Dough, Fermentation and Gluten

An Inferiority Complex Carbohydrate

Flour

Milled Ground Starch – primarily wheat but other seeds can be used (e.g. rice, potato, corn…) Varieties:
- Soft wheat – breads and batters
- Hard wheat – bread dough using eggs and yeast
- Durum wheat – hardest with most gluten and used for pasta

Hard or Soft Wheat

Hard wheat has high protein content – with gluten and is used in breads and quick bread
Soft wheat is low protein – used in cakes, pastries and cookies

Wheat Anatomy

Kernel – Endosperm, used to make white flour.
Germ – Embryo – where the sprout emerges, Filled with oil and nutrients.
Bran – Protective outer shell of the kernel. Fiber supplement

White Flour

White Flour is made mostly of the kernel
- All-Purpose – used for many recipes and as a thickener (10-12% protein)
- Southern Brands – for biscuits and frying – (8% protein)
- Unbleached – Preferred for yeast requiring breads (bleach inhibits growth of microbes)
- Bread Flour – Higher protein content (12-14% high gluten content)
- Cake Flour – High protein 6-8%, low gluten content
- Seminola/Durum – high gluten from endosperm

Whole Wheat Flour – Ground bran and germ plus the kernel. More dense and will not rise as well (poor gluten formation).
**SCIENCE of COOKING**

**Wheat Flour**

- Starches – complex carbohydrates (70%)
- Fats – low amounts (germ)
- Proteins – several proteins including glutenin and gliadin (make up gluten)

**Gluten**

- Gluten – a combination of two proteins which can stretch to form long elastic strands and gives dough plastic (ability to rebound its shape and keep a shape under pressure).
  - Helps to keep bubbles of gas in breads and other dough (slice-o-scope)
  - Called the muscle of flour

**Gluten – two proteins**

- **Glutenin** – Long and very large proteins which have lots of sulfur atoms. Coiled proteins which can stretch and recoil. Suffers help hold these together
- **Gliadins** – Smaller proteins which act like lubricants or ball bearings – allowing parts of glutenins to move past each other

**Gluten Formation**

- Stretching of dough pulls the glutenin into long strands which pulls back when relaxed. Kneading unfolds and aligns the proteins into strands

**Dough Strength = Gluten Formation**

- Oxidizing agents – alter sulfur links and increases strengths of gluten
  - Oxygen in air “ages” by allowing sulfur links to form – giving more cross-links
  - Chlorine gas and brominates (can do same thing) but no longer approved
  - Ascorbic acid (vitamin C) is now used
  - Also causes the flour to whiten (bleaching)
Gluten Formation

Stirring and kneading – release the sulfur ends of glutenin and organize the protein into long strands – more elastic/strong
Salt – increases the gluten network by decreasing the charged repulsions between proteins
Sugar – added sugars limit gluten development
Fats and Oils – weaken bonds between glutenin strands
Acidity – create more of the same charge (negative) amino acids on glutenin and repulse each other – weaker breads like sourdough (made sour by lactic acid producing bacteria)

Shortening

To shorten a dough is to weaken the structure of the protein so the bubbles are not trapped and the network collapses
- Fat (shortening) gives thin layers of gluten and fat are used to make pie crusts and puff pastry
- Strong rich bread (lots of gluten) panettone – mix flour + water then kneads to get gluten, then add fats.

Gas Bubbles

Gas bubbles, trapped by the gluten and starches create the empty space in breads, smaller bubbles are found in pastries
- Kneading and knocking down bread works to create smaller bubbles and work large gas pockets into more smaller spaces

Yeast and Leavening

Where do the gas bubbles to make the dough rise come from?
Fermentation (yeast) and CO₂ (leavening agents)

Yeast

Baker’s Yeast – Saccharomyces cerevisiae
- Single cell fungus – over 160 species of yeast
- Yeast use sugar to metabolize that food for energy: Glucose is converted to alcohol and carbon dioxide
- Baking expands the CO₂ gas and burns off the alcohol

\[
\text{C}_6\text{H}_{12}\text{O}_6 + \text{O}_2 \rightarrow \text{C}_2\text{H}_5\text{OH} + \text{CO}_2 + \text{energy}
\]

Growing Yeast

Louis Pasteur (1859) discovered how yeast works:
- Yeast feeds on starches (sugars) in flour (metabolism/fermentation) to produce carbon dioxide
- The CO2 expands pushing the gluten proteins around in the flour
- Bubbles are trapped by gluten and the proteins become fixed as the bread is baked
**Foods for yeast**

Simple sugars (sucrose, fructose, glucose and maltose) are found in smaller amounts in unsweetened flour

- Since yeast need sugar to grow and produce gasses, this flour will give low rising breads
- Added sugar increases yeast activity
- YET – large amounts can decrease the yeast – sweet breads. So does salt!

**Forms of Yeast**

Cake or compressed yeast – live pressed blocks of yeast.

- Must be kept moist and cold
- Only lasts a few weeks
- Used by professional bakers and gives best results

**Active dry yeast** – dormant, dried yeast.

- Granules of yeast with a coating from yeast culture
- Long shelf life (several months)
- To hydrate, must be soaked in 105-110°C water

**Instant dry yeast** – dormant, dried yeast.

- Improved version of active dry yeast, less debris and healthier yeast
- Long shelf life (several months)
- No need to hydrate – can add as dry mix

**Leavening Agents**

Dough with low gluten, runny batter and minimal mixing (biscuits, pancakes) do not have ability to hold gas bubbles for long

- Yeast production takes too long
- Quick breads – use a chemical means to produce gas in a short time

Most chemical leavening agents produce CO₂ gas bubbles from one source or another

**Quick Breads – chemical reactions**

Early breads used potash (extract of wood ash) for its potassium carbonate.

- When reacted with lactic acid produce carbon dioxide gas

Baking Soda – sodium bicarbonate

- When reacted in water with an acid will produce CO₂ gas
Baking Powder – a double agent!

Baking Powders – dried forms of acids and bicarbonate
- Goal is to produce the gas when chemicals are dissolved in water or other liquid
- Mixed with starch to keep dry
- Acids vary from tartaric acid (cream of tartar) to phosphate acids (which take longer to produce acid and work when heated)

Double acting powders — create two sets of reactions — one set when wet, the other during baking

Preparing the Dough

Mixing – add all ingredients together
- Starch will swell when wet
- Enzymes from flour will digest some of the sugars reducing yeast growth
- Initial mixing of gluten draws proteins together but as air oxidizes sulfur ends, the glutens form end to end bonds creating long chains

Autolysis – mix water and flour first to let gluten and starch absorb water before adding rest of components

Kneading

Kneading stretches and compresses proteins over and over to strengthen the gluten network
- Aligns proteins on long strands
- Encourages links between strands
- Also creates pockets of air to expand when heated
- Low kneaded breads will result in large air pockets with less developed gluten

Rising

Rising is fermentation (quick breads don’t rise)
- Low to mid temps avoid unpleasent yeast products
- When dough doubles in size, bread has finished fermenting/rising
- High protein flours may need a second rise to fully develop gluten – these breads are knocked down or kneaded again and allowed to rise during baking

Baking

Ovens – see book chapter on types of ovens and processes
Early Baking – Steam of water in bread or oven creates further expansion of gasses
- The dough rises from steam and heating of gluten-trapped gas bubbles
- Alcohol from yeast evaporates and brings small aromatic molecules with it some caramelization — the smell of baked bread!

Late baking – as the temp approaches boiling point:
- the starch turns into a gel
- and the crust browns
- Finished bread will be fully set and detected by indirect tapping on the bottom of the loaf
- Uncooked bread will be wet with gluten gel and should sound heavy and dense
- Cooked bread will be an open sponge and sound hollow
**Sourdough Bread – Acid Flavor**

which enhance gluten formation

- Acid comes from bacterial culture in dough
- Maintaining cultured dough with lactic acid producing bacteria and specific strains of yeast—can be used over and over
- Cultures are fed flour and water over time.
- Other forms of acid used are buttermilk or yogurt

**Biscuits**

French for twice cooked – originally baked until dry and hard (biscotti cookies are twice baked)

- Leavened with carbon dioxide producing agents not yeast
- Early and European biscuits are more like cookies than what we think of biscuits
- US biscuits – no sugar and sometimes no eggs – instead have moist loose dough with baking soda

**Pancakes**

More flour and thick batter than crepes or popovers (more fats and water)

- Folding batter with low water, a bit more salt and cooking slow create softer thicker pancakes (less gluten and bigger gas bubbles)
- High mixing, more water, higher heat (quick cooking time) and low salt will produce thinner but more dense pancakes

**Cakes**

Web of flour eggs sugar and fat (shortening) to produce mostly thin cages of protein around the gas bubbles.

- The more bubbles the more “light” the cake
- Sugar, butter or fat and low protein cake flour (about half of all purpose flour) create poorly connected and low amounts of gluten.
- Too much inhibition of gluten will collapse the cages around the bubbles and a thick cake results

**Cake Baking Secrets**

- **Cake shortening** – hydrogenated vegetable oil with nitrogen gas bubbles works at room temp to mix will. N2 gas provides additional bubbles.
- **Cake flour** –
  - Fine milled low protein/high starch – smooth texture
  - Chlorine gas treatment (now oxidized with other chemicals) helps to swell starch and bind fat to limit gluten formation

**Mixing and baking**

Mixing is critical – introduces bubbles to expand during heating

- Different methods of aerating – see book
- Flour is often added only after a foam is created to limit the strengthening of gluten

Three stages of baking

- Batter expands (based on aerating and leavening)
- Then egg proteins denature to form protein cages around bubbles and starch swells
- Final stage solidifies protein/starch and browns proteins for final flavor