1. STRUCTURE OF THE WHEAT GRAIN

1.1 Germ:
Contains:
- All rudimentary tissues for growth (germination)
- High in protein (25% enzymes)
- High in sugar (18% sucrose + raffinose)
- High in lipids (removed during flour milling to avoid rancidity during storage)
- No starch
- Vitamin B and E

1.2 Bran: protects the grain against pest, illnesses, etc.
Contains:
- Vitamin B and minerals
- Insoluble fibres
- Removed during milling

1.3 Starchy endosperm: used to make white flour
Contains mostly starch

1.3.1 Aleurone layer: surrounds the starchy endosperm
Synthesizes most enzymes to digest and mobilise nutrients (eg: hydrolytic activity for melting barleys to reduce starch to fermentable sugars).
This is undesirable in wheat for flour making.

1.3.2 Starch
Energy store for grains (60 to 75% of the grain weight)
Insoluble and high molecular weight
Influences degree of gelatinisation of foods (setting of cakes, gravy thickening, etc)
2. STARCH MOLECULES

2.1 Amylose (25-30% of cereals starches)

Linear polymer of $\alpha$-1,4 linked $\alpha$-D-glucose, (low degree of branching)
Molecular weight: varies around 250 000 (1500 anhydroglucose units)
Chain arranged as a helix

Amylose structure:

- A chains: they are linear with only $\alpha$-1,4 linkages
- B chains: They are branched with only $\alpha$-1,4 linkages and $\alpha$-1,6 linkages
- C chains: $\alpha$-1,4 linkages and $\alpha$-1,6 linkages plus a reducing group which is at the start of the structure

2.2 Amylopectin

Randomly branched polymer of $\alpha$-D-glucose
Molecular weight: about 100 millions
4-5% of $\alpha$-1,6 glycosidic branches
average unit chain contains only 20-25 glucose units

Amylopectin structure:

- A chains: they are linear with only $\alpha$-1,4 linkages
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2.3 Properties of starch

**Heating:** it increases the size and permeability of the starch granule
It hence increases the leaching into the solution and then the viscosity of the solution. The structure of the solution becomes amorphous.

**Retrogradation:**
On cooling, the starch paste forms a gel
Prolonged storage of gels leads to retrogradation (hardening)
Due to crystallisation of amylose to from double helices. (eg: hardening of cooked rice of bread staling)

To prevent retrogradation:
  - **Humectants** (hygroscopic): salt and sugar. They absorb the water from the air (moist feeling) and keep the water away from the starch.
  - **Fat + oils:** they form a complex with the starch but interfere with the gluten development.
  - **Emulsifiers** (lecithin, monoglycerides): they act as fat but do not interfere with gluten.

2.4 Modified starches

They change properties in products by:
  - **Cross linking** between hydroxyl groups and gives a resistance to heat and acids.
  - **Partial degradation:** break the long chains down into simpler molecules like dextrin, polydextrin, and maltodextrin
  - **Esterification:** decrease the tendency to create gels
  - **Derivitisation:** Makes the starch more hydrophilic and hence decreases the retrogradation tendency
3. PROTEINS

**Glutenins**
- resilient
- rubbery
- resistant to extension
- prone to rupture
- MW: millions of kDa

**Gliadin**
- glutty
- very cohesive
- little resistance to extension
- MW: 40-80 kDa

**Gluten**
- has properties between gliadin and glutenin

**Wheat Flour protein**

- Non Gluten (15%)
  - non dough forming
  - water soluble
- Gluten (85%)
  - dough forming
  - water insoluble

- Albumin (60%)
  - water soluble
- Globulins
  - soluble in dilute salt solutions

3.1 Gliadin

- Low intrinsic viscosity
- Hydrophobic interaction and hydrogen bonds in dough formation
- There are four types: α, β, γ and ω:
  - α, β and γ have got intra-chain disulphide bonds (Cys, Met). They hence are made of α helix and β sheets.
  - ω has got no disulphide bonds (no Cys or Met and low amount of basic amino acids (His, Arg and Lys). They are made of β turns.

3.2 Glutenin (35 to 40% of flour proteins)

Consists of subunits stabilised by interchain disulphide bonds.

3.2.1 HMW subunits

Contain x types (3 residues) and y types (5 residues)
3.3 Summary

Gluten

Gliadin monomers
α, β, γ glyadin
ω glyadin

Aggregative glutenin
LMW subunits

HMW subunits

S-poor
S-rich

Prolamins (soluble in 70% ethanol)
4. DOUGH FORMATION

- Hydrogen bonding (high content of Gln and Asn)
- Disulphide bonding → thiol-disulphide exchange reactions

4.1 Thiol-disulphide exchange theory
Non permanent disulphide bonds

1: The group R-SH approaches the disulphide bound

2: The group is bound to the S atom

3: The sulphide bonds to another sulphide (blue)

4: The thiol-disulphide bond is formed with another sulphide

R-SH = Glutamyl-Cys-Gly

4.2 Hydrogen bonding “Loops and trains”

- β sheet formation during hydration → β sheet stabilised by hydrogen bonding can be inter-molecular.

Low hydration: Mainly hydrogen bonds between chains

High hydration: Loops and chain form. Chains are helpd together by hydrogen bonds (trains)

These hydrogen bonds can break and reform (as in thiol-disulphide theory). The stretching and unzipping can be caused by extension of the dough.
5. BREAD MAKING

5.1 Traditionally

- **Ingredients**: (strong flour, water, yeast and salt) are mixed together to form a dough.
- **Fermentation**: for 3 hours (depends on amount of yeast and dough temperature): production of CO$_2$ (Cellular network crumb structure, aroma development)
- **Proof**: dough allowed to rise gently under controlled temperature and humidity.
- **Baking**

5.2 Chorleywood process

- Can use higher proportion of low protein (weak) flour.
- No fermentation
- Dough development during high speed mechanical mixing for a few minutes
- Use of ascorbic acid

5.3 Ascorbic acid (only oxidant used in European Union)

Bread improver to strengthen the dough and aid rise:
- Improves volume, crumb structure and softness and colour.
- Decreases dough stickiness

Dose: 2-6g/100kg flour

2 theories about the mechanism:

5.3.1 Theory 1:

Ascorbic acid (AsA) → Dihydro-ascorbic acid (DHAAsA)

- DHAAsA acts as the real oxidant
- Oxygen is needed, so AsA only active for a few minutes after mixing
5.3.2 Theory 2:

- Rapid removal of endogenous GSH
  - causes dough weakening by disulphide exchange reactions with gluten proteins
  - promotes dough extensibility
- Two cysteine residues can reduce GSSG to free GSH

5.4 L-cysteine (reducing agent)
- Facilitate dough formation with strong flour → increase extensibility
- Promotes depolymerisation of HMV glutenins
- 10-30 g 10% L-cysteine/100 kg flour

5.5 Emulsifiers
- Improve
  - Texture: crumb softness
  - Shelf life: influences retrogradation
- Form water insoluble complexes with amylase:
  - Prevent gelatinisation during baking
  - Less water absorption
  → Decrease retrogradation

5.6 α-amylases
- Endogenous enzyme that hydrolyses glycosidic bonds of damaged / gelatinised starch.
- Flour standardisation of amylase activity
- Increase loaf volume by providing fermentable sugars (maltose) for yeast fermentation.
- Increase crust colour and aroma (sugars for Maillard reaction)
- Antistaling by generation of LMW dextrins that interfere with starch-starch interactions.

5.7 Lipids
Wheat flour lipids are heterogeneous:
- Starch lipids (25-33% flour lipids) form complexes with amylase
- Non-starch lipids have a negative effect on the loaf volume