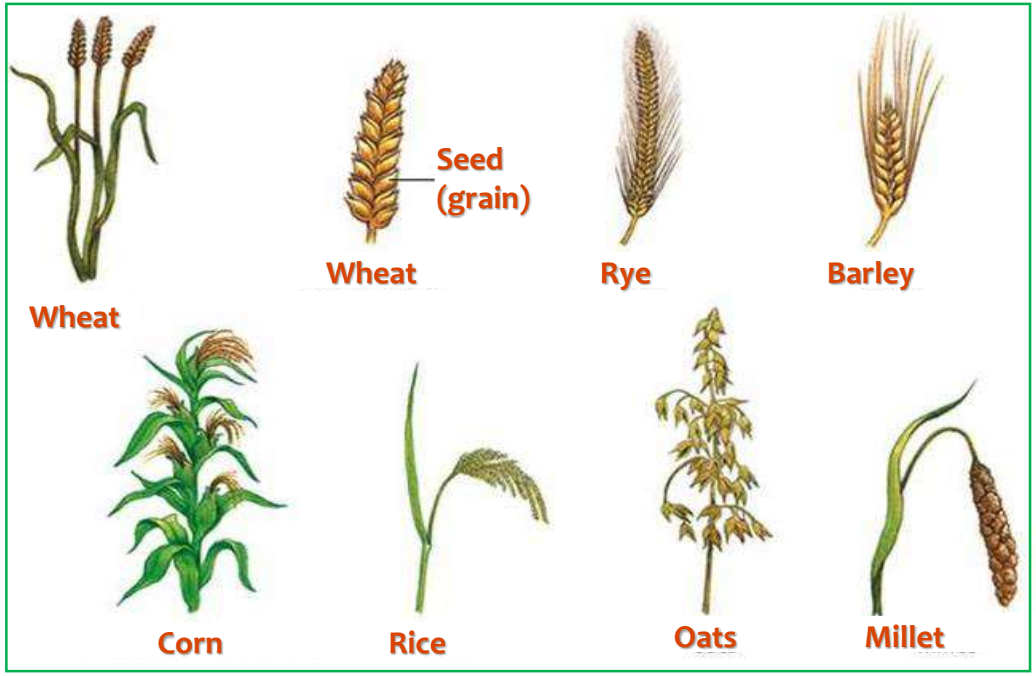
CEREALS & THEIR PRODUCTS

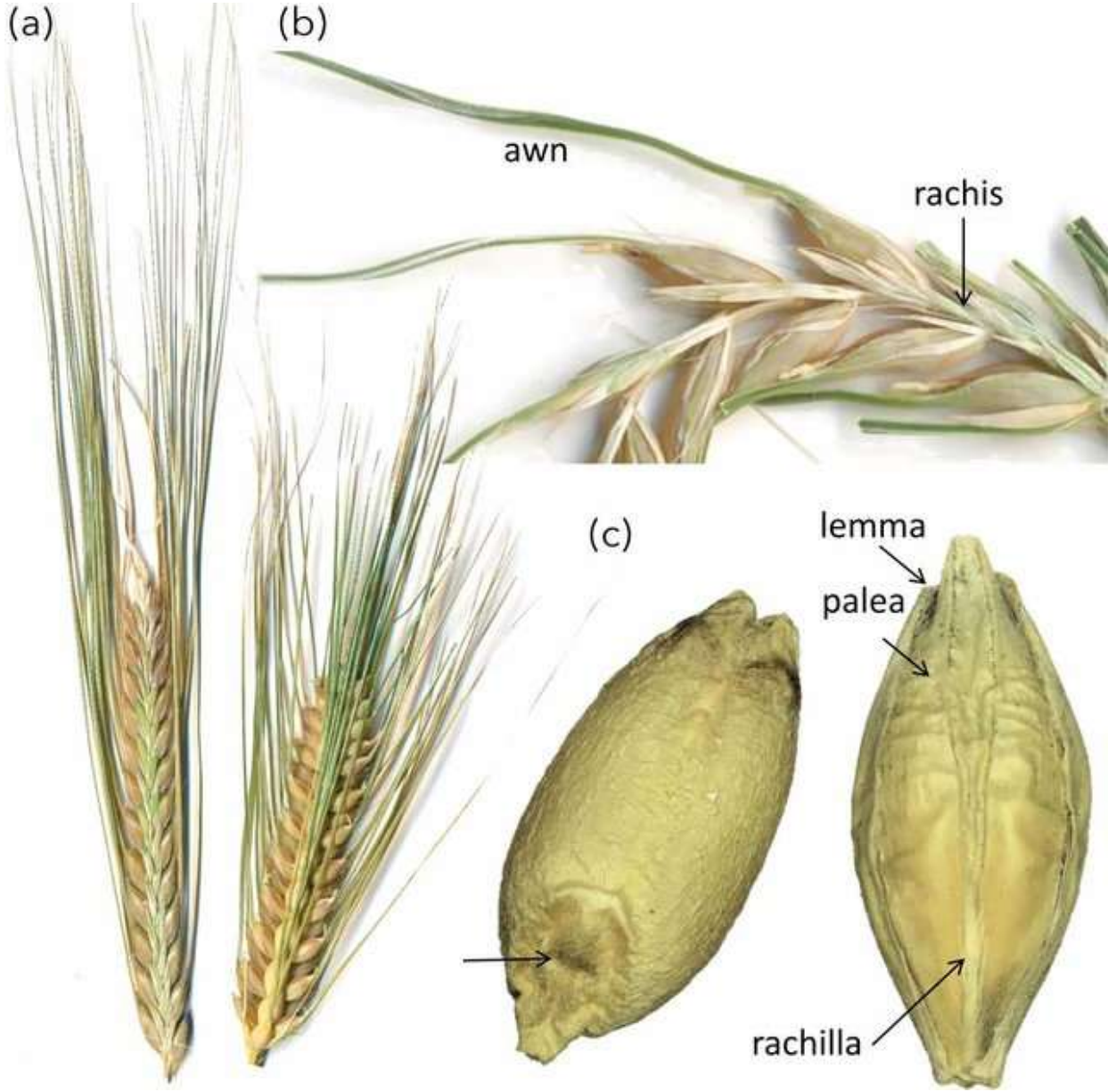
Cereals (grains):

- among the most important staple foods of humanity
- They provide nutrients that only from the consumption of bread in developed countries cover 50% of the daily requirement for carbohydrates, the 1/3 of the daily protein requirement, and 50-60% in B vitamins
- They are sources of minerals & trace elements

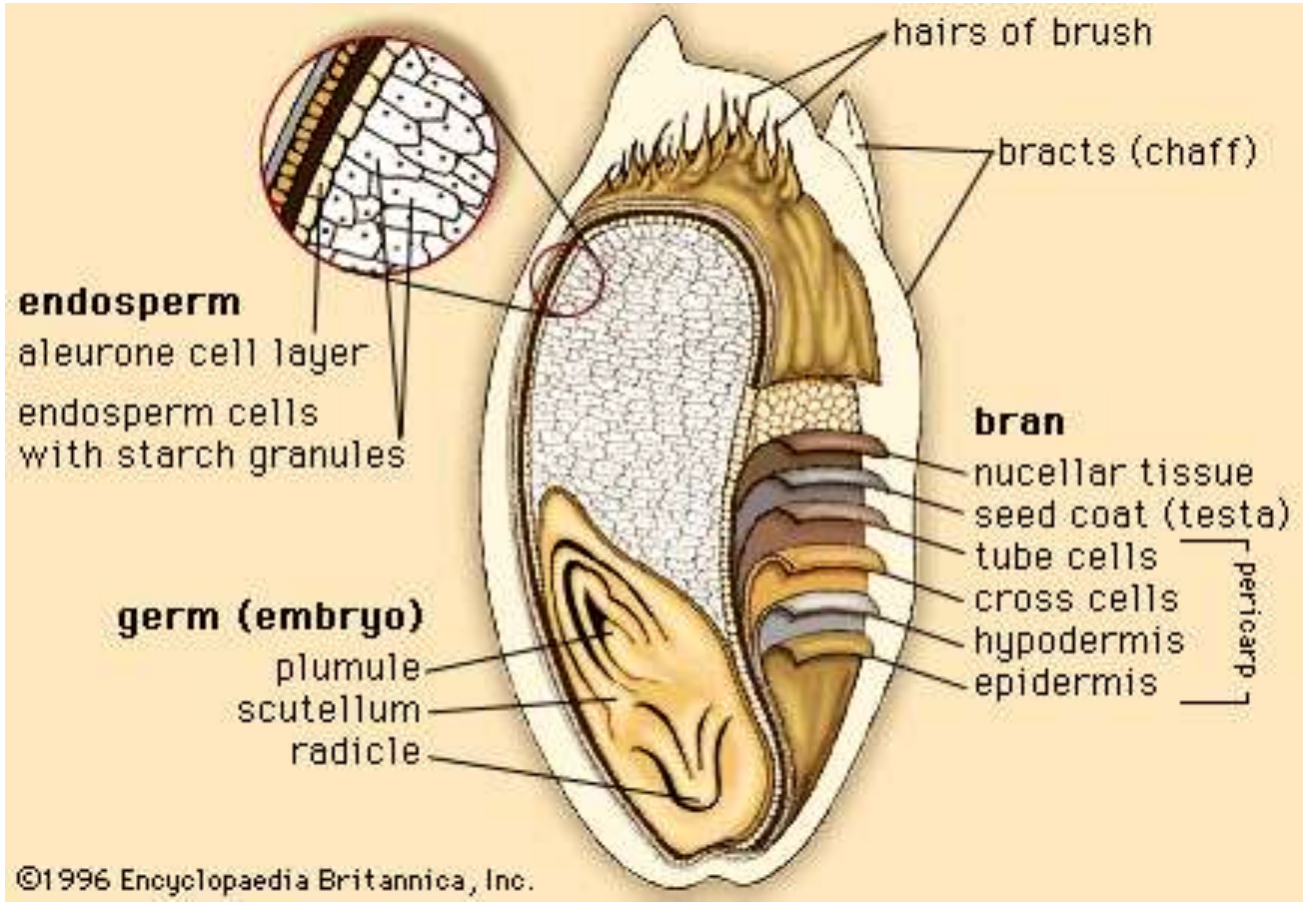


- The main food cereals are wheat, rye, rice, barley, millet and oats.

- Cereals consist of big spikes (a) that contain seeds (c) (*grains or kernels*) strongly bound to their rachis (b)
- The main components of cereals are similar with quantitative variations

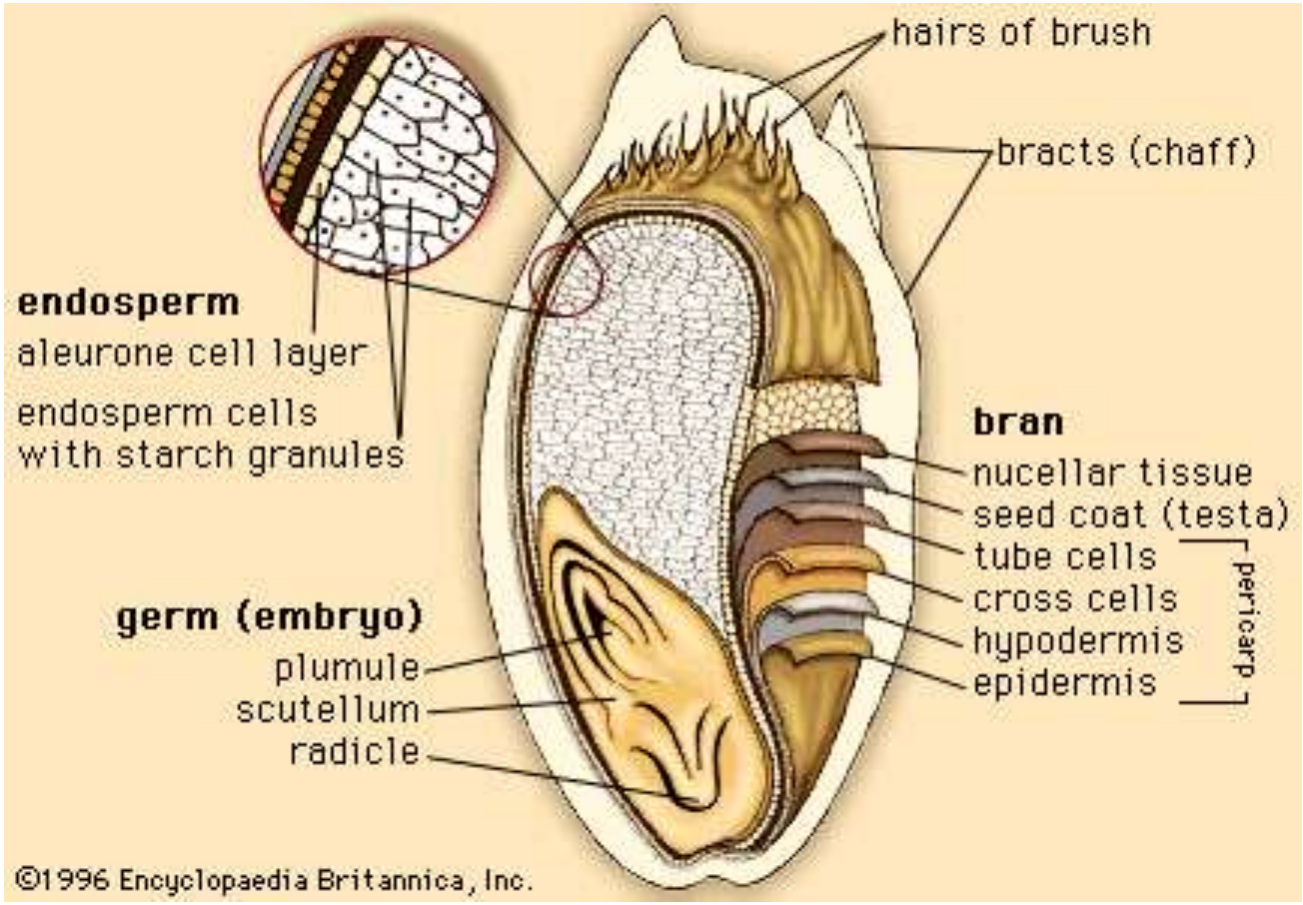


- The carbohydrates mainly contain starch, but there are also non-starchy polysaccharides
- The cells of the endosperm are stacked with starch grains (70-80% of the endosperm is composed of starch)



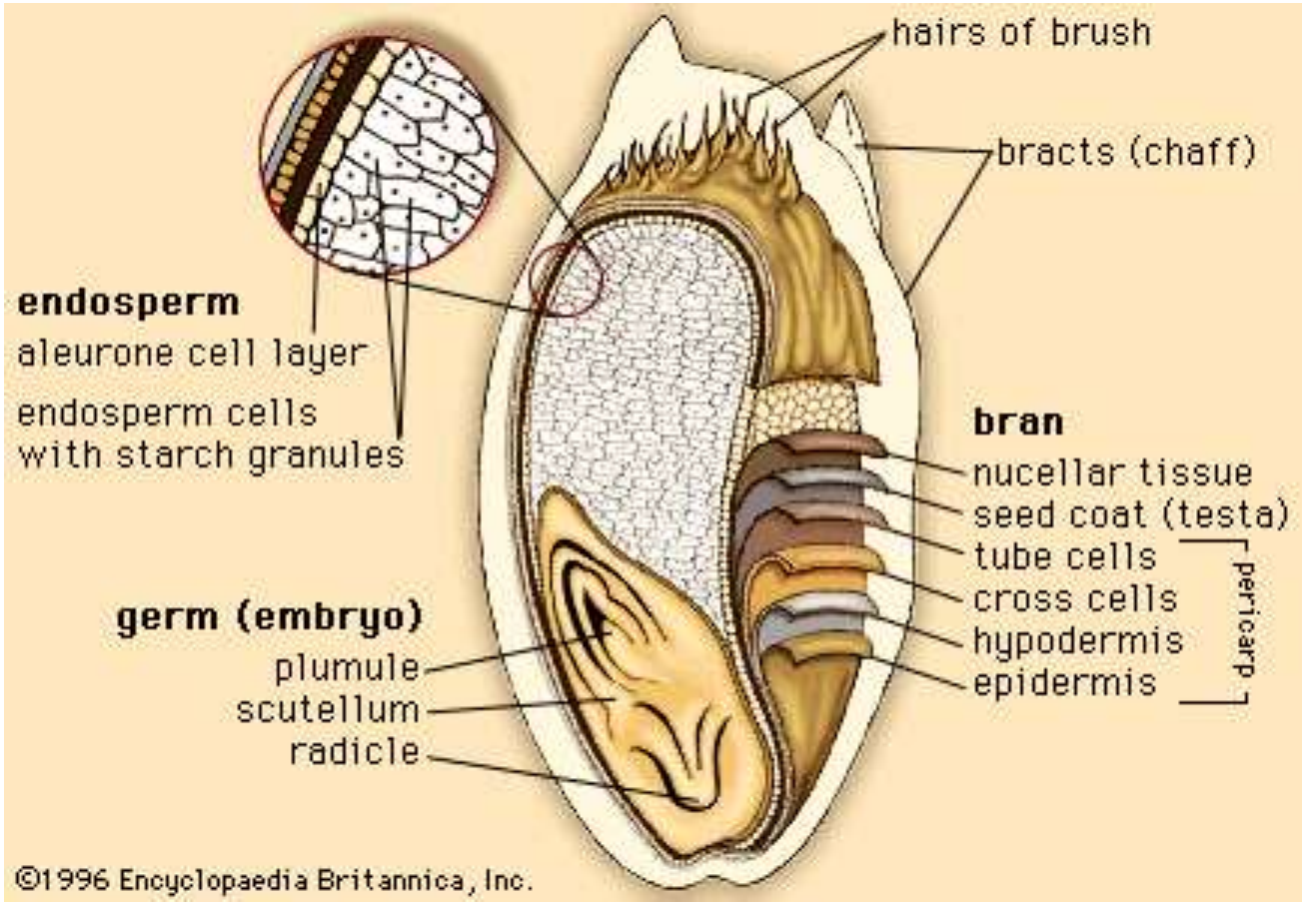
- The endosperm contains a high percentage of proteins, part of which makes up the gluten proteins, which are responsible for the bread making capacity of flour

- Protein and other nutrients (vitamins, trace elements) are reduced from the outside to the inside of the endosperm



- Grinding of cereals and separation of the the germ and the bran leads to significant loss of nutrients

- The role of the individual components of cereals is very important for their functional properties during proccesing for the production of baking products (mainly those from rye and wheat)



Bakery products - objects and fields of research

Bread

RAW MATERIALS

FLOUR
- **STARCH**
  - ✓ **AMYLOLYTIC ENZYMES**
  - ✓ **PROTEINS**
    - ✓ **GLUTEN**

- **RISING**
  - ✓ **YEASTS**
  - ✓ **LACTIC ACID BACTERIA**
    - ✓ **ALCOHOLIC & LACTIC ACID FERMENTATION**

BAKING CAPACITY OF FLOUR

PREPARATION OF BREAD

COMPOSITION OF BREAD

MICROBIAL SPOILAGE OF BREAD

"STALING" OF BREAD

MODERN TRENDS IN BAKING TECHNOLOGY

YEASTS & NEW CULTURES IN BAKING

GENETIC ENGINEERING APPLICATIONS

ENZYMES & OTHER ADDITIVES

NOVEL BAKERY PRODUCTS

Bread - Raw materials

- FLOUR (WHEAT etc.)
- RISING AGENT (YEAST, SOURDOUGH or CHEMICALS)
- WATER
- SUGAR
- FAT
- SALT
- ADDITIVES (PRESERVATIVES, CONDITIONERS, etc.)

FLOUR: the product of the milling of cereal grains, free from germ and husks.
Composition:

- WATER (11-16%)
- STARCH (>50%)
- PROTEINS (25-30%)
- ACIDS
- FAT
- ENZYMES
- VITAMINS (A, E and B1)
- INORGANIC MATERIALS (mainly phosphates)

!

Flour – Bread making capacity

"The properties that flour must have in order to produce good quality bread"

Assessed by:

- Yield in dough & bread
- Taste & aroma
- Product appearance (shape & size of the crumb pores, etc.)

Flour – Bread making capacity

It depends on:

- The content & MW of gluten
- The pH & processing (kneading) temperature
- The presence of oxidants (increase of intermolecular -S-S- bonds in gluten)
- The presence of enzymes (amylolytic & proteolytic)
- The degree of milling of the flour
- The mechanical processing of bread dough

*amylolytic = starch degrading

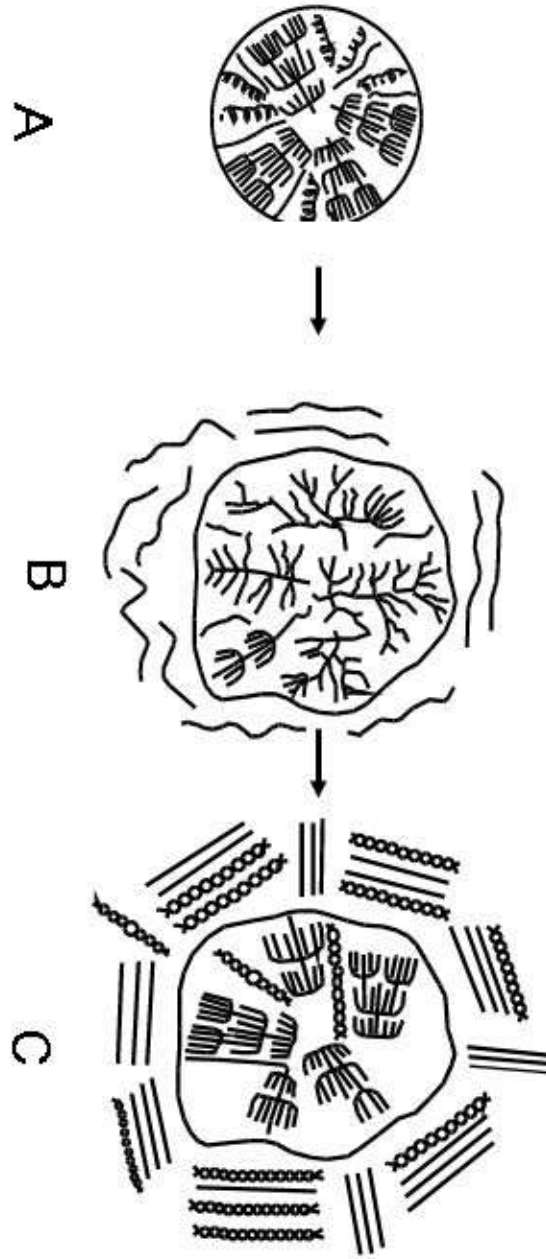
Flour - Starch / functional properties

- The presence of starch hydrolysis enzymes & starch hydrolysis products is of great importance for the production technology and the quality of bread
- During baking:

- ✓ Water migrates from the protein network and is absorbed by the starch granules
- ✓ The starch is gelatinised
- ✓ Sugars are caramellized (interact with amino acids and peptides, producing the characteristic colour, aroma and taste of bread)

Flour - Starch / gelatinization

- The starch granules in the presence of water:



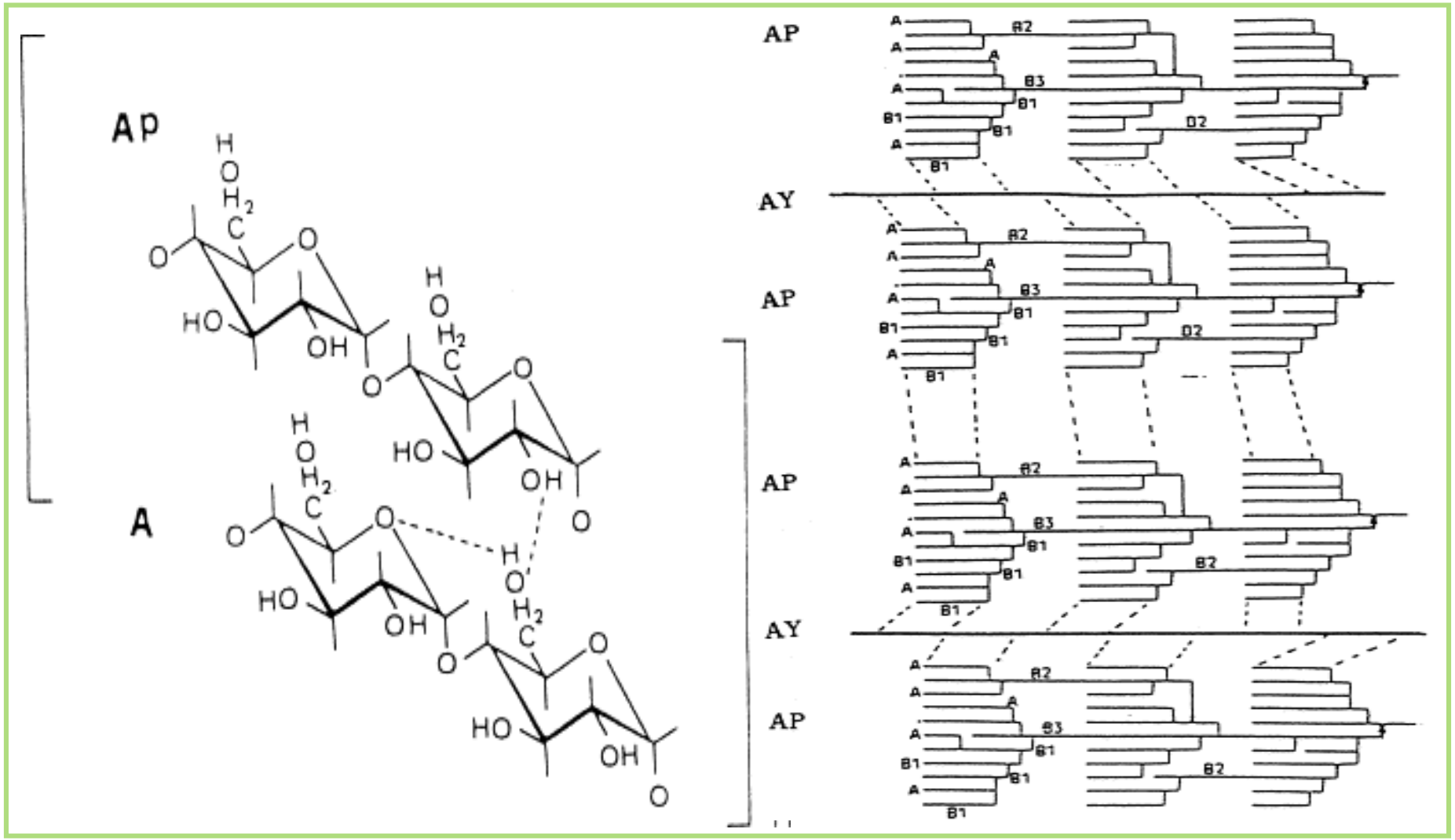
✓ swell but retain their structure

✓ with increasing temperature intermolecular H bonds are formed between the polymers of starch (amylose & amylopectin)

✓ the activity of the water decreases and the viscosity increases

✓ the crystalline structure of starch is completely lost and the starch is "gelatinised"

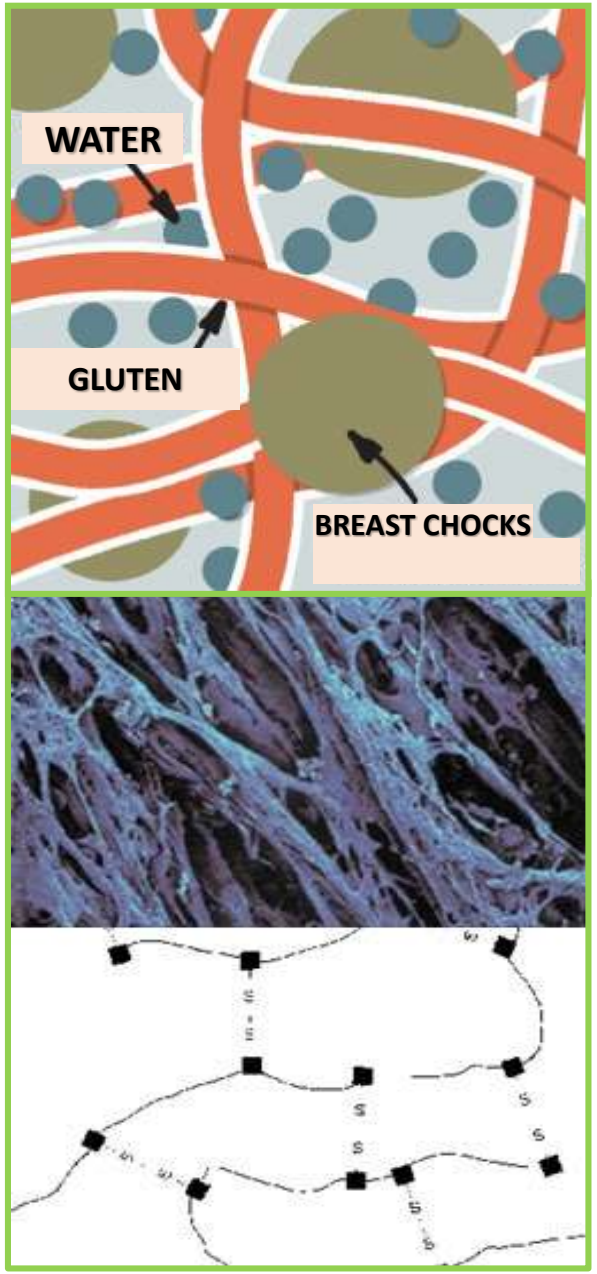
Flour - Starch / gelatinization



Flour - Proteins / Gluten

- By adding water to the flour (wheat) and processing (kneading), a viscoelastic, cohesive mass is obtained: the dough

- If the dough is washed with water to remove starch and other ingredients, gluten remains, which is the elastic mass consisting of the mixture of the wheat proteins that are able to form gluten



Flour - Protein / Gluten

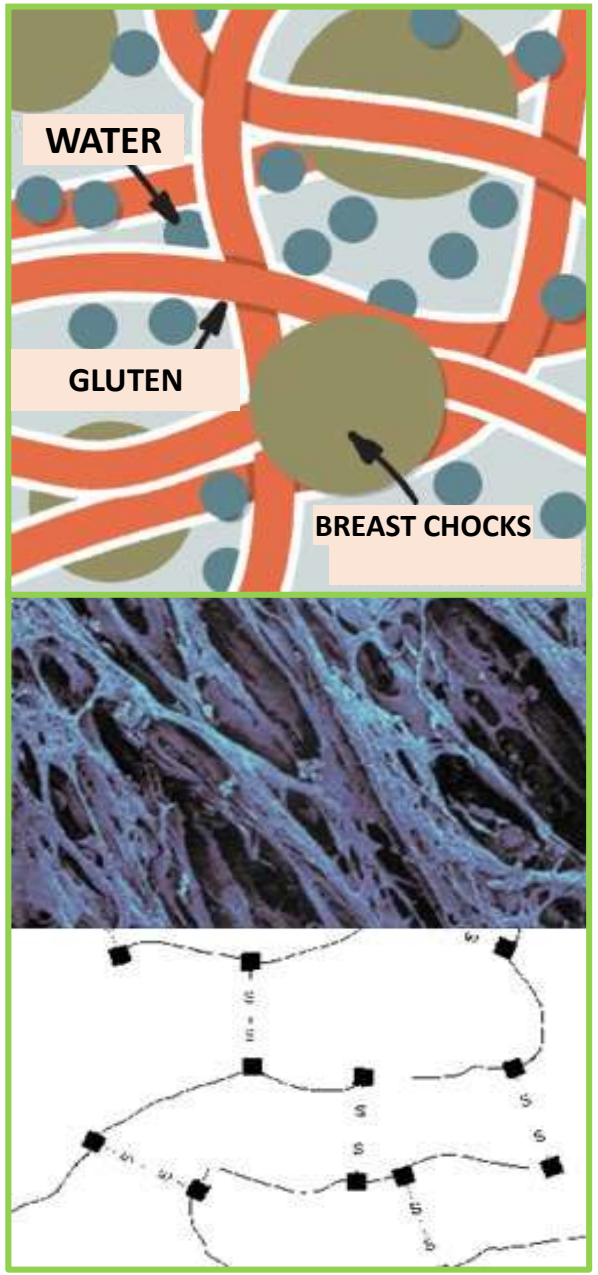
- Gluten contains

✓ 90% protein

✓ 8% lipids (as lipoprotein complexes with various gluten proteins)

✓ 2% carbohydrates (mainly water-soluble pentosans)

✓ enzymes (proteinases & lipoxygenases) are also detected in gluten



Flour - Protein / Gluten

- Gluten is responsible for the "baking capacity" of a flour, which is determined by the viscoelastic properties of the dough, i.e:

✓ Gas retaining capacity & dough expansion (*leavening*)

✓ Consistency & Elasticity (resistance to mechanical mixing & effect on the required energy consumption)

✓ Porosity of the bread crumb

Flour - Protein / Gluten

- Rye and other cereals cannot form gluten

- The baking ability of rye is attributed to the pentosans & proteins that swell after acidification and can retain gases

Rye bread

Flour - Protein / Gluten

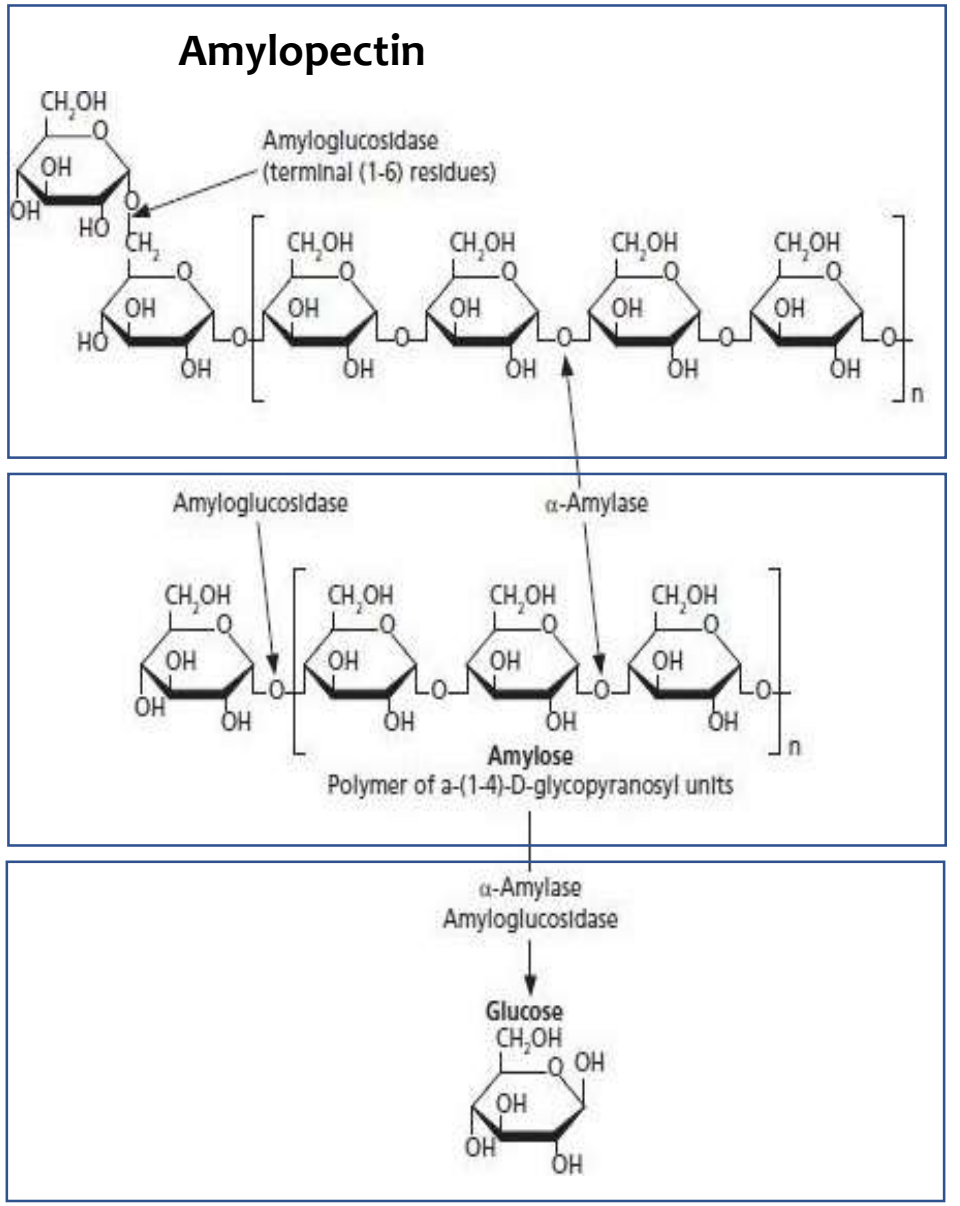
The viscoelastic (rheological) properties, which determine the baking capacity of a flour, depend on:

- **MW of the individual protein fractions of gluten**
- **Number of disulfide (-S-S-) bonds**
- **Number & strength of other weaker bonds (*covalent or non-covalent, van der Waals forces, H-bonds, electrostatic and hydrophobic interactions, etc.*, between protein molecules)**
- **Presence of oxidants (e.g. bromates or natural antioxidants such as Vit. C & E)**
- **Presence of proteolytic enzymes**

Bakery products - objects and fields of research !!!

Flour - Starch enzymes (endogenous)

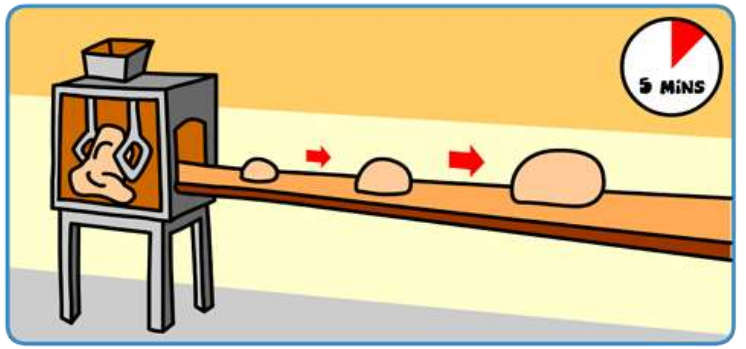
- *alpha-amylase:*
  hydrolyzes random α(1-4) bonds →
  dextrins + sugars
- *beta-amylase:*
  hydrolyzes terminal a(1-4) bonds →
  maltose
- *phosphorylase:*
  hydrolyzes terminal α(1-4) bonds →
  1-phosphate-glucose
- *alpha-glucosidase (glucoamylase):*
  hydrolyzes terminal α(1-4) or α(1-6) →
  glucose

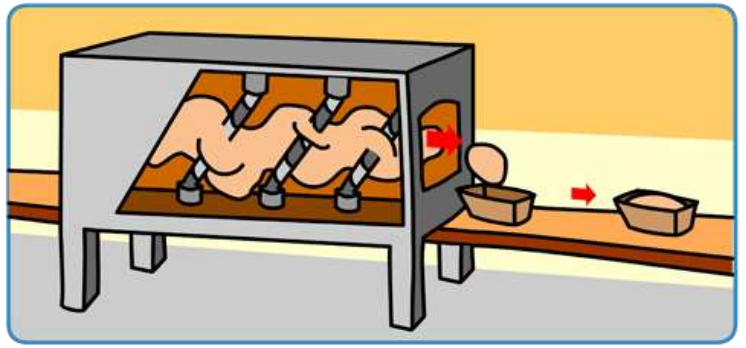


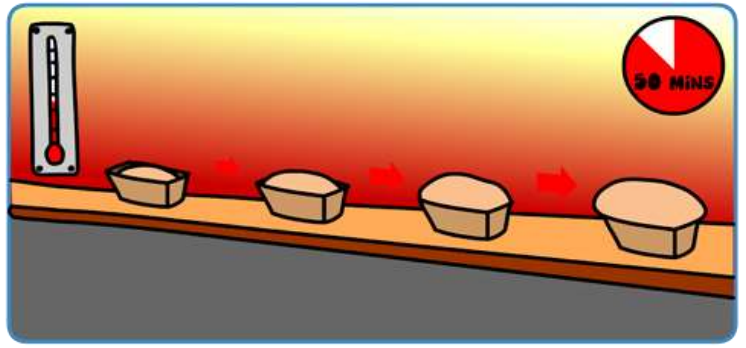
Bread - Stages of production

- **Preparation of bread dough**
  (mixing → starch expansion → gluten development)
- **Dough rising**
  (gas trapping)
  - ✓ Natural or sponaneous: by sourdough
  - ✓ With yeast: in the form of fresh (pressed) or dry (powdered) baker's yeast
  - ✓ Chemical: baking powders:

Potassium hydrogen tartrate + sodium carbonate →
sodium potassium tartrate + ↑ CO_2 + H_2O

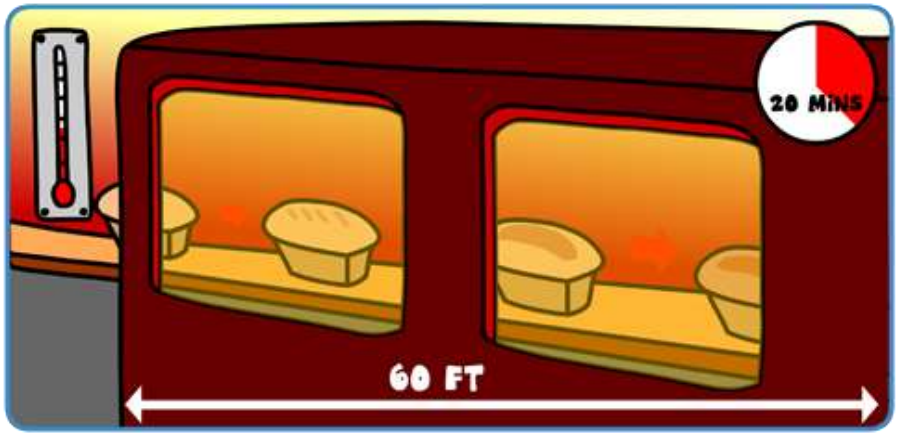


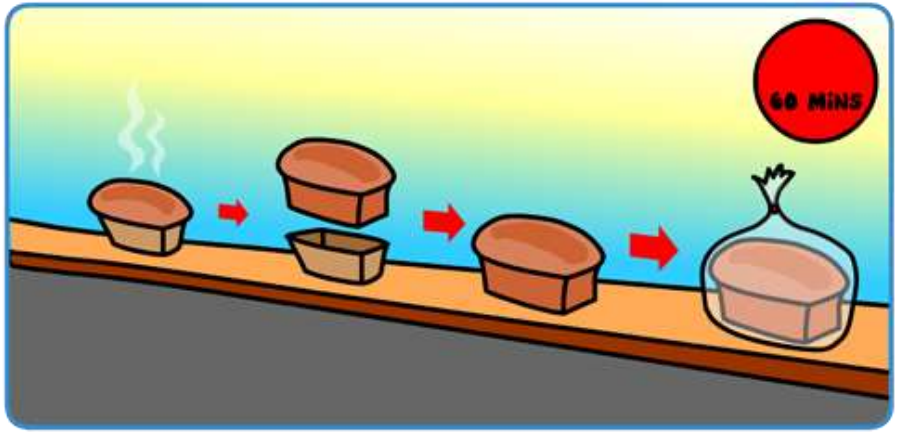




Bread - Stages of production

- **Baking**
  - ✓ inactivation of enzymes & yeast
  - ✓ starch gelatinisation
  - ✓ development of desired aroma & colour by sugar – protein browning reactions reactions
- **Packaging**





Bread – Rising (or leavening)

Baker's yeast:

Saccharomyces cerevisiae

Forms of commercial yeast products:

- **pressed baker's yeast (27-30 % dry ingredients)**
- **dry baker's yeast: freeze-dried, instant (active dry yeast, instant dry yeast), etc.**

Bread – Rising (or leavening)

Sourdough: dough from a previous baking batch containing a rich microflora of yeasts & bacteria):

Lactic acid bacteria:

Lactobacillus **species etc.**

- Used in traditional bread making
- They do not contribute to bread rising but they highly contribute to the development of good aroma and better preservation of bread by producing natural antimicrobial substances (organic acids, bacteriocins, H_2O_2 etc.)

Bread - spoilage due to physicochemical changes (*staling*)

The sum of undesirable changes (physicochemical), other than microbial spoilage, occurring in bread from baking until consumption

The characteristics that describe staling are:

- **Hardening of the crumb (*crumb firming*)**
- **Moisture changes (*evaporation or migration*)**
- ***Crust softening***
- **Loss of aroma & taste**

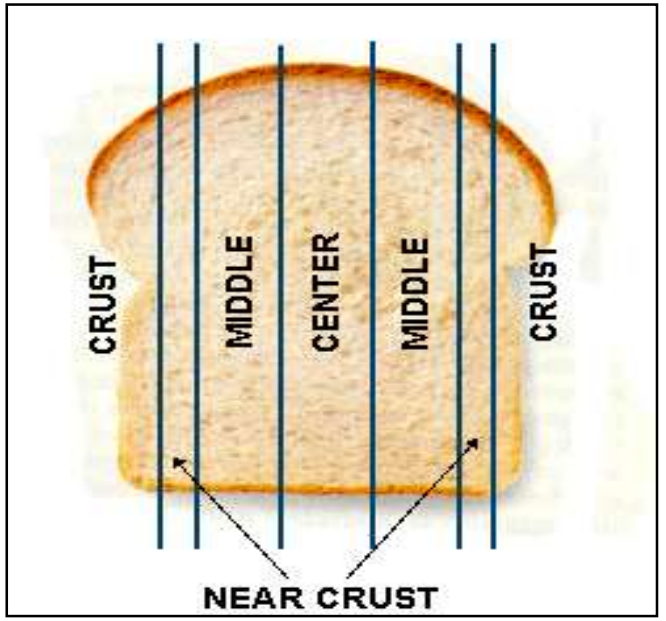
Bakery products - objects and fields of research !!

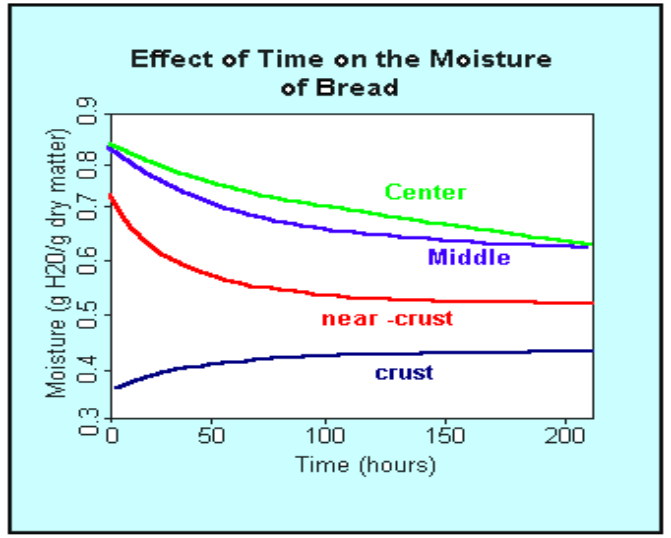
Bread - Physicochemical deterioration (*staling*)

Hardening of the crumb:

due to the following phenomena:

- during baking:
  - ✓ Fast diffusion of amylose to the outside of the starch granules
- with cooling and storage:
  - ✓ rapid *retrogradation* of the amylose chains
  - ✓ slow retrogradation of the amylopectin chains remaining in what is left of the starch granules



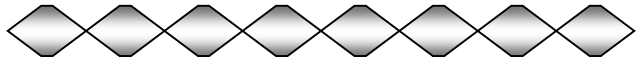


Bakery products - objects and fields of research !!!

Bread - spoilage due to physicochemical causes (*staling*)

Amylose retrogradation

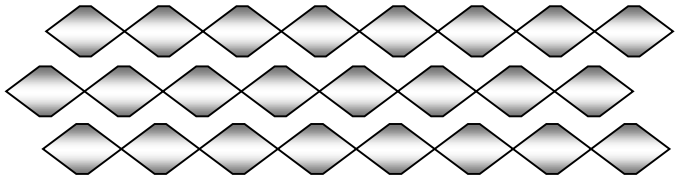
Gelatinised starch (amorphous) →



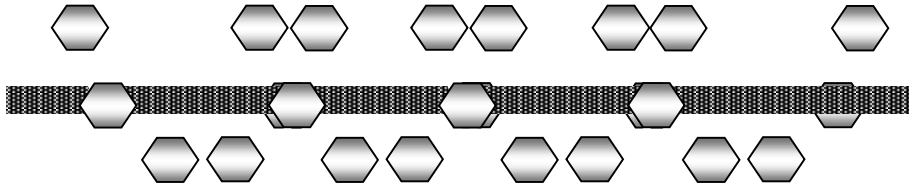
Amylose

Avoidance of retrogradation by addition of emulsifiers in commercial products

After baking and cooling of bread, rapid formation of -H bonds in amylose → increase in crystallinity



Retrograded amylose (hard)



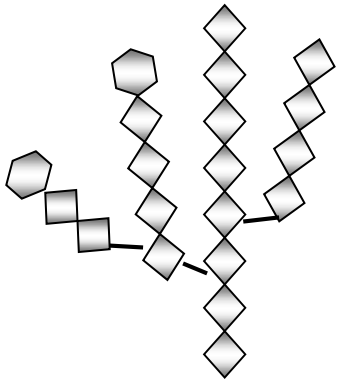
Amylose-emulsifier complex (soft) (does not allow tetrogradation)

Bakery products - objects and fields of research !!!

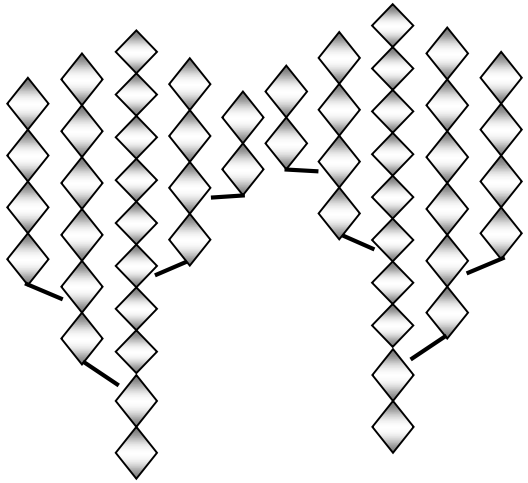
Bread - spoilage due to physicochemical causes (*staling*)

Amylopectin regression

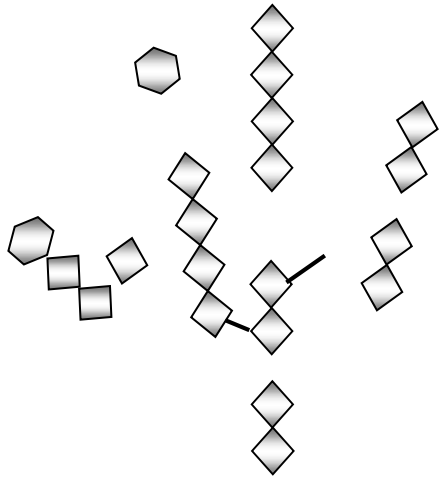
Gelatinised starch (amorphous)



Addition of alpha-amylase



amylopectin



Retrograded amylopectin (hard)

Amylopectin after partial enzymatic hydrolysis by a-amylase does not retrograde (soft)

Bakery products - objects and fields of research !!!

Bread - spoilage due to physicochemical causes (*staling*)

Therefore the factors that affect staling are:

- **Emulsifiers (*surfactants*)**
  - ✓ **bind to amylose by preventing its retrogradation**
  - ✓ **do not affect amylopectin**
  - ✓ **do not prevent the migration of moisture from the crumb to the crust**

- **Enzymes (*amylases*)**
  - ✓ **They hydrolyze amylopectin by preventing its retrogradation**

Bakery products - objects and fields of research !!!

Bread - spoilage due to physicochemical causes (*staling*)

Therefore the factors that affect staling are:

- **Packaging** (*packaging*)
  - ✓ retains the aroma, texture & taste, but makes the crust soft

- **Storage temperature**
  - ✓ At -7°C to 10°C: (*refrigerator*) rapid hardening of the crumb
  - ✓ Above 35°C: the aroma & taste is altered
  - ✓ At 20°C to 35 °C: (*ambient*) optimal
  - ✓ At -30°C to -18° C: (*freezer*) stops retrogradation

Style of exam questions

- Describe the principle of the analytical methods: (a) Detection of oxidants in flour, (b) Determination of gluten, etc.
- What is starch and what is its importance for food technology?
- (a) What is "flour"? (b) What is the "baking capacity" of flour, what does it depend on and what is it assessed by?
- Functional properties of (a) gluten, (b) starch in baking technology.
- Why can (a) enzymes or (b) emulsifiers or (c) oxidants be added to standard bakery products?
- Which amylolytic enzymes are present in cereals and which are their activities?
- What is (a) "gelatinization" and (b) "retrogradation" of starch?

CEREALS & THEIR PRODUCTS

Thank you!