Chapter 11
Leavening Agents

How Baking Works

Words, Phrases, and Concepts

- Leaveners
- Air bubbles/air cells
- Retarded dough
- Pre-ferment
- Antimicrobial agents
- Osmotolerant yeast
- Bench tolerance
- Acid salt
- Single-acting and double-acting baking powders
- Fast-acting and slow-acting baking powders

Process of Leavening

- Leavening agents:
  - Also called leaveners.
  - Allow baked goods to rise.
- Leavened baked goods: are lighter in density and higher in volume than batter/dough.
- Leavening: starts in mixing bowl.

Process of Leavening

For baked goods to rise properly:

1. Air bubbles must be added to batter/dough.
2. Gases (carbon dioxide, steam) must form and expand from heat of oven.
3. Still-flexible cell walls must stretch from pressure of expanding gases.
4. Structure builders in cell walls must dry out and set, defining final volume and shape.
   - Once cell walls set, leavening ceases; pressure builds, breaking cell walls; gases escape.

Process of Leavening

Timing is important.

For best volume, gas expansion must occur while cell walls are stretchy and flexible.

- With yeast-raised doughs, this occurs during bulk fermentation, proofing, and early stages of baking.
- With cakes, muffins, pastries, this occurs as proteins coagulate and starches gelatinize during baking.

Leavening Gases

Leavening agents can be categorized as:

- Physical (mechanical)
  - Water/steam
  - Air
- Biological (organic)
  - Yeast fermentation
- Chemical
  - Baking soda + acid
  - Baking powder
  - Baking ammonia

Leavening Gases

These leavening agents generate three main leavening gases:

1. Steam
2. Air
3. Carbon dioxide

Other liquids and gases that leaven:

- Alcohol (from yeast fermentation, flavor extracts)
- Ammonia (from baking ammonia)

Leavening Gases

1. Steam
   - Gaseous form of water.
   - All baked goods rely on steam for some leavening:
     - Because all baked goods contain water or another liquid (milk, eggs, etc.).
     - Sponge cakes, popovers, choux pastry rely heavily on steam for leavening.
   - Steam is an extremely powerful leavener: it occupies over 1,600 times more space than water.

Leavening Gases

1. Steam
   - Very hot ovens often maximize leavening from steam.

Leavening Gases

1. Steam is sometimes injected into oven during early stages of bread baking:
   - Delays setting of crust.
     - Allows bread to rise higher.
     - Results in crisper, glossier, thinner crust.

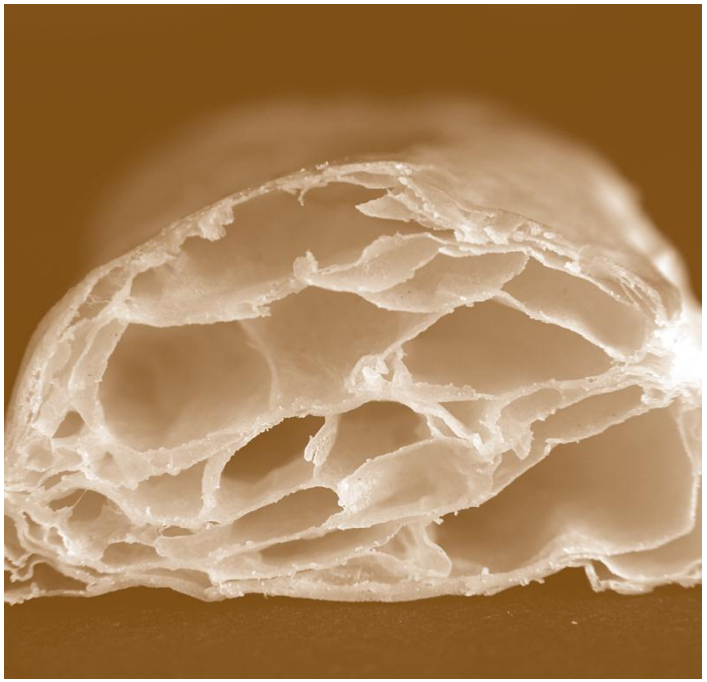
Leavening Gases

2. Air
   - All baked goods rely on air for leavening.
     - This is because all batters and doughs contain air trapped during mixing, stirring, whipping, sifting, folding, etc.
     - Sponge cakes and angel food cake rely heavily on air for leavening:
       - they contain lots of air bubbles whipped into egg whites.
     - Laminated doughs and flaky pastries rely heavily on air for leavening:
       - they contain large gaps of air, when chunks of fat melt.

Leavening Gases

2. Air itself does not expand much during baking.
    - Because it is already a gas.
  - Air's important role in leavening: provides empty space for gases, like steam, to expand into.
    - Without these empty spaces, leavening gases would have no place to go except out.
    - Empty spaces can be:
      - air bubbles or air cells in batters and doughs.
      - gaps of space between layers in laminated doughs.

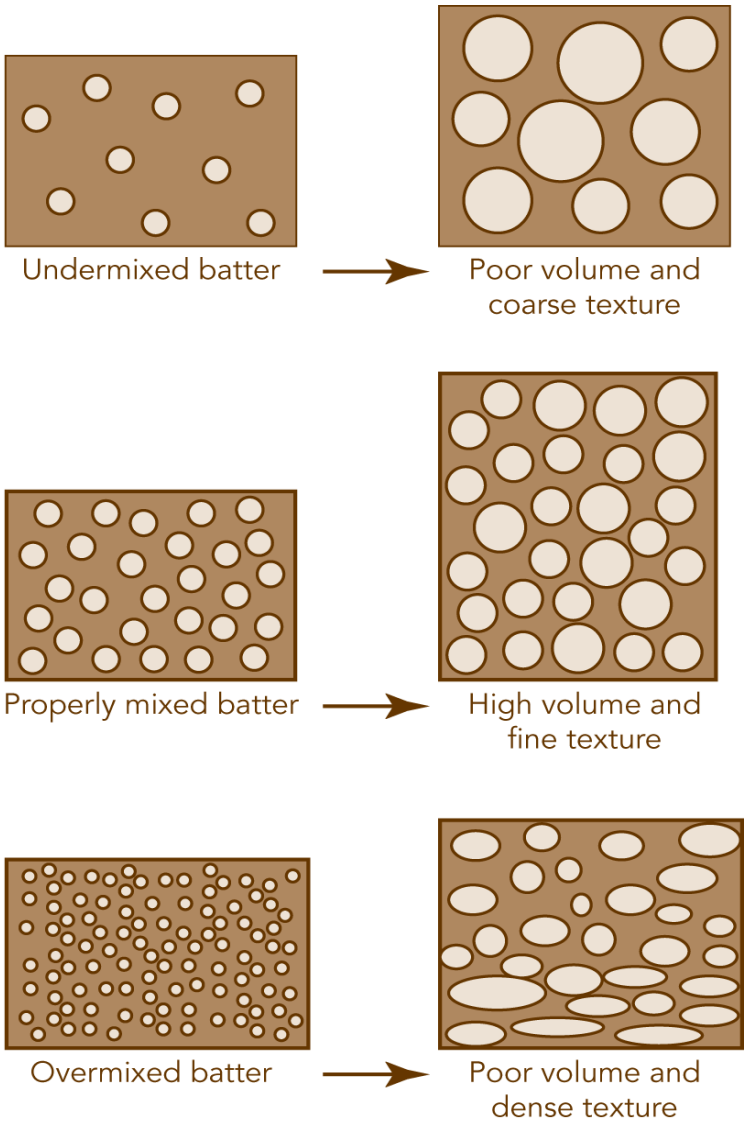
Leavening Gases



Puff pastry rises when steam expands into gaps of air left from layers of fat melting into dough.

Leavening Gases

- No new air bubbles form during baking; existing ones simply grow in size from expanding gases.
- The number of air cells in a batter or dough directly affects crumb structure of the baked item.



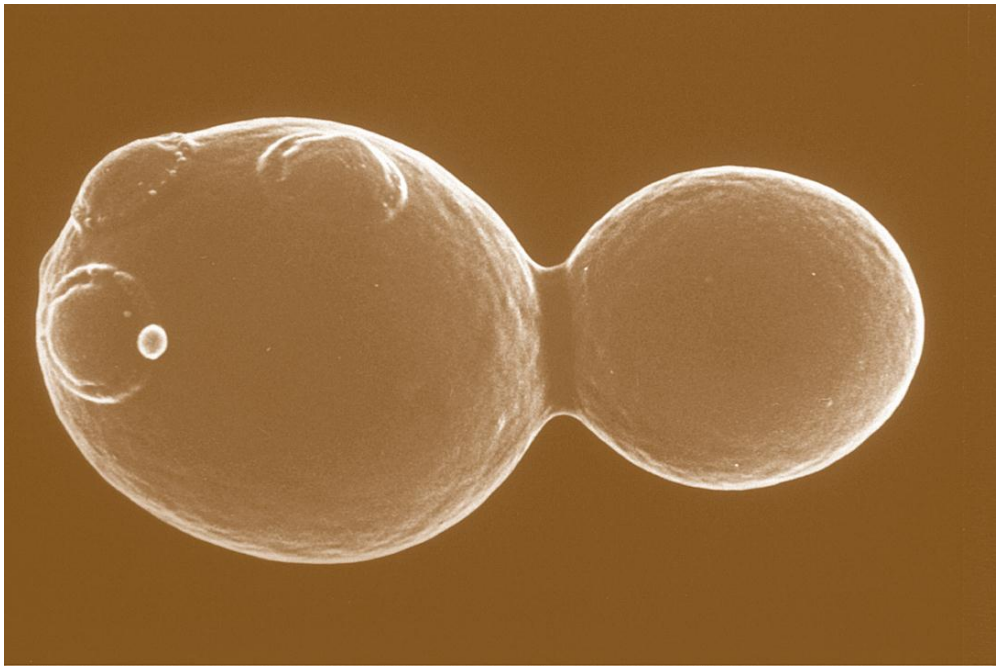
Leavening Gases

3. Carbon Dioxide
   - From yeast fermentation.
     - Biological leavener.
   - From baking soda and baking powder.
     - Chemical leaveners.

Yeast Fermentation

Yeast are single-celled microorganisms

- Fermentation is how yeast generate food energy for survival, growth, and reproduction.



Yeast Fermentation

Fermentation

- Yeast break down sugars into:
  - Carbon dioxide (CO_2) and alcohol, for leavening.
  - Energy, for growth and reproduction.
  - Flavor molecules, including acids.

$$\text{sugar} \xrightarrow{\text{yeast}} CO_2 + \text{alcohol} + \text{energy} + \text{flavor molecules}$$

- Yeast lack amylase; they cannot break down starch on their own.

Yeast Fermentation

Many factors affect how quickly yeast ferment.

- Bakers adjust these, to optimize fermentation.
- Fast is not always best.
  - Slow fermentation is desirable for developing flavor and for maturing dough.
    - Mature dough has the right balance of strength and stretchiness.

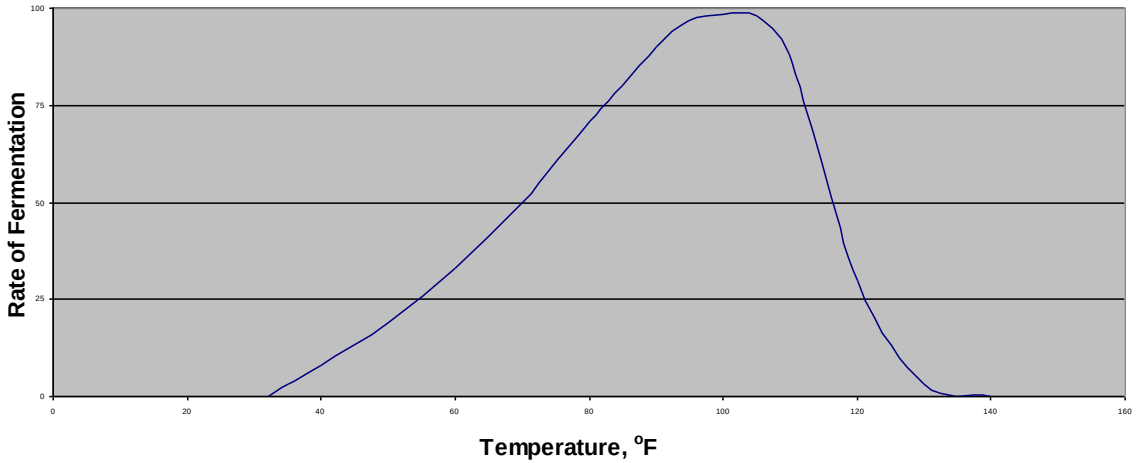
Factors Affecting Yeast Fermentation

1. Temperature of dough.
2. Amount of salt.
3. Amount of sugar
4. Type of sugar.
5. The pH of dough.
6. Presence of antimicrobial agents, including spices, and chlorine in water.
7. Addition of yeast foods.
8. Amount of yeast.
9. Type of yeast.

Factors Affecting Yeast Fermentation

1. Temperature of dough
   - Optimum for many breads: 78–82ºF (25-28ºC).
     - At lower temperatures, fermentation of bacteria is favored.
       - Retarded (refrigerated) doughs develop a sour taste from bacterial fermentation.
     - At higher temperatures, dough rises quickly but flavor is less developed.

Factors Affecting Yeast Fermentation



- Yeast are dormant at refrigerator temperatures.
- As temperatures rise, yeast fermentation speeds up.
  - Remember, fast is not necessarily best.
- Fermentation slows significantly by 120ºF (50ºC) as yeast die off, and ceases by 140ºF (60ºC).

Factors Affecting Yeast Fermentation

2. Amount of salt
   - Salt retards (slows) yeast and bacterial fermentation.
   - Salt is easily adjusted in a pre-ferment.
     - Pre-ferments are made and fermented before final dough is made up. Pre-ferments contain yeast and other ingredients from the formula.
       - For short fermentation, add a low amount of salt (or no salt).
       - For lengthy fermentation, add a higher amount of salt.
   - Amount of salt in final dough: generally falls between narrow range of 1.8–2.2 percent of weight of flour.

Factors Affecting Yeast Fermentation

3. Amount of sugar
   - At low amounts of sugar (baguettes, pan bread):
     - The more sugar, the faster the fermentation.
   - At high amounts of sugar (brioche, Danish, stollen):
     - Fermentation is very slow.
     - To compensate for slow fermentation, use:
       - A sponge or other pre-ferment, with little sugar is added.
       - Special osmotolerant yeast, which tolerate high levels of sugar.

Factors Affecting Yeast Fermentation

4. Type of sugar
   - Sugars vary in how quickly yeast ferment them.
     - Fast-fermenting sugars: sucrose (granulated sugar), glucose, and fructose.
     - Slow-fermenting sugars: maltose.
       - Sources of maltose: malt syrup, glucose corn syrups, malted barley flour (and other sources of amylase).
     - Lactose is not fermented by yeast (yeast are lactose-intolerant).
   - A mix of sugars is desirable for continued fermentation from beginning to final proof.
     - Avoids “feast or famine”.

Factors Affecting Yeast Fermentation

5. The pH of dough
   - Optimum pH for maximum yeast fermentation is an acidic 4–6.
   - Above or below pH 4–6, yeast fermentation slows.
     - As fermentation progresses, pH drops to 4–6, and yeast fermentation naturally slows.

Factors Affecting Yeast Fermentation

6. Presence of antimicrobial agents
   - Antimicrobial agents prevent the growth of microorganisms, including yeast, mold, and bacteria.
     - Calcium proprionate is sometimes added to prevent mold growth, but it will inhibit yeast fermentation if used incorrectly.
   - Spices can be powerful antimicrobial agents.
     - Cinnamon rolls are made by sprinkling cinnamon onto dough, not mixing it into dough.
   - Chlorine in water is an antimicrobial agent.
     - High chlorine levels should be removed by filtering water.
   - Osmotolerant yeast are also tolerant of low levels of antimicrobial agents.

Factors Affecting Yeast Fermentation

7. Addition of yeast foods.
   - Yeast require more than sugar for optimal growth.
   - Dough conditioners often contain yeast food and nutrients for optimal growth.
   - Two main yeast nutrients: nitrogen and calcium.
     - Sources of nitrogen: ammonium salts, such as ammonium chloride or ammonium phosphate.
     - Sources of calcium: calcium salts, such as calcium carbonate and calcium phosphate.

Factors Affecting Yeast Fermentation

8. Amount of yeast.
   - More yeast means faster fermentation.
   - Good starting point: 2 percent or less (baker's percentage)
     - Use higher amounts of yeast for shorter fermentations.
       - But very high amounts can add an undesirable yeasty flavor.
     - Use lower amounts of yeast for lengthy fermentations.
       - This prevents the yeast from exhausting the dough of sugars needed for final proof and oven spring.

Factors Affecting Yeast Fermentation

9. Type of yeast.
   - Yeast strains differ in:
     - How quickly they ferment.
       - Quick-fermenting yeast strains are useful for no-time doughs. *example*: SAF-Instant Premium
     - How tolerant they are of rich, high-sugar doughs.
       - Osmotolerant yeast grow well in high-sugar environments. *example*: SAF-Instant Gold

Sources of Yeast

Wild yeast

- Sourdough starters, also called levains
- Patê fermentée (“old dough”)

Pure yeast cultures

- Three main types:
  - Fresh compressed
  - Active dry (ADY)
  - Instant

Wild Yeast

Sourdough starters/levains

- Flour and water.
  - Sometimes rye flour, onion, potato, etc. added
- Flour and air provide wild yeast and lactic acid bacteria for fermentation and flavor.
- Requires about one week of feeding and care.
- Uses: sourdough bread, pain au levain.

Patê fermentée (“old dough”)

- Dough from one day is added to next day’s pre-ferment.

Pure Yeast Cultures

Fresh Compressed Yeast

- Has short shelf life; 2 weeks when refrigerated.
- To use: dissolve in twice its weight of warm water.

Active Dry Yeast (ADY)

- To use: dissolve in four times its weight of very warm water.
- Use half as much ADY as compressed yeast.
- Contains high amount of dead, damaged yeast that produce softer, slack doughs.

Pure Yeast Cultures

Instant Yeast

- Different types:
  - SAF Red Label; contains ascorbic acid, to strengthen gluten and counteract weakening from dead yeast.
  - SAF Gold Label; osmotolerant.
  - SAF Premium; for no-time doughs; fast, vigorous fermentation.
- To use: add directly to dough without hydrating.
- Use one-quarter to one-half as much instant yeast as compressed yeast.

Chemical Leaveners

Baking Soda

- An alkali; raises pH of batter/dough.
- Also called sodium bicarbonate or bicarbonate of soda.
- Breaks down and gives off CO_2 gas in presence of water and heat.
  - Not practical for leavening because of off-flavors, excessive browning, and yellow or green discoloration of crumb.
- To use for leavening: need baking soda + acid.

Chemical Leaveners

Baking Soda + Acid

- Acid reacts with baking soda, releasing CO_2 for leavening.

- Any acid can be used; many are fast-acting.
  - Batters with fast-acting leaveners tend to have poor bench tolerance; that is, they lose a large amount of leavening gases when held on the bench.

Chemical Leaveners

TABLE 11.1 COMMON ACID INGREDIENTS USED IN BAKING

Buttermilk
Yogurt
Sour cream
Fruits and fruit juices
Vinegar
Most syrups, including molasses and honey
Brown sugar
Unsweetened chocolate and natural cocoa

Baking Powder

All brands of baking powder:

- Contain
  - Baking soda.
  - One or more acids (in the form of acid salts).
    - Acid salts release acid as soon as they dissolve in water.
  - Starch or other filler.
- Release same amount of CO_2 , by law.
- Are interchangeable but not identical.

Baking Powder

Several ways to categorize baking powders:

- Single-acting or double-acting.
- Fast-acting or slow-acting.
- By type of acid salt(s).

Baking Powder

Single-acting:

- Releases all carbon dioxide at room temperature.
  - Because all of the acid salt fully dissolves at room temperature.
  - *Example*: the first baking powder from the 1800's, made with cream of tartar.

Double-acting:

- Releases some carbon dioxide at room temperature, some during baking.
  - Because some of the acid salts dissolve at room temperature, some only when heated.
  - Today, essentially all baking powders are double-acting.

Baking Powder

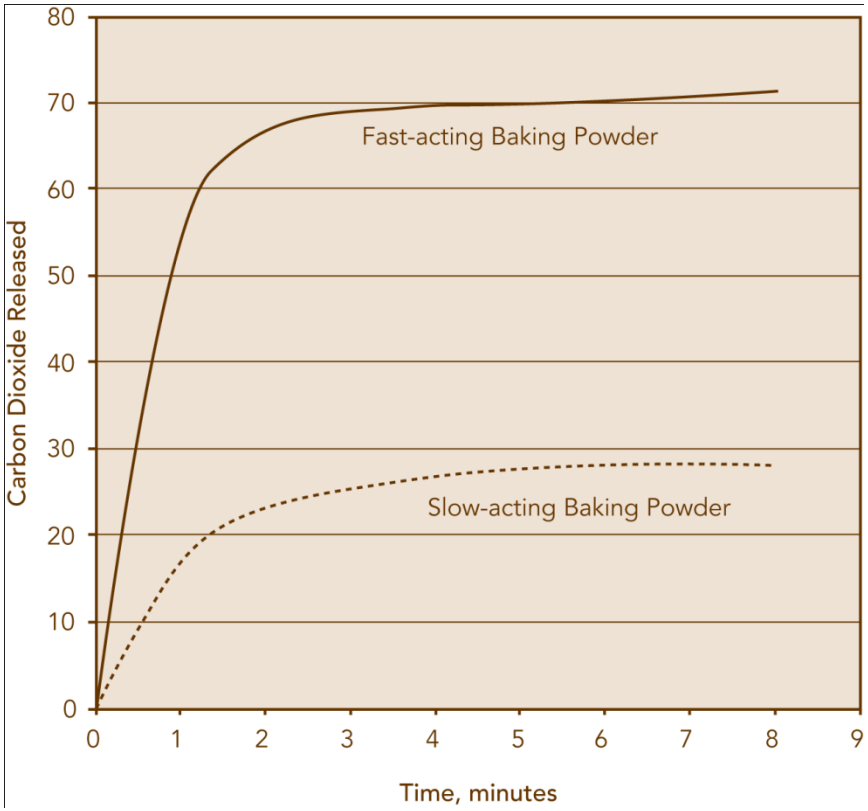
Fast-acting:

- Releases more of its carbon dioxide at room temp:
  - Because most of its acid salts dissolve at room temperature.
  - Helps add gas bubbles to batter; lightens and thickens.
  - Example: Rumford brand Baking Powder

Slow-acting:

- Releases more of its carbon dioxide during baking:
  - Because little of its acid salts dissolve at room temperature.
  - Use in bench-tolerant batters and doughs.
  - Most baking powders in commercial bakeshops are slow-acting.
  - Examples: Red Star Double Acting, Clabber Girl

Baking Powder



- Fast-acting baking powders release most of their carbon dioxide during the first few minutes of mixing.
- Slow-acting baking powders release a much smaller amount of carbon dioxide during mixing.

Baking Powder

Different acid salts have:

- Different tastes.
  - Some are mild-tasting (cream of tartar, MCP).
  - Some have a strong chemical aftertaste (SAPP).
- Different costs.
  - Cream of tartar is expensive.
- Different rates of reaction.
  - Cream of tartar and MCP are fast-acting because they dissolve quickly in liquid.
  - SAPP and SAS are slow-acting because they require heat to fully dissolve.

As soon as acid salt dissolves,
it reacts with baking soda and produces carbon dioxide.

Functions of Chemical Leaveners

1. Leavening.
   - Some products rely heavily on chemical leaveners for rise:
     - muffins, quick breads, baking powder biscuits.
2. Tenderizing.
   - As baked goods rise, cell walls stretch and thin out, making them easier to bite through.

Functions of Chemical Leaveners

3. Adjusting pH of batters/doughs.
   - Cream of tartar and other acids decrease pH.
     - Weakens gluten; *example*: strudel dough.
     - Slows browning and whitens crumb.
   - Baking soda and baking ammonia increase pH. In cookies:
     - More spread.
     - Drier, crisper texture, with more open crumb.
     - Faster browning.

Functions of Chemical Leaveners

4. Providing for a finer crumb.
   - Helps add small air (gas) cells into batters and doughs.
5. Adding flavor.
   - Small amounts add distinct salty-sour taste.
     - Taste is characteristic of baking powder biscuits, scones, Irish soda bread.
   - Large amounts add chemical off-flavors.

Storage and Handling

Yeast:

- Loses potency over time.
- To store:
  - Compressed yeast: refrigerate 2 weeks; freeze 2-4 months.
  - Active dry yeast: unopened, up to 24 months at room temperature; opened, several months at room temperature.
  - Instant yeast: unopened, up to 24 months at room temperature; opened, several months or more when refrigerated, or freeze.

Storage and Handling

Chemical Leavening Agents:

- Can clump and cake when wet.
- Can lose potency over time.
- To store:
  - Cover well and store at room temperature.
  - Make sure utensils are dry.