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Dough, Fermentation and Gluten

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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

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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

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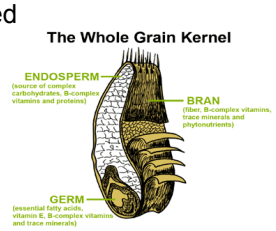
Wheat Anatomy

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



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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).

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Wheat Flour

Starches – complex carbohydrates (70%)

Fats – low amounts (germ)

Proteins – several proteins including glutenin and gliadin (make up gluten)

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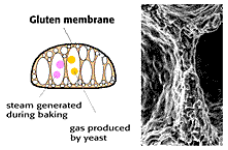
Gluten

Gluten – a combination of two proteins which can stretch to form long elastic strands and gives dough plastic (ability to rebound it's 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



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Gluten – two proteins

Glutenin – Long and very large proteins which have lots of sulfur atoms. Coiled proteins which can streatch and recoil. Sulfers help hold these together

Gliadins – Smaller proteins which act like lubricants or ball bearings – allowing parts of glutenins to move past each other

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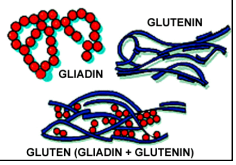
Gluten formation

Stretching of dough pulls the glutenin into long strands which pulls back when relaxed.

Kneading unfolds and aligns the proteins into strands



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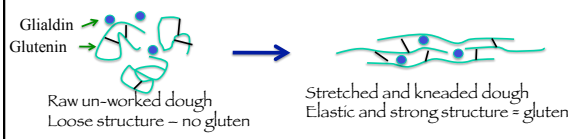
Dough Strength = Gluten Formation



Coils and sulfur cross-links (black lines) of glutenin give the elastic ability to dough

- High protein (and gluten) flour give strong gas pockets good for breads
- Low gluten flours are weaker tender baked goods – cakes and cookies (that is why you don't over mix pancake mix)
- High water dough (called batter) dilutes gluten so they don't mix/ bind - Click here to explore Gluten

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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)

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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)

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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.

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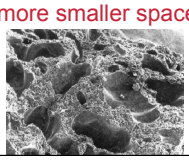
Gas Bubbles

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



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Yeast and Leavening

Where do the gas bubbles to make the dough rise come from?

Fermentation (yeast) and CO_2 (leavening agents)

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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 CO_2 gas and burns off the alcohol

$C_6H_{12}O_6 + O_2 \rightleftharpoons C_2H_5OH + CO_2 + \text{energy}$

Sugar — Oxygen — Ethyl alcohol — Carbon dioxide

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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

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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!

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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

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Forms of Yeast

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

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Forms of Yeast

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

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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 CO_2 gas bubbles from one source or another

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Quick Breads – chemical reactions

Early breads used potash (extract of wood ash) for it's potassium carbonate.

- When reacted with lactic acid produce carbon dioxide gas

Baking Soda– sodium bicarbonate

- When reacted in water with an acid will produce CO_2 gas

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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

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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

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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

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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

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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!

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Baking

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

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Special Breads

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

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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

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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 glutten and bigger gas bubbles)
- High mixing, more water, higher heat (quick cooking time) and low salt will produce thinner but more dense pancakes

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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

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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

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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