Code and Title of the Paper: F01FS Food Science
Code and Title of the Module: F01FS21 Gluten Formation
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GLUTEN FORMATION

1. INTRODUCTION:

It's not surprising that people have a difficult time understanding gluten, because it doesn't exist in nature. Gluten is a water-insoluble protein that is formed when water is mixed with wheat flour. Proteins are very large molecules composed of amino acids. Two of the naturally occurring proteins in flour are called *glutenin* and *gliadin*. Glutenin: provides strength and elasticity. Strength is also called as tenacity which is a measure of how much force is needed to stretch dough. Elasticity refers to the ability to bounce back once dough is stretched. Gliadin provides extensibility, or stretchiness.

When sufficient water is added to dry flour, the two proteins emerge from a "frozen state" and become flexible and able to move about. The process of wetting the proteins is called hydration. As water and flour are mixed the hydrated proteins are brought together and begin to interact. They literally begin to stick to each other through the formation of chemical bonds. These new chemical bonds are called cross-links.In the case of gluten a number of different types of chemical bonds form between the proteins, with some (disulfide bonds) being stronger than others (ionic bonds and hydrogen bonds).

GLUTEN DEVELOPMENT

Gliadin + glutenin

↓

Hydration of hydrophilic protein

Breaking of particles

Stretching & pulling of glutenin

↓

more water

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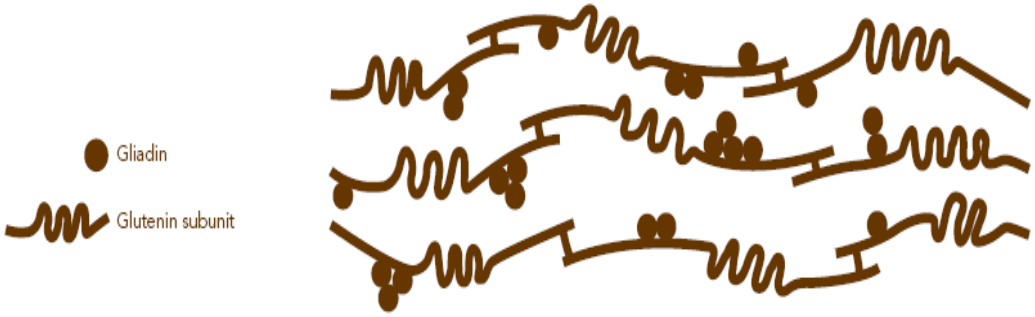
Gluten (gliadin+glutenin+H_2O)

Gluten is the common name for proteins present in all forms of wheat and related grain species like barley, rye and triticale. Gluten is a critical functional protein component in wheat based doughs. Gluten is formed when two classes of water-insoluble proteins in wheat flour (glutenin and gliadin) are hydrated with water and mixed. From this process gluten bonds are formed and a tough rubbery substance is created providing strength and structure. The mechanical shear causes the gluten bonds to form and become a viscoelastic matrix holding the starch granules in the flour. Only a batter or dough can contain gluten, not the raw flour alone. The bonds that form between the glutenin and gliadin are called disulphide bonds, as illustrated in the picture below.



OBJECTIVES:

Define the formation of gluten
Identify the use of gluten in bakery
Describe the factors affecting gluten strength

2. Uses of Gluten

Grains containing gluten are used as ingredients for a wide range of prepared and commercial foods. Wheat flour alone is found in thousands of products due to its ability to give products structure and assist with the thickening and coating of products.

In addition to the gluten found in grains, gluten can also be added as a separate ingredient in its own right. This product is made from washing the starch out of a flour slurry.

This additional Gluten is used in the bread industry to supplement the gluten proteins already naturally present in flour and subsequent dough. To the baker gluten adds valuable properties:

- increased dough strength
- better gas retention and elasticity, which gives products good structure and uniform shape to bread
- better water absorption and retention, improving yield, product softness and extending shelf life of bread
- enhanced flavour

An example of additional gluten being added to the ingredients of a bakery product is in the manufacture of hamburger buns. The addition of gluten to the dough provides the elasticity needed so that the buns retain a uniform shape when filled.

Gluten can also be a useful ingredient in products other than bakery products, as the following examples highlight:

- Batter: Ensuring a durable adhesion of batter crusts to foods is a quality problem, especially in frozen foods. Using a dusting of gluten powder before applying the batter vastly improves the adhesion in both hot and cold temperatures and the results are comparable to (more expensive) egg. The gluten also assists with food moisture as the product is better sealed and the surface crust that results is crispier and more appealing.

- Pasta: Pasta manufacturers prefer to use semolina made from Durum wheat as it produces better quality pasta. However the addition of gluten to semolina made from other wheat varieties can improve their suitability for pasta doughs.

- Meat products: Gluten is widely used in processed meats, as a binding and enriching ingredient. It is used in beef, pork and chicken sausage products and as a common ingredient of pizza toppings.

Continued mixing causes more cross-links to form between the proteins until a large *network* of chemically linked proteins is formed. Mixing can be done with a stand mixer, or by hand, such as when dough is *kneaded*. When dough is mixed or kneaded the hydrated flexible proteins are stretched and aligned in the direction of kneading providing more opportunities to form cross-links between the proteins. Kneading also incorporates air, which helps to form strong disulfide bonds. As kneading continues the protein networks combine to form *sheets* of proteins. Think of this step in the process as being similar to unraveling thread (proteins), and weaving the straightened thread into pieces of cloth (networks), and then pieces of cloth being stitched together to form large sheets of cloth similar to a quilt (see figures on following page).

The chemical cross-linking of glutenin and gliadin forms gluten, a very elastic substance. Neither protein alone is as elastic and stretchable as gluten. But when chemically linked together the new protein becomes elastic and stretchable like a rubber balloon. The gluten becomes stronger and stronger as more bonds form between the proteins, like a weak thin rubber balloon becoming a strong thick rubber balloon. Like a balloon, gluten can be inflated with gas and steam as dough rises and bread is baked in the oven. Think of an inflated balloon covered with paper mache. This is how we made puppets when I was young. When the paper mache dries the balloon can be popped and removed leaving a rigid sphere. In the same way, as bread bakes the inflated gluten dries turning

into a strong but flexible structure that creates the holes in chewy bread (Note that freshly baked bread still contains about 35% moisture by weight, which is sufficient to keep the starch soft and the gluten elastic)

3. Many factors affect the development and strength of gluten:

If too much gluten develops, it can make baked goods, like pie crust, tough rather than tender. The extent of gluten
development also affects how high leavened baked goods will rise, and if the crumb is tender or chewy. Weaker gluten is more extensible (stretchable) and doesn't shrink as much. Here are some factors that affect gluten development.

1) Variety of wheat: Soft wheat contains less protein (6-8%), less glutenin, smaller proteins, forms weaker gluten. Hard wheat contains more protein (10-14%), more glutenin, larger proteins, forms stronger, more cohesive, elastic gluten.

2) Amount of water: Hydration is essential for gluten development. Glutenin and gliadin absorb about twice their weight in water (hydration). Less water results in less gluten development (reduces protein mobility), but too much water also reduces gluten development by diluting the proteins so much that their interaction is restricted.

3) Water hardness: Calcium and magnesium in hard water strengthen gluten. Water in Boston, MA is soft containing only 0-60 ppm of calcium and magnesium.

4) Water pH: The ideal pH for gluten development is 5-6. Above and below pH 5-6
reduces gluten strength producing more extensible (easier to stretch) dough. Adding baking soda raises pH producing more cookie spread, and more porous, tender crumb.

5) Leavening: Expanding air bubbles strengthen gluten, increasing cohesiveness, and elasticity, producing higher volume and finer crumb.

6) Enzymes: Enzymes that break down proteins are naturally present in flour, but

inactive when dry. Enzymes break down gluten into smaller pieces so dough becomes softer and more extensible. The process known as autolyse (resting dough for 15-30 minutes), allows time for enzymes to break down gluten to produce more extensible dough, providing more volume and open crumb.

7) Salt: Bread dough contains 1.5-2.0% salt by weight of flour. Salt slows enzyme activity and rate of fermentation. Salt strengthens gluten, producing bread with higher volume and finer crumb.

8) Fat, oil, emulsifiers, and sugars tenderize dough. Fat and emulsifiers coat proteins reducing hydration and gluten development (like oil coating spaghetti). Shortening shortens gluten strands producing more tender baked goods. Sugarcompetes for water reducing protein hydration and gluten development.

4. Manufacturing of gluten

To obtain gluten, flour is mixed with water and the starch is washed out. This process is completed commercially and a great deal of care is needed to maintain the baking quality of gluten.

Step 1: The flour and water are mixed together. The resulting dough is left to rest to allow the protein components time to absorb the water.
Step 2: The dough is then conveyed into long horizontal water filled tank containing screw-type conveyors, which knead the dough until all the starch is suspended in the wash water.

Step3: All that remains between the screws is the gluten mass which is then forced through fine openings, chopped into small pieces and dried in a hot turbulent air stream ready for bagging.

There are different strengths of commercial gluten – stronger glutens are usually a greyish green colour while weaker glutens are yellow. Commercial gluten is available as either a dried powder or in a wet form

The approximate composition of dry gluten is:

Moisture	8%
Protein	70-75%
Fat	5-8%
Starch	11-16%
Fibre	1%

5.Using commercial gluten

When compared to flour, commercial gluten is an expensive product at about six times the price, so it should be used at only the required level to meet product quality requirements.. Some useful points to remember when using gluten as an ingredient at home or in a bakery setting are:

- To make a useful improvement in the dough structure, approximately 4% of extra gluten is added (based on cereal weight).
- If adding dried gluten to a bread formula then more water is required. This is approximately 1.5 times the weight of gluten added**.**

6. Function of gluten in baking and cooking

Gluten formation is critical to the volume, texture and appearance of a product. When the proteins in the flour are hydrated and the dough/batter is mixed, gluten bonds form providing structure and elasticity. This happens because the proteins in the dough form linkages and gluten strands are created. As mixing increases, so does the strength of the dough. The amount of gluten formation is dependent on the application. Less gluten formation is desired in a tender cake, whereas high amounts of gluten formation is needed for chewy

artisan bread. You can purchase various types of flour with more or less protein, depending on the desired level of gluten forming potential.

When gluten bonds are formed, the protein then has the ability to form elastic films in the dough, which provide structure and helps to trap gases, assisting in leavening of products. When heated, the gluten proteins coagulate (solidifies) and a semi-rigid structure forms providing characteristic textures of various wheat based products. Starches are also an important component in wheat flour (63-77%). As the product is heated, the starches absorb moisture and gelatinize (stiffens), adding to the texture of the finished product. The unique composition of nutrients in wheat flour (fat, minerals, moisture, starches and proteins) provide the characteristic taste and texture attributes to wheat based products.