

MIT Splash 2025
Cooking for Experimentalists - The Science of Food

Mini-Lab 1: Ice Cream

Materials:

- Two plastic, ziplock bags
(one small, one large)
- Ice (enough for the larger bag)
- Hand towel
- Salt (2-3 TB)
- Ice cream mix:
 - Cream + half-and-half (about $\frac{1}{3}$ cup)
 - Sugar (1-3 TB)
 - Flavoring (1 tsp)
 - + Other add-ins

Methods:

1. Mix cream and half-and-half to a total volume of $\frac{1}{3}$ - $\frac{1}{2}$ cup in a bowl. Stir in sugar and flavoring to taste.
2. Fill smaller ziplock with the ice cream mix, and seal tightly, removing as much air as possible.
3. Fill larger ziplock $\frac{1}{3}$ of the way with ice, then sprinkle in salt, and shake to distribute. Place the smaller ziplock inside, fill the rest of the space with ice, then seal tightly.
4. Wrap the hand towel around the ziplock, and shake continuously until cream mixture solidifies.

Concept Questions:

What effect does the cooling rate have on solidification?

Faster cooling rate = faster solidification, more nucleation sites;

More crystals growing faster (rather than a few crystals growing slower) result in SMALLER crystals overall.

What are the properties of an ice cream that was rapidly cooled versus cooled slowly?

Smaller crystals mean smoother texture overall (creamier, less gritty, easier to scoop/melt evenly).

What purpose does the salt serve? What ice cream properties would be different if the processing was changed?
Salt decreases the effective temperature that the cream experiences so that it *freezes faster*. This means that the crystals of water and fat will be smaller than if they were frozen more slowly.

What is the significance of the water-to-fat ratio?

Water and milk-fat have different freezing temperatures, so their crystals will start nucleating at different time-points, and therefore grow for more or less time.

Why do you need to agitate the ice cream mix as it freezes?

To circulate contact with the cold exterior so that the temperature decrease is as uniform as possible (homogeneous nucleation).

Mini-Lab 2 (advanced): Tempering Chocolate

Materials:

- Hot plate
- Double-boiler
(saucepan filled with water
+ metal bowl)
- Thermometer
- Spatula
- Chocolate (65% cocoa solids or less)
+ seed chocolate

Methods:

1. Prepare double-boiler by heating on hotplate until water is just boiling.
2. Place chocolate (chopped into ~1 cm³ pieces) into bowl of double-boiler.
3. Heat until fully melted (50°C), stirring occasionally.
4. Cool to solidification onset (32°C), and add the seed chocolate. Stir continuously until fully melted and smooth.
5. Cool to crystallization completion (27°C) of the desired cocoa fat phase.
6. Reheat to melt undesirable crystal phase (32°C).
7. Test if tempered by swiping a small patch of the melt on a non-stick surface. If this solidifies in less than 1-2 minutes, and the result is shiny and snaps when stressed, the tempering was done correctly.
8. Cool to room temperature.

Concept Questions:

What does tempering chocolate do on a structural level?

Selectively crystallize the most stable crystal to avoid "fat bloom" (other phases separating out). This is done by heating and cooling to melt out phases we don't want (beta'), and by seeding with a chocolate that's already tempered.

What properties are different between a tempered and untempered chocolate?

Tempered: Smooth/shiny, hard and brittle (doesn't dent, but does snap), thermally stable (melts at a higher temperature).

Untempered: Dull with possible splotches (fat bloom), softer, unstable.

Why use a double boiler?

Prevents overheating and/or burning the chocolate (water vapor is consistently ~100°C, and is evenly distributed under the bowl). Therefore brings temperature up slowly and "gently".

Why chop up the chocolate? Is this necessary?

Smaller pieces = more surface area:volume, therefore faster melting.

What purpose does the seed chocolate serve? Why add it to the melt at this stage?

Seeding encourages solidification that matches the crystals already present (in-line with those in the seed). This means most of the solidification will yield the chocolate that we want.

Why does this test work? What would happen if it wasn't tempered?

The chocolate phase we want solidifies more quickly, especially when not competing. If not tempered, the sample would not solidify quickly, and when it did it would not be shiny or snap (instead, it would be dull and soft/bend/dent).

Glossary of Terms

Phase (transformation):

A phase is a region of **uniform properties**. In a PB&J sandwich, the peanut butter, jelly, and bread are all phases. In a glass of ice water, the solid ice and liquid water are phases. In chocolate, the alpha, beta, and beta' crystals are all different phases too.

A phase transformation is the transition from one phase to another (like melting ice, or recrystallizing chocolate while tempering). This can be visualized in a phase diagram.

Macromolecule:

The different molecules that make up life (and therefore food). These are made out of smaller molecules and atoms to form **macromolecules** (or bigger, more complicated molecules).

Lipid:

Also known as fatty acids, these are common in the forms of waxes or saturated/unsaturated **fats**. **Cis-unsaturated** fats (oils, oleic acid) are liquid at room temp because they don't pack densely/easily due to the bent chains and resultant wiggling. **Saturated** fats (butter, stearic acid) are solid at room temperature because the chains are linear, and can pack more easily together. These are good for **storing energy**.

Carbohydrate:

Saccharides/carbohydrates are made out of **sugars** (mono-/di-saccharides) as building blocks made into long chains like cellulose and starch (poly-saccharides). Depending on the structure, these either are broken down quickly in the body for **releasing energy**, or aren't at all (like cellulose/fiber, which make up the structure of plants).

Protein:

Long, tangled chains made out of amino acids; these are called polypeptide chains, and largely make up the **structure** of muscles and strong, flexible networks. Examples include eggwhite (ovotransferrin), and gluten in bread (gliadin and glutenin, tangled together).

Equilibrium:

Stable state of a system, where no observable change can be seen over time. NOTE: this doesn't mean nothing is happening, just that there is no net change (dynamic vs static equilibrium).

Nucleation:

When **crystal growth begins** in a liquid as it begins to solidify. Homogeneous nucleation is when crystals begin to form everywhere spontaneously in a liquid, while heterogeneous nucleation starts at a location like a **seed crystal**, or the edge of the container.

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