Heat treatment of meat products serves two main purposes:

- **Enhancement of desirable texture, flavour and colour**, in order to make meat products more palatable and appetizing for consumption.
- **Reduction of microbial content** thus achieving the necessary preservation effects for an extended shelf life (storability) of the products and food safety effects by eliminating potential food poisoning agents.

The heating parameters to be applied in meat processing can vary considerably in temperature and time depending on the type of product. Heat treatment methods cause various physical-chemical alterations in meat, which result in the beneficial sensory and hygienic effects on the processed products.

When mankind learned to use fire for food preparation, the aspects of palatability were clearly important. Heat treatment became the common way of making meat palatable for consumption. The impact of high temperatures induces coagulation and denaturation of meat proteins and structural and chemical changes of fats and carbohydrates, which make meat tastier and also more tender. In addition, the absorption of nutrients from heat treated meats in the digestive tract of humans is improved.

In modern times, with longer distribution channels for meat and the popularity and steadily growing quantities of processed meat products on the markets, the hygienic aspects of heat treatment of such processed meats, which result in germ reduction, became increasingly important.
Heat treatment for microbial control

Contrary to meat dishes (see box page 90), which are usually consumed hot immediately after preparation, most processed meat products are heat treated during manufacture and cooled down in a next step, as they undergo shorter or longer cold storage periods for distribution and sales. Hence, processed products must have an adequate shelf life, which can only be achieved if their microorganism content is low or practically zero. During slaughtering, subsequent meat cutting and initial processing steps, the numbers of microorganisms in meat are steadily increasing. The thermal treatment at the end of the processing stage is therefore important for microbial control. It is the effective tool to reduce or eliminate the contaminating microflora (see Fig. 452).

Enhancement of texture, flavour and colour through heat treatment

Firstly one should distinguish between heat treatment as part of the processing (here called “treatment A”) and heat treatment immediately before consumption (here called “treatment B”). For some processed meat products only (A) is required and such products are consumed cold. Other products, which were submitted to (A) during manufacture, are warmed-up again before consumption (B) and eaten hot.

For products of the cured-cooked type (e.g. cooked ham, Fig. 116) (see page 171, 177) or of the raw-cooked sausage type (e.g. frankfurter or bologna type sausage, Fig. 115, 120) (see page 127), heat treatment (A) applied in the final processing stage is indispensable in order to achieve

- the desired firm elastic texture through heat coagulation of previously liquid or semi-liquid muscle protein structures,
- refinement of flavour and taste through biochemical processes,
- a stable red curing colour, as for most of these products (different to meat dishes) curing salt is used (Fig. 117, 118, 119).
Precooked-cooked meat products (e.g. liver sausage, blood sausage, corned beef, etc., see page 149), are submitted to two heat treatments (A). The raw meat materials are precooked (Fig. 121) and further processed and after filling in casings or cans, the second heat treatment is applied (Fig. 185, 186). This serves primarily for taste and flavour improvements, but due to germ reduction also for shelf life extension of the final products. Another group, the fresh meat
products (such as sausages for frying or burgers, see page 103), are manufactured without any heat treatment. For this type of products, fresh raw ingredients are comminuted and mixed together. Eventually, heat treatment, mostly frying, takes place immediately before consumption (treatment (B), as the products are usually eaten hot (Fig. 122 and 123).

Only two types of meat products exist, which are manufactured and normally also consumed without any heat treatment, raw fermented meat products (such as raw ham, dry sausages, see page 115 and 172) and the raw dried meat products (such as biltong, pastirma, see page 237/238).

**Meat dishes**

For the cooking of meat for meat dishes, two basic methods are of relevance: dry heat, in which the meat is surrounded by hot air, and moist heat, in which the meat is surrounded by hot liquid.

**Dry-heat methods are**
- Broiling (meat is placed in an oven)
- Pan frying (browned on both sides in the pan)
- Stir frying (small meat pieces under constant stirring in a wok/ Asian frying pan)
- Deep fat frying (meat completely immersed in fat)
- Roasting (meat placed on a grill or in an open roasting pan with the fat side up, no water added)

**Moist-heat methods are**
- Braising (water and other ingredients such as milk or vegetable are added),
- Stewing (cooking in liquid of small meat pieces),
- Simmering (cooking in liquid of large meat pieces, normally low temperature and long time)
Heat treatment of meat products

For preparation of meat dishes in households or restaurants, exact temperature control is normally not needed and it is only differentiated between low, medium and high dry or moist heat (see box above). Meat dishes are usually consumed immediately after cooking, so the heat treatment is (besides basic food safety aspects\(^1\)) mainly for sensory reasons. The achievement of a prolonged shelf life is not intended\(^2\).

For processed meat products exact temperature control is indispensable, as the balance between two opposite requirements has to be found:

- Heat treatment temperatures should be raised high enough to accomplish adequate microbial reduction for shelf life extension.
- Heat treatment temperatures should be kept low enough to prevent deterioration of the eating quality.

Heat treatment of processed meat products will therefore always be a compromise between sensory and hygienic requirements.

In case of difficult hygienic conditions (e.g. tropical environment, highly contaminated raw meat, risk of interrupted cold chain) more intensive heat treatment must be applied. However, this may result in a certain degradation of the eating quality and higher cooking losses. If meat production and meat handling conditions are good (e.g. moderate climate, fresh hygienic raw materials, excellent processing and storage conditions), the heat treatment can be less intensive, which results in better sensory quality, but in hygienically more sensitive products.

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1) Naturally, basic food safety aspects play also a role in heat treatment of meat dishes, such as elimination of potentially food poisoning microorganisms.

2) Exception: For supplying canteens, supermarkets, etc. with pre-packed cooked and afterwards chilled ready-to-eat dishes, which have to be reheated before consumption, exact temperature control during cooking is necessary as the product will be stored.
"Hurdle technology" of heat treated products

In modern meat processing, the effect of heat treatment can be supported by the application of additional "hurdles", which have the potential to slow down microbial growth. Such "hurdles" allow keeping the heat treatment of sterilized products at lower temperature levels, so that the product quality is less affected (see page 294 “Commercially sterile products”). Alternatively, this technology can be used to produce shelf-stable products of the non-sterilized type through heat treatments below 100°C. This kind of heat treatment alone would not be enough to stop microbial growth, but the additional "hurdles" complete the effect. This kind of meat preservation is called hurdle technology.

Frequently used "hurdles" are lowering of water activity ($a_w$) (see page 323) or acidity (pH) (see page 321) in a product, or the utilization of chemical preservatives (see page 74), to which amongst many others also the commonly used nitrite curing salt (see page 68) belongs. All these measures on their own would not stop microbial growth, but some or all of them in combination with heat treatment account for a number of "hurdles", which cannot be overcome by microorganisms surviving in the product (see Fig. 124). The result of such “built-in hurdles” is that meat products can be moderately heated, but surviving microorganisms can not grow. In most efficient combinations of such "hurdles", microorganisms do not even grow under ambient (“room temperature”) storage conditions. Such products do not need refrigeration, they are shelf-stable, but much less heat treatment was needed than for fully sterilized canned products (see page 294). Naturally, in the meat sector the range of products, which can be made shelf-stable according to the hurdle technology, is limited but may be of significance in certain circumstances, in particular if no uninterrupted cold chain is available.

Examples:
Meat mixes of the raw-cooked type (see page 127), with high amounts of coarsely cut lean meat pieces (about 90%) and the rest raw-cooked batter for binding purposes, are filled into permeable casings (see page 264) and pasteurized. Built-in hurdles are the pasteurization temperature, nitrite curing salt (and possibly other preservatives) and most
importantly low $a_w$. The low $a_w$ is achieved through smoking and drying of the sausages in hot air/hot smoke. Such sausages or pieces are vacuum-packed in synthetic films and heated again in the package. The second heat treatment may be close to 100°C or slightly above and eliminates unwanted spoilage bacteria in the sausage and secondary contamination caused through the manipulation by vacuum packaging. Correct arrangements of all hurdles make the product shelf-stable.

Meat mixes of the **precooked-cooked type** (see page 149), such as liver sausage, possess due to relatively high fat contents (about 30%) relatively low $a_w$-values. If this $a_w$-hurdle is combined with nitrite curing salt or common salt (and/or other preservatives) and heat treatment in the range of 100°C or slightly above, such sausages can be made shelf-stable. Precondition is to fill such sausages in impermeable heat resistant casings, which sustain the mentioned heat treatment.

### Important hurdles for meat preservation

<table>
<thead>
<tr>
<th>High temperature:</th>
<th><strong>Heat treatment</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low temperature:</td>
<td><strong>Cooling, freezing</strong></td>
</tr>
<tr>
<td>Water activity ($a_w$):</td>
<td><strong>Drying, salt, sugar, fat</strong></td>
</tr>
<tr>
<td>Acidity (pH):</td>
<td><strong>Acidification</strong></td>
</tr>
<tr>
<td>Redox potential:</td>
<td><strong>Decrease oxygen (vacuum, ascorbate)</strong></td>
</tr>
<tr>
<td>Preservatives:</td>
<td><strong>Sorbate, nitrite etc.</strong></td>
</tr>
<tr>
<td>Competitive flora:</td>
<td><strong>Fermentation (only applicable for non-heat-treated products)</strong></td>
</tr>
</tbody>
</table>

### Types of heat treatment

Principally, for heat treatment (also called “thermal treatment”) of meat and meat products, it can be distinguished between products which undergo

a. Heat treatment at temperatures below 100°C, mostly in the temperature range of **60 to 85°C**, also called “**pasteurization**” or simply “**cooking**”.

b. Heat treatment at temperatures of **above 100°C**, also called “**sterilization**”.

All such products will achieve a more or less prolonged shelf life through reduction or complete destruction of microbial populations by the heating process (thermal reduction/thermal destruction).
Both groups of products have the following in common: They are

- **filled in containers** such as casings, cans, glass jars or synthetic pouches, which are closed or sealed after filling
- submitted to **thermal treatment** with a defined temperature and time combination that reduces or eliminates the microorganisms in the product, thus providing a prolonged shelf life.

The difference between the two groups (a) and (b) of heat treated meat products lays in their microbial status achieved, which determines how these products can be stored after thermal treatment:

- **Cooked** or **pasteurized** products (which are heated at temperatures below 100°C or maximum up to 100°C) still contain a certain amount of viable or “living” microorganisms. These are the more heat resistant spore forming types (see box page 95), which survive boiling temperatures (100°C). Their renewed growth in the finished and stored product can only be prevented by applying low temperatures. Such products (group a above) must therefore be **stored refrigerated** (0°-5°C).

  The best known pasteurized animal product is pasteurized fresh milk, where pathogenic (zoonotic) microorganisms (such as agents of Tuberculosis, Brucellosis or Listeriosis), if present, are destroyed, but spoilage bacteria may have survived. Pasteurized milk has therefore to be kept under refrigeration. In the meat sector, cooked ham in sealed and afterwards mildly heat treated plastic pouches, or sausages heat treated in casings, are examples for pasteurized products. The internal temperatures, for sensory reasons, should not exceed 72-78°C (see Fig. 118, 120). Refrigerated storage is therefore mandatory after processing.

- **Sterilized** products (group b above) (which were heated at temperatures of above 100°C combined with sufficient heat impact time to achieve the necessary sterilization effect), are produced free of viable microorganisms and can therefore be stored **under ambient temperature** (“shelf stable”).

Practically all meat products in hermetically sealed containers (tin cans, glass jars, retortable pouches) are sterilized products and can be stored at ambient temperature (chapter “Canning”, page 277). In the rare event of only pasteurizing meat products in cans, glass jars or retortable pouches, a clear indication on their label must inform consumers that storage under refrigeration is mandatory. It is of utmost importance that meat processors, food handlers and consumers are aware of the difference between pasteurized and sterilized products. The presence or
absence of spore forming microorganisms, which depends on the intensity of the heat treatment, decides on the classification “pasteurized” or “sterilized” products.

Reactions of microorganisms to thermal treatment

- Microorganisms are sensitive to heat and are killed at certain temperatures, which may be below or, in the case of spore forming microorganisms, above 100°C (see also box below).
- Each species of microorganisms reacts differently to heat treatment, due to their different heat resistance.
- Microorganisms are quickly killed when they are exposed to relatively high temperatures.
- Microorganisms can also be killed at relatively low hot temperatures, but longer heat treatment periods will be necessary in such cases.

Vegetative microorganisms are living bacterial cells. Each cell is surrounded by a cell wall, which does not provide strong protection against adverse conditions (high or low temperature, dry environment), with the result that such microorganisms will be killed or damaged to such an extend that no further growth is possible.

Spores are strong resistant capsules, which are formed by bacterial cells of genus Bacillus and Clostridium only. Spores contain all vital structures of the microorganisms. In dry, cold or hot environment, where the bacterial cell will be destroyed, the spore has a much stronger resistance against such adverse conditions. The spores remain dormant (without growth) as long as the unfavourable conditions prevail. Under more favourable conditions (sufficient water/humidity and temperatures in the range of 10-40°C), spores will transform again into vegetative bacterial cells capable of multiplying and fast growing to high numbers, which can spoil and/or intoxicate food.

Bio-physically the heat inactivation of microorganisms is relatively complex. The heat destruction of a population of microorganisms does not occur instantly but gradually. Mathematically, it can be expressed by the term “decimal reduction time” (also called D-value, see page 290), i.e. after a defined heat impact period (constant heat) 10% of the original population will survive, after the same impact period again 10% and so on.

Example:

Salmonella species, 100000 (10⁵) microorganisms per gram
Treatment temperature 65°C
Decimal reduction time 6 sec

6 sec       6 sec       6 sec       6 sec       6 sec
10⁵ ------→ 10⁴ ------→ 10³ ------→ 10² ------→ 10¹ ------→ 10⁰ = 30 sec

(In this example the temperature impact of 30 seconds at 65°C is needed for the elimination of the microbial load of originally 10⁵/g).
Table 4: Examples for heat resistance/decimal reduction times of selected microorganisms (experimental results from various sources)

<table>
<thead>
<tr>
<th>Vegetative organisms</th>
<th>50°C</th>
<th>55°C</th>
<th>60°C</th>
<th>65°C</th>
<th>70°C</th>
<th>75°C</th>
<th>80°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. coli</td>
<td>4-7 min</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salmonella ssp. (average)</td>
<td>0.02-0.25 min</td>
<td>1.2 sec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salmonella typhimurium</td>
<td>0.06 min</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salmonella senftenberg*</td>
<td>0.8-1 min</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salmonella typhi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 sec</td>
<td></td>
</tr>
<tr>
<td>Mycobacterium tuberculosis</td>
<td>12-18 sec</td>
<td>5 sec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listeria monocytogenes</td>
<td>5-8 min</td>
<td></td>
<td></td>
<td>0.1-0.3 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staph. aureus</td>
<td>0.2-2 min</td>
<td></td>
<td></td>
<td></td>
<td>2 sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Campylobacter</td>
<td>1.1 min</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enterobacter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactobacillus spp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.5-1 min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spoilage bacteria, yeasts, moulds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.5-3 min</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bacterial spores</th>
<th>100°C</th>
<th>105°C</th>
<th>110°C</th>
<th>121°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacillus spp.</td>
<td>0.1-0.5 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacillus cereus</td>
<td>5 sec</td>
<td>0.5 sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacillus anthracis</td>
<td>15 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacillus stearothermophilus</td>
<td></td>
<td>&lt;300 min</td>
<td>4-5 min</td>
<td></td>
</tr>
<tr>
<td>Cl. botulinum type E</td>
<td>0.01 min</td>
<td>&lt;1 sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl. botulinum spp.</td>
<td>50 min</td>
<td></td>
<td></td>
<td>0.1-0.2 min</td>
</tr>
<tr>
<td>Cl. sporogenes</td>
<td></td>
<td></td>
<td></td>
<td>0.1-1.5 min</td>
</tr>
</tbody>
</table>

* = most heat resistant Salmonella type

As can be seen in table 4, **vegetative microorganisms** can all be destroyed at temperatures below 100°C, basically in the temperature range of 60°C to 85°C (depending on the type of microorganisms). Only those microorganisms capable of forming **spores** (which all belong to the groups of **Bacillus** and **Clostridium**) can survive temperatures of 100°C and above.

The above data on heat resistance of microorganisms clearly demonstrate the importance of accurately applying heat treatment temperatures and times recommended for specific meat products. So called **undercooking**, which means that recommended temperature/time parameter were not reached, must be avoided. Equally important is the need for strict refrigeration for certain products after mild heat treatment (pasteurization) because of the surviving more heat resistant microorganisms. Non-compliance with these basic rules may result in economic losses through product spoilage and/or public health problems through food poisoning.
CATEGORIES OF PROCESSED MEAT PRODUCTS

When viewing meat products of various size, shape and colour in butcher shops or meat sections of supermarkets, there appears to be is a great variety of such products with different taste characteristics. In some countries there may be several hundred different meat products, each with its individual product name and taste characteristics.

At a closer look, however, it turns out that many of the different products with different product names have great similarities. This issue can be even better understood and becomes more transparent when the processing technologies are analyzed. Based on the processing technologies used and taking into account the treatment of raw materials and the individual processing steps, it is possible to categorize processed meat products in six broad groups.

Table 5: Meat products grouped according to the processing technology applied

Based on the grouping the meat products and their processing technologies are described in detail in the respective chapters (page 103, 115, 127, 149, 171, 221). Hereunder, a definition of each group is given:
**Categories of processed meat products**

**Fresh processed meat products**

**Definition**

These products are meat mixes composed of comminuted muscle meat (Fig. 125, 126, 127), with varying quantities of animal fat. Products are salted only, curing is not practiced. Non-meat ingredients are added in smaller quantities for improvement of flavour and binding, in low-cost versions larger quantities are added for volume extension. All meat and non-meat ingredients are added fresh (raw). Heat treatment (frying, cooking) is applied immediately prior to consumption to make the products palatable. If the fresh meat mixes are filled in casings, they are defined as sausages (e.g. frying sausages). If other portioning is customary, the products are known as patties, kebab, etc. Convenience products, such as chicken nuggets (see page 190), have a similar processing technology and can also be included in this group. In contrast to the rest of the group, chicken nuggets etc. are already fried in oil at the manufacturing stage during the last step of production.

![Fig. 125: Fresh raw beef patties](image1)
![Fig. 126: Fried fresh sausages (left) and beef patties (right)](image2)
![Fig. 127: Chicken nuggets](image3)

**Cured meat cuts**

**Entire pieces of muscle meat and reconstituted products**

**Definition**

Cured meat cuts are made of entire pieces of muscle meat and can be sub-divided into two groups, cured-raw meats (Fig. 128) and cured-cooked meats (Fig. 129). The curing for both groups, cured-raw and cured-cooked, is in principle similar: The meat pieces are treated with small amounts of nitrite, either as dry salt or as salt solution in water.
The difference between the two groups of cured meats is:

- **Cured-raw meats** do not undergo any heat treatment during their manufacture. They undergo a processing period, which comprises curing, fermentation and ripening in controlled climatized conditions, which makes the products palatable. The products are consumed raw/uncooked.

- **Cured-cooked meats**, after the curing process of the raw muscle meat, always undergo heat treatment to achieve the desired palatability.

**Raw-cooked meat products**

**Definition**

The product components *muscle meat, fat* and *non-meat ingredients* which are processed raw, i.e. uncooked by comminuting and mixing. The resulting viscous mix/batter is portioned in sausages or otherwise and thereafter submitted to heat treatment, i.e. “cooked”. The heat treatment induces protein coagulation which results in a typical firm-elastic texture for raw-cooked products (Fig. 130, 131). In addition to the typical texture the desired palatability and a certain degree of bacterial stability is achieved.
Precooked-cooked meat products

Definition

Precooked-cooked meat products contain mixes of lower-grade muscle trimmings, fatty tissues, head meat, animal feet, animal skin, blood, liver and other edible slaughter by-products. There are two heat treatment procedures involved in the manufacture of precooked-cooked products. The first heat treatment is the pre-cooking of raw meat materials and the second heat treatment the cooking of the finished product mix at the end of the processing stage. Precooked-cooked meat products are distinguished from the other categories of processed meat products by pre-cooking the raw materials prior to grinding or chopping, but also by utilizing the greatest variety of meat, animal by-product and non-meat ingredients (Fig. 132, 133, 134).

Raw-fermented sausages

Definition

Raw-fermented sausages are uncooked meat products and consist of more or less coarse mixtures of lean meats and fatty tissues combined with salts, nitrite (curing agent), sugars and spices and other non-meat ingredients filled into casings. They receive their characteristic properties (flavour, firm texture, red curing colour) through fermentation processes. Shorter or longer ripening phases combined with moisture reduction (“drying”) are necessary to build-up the typical flavour and texture of the final product. The products are not subjected to any heat treatment during processing and are in most cases distributed and consumed raw (Fig. 135, 136).
Dried meat products

Definition

Dried meat products are the result of the simple dehydration or drying of lean meat in natural conditions or in an artificially created environment (Fig. 137, 138). Their processing is based on the experience that dehydrated meat, from which a substantial part of the natural tissue fluid was evaporated, will not easily spoil. Pieces of lean meat without adherent fat are cut to a specific uniform shape that permits the gradual and equal drying of whole batches of meat. Dried meat is not comparable to fresh meat in terms of shape and sensory and processing properties, but has significantly longer shelf-life. Many of the nutritional properties of meat, in particular the protein content, remain unchanged through drying.
FRESH PROCESSED MEAT PRODUCTS

**Definition**

This group comprises meat mixes composed of finely comminuted, minced or sliced muscle meat, with varying quantities of animal fat adhering to the muscle meat or added separately. Flavouring is done by adding common salt and spices; curing is not practiced. In many products other non-meat ingredients are added in smaller quantities for improvement of flavour and binding, in low-cost versions larger quantities are added to extend the existing volume. The characteristic of this group is that all meat and non-meat ingredients are added fresh (raw), either refrigerated or non-refrigerated. The heat treatment (frying, cooking) is only applied immediately prior to consumption to make the products palatable (Fig. 139). In many instances, the consumer cooks the products prior to serving and products are consumed hot. Most of the fresh meat mixes are filled in casings, which defines such products as sausages. If other portioning is customary, the products are known as burgers, patties, kebab, etc.

**Patties, Kebab, etc.** (recipes page 390 – 392)

**Patties** are formed from minced meat usually in a disc-like shape with diameters of 80-150mm and 5-20mm height (Fig. 140, 411). In commercial fast-food outlets the common name is hamburgers or simply burgers. Originally, burgers were made from beef (preferably lean cow meat), but in recent years chicken and mutton burgers have become more common. Other animal tissues such as fats or connective tissue/tendons can also be part of the mixture, with quantities depending...
on the type and quality of the products. In industrial manufacture, these tissues could have been previously separated from the lean meat and are added again in defined quantities to ensure identical chemical composition (protein, fat, water) of all products. A common feature of burgers is that during mincing (1-3mm disc) and consecutive blending, salt and spices (mainly black and white pepper, in some instances also herbs, garlic or onions) are added. In some cheaper industrial formulations textured soy protein is commonly used as a non-meat ingredient in quantities up to 25%. Other non-meat ingredients suitable for this purpose could include rusk, breadcrumbs and dried flakes from roots and tubers (see also page 197 and recipes page 383, 392).

Burgers are stored frozen and individually pan-fried before consumption. Ideally, internal temperatures of 80°C should be reached to destroy food poisoning agents potentially present in the raw meat mixes (such as Listeria, Salmonella or E. coli O157H7, see page 357). Burgers are often served on bread rolls or buns with slices of cheese, mayonnaise, mustard, green salad, etc.

Step 1: Beef, salt and spices are mixed prior to grinding
The **Kebab** is a Middle East product, but popular in many places and usually eaten in pieces of flat white bread with yogurt sauce or sheep cheese. These preparations of kebab are also known by the name of **doener** or **gyros**. The term “kebab” refers to processed meat on skewers. Kebabs are usually made of sliced lean meat from veal, mutton or chicken or mixes of them. The lean meat has been marinated (mixture of salt, spices and oil) and the marinated meat pieces are arranged around a skewer bar. The usual quantity of meat on the skewer is 3-4 kg.
For preparing the product for consumption, the skewer is slowly rotated in a vertical position close to a source of heat. Traditionally glowing charcoal was positioned on the backside of the skewer in a metal basket. Nowadays gas elements, electro coils or infrared devices are used. The outside layers of the meat bulk, once they are sufficiently heated (slightly crispy), are carefully trimmed off as thin slices. In doing so, the deeper layers, which are still uncooked, will be exposed to the heat and trimmed off when cooked. The process is repeated until all meat has been trimmed off. A special kebab is produced using minced or finely comminuted meat mixes similar to patty mixes. This type of kebab must be heat treated (coagulated) prior to final roasting to make sure that the big chunk of meat firmly sticks to the vertical skewer and maintains its shape and position.

![Fig. 141: Arranging meat slices on a kebab skewer and trimming off meat pieces from the skewer for consumption.](image)

1 = Loading skewer with marinated meat slices
2 = Skewer ready for exposure to heat
3 = Skewer during heat treatment, fully cooked outer portions being trimmed off
   a = heating device (charcoal, electric or gas)
   b = slow rotation of skewer in front of heat source
   c = plate with trimmed-off cooked meat pieces
Other varieties of kebabs are prepared in individual portions in fast-food outlets. These kebab types usually consist of fresh or marinated small meat dices or flakes on a skewer. Some variations can contain visible portions of vegetables (bell pepper, onions, etc) or even liver/kidney pieces. A typical marinated meat-only variety is the Greek **souflaki** containing veal or lamb meat which is marinated with lemon juice, herbs and garlic. Souflaki is grilled over charcoal. Another variety, where often vegetables and liver/kidney pieces are included, is known as **shashlik**. This type is briefly fried (browned) in little oil and simmered in a heavy sauce. These individually portioned kebab varieties are nowadays also available raw (fresh or frozen) as convenience products and prepared by customers at home.

[Image: Fig. 142: Shashlik, raw, ready for cooking, left and middle. Skewers contain lean pork and pork belly (left), some additional beef slices (middle). Cooked and ready for consumption (right)]

**Fresh sausages** (recipes page 383 – 389)

Fresh sausages probably represent the oldest form of processed meat products. Their production could be carried out everywhere where animals were slaughtered, which produced both the meat and the casings. In the simplest way of manufacture, no tools other than knives are needed. Fresh meat and fat are mixed with salt and spices and stuffed into natural casings derived from small intestines of slaughter animals. Higher quality fresh sausages are primarily composed of lean meat and fat. In some low-cost formulations non-meat extenders are also used.

Fresh sausages products are well suited for small-scale meat processing outlets, as all ingredients including casings can be generated or procured locally. The manufacture can take place with basic meat processing tools and machinery (cutting board, knife, grinder, funnel or manual stuffer, see also page 244). These sausages do not undergo heat treatment at processor level, but are roasted, fried, boiled or otherwise heat treated before consumption upon demand by consumers or by consumers themselves.
Meat and non-meat ingredients

The animal tissues (meat and fat) used in fresh sausages can originate from different animal species (pigs, cattle, small ruminants, game, poultry, fish). The meat selection and lean/fat ratio vary, depending on cultural preferences and consumer expectations. Most fresh sausages are coarsely chopped products. Hence the lean meat should be free of tendons or hard connective tissue and only solid fats (beef body fat, pork back fat) should be used. The hard connective tissue would remain relatively tough in the ready-to-eat product and soft fatty tissues would make the product greasy. In addition, the fat content in the final product should not exceed 25%, as otherwise the shrinkage by melting fat during frying or cooking would be high.

In traditional recipes only common salt is used (10-15 g per kg raw material) as red cured meat colour is not required in these products. Hence curing salt is unnecessary. The most common spices used in fresh sausage production are pepper, mace, coriander, red chilli, cardamom, ginger and cumin. Depending on availability and desired flavour and taste smaller quantities of onions and/or garlic can also be added. Sausages composed primarily of meat and fat are “frying sausages” (Fig. 143), which are popular around the globe. Those made from beef or pork or containing mixtures of both are the best known.

Processing of higher quality fresh sausages

Raw fresh lean meat and fatty tissue are the main components of fresh sausages. Typical examples for this sausage type exist in all regions of the world. The most popular products are:
“bratwurst” which means “frying sausage” in Central Europe
“longaniza” and “chorizo criollo” in countries with Spanish tradition
“merguez” in Northern Africa and Middle East
“breakfast sausage” in countries with British tradition
“boerwors” in South Africa (recipes see page 381-391)

For the manufacture of **coarsely chopped fresh sausages** lean meat and fats are cut by hand into pieces (Fig. 144, step 1), mixed with salt, spices and other non-meat ingredients (step 2) and minced in a meat grinder (step 3), using a grinder disc with the desired size of disc perforations (4 to 6 mm).

Other types of fresh sausages are composed of **finely chopped** raw materials or a **combination of coarse meat and finely chopped** portions. In these variations additional ingredients such as eggs, milk, starches, etc. can be used, primarily to improve the binding of the final product. For the preparation of such finely chopped meat mixtures a bowl cutter is necessary (see Fig. 145, steps 1-4). The use of a bowl cutter also enables the incorporation of larger quantities of extender materials for low-cost recipes.

After grinding, the mixture is usually stuffed into thin or medium size calibre natural casings of the “edible” type (see page 251). These casings, derived from the small intestines of pigs or sheep, are either freshly prepared from local slaughter, or salted and stored until used (see page 251, 255). In any case, these fresh natural casings need to be rinsed with sufficient quantity of clean water before being used for stuffing (Fig. 144, step 4). The casings are filled almost to their maximum capacity (step 5) and thereafter divided into shorter units of the desired size by linking and twisting (step 6).

Natural casings can also be replaced by edible collagen casings of similar diameter. This allows for better standardisation of sausages and larger volumes of production (see chapter “casings” page 263). In the absence of casings the mixture can also be shaped into meat rolls (also known as skinless sausages), meat balls or burger patties. This is done either by hand or by using simple tools.