Cooking of food and heat transfer

Why do we cook food?

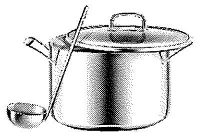
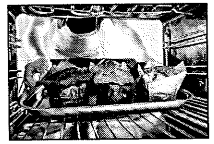
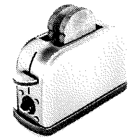
Applying heat to food is advantageous for a number of reasons. It not only makes the food safe to eat, but also gives it the desired palatability and organoleptic qualities.

	Explanation	Example
To make it safe to eat	Heat kills bacteria and parasites, inactivates harmful enzymes and toxins	Salmonella in chicken, listeria in milk, solanine in potatoes and green tomatoes
To develop flavours	Water evaporation makes flavours more pronounced, sugar caramelisation and other reactions change the initial flavour of the food	Stew, goulash, sauces, crème brûlée
To improve texture	Cooking alters the texture of food products, making them easier to chew and more pleasurable to eat	Roast meat becomes softer and easier to chew; chips become crunchy
To improve shelf life	Cooking kills microorganisms which could spoil the food, so it can be stored for longer	Clostridium botulinum in meat preserves, mould in jam
To increase variety	One product may be cooked in many different ways	Potatoes can be served boiled, mashed, as chips, in a salad, roasted, dauphinoise, etc.

Heat transfer

Various methods of heat transfer are often combined to obtain the desired meal.

	Conduction	Convection	Radiation
How does it work?	Direct transfer of heat from the saucepan to the food inside → Heat makes metal particles vibrate → Vibrations of the metal are transferred to the particles of food → Food particles vibrate and the meal heats up	Indirect transfer of the heat through water or air Convection current makes the hot air / steam go up while the colder air falls	Indirect transfer of heat through heat waves → Microwaves send electromagnetic waves, which heat up water particles in the food → Water particles begin to vibrate and, therefore, heat up the whole meal Infrared radiation is used in grills and barbecues
Pattern	**Hob → pan → food**	**Oven → Air → Food**	**Heat → waves → food**
Example	• Melting butter in a pan • Boiling water • Roasting meat	• Steaming vegetables • Boiling eggs • Baking muffins	• Grilling meat • Toasting bread • Microwaving soup

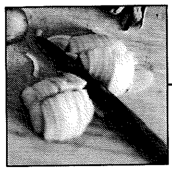
Methods of cooking

Various methods of cooking have different effects on the nutritional value and palatability of food. Choosing the right method helps to obtain a desired meal without decreasing the amount of vitamins and minerals in it.

How does cooking affect food?

Appearance	Meats shrink, cakes rise, eggs become solid, sauces thicken, rice and pasta increase in size.
Colour	Foods become golden or brown. Red and green vegetables may lose colour.
Flavour	May become sweeter, more pronounced, rich.
Texture	Eggs set, vegetables and meats soften, chips become crunchy, bread becomes crispy, custard becomes creamy, sauces thicken.
Smell	Is more pronounced because essential oils fill the air and are more easily detected by the olfactory system.

At high temperatures, sugar and protein react with each other, producing brown compounds which affect the colour, taste and smell of foods such as cocoa or coffee. This is called the **Maillard reaction**.



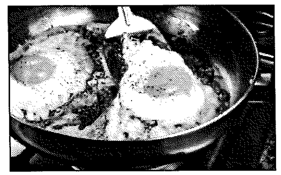

During cooking, onion becomes brown, soft and sweet.

Cooking methods...

Cooking improves the shelf life of food. Cooked food can be safely stored and eaten for longer than raw food.

Water-based methods	
Steaming	Helps preserve nutritional value of food. Low in fat.
Boiling	May cause vitamin loss. Low in fat.
Simmering	Long time required. Causes vitamin loss.
Blanching	Prevents enzymic browning and oxidation, preserves nutritional value.
Poaching	Ideal for preparing delicate ingredients.
Braising	Long time required. Causes vitamin loss

Dry methods	
Baking	Long time required. Causes vitamin loss. Palatability is improved (cakes and other baked goods become sponge-like and often have crispy top).
Roasting	Helps to reduce amount of fat in food. Long time required. Decreases vitamin content. Helps to obtain a crispy skin or surface.
Grilling	May create harmful substances. Usually low in fat.
Dry-frying	Reduces amount of fat in food. Nutritional value is preserved.



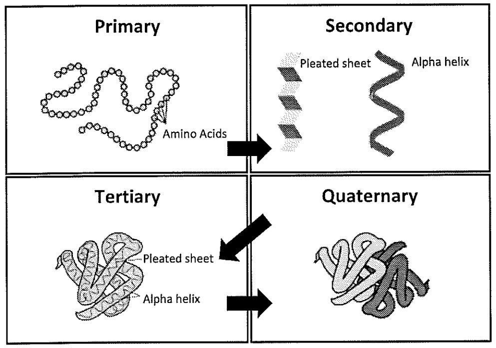
Oil-based methods	
Deep-frying	Foods become golden and crunchy, but their nutritional value is poor (loss of vitamins, and high fat content).
Shallow-frying	Seals the surface of food and helps to obtain crunchy top and juicy interior.
Stir-frying	Low-fat. Helps to preserve nutritional value of food.

Functional and chemical properties of food 1

Proteins

Macromolecules built of thousands of amino acids bonded together into long chains
Amino acids → peptides → polypeptides (proteins)

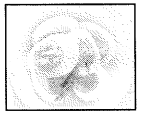
The structure of proteins:



Functional and chemical properties:

1. **Denaturation** – damage of the protein's structure caused by:
   a. **Heat** – during cooking, proteins vibrate quickly and, as a result, hydrogen bonds in them rupture.
   b. **Acid** – hydrogen atoms from the acid bind with nitrogen from the protein, preventing it from forming hydrogen bonds within protein molecule, and so it cannot form a 3D structure.
   c. **Mechanical action** – during whisking, protein uncoils and exposes hydrophobic areas, which stick together and form a foam.

2. **Coagulation** – aggregation of protein particles into larger lumps, causing it to set. Examples of protein coagulation include cheese becoming rubbery when overheated and egg whites becoming solid when cooked.



During cooking, the protein in eggs coagulates and denatures, and causes the eggs to set.

3. **Syneresis** – leakage of water from overcooked (and over-coagulated) proteins. Usually associated with eggs.

4. **Gluten formation** – complex, net-like protein built of glutenin and gliadin, simple proteins present in wheat, rye, barley and oats; the two proteins cross-link with each other, creating a net (as in a sweater) which can hold air bubbles during proving and baking of bread and bakery products.

   glutenin + gliadin + water → gluten net → soft, springy texture

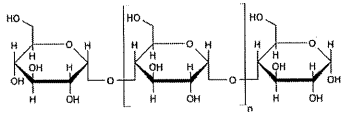
5. **Foam formation** – air bubbles trapped in a liquid (e.g. egg white). Whisking makes proteins unravel and denature.

The chemical structure of food ingredients plays a vital role in how they can be used in cooking. Applying heat to proteins, carbohydrates and fats usually damages their structure, which helps to obtain the desired effect.

Carbohydrates

Macromolecules which include mono-, di- and polysaccharides (built of thousands of monosaccharides bonded together)

Carbohydrate
- Sugars
  - Monosaccharide
  - Disaccharide
- Polysaccharide
  - Starch
    - Branched
    - Unbranched
  - Fibre
    - Soluble
    - Insoluble

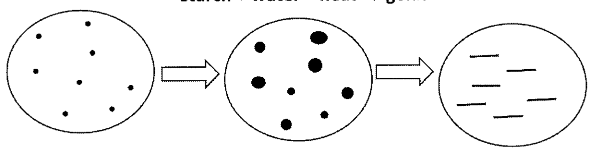


Amylose is an example of a polysaccharide built of thousands of glucose molecules

Functional and chemical properties:

1. **Gelatinisation** – happens when starch granules absorb water, swell and break during heating, causing mixture to thicken and form a gel when cooled; used to prepare sauces and puddings.

   starch + water + heat → gelatinisation



Starch granules in cold water. Starch granules absorb water when heated. Starch granules burst and break and turn the liquid into gel.

2. **Dextrinisation** – happens when starch chains break down into shorter chains of dextrins; during the process, molecules of water evaporate and carbon is left to give brown colour; occurs during baking and toasting bread and other baked goods.

   starch + heat → dextrinisation

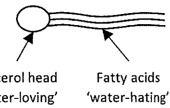
3. **Caramelisation** – happens when sugar is heated to a very high temperature, causing it to liquidise and form a thick, brown syrup; during the process, water evaporates and carbon is left to create a brown or black colour; occurs during roasting of vegetables, making caramel and fudge, etc.

   sugar + heat → caramelisation

Fats and oils

Macromolecules built of a glycerol head and fatty acid tail

Fat particles are **immiscible** – they are repelled by water molecules and separate from it, forming little droplets of oil in the mixture, and eventually creating a coat on top of it.



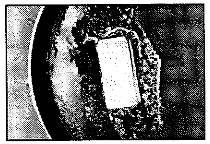
Fats
- Saturated
  - Solid (fats)
- Unsaturated
  - Mono
  - Poly
  - Liquid (oils)

Functional and chemical properties:

1. **Shortening** – when fat particles surround starch so that it cannot access water and, therefore, prevent gluten formation; technique used to obtain crunchy, crumbly pastry such as biscuits.

2. **Aeration** – trapping air bubbles in a fat mixture, e.g. cream or butter, to improve its texture.

3. **Plasticity** – ability of fat to be easily spreadable and melt at various temperatures, depending on the length of the fatty acid chains in the fat particle.



Plasticity is increased when butter melts.

4. **Melting point** – temperature at which fat turns into oil.

5. **Emulsion** – stable mixture of oil and water

   Water-in-oil emulsion → butter
   Oil-in-water emulsion → milk

   To create a stable emulsion, **emulsifiers** need to be used, e.g. lecithin from egg yolk is used to make mayonnaise. Emulsifiers bind together molecules which normally wouldn't bind and prevent them from separating.

Functional and chemical properties of food 2

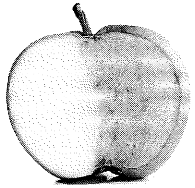
Fruit and Vegetables

Food preparation and cooking may have a large impact on the nutritional value, appearance, flavour and smell of food products.

Foods such as bananas, apples and tomatoes need time to ripen. This ripening process is caused by enzymes.

Enzymic browning

Involves the discoloration of fruits and vegetables as a result of oxygen reacting with enzymes and plant cells substances.



Cutting, shredding, grating, biting, peeling, etc. → Leads to damage of cell vacuoles (spaces) and cytoplasm (outside of vacuole) → Enzymes from the cytoplasm are activated by oxygen from air and mix with the substances from the vacuole → Leading to a corrosive effect (brown colour and vitamin loss)

This process can be slowed down or accelerated...

Slowed down by:
- ↓ lowering temperature
- ↓ inactivating enzymes with the use of heat (blanching) or acid (vinegar / lemon juice)
- ↓ removing oxygen / protecting from air

Accelerated by:
- ↑ iron and copper
- ↑ diminution
- ↑ oxygen exposure

Foods most prone to enzymic browning:
- **Fruit**: avocados, bananas, peaches, pears, apples, mangoes, apricots, plums, grapes
- **Vegetables**: aubergines, mushrooms, potatoes, lettuce

Oxidation

- The process when substances combine with oxygen
- Destruction of chemicals in food due to oxygen exposure
- Causes changes in the appearance, smell and nutritional value of food

Slowed down by:
- ↓ covering food
- ↓ packing food in oxygen-free conditions
- ↓ covering food with sauces and dressings

Accelerated by:
- ↑ diminution
- ↑ oxygen exposure

Raising Agents

Some ingredients and processes are used in cooking to allow gases into a mixture causing it to rise in order to create a desired texture.

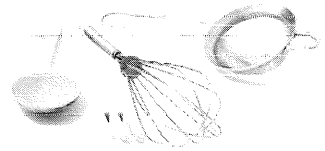
Three gases are used for leavening:
- **air** – introduced by mechanical processes
- **carbon dioxide** – introduced by biological and chemical processes, such as yeast in bread or using bicarbonate of soda
- **water vapour (steam)**

Raising agents are used to:
- lighten the texture of the food
- enable raising during cooking
- make food more appetising

Mechanical raising agents

Mechanical methods trap **air bubbles** in the mixture or between layers. During cooking the air expands, causing the mixture to rise.

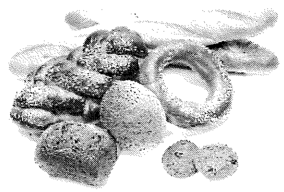
Method	Examples
Whisking	meringue, whisked sponge, cloud eggs
Beating	batter, rich sponge
Folding	flaky pastry, filo pastry
Rubbing in	pastry, scones, crumble
Sieving	sponge, pastry, scones
Creaming	rich sponge, cakes, buttercreams



Methods can also be combined to obtain the desired effect.

Steam or water vapour is the gaseous form of water. It is produced each time a wet food is heated up. As the hot steam rises and expands, it causes a pastry or dough to rise with it.

Biological raising agents



Yeast is a single-celled fungus used in the production of baked goods, cheese, wine and beer.

Yeast + sugar + warmth + liquid → carbon dioxide + alcohol/acid

During fermentation, yeast transforms sugar into carbon dioxide and alcohol or acid. The carbon cioxide causes small bubbles to form, raising the dough.

Chemical raising agents

Bicarbonate of soda + acid + water + heat → carbon dioxide + water

Baking powder = bicarbonate of soda + calcium phosphate

- Baking powder doesn't need the addition of acid because it already contains an acidic ingredient.
- Self-raising flour contains baking powder or other leavening agents.
- During baking, CO_2 bubbles form and cause the batter to rise, while proteins set and, therefore, a cake obtains a stable structure.