labeled 40°C on hot plates and insert thermometers.
6. Place the three beakers labeled 4°C in an ice bath and insert thermometers.
7. Monitor the temperatures of the solutions. When the desired temperature is reached, carefully taste each solution. 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 the brain, intensifying the flavor and enhancing taste recognition. Certain desserts, like ice cream, taste sweeter when warmed. Likewise, beer tastes less bitter when it is chilled. Have you ever noticed that soups taste saltier when cold? Higher food temperatures enhance our ability to perceive sweetness.

Reference

Bibbins, A. (2010, April 5). *How the temperature of food affects our taste*.

Experiment 4: Supercooling Water

Purpose

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

Method 1 Materials

- 20 ml of bottled distilled water
- Ice cubes
- 2 tbs of salt
- Large glass bowl
- Thermometer
- Clear plastic cup

Procedure

1. Pour 20 milliliters of 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 to the bowl until the ice level is above the water level in the cup.
4. Sprinkle 2 tablespoons of salt over the ice cubes. Uncover the cup and insert a thermometer.
5. Monitor the temperature of the water. When the temperature reaches between -1 and -3°C, carefully remove the cup from the ice.
6. To freeze the water, pour it over a piece of ice or drop a small ice cube into the cup.

Reference

Science Buddies Staff. (2020, November 20). *Supercooling water and snap freezing*.

Helmenstine, A. M. (2019, September 8). *Two methods for supercooling water*. Thought Co.

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. Use a pipette to place several drops of distilled water onto 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. Observe that the opaque drops are frozen, while the translucent drops remain liquid.
5. Touch the translucent drops with an ice cube and watch them freeze instantaneously.

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 they grow within the water. Impurities in water can trigger ice crystal formation, which prevents 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 g of breakfast cereal (Total cereal works best)
- Plastic bag with a 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 the cereal into the plastic bag, close the bag, and carefully crush it into a fine powder.
2. Transfer crushed cereal into a beaker. Place stir bar in beaker.
3. Add enough warm water to cover the crushed cereal completely. Stir contents until the mixture becomes brown and soupy. Allow the mixture to stand for 30 minutes.



- Remove stir bar with a stir rod.
- You should notice a fine gray powder (iron) attached to the stir rod. Wipe the powder onto 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 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 to make only two small nails.

Reference

Institute of Food Technologists.

Steve Spangler Science.

Experiment 6: Reverse Spherification

Purpose

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



Materials

- 2 g of sodium alginate
- ½ tsp of calcium lactate (or calcium chloride)
- 6 cups of distilled or bottled water
- 1½ cups of fresh or frozen berries
- 2 tbs of sugar
- 2 medium bowls
- Measuring spoon
- Slotted spoon
- Blender
- Balance

Procedure

Please do not eat any of the food products.

- Combine berries, sugar, and calcium lactate in a blender bowl. Puree the mixture.
- In a separate bowl, mix the sodium alginate with 2 cups of water until the sodium alginate is completely dissolved. Refrigerate the mixture for 15 minutes.
- Remove the sodium alginate bath from the refrigerator.
- Using a measuring spoon, carefully transfer several spoonfuls of the berry puree into the sodium alginate bath. Spherification should occur immediately after transfer. Allow the spheres to sit in sodium alginate bath for 2-3 minutes.
- Pour the remaining water into a clean bowl for rinsing. Transfer the spheres to the rinsing bowl using a slotted spoon.
- 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 that have a thin gel membrane filled with the original liquid. Reverse spherification occurs due to 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 jellification stops when the sphere is removed from the alginate bath and rinsed with water. Jellification occurs only on the surface, as the alginate fails to penetrate the sphere. Thanks to these characteristics, reverse spheres are long-lasting, can be manipulated more easily, and can be used in more ways.

Reference

MolecularRecipes.com. (n.d.) *Spherification class*.

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 vinegar with unknown acidity. Use only well-tested, reliable recipes.
- Do not use copper, brass, iron, or galvanized cookware or utensils at any stage of this experiment, as doing so can result in toxic compounds and undesirable colors or flavors.

Materials

- 4 lb of pickling cucumbers (preferably 4-5 inches)
- 1.42 L vinegar with 5% acidity
- 2.72 lb of sugar
- 38.2 g of pickling/canning salt
- 7.6 g of pickling spice (which 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 the jars, lids, and rings. Rinse them thoroughly to remove detergent residue. Put jars in canner and bring to a boil. Remove the jars and set them on a towel.
2. Keep the lids and rings in simmering water (180°F) until needed.
3. Wash the cucumbers and remove the ends. Slice cucumbers into quarter-inch rounds.
4. Pack sliced cucumbers into jars, leaving enough space for pickling solution.
5. In a saucepot, combine the vinegar, sugar, pickling salt, and pickling spice. Heat the mixture over medium heat and bring to a boil.
6. When the pickling solution begins to boil, quickly ladle hot solution over cucumbers, leaving a quarter-inch of headspace. If the 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 the heated lid on the jar and screw the ring down evenly and firmly until you feel resistance.
8. After all the jars have been filled and capped, place jars in the canner. The water level should be 1 to 2 inches above the top of the jars. Place the lid on canner and bring the water to a steady boil. Boil according to your elevation. If you are at an elevation of 1,000 feet or below, jars should process for 15 minutes; if you are at 1,001 feet to 6,000 feet, jars should process for 20 minutes.
9. After processing, remove the jars with a jar lifter and allow them to cool. When the jars are cool, test each 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).

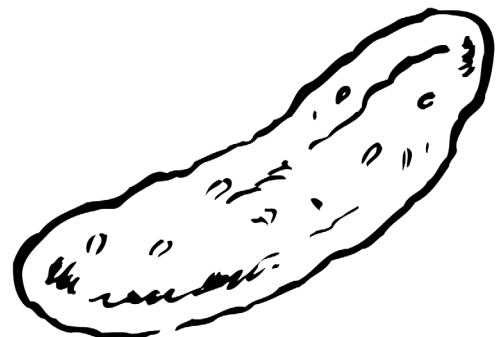
Notes

Pickling is an ancient form of preservation in which an acidic medium, such as vinegar, is used to lower the pH of food. Pickled foods should have a pH of 4.6 or lower 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 can 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, PhD, North Dakota State University Extension Service (NDSU) in cooperation with Joan Hegerfield-Baker, MS, South Dakota Cooperative Extension Service.



Experiment 8: Emulsions

Purpose

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

Materials

For best results, ensure all ingredients are at 50°F.

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

Procedure

1. Combine the water, sugar, salt, corn syrup, mustard, garlic powder, and vinegars in a food processor bowl. Blend the mixture well.
2. Blend the egg yolks into the 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 the emulsion could fail! Blend until all the oil has been incorporated and the mixture becomes smooth and creamy.

Reference

Science Project Ideas.

Notes

Emulsifiers are molecules that have two different ends: one that is hydrophilic (attracted to water) and the other that is hydrophobic (repels water and attracts oil). An emulsion is a stable mixture of oil and water that does not separate easily. 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.



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