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.

Food spoilage and contamination

Food spoilage may be caused by many various microorganisms – bacteria, yeast and moulds – as well as by enzymes naturally present in the food products. It is important to correctly store food and apply food safety principles to avoid spoilage and contamination of other products.

Microorganisms

Tiny organisms visible only under a microscope, e.g. bacteria, yeast and mould

Growth conditions

Warmth – ideally a temperature between 5 °C and 63 °C
Water – microorganisms grow better in moist conditions
Food – ideally protein, but sometimes also sugar
Time – the longer the time, the more time microorganisms have to multiply

Most microorganisms will grow rapidly in **danger zone temperatures** (5 °C to 63 °C) but will not grow below or above this limit. This is because enzymes necessary for replicating the cell become inactive at temperatures below 5 °C and over 63 °C.

Microorganisms' growth can be controlled by:
- ✓ Storing food in proper conditions
- ✓ Freezing or refrigerating fresh food
- ✓ Cooking food thoroughly before eating
- ✓ Not refreezing food once it has been defrosted

High-risk foods

Foods which have **optimal** conditions for microorganisms' growth

Protein-rich, moist and usually raw
Include meat and poultry, fish and seafood, eggs and milk

Enzymes

Biologically active protein-based molecules.
They are **catalysts**, which means that they can speed up the rate of chemical reactions.
Enzymes are necessary for fruit to ripen.

Darkening of fruit and vegetables caused by enzymes is called **enzymic browning** and should be avoided to preserve nutritional value of food.

Enzymic action can be stopped by:
- ➢ **Blanching** vegetables before freezing
  Blanching means that food is put into boiling water then immediately plunged into cold water or ice.
- ➢ **Use of acids** (lemon juice or vinegar)
  Acid denatures and deactivates enzymes, because they are built of protein.

Enzymes are also used in food production.

Cross-contamination

- ◎ **Cross-contamination** is when bacteria, toxins or food particles are transferred to a food product.
- ◎ Cross-contamination can cause **food poisoning** and allergic reactions.
- ◎ **Anaphylactic shock** is a life-threatening reaction of the immune system to an allergen, e.g. food

Food can become contaminated by:
- × waste food and rubbish
- × pests and rodents
- × the cook's hands
- × work surfaces and equipment
- × other contaminated foods, including high-risk foods

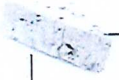
Most common allergens:
Nuts
Fish and seafood
Milk
Eggs

More on p. 14

Use in food production and signs of food spoilage

Many species of microorganism and some enzymes can cause food spoilage or diseases.
Others are used in manufacturing of various food products.

	Food spoilage	Use in food manufacturing	Why does this work?
Bacteria	*Clostridium botulinum* produces a toxin which causes meat preserves to bulge. Most bacteria do not cause visible signs of spoilage, so poisoning is possible even if the food looks and smells normal.	Cheese uses a starter culture called *Lactobacillus* bacteria to give it a balanced aroma taste and texture. Yoghurt also uses the same starter culture to help milk clot. Probiotics are also used to help benefit health.	Bacteria ferment lactose from milk and turn it into lactic acid, which gives the food a sour taste and coagulates protein in milk, which, for example, causes yoghurt to become thicker.
Yeast	Ferments sugar in juices and beverages, making them sour, fizzy and foamy.	Bread, doughnuts and other baked goods use yeast to help them rise.	Yeast ferments sugar in foods and produces carbon dioxide to help it rise. It also creates fizz in some alcoholic drinks.
Mould	Creates a green, white or black coating on food products such as bread, grapes, tomatoes and jams.	Blue cheeses, such as Stilton, have a mould called *Penicillium* added to give them a distinctive texture, taste and aroma.	Mould breaks down polysaccharides into shorter chains, which changes the taste of the food.
Enzymes	Turn bananas, apples, potatoes and other foods brown.	Rennet is an enzyme used in cheese production to coagulate milk.	Enzymes react with oxygen and turn yellow pigments in food into brown melanin.



Faecal contamination with *E. coli* may take place when people don't wash their hands after using the toilet or when human and animal body waste is used to fertilise crops.

Food poisoning

- ◎ Food poisoning is a disease caused by eating spoiled or contaminated food. Such food may contain certain microorganisms, toxins or enzymes.
- ◎ Microorganisms which cause diseases are called **pathogenic**.
- ◎ A person who carries a pathogen but shows no symptoms of a disease is called a **carrier**.

Food poisoning bacteria and where to find them:
- × ***Campylobacter*** → raw poultry and unpasteurised milk
- × ***E. coli*** → undercooked beef, unwashed vegetables, dirty hands
- × ***Salmonella*** → raw eggs, meat and poultry, unpasteurised milk
- × ***Listeria*** → ready-to-eat foods, unpasteurised milk, dirty hands
- × ***Staphylococcus aureus*** → salads, ham, eggs, tuna, poultry, cream, hands of an infected person

Cross-contamination and food poisoning may be avoided by:
- ✓ washing hands after dealing with high-risk foods, rubbish or using a toilet
- ✓ properly cleaning work surfaces and utensils
- ✓ using dedicated, colour-coded utensils only
- ✓ storing food in proper conditions
- ✓ storing raw and cooked foods separately
- ✓ cooking food thoroughly before eating
- ✓ applying food safety standards and schemes, such as the British Lion Scheme

Symptoms of food poisoning:
- ☹ Stomach pains and cramps
- ☹ Nausea and vomiting
- ☹ Diarrhoea
- ☹ Fever
- ☹ Shivering

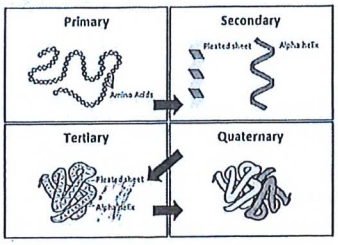
British Lion Scheme
Food safety mark which guarantees that eggs are produced in the UK and that all the hens have been vaccinated against salmonella.

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.

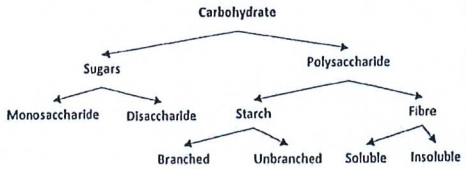
3. Syneresis – leakage of water from overcooked (and over-coagulated) proteins. Usually associated with eggs.
4. Gluten formation – complex, net-like protein built of glutenin and gliadin, simple proteins present in wheat, rye, barley and oats; the two proteins cross-link with each other, creating a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

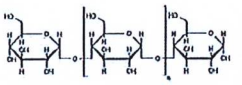
   glutenin + gliadin + water → gluten net → soft, springy texture
5. Foam formation – air bubbles trapped in a liquid (e.g. egg white). Whisking makes proteins unravel and denature.

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)



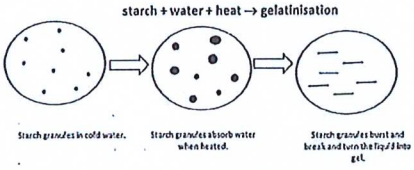


Amylose is an example of a polysaccharide built of thousands of glucose molecules

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



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.

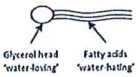
   starch + heat → dextrinisation
3. Caramelisation – happens when sugar is heated to a very high temperature, causing it to liquidise and form a thick, brown syrup; during the process, water evaporates and carbon is left to create a brown or black colour; occurs during roasting of vegetables, making caramel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

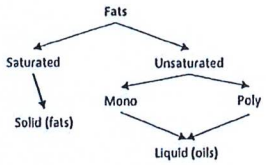
   sugar + heat → caramelisation

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.





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

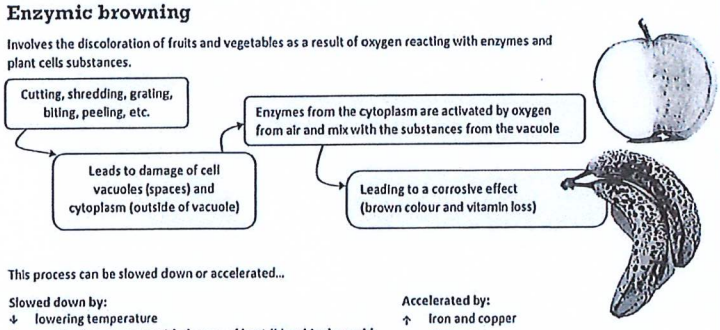
Fruit and Vegetables

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.



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 dioxide 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.

Principles of food safety

Applying certain hygiene rules and properly storing food products helps to prevent food spoilage and contamination, and lowers the risk of food poisoning or allergic reaction.

Temperature control

is important for preventing food spoilage and bacterial growth.

The following temperature guidelines are set out for storing and cooking foods.

Freezing	-18 °C
Chilling	0 °C to 5 °C
Cooking	75 °C
Reheating	75 °C

5 to 63 °C

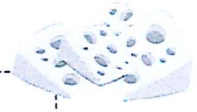
Temperature Danger Zone

Range of temperatures at which microorganisms grow the fastest, posing a risk of food spoilage and food poisoning

Key Terms

Shelf life: Period of time during which food can be safely stored and eaten
Food poisoning: Illness caused by eating contaminated food or drinking contaminated water
First in, first out: Rule which says that the oldest foods should be eaten first
Vacuum packing: Packing food in airtight foil bags to remove oxygen and prevent spoilage

PERISHABLE FOODS



Foods which have a fairly short shelf life and need to be stored in the fridge

- Raw and cooked meat, especially minced
- Raw and cooked poultry
- Raw and cooked fish and shellfish
- Milk and dairy
- Eggs
- Vegetables and fruit

An **insulated cold bag** can be used to transport high-risk foods and maintain their low temperature.

Correct use of a domestic fridge and freezer

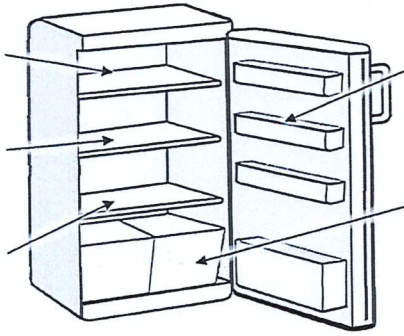
will ensure freshness and safety of food

Fridge temperature: 0 to 5°C

Top shelf
Ready-to-eat foods, dairy, yogurt, cream

Middle shelf
Butter, covered cooked meats, packaged foods

Bottom shelf
Raw meat, poultry and fish in sealed boxes



Door
Eggs, condiments, sauces

Drawers
Fresh vegetables and salads

Important storage points

Tainting means that the smell of one food contaminates another food	Always keep food covered or sealed to avoid tainting!

Freezer temperature: -18 °C

Fast-freeze button: -25 °C

Freezer burn involves the dehydration and oxidation of food caused by improper freezing (e.g. inadequate packaging)	Use special freezer bags to avoid freezer burn Do not overload to enable air circulation

STOP

Defrosting = thawing

Defrost foods in a box or on a tray to catch any leaking liquids.

Never refreeze defrosted food!
The bacteria in food begin to multiply in defrosted food so it's best to use it straightaway to avoid the risk of food poisoning.

Food covering

- ✓ Protects from light
- ✓ Protects from air, oxygen and dust
- ✓ Protects from pests and rodents
- ✓ Prevents tainting

Date marks

Best before – applies to food quality (look, flavour and colour) and it's relatively safe to eat the food after that date; it is used on dry, frozen or tinned foods and eggs

Use by – applies to food safety so it might be harmful to eat a food after that date; used on fresh foods such as milk and dairy

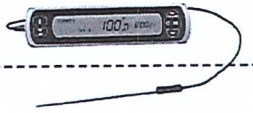
Ambient Storage

Storing food at room temperature (usually around 20 °C)

Food temperature probe

Helps measure the temperature in the food core and ensures that it is properly cooked

1. Clean and disinfect the probe before using
2. Insert into the thickest part of the food, making sure not to touch the tin or bone with the tip of the probe
3. Wait a couple of minutes for the temperature to stabilise
4. Read the temperature
5. Remove the probe
6. Clean and disinfect after use



Food safety principles when cooking and preparing food

Applying these rules will help to keep the food safe for consumption and prevent spoilage

Personal hygiene

- ✓ Always wash hands before and after cooking and dry with disposable paper towels
- ✓ Avoid touching your face or hair
- ✓ Tie your hair back and cover with a hairnet
- ✓ Avoid cooking when you're ill
- ✓ Change clothes and use an apron
- ✓ Cover any wounds with a waterproof plaster
- ✓ Do not wear rings or other jewellery when cooking

Work surfaces

- ✓ Clean thoroughly after dealing with high-risk foods
- ✓ Use soapy hot water or antibacterial spray to clean any spills
- ✓ Use a clean kitchen towel or disposable paper towels

Separate foods

- ✓ Separate raw and cooked foods, both when preparing and storing food
- ✓ Cover prepared food and store in closed containers
- ✓ Use dedicated, colour-coded utensils
- ✓ Wash dishes straightaway in hot water to avoid pests and cross-contamination

Temperature control

- ✓ Make sure the temperature inside food reaches 75 °C both when cooking and reheating
- ✓ Make sure the temperature of served food is above 63 °C
- ✓ Do not put hot food straight into the fridge – let it cool for 90 minutes
- ✓ Ensure correct cooking time to avoid cold spots
- ✓ Defrost thoroughly to avoid cold spots