PREMIUM RESOURCE

Food Science Experiments Lab Kit

15 Hands-On Labs Exploring Chemistry Through Cooking

Grades 5 – 9

Emulsification • Protein Denaturation • Fermentation
Crystallisation • Maillard Reaction • Gluten Development
Acid-Base Reactions • Colloids & Gels • Osmosis & Diffusion
Enzymatic Browning • Protein Coagulation • Starch Gelatinisation
Density & Solutions • Freezing Point Depression • Pickling & pH

UM Printables

Table of Contents

Safety Checklist

Review these safety rules before beginning any lab. Check each box to confirm understanding.

- ■ Wash hands thoroughly with soap and warm water before and after handling food.
- ■ Tie back long hair and secure loose clothing before working near heat or open flames.
- ■ Do not eat or drink in the lab area unless specifically instructed to do so as part of a taste test.
- ■ Use oven mitts or heatproof gloves when handling hot pans, boiling water, or hot sugar syrups.
- ■ Wear safety goggles when mixing acids (vinegar, lemon juice) and bases (baking soda), as reactions can splash.
- ■ Alert the teacher immediately about any food allergies (nuts, dairy, eggs, gluten, etc.) before each lab.
- ■ Use cutting boards and knives safely — cut away from your body, and let the adult handle sharp knives if required.
- ■ Clean up spills immediately to prevent slips and falls.
- ■ Do not touch hot surfaces (stoves, hot plates, pans) with bare hands.
- ■ Taste-test samples only with a clean spoon — never double-dip.
- ■ Do not taste any raw eggs, raw flour, or samples that have been contaminated during the experiment.
- ■ Dispose of food waste properly and wash all equipment after each lab.
- ■ Work in a well-ventilated area, especially when heating vinegar or other strong-smelling substances.
- ■ Read all lab instructions completely before starting the procedure.

Student Pledge: I have read and understand the safety rules above and agree to follow them during all lab activities.

Signature: ____ Date: ________________

Food Science Vocabulary Guide

These key terms appear throughout the 15 labs. Refer back to this guide whenever you need a reminder!

Term	Definition
Acid	A substance with a pH below 7; acids taste sour and can react with bases.
Amylose	A straight-chain starch molecule that contributes to gel firmness.
Amylopectin	A branched-chain starch molecule that contributes to gel viscosity.
Anaerobic respiration	Energy production without oxygen; yeast uses this process to ferment sugar into ethanol and CO_2.
Antioxidant	A substance that prevents oxidation; vitamin C (ascorbic acid) is a common antioxidant.
Base	A substance with a pH above 7; baking soda is a common base used in cooking.
Caramelisation	The browning of sugar through heat decomposition, producing nutty flavours and brown colour.
Casein	The main protein in milk (about 80 % of milk protein); forms curds when acidified.
Coagulation	The process where proteins clump together, forming a solid mass (e.g., curds in cheese making).
Colloid	A mixture where tiny particles of one substance are dispersed throughout another (e.g., milk, gelatin gels).
Crystal lattice	An orderly, repeating three-dimensional arrangement of atoms or molecules in a crystal.
Denaturation	The unfolding of a protein's shape due to heat, acid, salt, or mechanical force.
Density	Mass per unit volume; determines whether a substance floats or sinks in another liquid.
Emulsion	A stable mixture of two liquids that normally do not mix (e.g., oil and vinegar with mustard).
Enzymatic browning	Browning caused by enzymes (like polyphenol oxidase) reacting with oxygen.
Fermentation	A metabolic process where microbes convert sugars into acids, gases, or alcohol.
Freezing point depression	Lowering the freezing point of a liquid by dissolving a solute (e.g., salt in water).
Gel	A semi-solid colloid where a solid network traps liquid within its structure.
Gelatinisation	The swelling and bursting of starch granules when heated in water, thickening the liquid.
Gluten	An elastic protein network formed when glutenin and gliadin are mixed with water and kneaded.
Hydrophilic	Water-loving; attracted to water molecules.
Hydrophobic	Water-fearing; repelled by water molecules.
Hypertonic	A solution with a higher solute concentration than the cell; water moves out of the cell.
Hypotonic	A solution with a lower solute concentration than the cell; water moves into the cell.

Term	Definition
Leavening agent	A substance that produces gas (CO_2) to make baked goods rise (e.g., baking soda, baking powder, yeast).
Maillard reaction	A reaction between amino acids and reducing sugars at high temperatures, creating browning and complex flavours.
Micelle	A tiny cluster of molecules (e.g., casein proteins in milk) with a charged surface that keeps them dispersed.
Nucleation site	A small imperfection or seed crystal that provides a starting point for crystal growth.
Osmosis	The movement of water across a semipermeable membrane from lower to higher solute concentration.
pH	A scale (0–14) measuring acidity (below 7) or alkalinity (above 7); 7 is neutral.
Polyphenol oxidase (PPO)	An enzyme that catalyses browning in fruits and vegetables when exposed to oxygen.
Semipermeable membrane	A membrane that allows some molecules (like water) to pass through but blocks others.
Supersaturated solution	A solution holding more dissolved solute than it normally could at that temperature.

Teacher Materials Shopping List

Quantities below are estimated for a class of 24 students working in groups of 3–4. Adjust as needed for your class size.

Produce

- Apples (2, for Lab 10)
- Cucumbers (3, for Labs 9 & 15)
- Carrots, red onions, or radishes (for Lab 15 extension, optional)
- Fresh pineapple (small, for Lab 8 extension, optional)

Dairy & Eggs

- Whole milk (1 gallon, for Labs 11 & 14)
- Half-and-half or heavy cream (1 pint, for Lab 14)
- Eggs (1 dozen pasteurised, for Labs 2 & 6)
- Butter or vegetable oil (for Lab 6)

Pantry — Dry Goods

- All-purpose flour (5 lbs, for Labs 6, 7, 12)
- Bread flour (optional, for Lab 6 extension)
- Cake flour (optional, for Lab 6 extension)
- Granulated sugar (5 lbs, for Labs 3, 4, 5, 7, 14)
- Brown sugar and honey (for Labs 3 & 10 extensions)
- Corn syrup (1 bottle, for Labs 13)
- Cornstarch (1 box, for Lab 12)
- Potato starch or tapioca starch (1 small bag, for Lab 12)
- Active dry yeast (3 packets, for Lab 3)
- Unflavoured gelatin (2 packets, for Lab 8)
- Baking soda (1 box, for Lab 7)
- Baking powder (1 can, for Lab 7)
- Salt (1 container, for Labs 2, 9, 10, 11, 15)
- Rock salt (1 large bag, for Lab 14)

Pantry — Liquids & Spices

- White vinegar (2 bottles, for Labs 1, 2, 7, 9, 11, 15)
- Lemon juice (1 bottle, for Labs 10 & 11)
- Vegetable oil (1 bottle, for Labs 1, 7)

- Dijon mustard (1 small jar, for Lab 1)
- Fruit juice (1 bottle, any flavour, for Lab 8)
- Vanilla extract (1 small bottle, for Lab 14)
- Food colouring (assorted, for Labs 4 & 13)

Kitchen Equipment & Tools

- Mixing bowls (assorted sizes)
- Measuring cups and spoons
- Whisks and spatulas
- Small jars with lids (for Labs 1, 3, 9)
- Clear plastic bottles or large test tubes + balloons (for Lab 3)
- Small saucepans (for Labs 4, 8, 11, 12)
- Frying pan or electric skillet (for Lab 5)
- Baking sheet (for Lab 6)
- Muffin tin (for Lab 7)
- Colander and cheesecloth or paper towels (for Lab 11)
- Cutting board and knives (adult use)
- Cooking thermometer (instant-read)
- Hot plate (if no stove is available)
- Oven mitts / heatproof gloves
- Ruler and timer / stopwatch
- Slotted spoons and tongs
- Resealable zip-top bags: sandwich and gallon sizes (for Lab 14)
- Tall clear glasses or jars (for Lab 13)
- Slotted spoon (for Lab 11)
- Turkey baster or pipette (for Lab 13, optional)
- Magnifying glass (for Lab 4)

Lab & Safety Supplies

- Safety goggles (1 per student)
- pH paper or pH meter (for Lab 15)
- Clean tasting spoons (disposable, many per class)
- Tasting plates or cups
- Paper towels
- Aprons (optional)
- Data recording sheets (photocopy from this resource)

Formal Lab Report Template

Use this template to write a complete, formal lab report for any of the 15 experiments. Follow each section carefully and write in complete sentences.

Name: ________________ **Date:** ______________ **Lab #:** ______________

1. TITLE

Give your lab report a clear, descriptive title.

2. QUESTION

State the scientific question you are investigating.

3. HYPOTHESIS

Write your prediction using the 'If... then... because...' format.

4. VARIABLES

Identify the independent variable (what you change), dependent variable (what you measure), and controlled variables (what stays the same).

5. MATERIALS

List all materials and equipment used, including quantities.

6. PROCEDURE

Write a numbered, step-by-step description of what you did. Be specific enough that someone else could repeat the experiment.

7. OBSERVATIONS & DATA

Record all qualitative observations (what you saw, smelled, heard, felt) and quantitative data (measurements, times, temperatures). Include tables or drawings if needed.

8. RESULTS

Summarise your data. What patterns or trends do you see? Was your hypothesis supported or not?

9. CONCLUSION

Explain the science behind your results. What caused the outcome? How does this connect to the key concept? What did you learn?

10. REAL-WORLD APPLICATION

How is this science used in the real world? Give at least one specific example from cooking, the food industry, or everyday life.

11. TASTE-TEST REFLECTION

Describe the sensory experience (taste, texture, aroma). How did the science affect the food's qualities?

12. EXTENSION IDEAS

What new question does this lab make you wonder about? How could you investigate it?

5

Lab 5

Golden & Delicious — The Maillard Reaction

Key Concept: Maillard reaction — how amino acids and reducing sugars create browning and new flavours

Background Science

The Maillard reaction (pronounced my-YAR) is a chemical reaction between amino acids (the building blocks of proteins) and reducing sugars that occurs when food is heated above approximately 140 °C (280 °F). It is responsible for the golden-brown crust on seared steak, the brown edges of toasted bread, and the rich colour of roasted coffee beans. The reaction produces hundreds of different flavour and aroma compounds, which is why browned food tastes so much more complex than raw or boiled food. The Maillard reaction is different from caramelisation, which involves only sugars breaking down under heat — no proteins or amino acids are involved in caramelisation.

Objective

Students will compare the Maillard reaction (bread containing proteins and starches) with caramelisation (sugar alone) and observe the differences in colour, aroma, and flavour development.

Materials

- 4 slices of white bread
- 4 tbsp granulated sugar
- Non-stick frying pan or electric skillet
- Hot plate (if using a frying pan)
- Spatula
- Oven mitts
- Timer
- Tongs
- Small plate for sugar sample
- Tasting plates (one per student)
- Data recording sheet

Safety Note

Hot pans and hot sugar can cause severe burns. Adult supervision is required for all heating steps. Use oven mitts and spatulas at all times. Ensure good ventilation — heating sugar can produce smoke. Allow all samples to cool before tasting. Students with gluten allergies should not taste the bread samples.

Procedure

Step 1: Observe and record the appearance and aroma of a raw slice of white bread and a small pile of granulated sugar. This is your control observation.

Step 2: CARAMELISATION TEST: Place 2 tbsp of sugar in a dry frying pan on medium heat (about 180 °C / 350 °F). Do not stir — allow the sugar to melt and brown. Observe and record the colour changes every 30 seconds for 3–4 minutes. Note when the sugar begins to melt, when it turns golden, and when it turns deep amber.

Step 3: Remove the caramelised sugar from the pan and place it on a plate to cool. Record the aroma.

Step 4: MAILLARD REACTION TEST: Wipe the pan clean. Place a slice of bread in the dry pan on medium heat. Toast for 1–2 minutes on each side until golden brown. Observe and record the colour changes and aroma.

Step 5: Toast a second slice until it is very dark (nearly black). Observe the colour and aroma — how has it changed from the lightly toasted slice?

Step 6: Set aside a raw (untoasted) slice of bread as a control.

Step 7: Allow all samples to cool for 2 minutes. Then taste: (a) the raw bread, (b) the lightly toasted bread, (c) the dark toast, and (d) the cooled caramelised sugar. Record flavour differences.

Step 8: Compare the aromas and flavours of the Maillard-browned bread and the caramelised sugar. How are they different?

The Science Behind It

When bread is toasted, the amino acids in the wheat proteins react with the reducing sugars (such as glucose and fructose from broken-down starch) at high temperature. This Maillard reaction produces melanoidins (brown pigments) and a wide variety of flavour compounds including pyrazines (nutty, roasted aromas) and furanones (caramel-like sweetness). In contrast, when sugar alone is heated, caramelisation occurs: sucrose breaks down into glucose and fructose, which then decompose into smaller molecules that produce a more one-dimensional, purely sweet and slightly bitter flavour. The over-toasted bread tastes bitter because the Maillard reaction progresses to pyrolysis (burning), which creates unpleasant compounds.

Real-World Connection

The Maillard reaction is one of the most important reactions in cooking. It creates the flavour of seared steak, roasted vegetables, baked bread crust, toasted marshmallows, fried onions, and brewed coffee. Professional chefs control temperature and cooking time to maximise Maillard browning while avoiding burning.

9

Lab 9

The Naked Egg — Osmosis & Diffusion

Key Concept: Osmosis and diffusion — how water moves through a semipermeable membrane

Background Science

Osmosis is the movement of water molecules across a semipermeable membrane from an area of lower solute concentration (more water) to an area of higher solute concentration (less water). The membrane allows water to pass through but blocks larger dissolved molecules. An egg has a shell made of calcium carbonate. Vinegar (acetic acid) reacts with the calcium carbonate in a chemical reaction that produces carbon dioxide gas, water, and dissolved calcium acetate. This dissolves the shell, revealing the egg's inner semipermeable membrane. Once the shell is gone, osmosis can occur through this membrane. If the egg is placed in pure water, water moves inside the egg (hypotonic environment), causing it to swell. If the egg is placed in corn syrup (a concentrated sugar solution), water moves out of the egg (hypertonic environment), causing it to shrink.

Objective

Students will dissolve an eggshell using an acid-base reaction, then observe osmosis by placing the naked egg in two different solutions (water and corn syrup) and measuring the change in egg size.

Materials

- 2 raw eggs (in their shells)
- White vinegar (enough to cover the eggs — about 2 cups)
- 2 clear jars or tall glasses
- Corn syrup (enough to cover one egg — about 1 cup)
- Water (enough to cover one egg — about 1 cup)
- Measuring cups
- Ruler
- Paper towels
- Spoon or slotted spoon
- 1 cucumber
- Salt
- Tasting plates
- Data recording sheet

Safety Note

Raw eggs may carry Salmonella. Do NOT taste the naked egg or any liquid the egg has been in. Wash hands thoroughly after handling raw eggs. The vinegar smell is strong — work in a well-ventilated area. Handle the naked eggs very gently;

the membrane is fragile and can break easily.

Procedure

Step 1: DAY 1: Place each raw egg carefully into a clear jar. Pour enough vinegar into each jar to completely cover the egg. Observe the immediate formation of bubbles on the shell — this is CO_2 gas being released.

Step 2: Let the eggs sit in vinegar for 24 hours. You may see a frothy foam on the surface.

Step 3: DAY 2: Carefully pour out the vinegar. Gently rinse each egg under cool running water, rubbing very lightly to remove any remaining shell flakes. You now have two naked eggs — they should feel rubbery and slightly larger than before.

Step 4: Gently measure the width (diameter) of each naked egg with a ruler and record it.

Step 5: Place Egg 1 in a jar of plain water. Place Egg 2 in a jar of corn syrup. Make sure each egg is fully submerged.

Step 6: Let both eggs sit for 24 hours.

Step 7: DAY 3: Carefully remove each egg from its jar. Gently pat dry with a paper towel. Measure the width of each egg again and record it.

Step 8: Observe the appearance and feel of each egg. Egg 1 (in water) should be larger and very plump. Egg 2 (in corn syrup) should be smaller and may look wrinkled or deflated.

Step 9: TASTE-TEST (Cucumber Osmosis): Slice a cucumber into thin rounds. Sprinkle salt on half the slices and leave the other half unsalted. Wait 10 minutes. Observe the water droplets on the salted slices (water drawn out by osmosis). Taste a salted slice and an unsalted slice. Note the texture and flavour difference.

The Science Behind It

The vinegar (acetic acid) reacted with the calcium carbonate shell ($CaCO_3$) in this equation: $CaCO_3 + 2\ CH_3COOH \rightarrow Ca(CH_3COO)_2 + H_2O + CO_2$. The CO_2 gas was visible as bubbles, and the shell dissolved. The remaining membrane is semipermeable. Egg 1 (water) swelled because water moved into the egg where the solute concentration was higher (hypotonic solution outside, higher concentration inside). Egg 2 (corn syrup) shrank because the syrup had a much higher sugar concentration than the egg's interior, so water moved out of the egg and into the syrup (hypertonic solution outside). The cucumber demonstrates the same principle: salt on the surface creates a hypertonic environment, drawing water out of the plant cells.

Real-World Connection

Osmosis is critical in food preparation. Salting eggplant draws out bitter moisture. Brining turkey or chicken uses osmosis (and diffusion) to move salt and water into the meat, keeping it juicy. Making pickles relies on salt drawing water out of cucumbers, preventing spoilage. In medicine, IV fluids must be isotonic (balanced) with blood to prevent cells from swelling or shrinking.

14

Lab 14

Chill Out — Freezing Point Depression

Key Concept: Freezing point depression — how adding salt to ice lowers the freezing point of water

Background Science

Pure water freezes at 0 °C (32 °F). When you dissolve a substance like salt (sodium chloride) in water, it disrupts the ability of water molecules to form orderly ice crystals. As a result, the freezing point of the saltwater solution is lower than that of pure water — a phenomenon called freezing point depression. The more salt dissolved, the lower the freezing point. When salt is added to ice, the ice begins to melt. This phase change from solid to liquid requires energy (latent heat of fusion), which the ice absorbs from its surroundings — including the cream mixture in the inner bag. The resulting brine can reach temperatures as low as -20 °C (-4 °F) before freezing, making it cold enough to freeze the cream into ice cream.

Objective

Students will compare the temperature and freezing effect of plain ice versus a salt-ice mixture, then use freezing point depression to make ice cream.

Materials

- 2 small resealable zip-top bags (sandwich size)
- 2 large resealable zip-top bags (gallon size)
- 2 cups ice (divided between the 2 large bags)
- 6 tbsp rock salt or table salt (for one large bag only)
- 1/2 cup whole milk or half-and-half
- 1 tbsp sugar
- 1/4 tsp vanilla extract
- Cooking thermometer
- Measuring cups and spoons
- Towels or oven mitts (the bags get very cold!)
- Tasting spoons
- Data recording sheet

Safety Note

The salt-ice mixture can reach temperatures well below freezing and can cause frostnip if handled with bare hands for too long. Use towels or oven mitts when shaking the bags. Do not eat the ice cream if the inner bag leaked — if the salty brine has mixed with the cream, discard it. Students with dairy allergies should use a non-dairy alternative (coconut cream works well).

Procedure

Step 1: PART 1 — OBSERVING FREEZING POINT DEPRESSION: Place 1 cup of plain ice in each of the two large bags.

Step 2: Measure and record the temperature of the ice in each bag (they should be similar, around 0 °C).

Step 3: Add 6 tbsp of salt to Bag A only. Seal both bags.

Step 4: Shake or stir both bags gently for 2 minutes. Then open and measure the temperature inside each bag. Record both temperatures.

Step 5: Observe: Which bag has more melted water? Which bag feels colder? Record your observations.

Step 6: PART 2 — MAKING ICE CREAM: In a small sandwich bag, combine the milk, sugar, and vanilla. Seal the bag tightly, squeezing out excess air. Double-check the seal.

Step 7: Place the sealed small bag inside the large Bag A (the salt-ice mixture). Seal the large bag.

Step 8: Wrap the large bag in a towel or use oven mitts to protect your hands. Shake vigorously for 5–8 minutes.

Step 9: After 5 minutes, carefully open the large bag and check the small bag. Gently squeeze it — is the liquid inside firming up? If it is still liquid, shake for another 2–3 minutes.

Step 10: Once the ice cream is firm, remove the small bag from the brine. Rinse the outside of the small bag briefly under cold water to remove any salt.

Step 11: Open the small bag, observe the texture of the ice cream, and taste it!

The Science Behind It

Adding salt to the ice lowered the freezing point of the water, causing the ice to melt even though the temperature was below 0 °C. The melting process absorbs latent heat from the surroundings, making the brine solution much colder than plain ice could ever be (plain ice cannot go below 0 °C because it starts melting). The super-cold brine absorbed heat from the cream mixture in the inner bag, lowering the cream's temperature below its freezing point (which is slightly below 0 °C because the cream contains dissolved sugars and fats). This rapid freezing, combined with the shaking motion, produced small ice crystals, resulting in smooth ice cream. Without salt, the plain ice would only reach 0 °C, which is not cold enough to freeze the cream quickly.

Real-World Connection

Freezing point depression is why salt is spread on icy roads in winter — it melts the ice. It is also essential in old-fashioned ice cream makers, which use a salt-ice brine to freeze the cream. Antifreeze in car radiators works on the same principle — it lowers the freezing point of the engine coolant to prevent it from freezing in cold weather.

8. Test and record the pH of the brine.

9. Pour the brine over the Group A cucumbers in the jar. Make sure they are fully submerged. Put the lid on the jar.

10. Let the jar sit at room temperature for 30 minutes (or refrigerate for a faster chill).

11. After 30 minutes, remove a few pickled cucumber slices (Group A). Observe their colour and texture compared to the raw slices (Group B). Are they softer? More translucent?

12. Taste one pickled slice and one raw slice. Compare the flavour, crunch, and overall taste.

6. OBSERVATIONS & DATA

Record what you see, smell, hear, and feel:

Trial / Time	Observation	Measurement / Notes
1		
2		
3		

7. RESULTS

What does your data tell you? Was your hypothesis supported?

8. CONCLUSION

Summarise your findings. What science explains the result?

Taste-Test Component

Taste-Test Prompt: Taste the raw cucumber slice and the pickled slice side by side. How has the acid changed the flavour? Is the pickled slice more tangy? Is the texture different? Do you prefer the raw or the pickled version? How might the flavour change if the cucumbers were left in the brine for a full week?

Attribute	Rating (1-5)	Notes
Appearance	■1 ■2 ■3 ■4 ■5	

Aroma / Smell	■1 ■2 ■3 ■4 ■5	
Texture / Mouthfeel	■1 ■2 ■3 ■4 ■5	
Flavour / Taste	■1 ■2 ■3 ■4 ■5	
Overall Preference	■1 ■2 ■3 ■4 ■5	

Would you eat this again? Why or why not?

Extension Challenge

Challenge: Try quick-pickling other vegetables (thinly sliced carrots, red onions, or radishes) using the same brine. Compare how quickly each vegetable absorbs the flavour and changes texture. Which vegetable pickles the fastest? Why might its cell structure affect the pickling speed?

Your plan and prediction:

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