Chemistry of Cereals
Wheat, Flour and the Action of H_2O
The Primary Structure of Gliadin

Alpha/beta-gliadin clone PW1215 precursor (Prolamin).
Triticum aestivum (Wheat).

Sumner-Smith M., Rafalski J.A., Sugiyama T., Stoll M., Soell D., "Conservation and variability of wheat alpha/beta-gliadin genes."; ***Nucleic Acids Res.*** 13:3905-3916(1985)

Amino Acid Sequence (Primary Protein Structure):

MKTFLILALL AIVATTATTA VRVPVPQPQP QNPSQPQPQG QVPLVQQQQF PGQQQQFPPQ QPYPQPQPFP SQQPYLQLQP FPQPQPFPPQ LPYPQPPPFS PQQPYPQPQP QYPQPQQPIS QQQAQQQQQQ QQQQQQQQQQ QQILQQILQQ QLIPCRDVVL QQHNIAHARS QVLQQSTYQP LQQLCCQQLW QIPEQSRCQA IHNVVHAIIL HQQQRQQQPS SQVSLQQPQQ QYPSGQGFFQ PSQQNPQAQG SVQPQQLPQF EEIRNLALQT LPRMCNVYIP PYCSTTIAPF GIFGTN

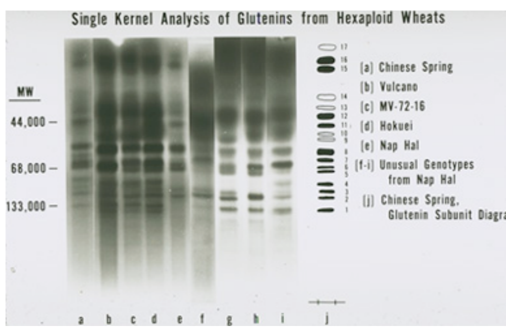
Chemistry of Cereals

http://www.fao.org/docrep/x2184e/x2184e04.htm

Compositionally, cereals consist of 12-14 percent water, 65-75 percent carbohydrates, 2-6 percent lipids and 7-12 percent protein. Cereals are quite similar in gross composition being low in protein and high in carbohydrates.

Early researchers divided the proteins of wheat into four solubility classes called Osborne fractions: albumins, which are water soluble; globulins, which are soluble in salt solutions, but insoluble in water; gliadins, which are soluble in 70-90 percent alcohol, and glutenins, which are insoluble in neutral aqueous solutions, saline solutions, or alcohol. The respective protein fractions from wheat are also applicable to other cereals and are generally known as albumins, globulins, prolamines, and glutenins. The distribution of these protein fractions varies among different cereals. There is considerable variation in the solubility classes among the cereals and also to some extent within each species of cereal.

Among the Osborne fractions in cereals, the prolamin fraction has been the most studied (Eliasson and Larsson 1993). This fraction is called gliadin in wheat, secalin in rye, hordein in barley, avenin in oats, and zein in maize. The fraction includes several protein bands when analyzed by sodium dodecyl sulfate polyacrylamide gel electrophoresis under both reducing and non-reducing conditions. The high molecular weight subunits of prolamins constitute a higher percentage of the total in wheat than in other cereals (Shewry and Mifflin 1985). The baking quality of wheat flour from different varieties is influenced by the glutenin content (Eliasson and Larsson 1993); however, rice flour, with it's high glutenin fraction, does not form gluten. The albumin and globulin fractions of cereals are also a complex mixture of proteins; however, they are of relatively low molecular masses and remain unchanged in size following reduction of their disulfide bonds. It is now recognized that cereal proteins exhibit biochemical polymorphism and can be distinguished through electrophoresis of the gliadin fraction (Alais and Linden 1991) as well as the glutenins.



Essential amino acids such as lysine, methionine, arginine, histidine, leucine, tryptophan etc. are produced only in plant cells, but they are of great importance for nutrition of animals and humans who are not capable of synthesizing these amino acids. Simple proteins are building materials in the human body, but act as a storage materials in plant seeds. Glutenin is built from essential aminoacids and it can be found in wheat, maize etc. Gliadins belong to this group, but they lack essential amino acids.

Glutenin and gliadin form a compound called gluten, which is important in dough. One particular wheat gliadin (alpha-gliadin) has been studied in detail. Researchers have found that this protein has 266 amino acids, with over 60 glutamines and over 30 prolines. This is very unusual; most proteins have a fairly random scattering of amino acids. These two amino acids range from 36% up to 45% for glutamine and from 17% to 23% for proline in wheat cultivars

Wheat, Flour & the Action of Water

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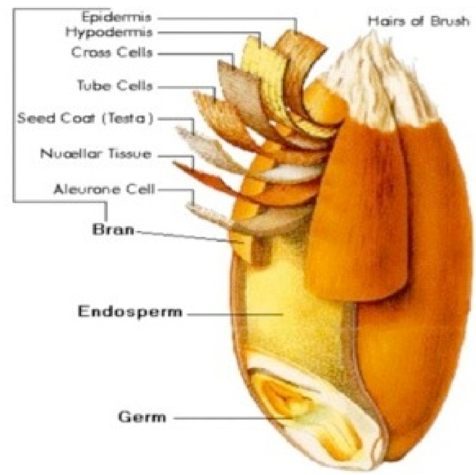
The wheat grain consists of three main parts: the endosperm, the bran, which is mostly wall tissue and the wheat's germ. The germ is rich in oil and it contains lots of vitamins. The endosperm is where the starch is stored. It also houses the protein that transforms into gluten during kneading. The wall tissue encapsulates the endosperm. The wall is made from several layers. The aleuron layer separates the endosperm from these adjoining layers. The wall contains a significant amount of fibre.

The aleuron layer is also rich in proteins and vitamins. Wheat is ground to separate the endosperm from these wall layers and the germ.



The aleuron layer is also rich in proteins and vitamins. Wheat is ground to separate the endosperm from these wall layers and the germ. During the grinding the endosperm is reduced to what we know as flour, after grinding the wall layers and germ make up the bran portion.

The wheat grain consists of about 8 to 15% of protein. The proteins are found enclosed between the starch grains. Wheat protein comes in a large variety of different molecules, with markedly divergent properties. The most import can be distinguished by their specific solvent :

a. albumin : dissolves in water
b. globulin : dissolves in salt solutions
c. gliadin : dissolves in 70 % alcohol
d. glutenin : dissolves in diluted acids or bases

The first two form about 20% of the total amount of protein, while the glutenin and gliadin contribution is the remaining 80 %. The latter are responsible for the formation of the gluten during kneading. The gliadin and glutenin form a network of molecules capable of holding the carbon-dioxide gas that is a by-product of fermentation. It is this network of lace that causes the bread to rise.

Flours having a low protein content or a bad protein quality are rarely used in bread preparation. For the preparation of most kinds of bread a flour with a protein content between 11 and 13% is used. For special applications like biscuits one uses flours with a protein content in the 15-16% range.

All flour improvers are oxidants i.e. they produce oxygen when mixed with water and when energy is added to the system (by the mixing). The oxygen in its turn reacts with protein in the flour. All the fine details of this chain reaction are still unknown. The action of the flour conditioners can be compared with what happens during storage of flour. It is a well-known fact that the baking properties of the flour improve when it is stored for some time after grinding. This is attributed to the oxidation of proteins by oxygen from the air. However, a too large dose causes a deeply advanced oxidation which makes the dough to stiff.

In the past and especially in the USA potassium bromate ($KBrO_3$) was used as oxidizer. It is the most effective substances of all the dough conditioners known. It gives the dough good working up properties and the bread a fine, soft and regular crumb. And it has a slow reaction. Interestingly, it is mostly seen in use in the Netherlands and the Anglo-Saxon or English speaking countries. During the 1980s bromate and many of its compounds became suspected as health threatening and prohibition of the use of potassium-bromate followed.

In countries where hearth baked breads is the favourite kind of bread the baker uses ascorbic acid (vitamin C) as dough conditioner. It is totally harmless. Heat decomposes the ascorbic acid completely. During the baking of the bread all vitamin C is lost. The function of ascorbic acid is the same as any other, oxidizing the dough.

The gluten lace is formed through sulphur bridges. Too many S-S bridges makes the dough stiff and sturdy. In the dough thiol groups (SH) influence of the mobility of the protein molecules with respect to each other. This can be demonstrated by adding extra thiol groups in the form of cystein to the dough. The dough gets much more flabby. Oxidation removes thiol groups, two SH groups are converted to one SS group plus water. The mobility of the proteins decreases, thereby making the dough less pliable.

Ascorbic acid differs in one aspect from other dough conditioners. In itself is it not an oxidizer but a reducer. Its activity stems from a preceding reaction during kneading with oxygen in the air. It is than converted to dehydro-ascorbic acid and that is an oxidizer. When this substance oxidises the proteins it is reduced back to ascorbic acid. The formation of dehydro-ascorbic acid is only possible during the kneading. This is the only moment that oxygen from the air can be beaten into the dough. After the kneading the yeast consumes all the remaining oxygen, leaving none in the dough during the rise.

An essential element of any recipe, is water , the importance of which is very often overlooked. A bread dough is roughly 40 % water. In making dough, the consistency depends clearly on the amount of water used in making it. The amount of water needed depends on the quality of the flour and the kind of bread we want to make.

Water is needed to form the gluten and give the dough consistency. It is also the solvent or medium for substances like sugar and enzymes that are indispensable for the fermentation. The next essential role is its function in homogenizing all this substances throughout the dough during kneading. The water is also needed for swelling and gelatinisation of the starch. This in its turn improves the easy digestion of the bread. The distribution of the heat through the bread during baking is done by water in the dough. And finally water influences the organoleptic properties of the bread.

Besides the amount of water we are using, its quality plays also an important role.

The most important criteria for water is its hardness. This is a measure for the content of calcium and magnesium salts dissolved in the water. Water with a mild hardness is the most useful, because the mineral salts reinforce the gluten network. If the hardness is too high (more then 180 parts ppm or 180 mg per litre) the fermentation slows down because of the too rigid gluten structure. Using more yeast or adding malt to the dough are the best ways to correct this condition. In the opposite case, where water hardness is less then 120 ppm the dough gets sticky. In this case one has to use less water and although the consistency of the dough looks normal.

Another important factor is the pH of the water used. Acids are responsible for the flavour and the taste of the bread. The acids, necessary for a good organoleptic experience will be neutralized if the alkalinity becomes larger then a pH of 8. The activity of the yeast and lactic acid bacteria drops if their environment becomes alkaline. The enzymatic activity also suffers from a too high pH. Their optimal pH must be in the range 4.0 to 5.5, which is also excellent for the yeast and the lactic bacteria.