MEAT PROCESSING TECHNOLOGY

FOR SMALL- TO MEDIUM-SCALE PRODUCERS

Gunter Heinz
Peter Hautzinger

RAP PUBLICATION 2007/20

MEAT PROCESSING TECHNOLOGY

FOR SMALL- TO MEDIUM-SCALE PRODUCERS

Gunter Heinz
Peter Hautzinger

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC
Bangkok, 2007

ISBN: 978-974-7946-99-4

Appreciation:

The cover photo was made available by the
Animal Products Development Center (APDC) in Manila / Philippines

Contact:

Senior Animal Production and Health Officer and Secretary of APHCA
FAO Regional Office for Asia and the Pacific (RAP)
39 Maliwan Mansion, Phra Atit Road
Bangkok 10200, THAILAND
Tel: +66 (0)2 697 4000
Fax: +66 (0)2 694 4445

TABLE OF CONTENTS

FOREWORD

Meat is the most valuable livestock product and for many people serves as their first-choice source of animal protein. Meat is either consumed as a component of kitchen-style food preparations or as processed meat products. Processed meat products, although in some regions still in their infancy, are globally gaining ground in popularity and consumption volume.

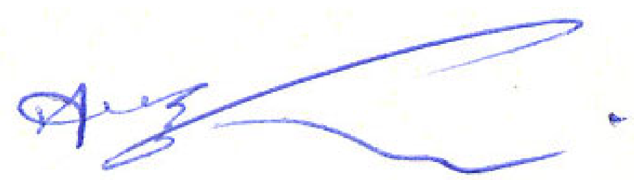
Meat processing has always been part of FAO's livestock programmes, not only because of the possibility of fabricating nutrient-rich products for human food, but also owing to the fact that meat processing can be a tool for fully utilizing edible carcass parts and for supplying shelf-stable meat products to areas where no cold chain exists. Moreover, small-scale meat processing can also be a source of income for rural populations.

In the mid eighties to early nineties of the last century, FAO published two books on meat processing (Animal Production and Health Series No. 52 and 91) in order to familiarize food processors in developing countries with meat processing technologies. However, due to the time elapsed since then they no longer fully reflect current techniques and processing procedures used in the meat sector.

FAO initiated two major projects in this sector. In the mid nineties and in early 2000, in cooperation with the Common Fund for Commodities (CFC) and the German Development Agency GTZ/CIM, FAO ran two comprehensive regional training and development projects on meat processing technology, the first one in sub-Saharan Africa and the second one in Asia.

The experience gained in these two meat processing projects led to the decision that an updated manual on meat processing technology should be prepared, which should take into account the above mentioned publications. It should also represent not only the latest developments of meat processing technology but also use modern publication techniques such as digital photography and computer-created charts and graphs in order to visually clarify and explain facts and procedures described in the text.

The result is a comprehensive compendium on all important topics relevant to the small- to medium-size meat processing sector, with more than 400 colour photographs, drawings and graphs. It can be anticipated that this publication will be a useful guidebook not only for meat processing industries in developing countries, but for all those who plan to establish small business enterprises in this sector or are interested, from the training point of view, in this important part of food manufacture.



He Changchui
Assistant Director-General and
FAO Regional Representative for Asia and the Pacific

ACKNOWLEDGEMENT

This manual is based on training materials used in FAO-organized Regional Training in Meat Processing Technology for Asian countries. The Animal Products Development Center (APDC) in Manila, Philippines offered its premises for the training courses and was instrumental in the preparation of the manuscript through the provision of staff and equipment for experimental and development work, photographs and technical drawings and in the finalizing of the text, for which we are grateful. The review of the text by APDC scientists is also highly appreciated.

The production of the manual is a joint activity between the Animal Products Group of the Animal Production Service (AGAP) of FAO Headquarters in Rome, Italy and the Livestock Section of the FAO Regional Office for Asia and the Pacific (RAP) in Bangkok, Thailand. The hard work of Anthony Bennett, Animal Production Officer (AGAP), in reviewing the publication and the technical editing is highly appreciated. AGAP's contribution to the printing cost is acknowledged.

In RAP the support of Chanrit Uawongkun and Yupaporn Simuang-ngam in the complex task to provide the layout for the manual is appreciated.

AUTHORS

Gunter Heinz, who holds a PhD in Veterinary Medicine, is a specialist in Meat Technology and Meat Hygiene. He worked as a scientist in meat research in Germany and was involved in veterinary sanitary control in export abattoirs and meat processing plants in all major meat producing countries. He is a retired FAO technical officer who was Senior Officer for Meat Technology and Hygiene at FAO Headquarters in Rome, Italy and Regional Animal Production Officer at the FAO Regional Office for Asia and the Pacific in Bangkok, Thailand.

Peter Hautzinger is a Meat Technologist with rich practical experience in meat processing at the artisan and industrial level. He served as an instructor at a German College for Engineers for the Food and Meat Sector. At the international level he was the Chief Technical Advisor to the two largest FAO Regional Projects on Meat Processing Technology, which were carried out in Africa and Asia respectively and both co-funded by the Common Fund for Commodities CFC and CIM/GTZ of Germany as well as the respective host governments Uganda and the Philippines. Currently he works for the support industry for the Asian meat sector and is based in Singapore.

INTRODUCTION

Meat consumption in developing countries has been continuously increasing from a modest average annual per capita consumption of 10 kg in the 1960s to 26 kg in 2000 and will reach 37 kg around the year 2030 according to FAO projections. This forecast suggests that in a few decades, developing countries' consumption of meat will move towards that of developed countries where meat consumption remains stagnant at a high level.

The rising demand for meat in developing countries is mainly a consequence of the fast progression of urbanization and the tendency among city dwellers to spend more on food than the lower income earning rural population. Given this fact, it is interesting that urban diets are, on average, still lower in calories than diets in rural areas. This can be explained by the eating habits urban consumers adopt. If it is affordable to them, urban dwellers will spend more on the higher cost but lower calorie protein foods of animal origin, such as meat, milk, eggs and fish rather than on staple foods of plant origin. In general, however, as soon as consumers' incomes allow, there is a general trend towards incorporating more animal protein, in particular meat, in the daily diet. Man's propensity for meat consumption has biological roots. In ancient times meat was clearly preferred, consequently time and physical efforts were invested to obtain it, basically through hunting. This attitude contributed decisively to physical and mental development of humankind. Despite the growing preference in some circles for meatless diets, the majority of us will continue eating meat. It is generally accepted that balanced diets of meat and plant food are most effective for human nutrition.

Quantitatively and qualitatively, meat and other animal foods are better sources of protein than plant foods (except soy bean products). In meat, the essential amino acids – the organic acids that are integral components of proteins and which cannot be synthesized in the human organism – are made available in well balanced proportions and concentrations. As well, plant food has no Vitamin $B_{12;}$ thus animal food is indispensable for children to establish B_{12} deposits. Animal food, in particular meat, is rich in iron, which is of utmost importance to prevent anemia, especially in children and pregnant women.

In terms of global meat production, over the next decade there will be an increase from the current annual production of 267 million tons in 2006 to nearly 320 million tons by 2016. Almost exclusively, developing countries will account for the increase in production of over 50 million tons. This enormous target will be equivalent to the levels of overall meat production in the developing world in the mid-1980s and place an immense challenge on the livestock production systems in developing countries.

The greater demand for meat output will be met by a further shift away from pastoral systems to intensive livestock production systems. As these systems cannot be expanded indefinitely due to limited feed availability and for environmental reasons, other measures must be taken to meet growing meat demand. The only possible alternatives are making better use of the meat resources available and reducing waste of edible livestock parts to a minimum.

This is where meat processing plays a prominent role. It fully utilizes meat resources, including nearly all edible livestock parts for human food consumption. Meat processing, also known as further processing of meat, is the manufacture of meat products from muscle meat, animal fat and certain non-meat additives. Additives are used to enhance product flavour and appearance. They can also be used to increase product volume. For specific meat preparations, animal by-products such as internal organs, skin or blood, are also well suited for meat processing. Meat processing can create different types of product composition that maximizes the use of edible livestock parts and are tasty, attractive and nourishing.

The advantage of meat processing is the integration of certain animal tissues (muscle trimmings, bone scraps, skin parts or certain internal organs which are usually not sold in fresh meat marketing) into the food chain as valuable protein-rich ingredients. Animal blood, for instance, is unfortunately often wasted in developing countries largely due to the absence of hygienic collection and processing methods and also because of socio-cultural restrictions that do not allow consumption of products made of blood. While half of the blood volume of a slaughtered animal remains in the carcass tissues and is eaten with the meat and internal organs, the other half recovered from bleeding represents 5-8 percent of the protein yield of a slaughter animal. In the future, we cannot afford to waste such large amounts of animal protein. Meat processing offers a suitable way to integrate whole blood or separated blood fractions (known as blood plasma) into human diets.

Thus, there are economic, dietary and sensory aspects that make meat processing one of the most valuable mechanisms for adequately supplying animal protein to human populations, as the following explains:

- All edible livestock parts that are suitable for processing into meat products are optimally used. In addition to muscle trimmings, connective tissue, organs and blood, this includes casings of animal origin that are used as sausage containers.

- Lean meat is one of the most valuable but also most costly foods and may not regularly be affordable to certain population segments. The blending of meat with cheaper plant products through manufacturing can create low-cost products that allow more consumers access to animal protein products. In particular, the most needy, children and young women from low-income groups, can benefit from products with reduced but still valuable animal protein content that supply essential amino acids and also provide vitamins and minerals, in particular iron.
- Unlike fresh meat, many processed meat products can be made shelf-stable, which means that they can be kept without refrigeration either as (1) canned heat sterilized products, or (2) fermented and slightly dried products or (3) products where the low level of product moisture and other preserving effects inhibit bacterial growth. Such shelf-stable meat products can conveniently be stored and transported without refrigeration and can serve as the animal protein supply in areas that have no cold chain provision.
- Meat processing "adds value" to products. Value-added meat products display specific flavour, taste, colour or texture components, which are different from fresh meat. Such treatments do not make products necessarily cheaper; on the contrary in many cases they become even more expensive than lean meat. But they offer diversity to the meat food sector, providing the combined effect of nutritious food and food with excellent taste.

Processing technology

Meat processing technologies were developed particularly in Europe and Asia. The European technologies obviously were more successful, as they were disseminated and adopted to a considerable extent in other regions of the world – by way of their main creations of burger patties, frankfurter-type sausages and cooked ham. The traditional Asian products, many of them of the fermented type, are still popular in their countries of origin. But Western-style products have gained the upper hand and achieved a higher market share than those traditional products.

In Asia and Africa, there are a number of countries where meat is very popular but the majority of consumers reject processed meat products. This is not because they dislike them but because of socio-cultural reasons that prohibit the consumption of certain livestock species, either pork or beef depending on the region. Because processed products are mostly composed of finely comminuted meat, which makes identifying the animal species rather difficult, or are frequently produced from mixes of meat from different animals, consumers stay away from those products to avoiding eating the wrong thing. But when the demand for meat increases and a regular and cost-effective supply can only be achieved by fully using all edible livestock parts, consumers will need to adjust to processed meat products, at least to those where the animal source can be identified. Younger people already like to eat fast-food products such as beef burgers or beef frankfurters. Outlet chains for such products and other processed meat products will follow when the demand increases.

This manual

In regions where processed meat products are widely popular and therefore produced in great variety, the consumer may get confused with the multitude of different products and product names. With this manual, we have set out to clarify the types of meat products and the techniques for producing them, with a specific focus on operational and technical requirements for small- and medium-scale processing units. As a first approach in international meat literature, this manual classifies existing meat products according to their processing technology into six clearly differentiated groups. Practically every processed meat product can be integrated into one of these groups. This system provides transparency in the meat-products market and allows for the exact characterization and defining of differences in the processing technology. The processing technologies, including meat processing equipment to be used, are described in detail in the respective chapters. In addition, Annex I contains detailed recipes for representative products for each group.

In meat-product manufacturing, the basic processing technologies, such as cutting and mixing, are accompanied by various additional treatments and procedures, depending on the type and quality of the final product. Such treatments involve curing, seasoning, smoking, filling into casings or rigid containers, vacuum packaging, cooking or canning/sterilization. Due to the importance of these procedures, suitable and up-to-date techniques for carrying out these processes and the equipment needed are described in separate chapters but are also referred to in the manual in connection with the respective product groups.

Processing technologies for meat products will not deliver satisfactory results if there is no adequate meat hygiene in place. In the interest of food safety and consumer protection, increasingly stringent hygiene measures are required at national and international trade levels. Key issues in this respect are Good Hygienic Practices (GHP) and Hazard Analysis and Critical Control Point Schemes (HACCP), which are discussed in detail in the manual. Extensive knowledge on hazards that microorganisms cause is indispensable in modern meat processing. Thus, along with technological aspects of meat processing, the manual includes reference to related aspects of meat processing hygiene, including causes for meat product spoilage and food borne illnesses as well as cleaning and sanitation in meat processing. For the purpose of consumer protection and the quality control of meat products, simple test methods are provided that can be carried out at the small enterprise level without sophisticated laboratory set-ups. However, some of these procedures have to be understood as screening methods only and cannot supplement specific laboratory control, which may be officially required.

As the authors, we have endeavoured to incorporate in this publication a series of practical topics, which are important in meat processing but which are usually not sufficiently referred to or not found at all in meat processing handbooks. This includes the handling and maintenance of equipment and tools, workers' appliances, workers' safety in using equipment and tools, meat processing under basic conditions, traditional meat drying, preparation of natural sausage casings from intestines of slaughter animals, the comprehensive listing and description of non-meat ingredients, the manufacturing of meat products with high levels of extenders and fillers, as well as sources and processing technologies for animal fats in meat product manufacturing. This much-needed practical advice and information will also provide incentives towards product diversification to meat processors.

This manual was designed in the first place as a guideline for practical meat processing activities, with focus on the small- and medium-scale sector. The technical content, therefore, was written to make it clearly and easily understood by processing artisans. However, in a number of cases it was necessary to provide more scientific background information for the explanation of technical measures recommended. The description of these mostly physical/chemical aspects is attached to the respective topics but clearly marked in grey or blue boxes. Readers who do not require the additional information will have no problems in understanding the content of the chapters without reading the text in those boxes. Readers who want an overall view of the topic will find the necessary details in the boxes.

This manual is intended for meat processors in developing countries, in particular those who want to improve the existing manufacturing methods and anyone who is interested in entering this specific food sector. Because the content reflects the most current techniques and procedures globally applied in the small- and medium-size meat processing enterprises and includes numerous instructive photographs and drawings, its use is also encouraged for information and teaching purposes.

Gunter Heinz
Peter Hautzinger

MEAT, FAT AND OTHER EDIBLE CARCASS PARTS

(Types, structure, biochemistry)

Sources of meat, fat and animal by-products.

Meat, fat and other carcass parts used as raw materials for the manufacture of processed meat products are mainly derived from the domesticated animal species **cattle**, **pigs** and **poultry** and to a lesser extend from **buffaloes**, **sheep** and **goats**. In some regions other animal species such as **camels**, **yaks**, **horses** and **game animals** are used as meat animals but play only a minor role in meat processing.

In this context, **meat** can be defined as "the muscle tissue of slaughter animals". The other important tissue used for further processing is **fat**. Other edible parts of the slaughtered animal and often used in further processing are the **internal organs**[1] (tongue, heart, liver, kidneys, lungs, diaphragm, oesophagus, intestines) and other slaughter by-products (blood, soft tissues from feet, head).

A special group of internal organs are the **intestines**. Apart from being used as food in many regions in particular in the developing world, they can be processed in a specific way to make them suitable as sausage casings (see chapter on Casings, page 249). Some of them are eaten with the sausage; others are only used as container for the sausage mix and peeled off before consumption.

The **skin** of some animal species is also used for processed meat products. This is the case with pork skin and poultry skin, in some cases also with calf skin (from calf heads and legs).

For more details on the utilization of animal tissues for processed meat products see also chapter "Selection and grading of meat materials for processing" (page 43).

---

1) With the emergence of BSE (Bovine Spongiform Encephalopathy), some edible animal tissues from ruminants, in particular brain, have been declared "specified risk materials (SRM)" and have to be condemned in BSE affected areas.

Muscle meat

Chemical composition of meat

In general, meat is composed of **water**, **fat**, **protein**, **minerals** and a small proportion of **carbohydrate**. The most valuable component from the nutritional and processing point of view is protein.

Protein contents and values define the quality of the raw meat material and its suitability for further processing. Protein content is also the criterion for the quality and value of the finished processed meat products. Table 1 shows the chemical composition of fresh raw and processed meats.

Table 1: Content of water, protein, fat, ash (in percent) and calories
(approximate values for selected raw and processed food products)

	Product	Water	Protein	Fat	Ash	Calories / 100g
FRESH	Beef (lean)	75.0	22.3	1.8	1.2	116
	Beef carcass	54.7	16.5	28.0	0.8	323
	Pork (lean)	75.1	22.8	1.2	1.0	112
	Pork carcass	41.1	11.2	47.0	0.6	472
	Veal (lean)	76.4	21.3	0.8	1.2	98
	Chicken	75.0	22.8	0.9	1.2	105
	Venison (deer)	75.7	21.4	1.3	1.2	103
	Beef fat (subcutaneous)	4.0	1.5	94.0	0.1	854
	Pork fat (back fat)	7.7	2.9	88.7	0.7	812
PROCESSED	Beef, lean, fried	58.4	30.4	9.2		213
	Pork, lean, fried	59.0	27.0	13.0		233
	Lamb, lean, fried	60.9	28.5	9.5		207
	Veal, lean, fried	61.7	31.4	5.6		186
	Raw-cooked sausage with coarse lean particles (ham sausage)	68.5	16.4	11.1		170
	Raw-cooked sausage finely comminuted, no extender	57.4	13.3	22.8	3.7	277
	Raw-cooked sausage (frankfurter type)	63.0	14.0	19.8	0.3	240
	Precooked-cooked sausage (liver sausage)	45.8	12.1	38.1		395
	Liver pate	53.9	16.2	25.6	1.8	307
	Gelatinous meat mix (lean)	72.9	18.0	3.7		110
	Raw-fermented sausage (Salami)	33.9	24.8	37.5		444
	Milk (pasteurized)	87.6	3.2	3.5		63
	Egg (boiled)	74.6	12.1	11.2		158
	Bread (rye)	38.5	6.4	1.0		239
	Potatoes (cooked)	78.0	1.9	0.1		72

As can be seen from the table, **water** is a variable of these components, and is closely and inversely related to the fat content. The fat content is higher in entire carcasses than in lean carcass cuts. The fat content is also high in processed meat products where high amounts of fatty tissue are used.

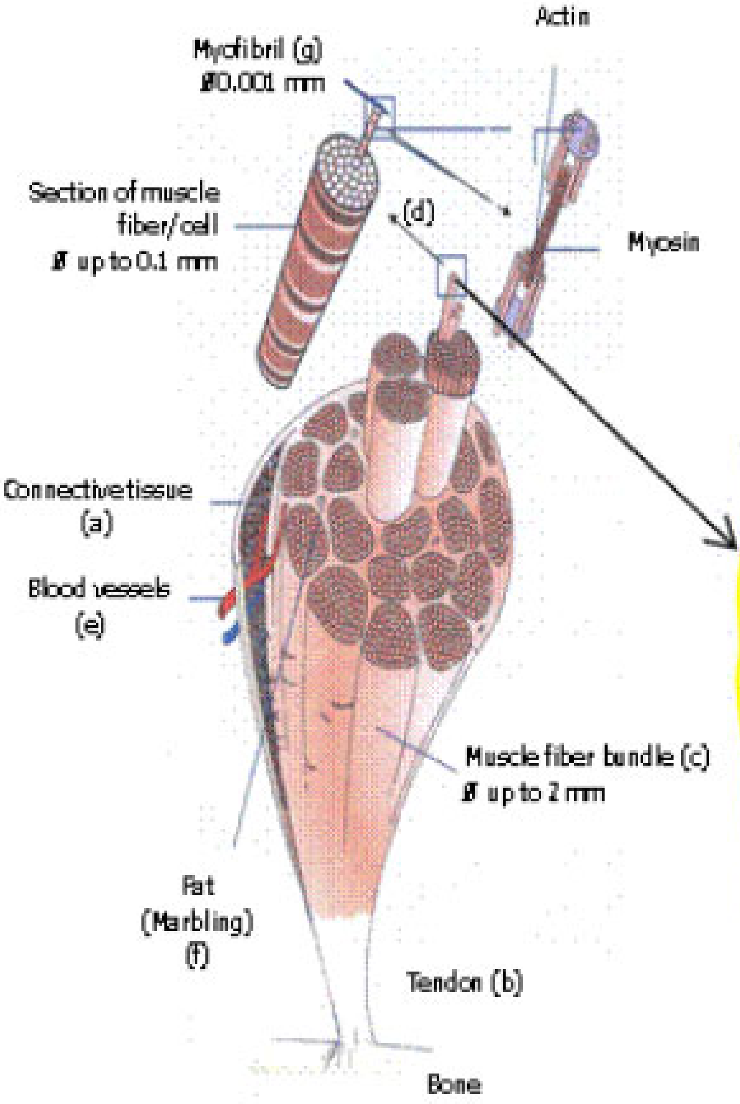
The value of animal foods is essentially associated with their content of **proteins**. Protein is made up of about 20 aminoacids. Approximately 65% of the proteins in the animal body are skeleton muscle protein, about 30% connective tissue proteins (collagen, elastin) and the remaining 5% blood proteins and keratin (hairs, nails).

Histological structure of muscle tissue

The muscles are surrounded by a connective tissue membrane, whose ends meet and merge into a tendon attached to the skeleton (Fig. 1(b)). Each muscle includes several **muscle fibre bundles** which are visible to the naked eye (Fig. 1(c)), which contain a varying number (30-80) of **muscle fibres** or muscle cells (Fig. 1(d) and Fig. 2) up to a few centimetres long with a diameter of 0.01 to 0.1 mm. The size and diameter of muscle fibres depends on age, type and breed of animals. Between the muscle fibre bundles are blood vessels (Fig. 1(e)) as well as connective tissue and fat deposits (Fig. 1(f)). Each muscle fibre (muscle cell) is surrounded by a cell membrane (sarcolemma) (Fig. 2, blue). Inside the cell are **sarcoplasma** (Fig. 2, white) and a large number of filaments, also called **myofibrils** (Fig. 1(g) and Fig. 2, red).

The *sarcoplasma* is a soft protein structure and contains amongst others the red muscle pigment **myoglobin**. *Myoglobin* absorbs oxygen carried by the small blood vessels and serves as an oxygen reserve for contraction of the living muscle. In meat the *myoglobin* provides the red meat colour and plays a decisive role in the curing reaction (see page 34).

The *sarcoplasma* constitutes about 30 percent of the muscle cell. The *sarcoplasmatic proteins* are **water soluble**. About 70 percent of the muscle cell consists of thousands of *myofibrils*, which are solid protein chains and have a diameter of 0.001 – 0.002 mm. These proteins, which account for the major and nutritionally most valuable part of the muscle cell proteins, are **soluble in saline solution**. This fact is of utmost importance for the manufacture of certain meat products, in particular the *raw-cooked products* (see page 97, 127) and *cured-cooked products* (see page 97, 171). A characteristic of those products is the heat coagulation of previously liquefied myofibril proteins. The achieved structure of the coagulated proteins provides the typical solid-elastic texture in the final products.



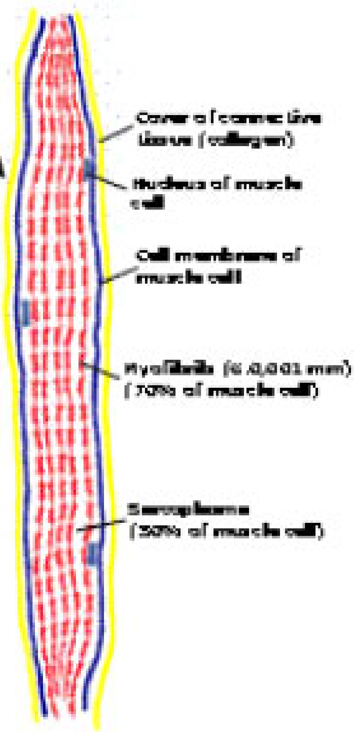


Fig. 1: Muscle structure (skeletal muscle)

Fig. 2: Entire muscle fibre or muscle cell, 0.01-0.1 mm

Changes of pH

Immediately post-mortem the muscle contains a small amount of muscle specific carbohydrate, called **glycogen**[1] (about 1%), most of which is broken down to lactic acid in the muscle meat in the first hours (up to 12 hours) after slaughtering. This biochemical process serves an important function in establishing acidity (low pH) in the meat.

---

1) In the live animal glycogen is the energy reserve for the muscles used as fuel for muscle contraction.

The so-called glycolytic cycle starts immediately after slaughter in the muscle tissue, in which glycogen, the main energy supplier to the muscle, is broken down to **lactic acid**. The build up of lactic acid in the muscle produces an increase in its acidity, as measured by the **pH**. The pH of normal muscle at slaughter is about 7.0 but this will decrease in meat. In a normal animal, the ultimate pH (expressed as pH_{24} = 24 hours after slaughter) falls to around **pH 5.8-5.4**. The degree of reduction of muscle pH after slaughter has a significant effect on the quality of the resulting meat (Fig. 3).

The typical **taste** and **flavour** of meat is only achieved after sufficient drop in pH down to 5.8 to 5.4. From the *processing* point of view, meat with pH 5.6-6.0 is better for products where good water binding is required (e.g. frankfurters, cooked ham), as meat with higher pH has a higher water binding capacity. In products which lose water during fabrication and ripening (e.g. raw ham, dry fermented sausages), meat with a lower pH (5.6–5.2) is preferred as it has a lower water binding capacity (see also page 322).

The pH is also important for the **storage life** of meat. The lower the pH, the less favourable conditions for the growth of harmful bacteria. Meat of animals, which had depleted their glycogen reserves before slaughtering (after stressful transport/handling in holding pens) will not have a sufficient fall in pH and will be highly prone to bacterial deterioration (see also box page 5/6).

PSE and DFD (see Fig. 3)

In stress susceptible animals pH may fall very quickly to pH 5.8 – 5.6 while the carcass is still warm. This condition is found most often in pork. It can be recognized in the meat as a pale colour, a soft, almost mushy texture and a very wet surface (**pale, soft, exudative = PSE meat**). PSE meat has lower binding properties and loses weight (water) rapidly during cooking resulting in a decrease in processing yields.

A reverse phenomenon may arise in animals which have not been fed for a period before slaughter, or which have been excessively fatigued during transportation and lairage. In these cases, most of the muscle glycogen has been used up at point of slaughter and pronounced acidity in the meat cannot occur. The muscle pH_{24} does not fall below pH 6.0. This produces **dark, firm, dry (DFD) meat**. The high pH cause the muscle proteins to retain most of their bound water, the muscle remain swollen and they absorb most of the light striking the meat surface, giving a dark appearance.

Dark meat has a “sticky” texture. Less moisture loss occurs during curing and cooking as a result of the higher pH and the greater water-holding capacity but salt penetration is restricted. Conditions for growth of microorganisms are therefore improved resulting in a much shorter “shelf life”. DFD conditions occur both in beef and pork.

DFD meat should not be confused with that resulting from mature animals through the presence of naturally dark pigmentation. PSE and DFD conditions can to a certain extend be prevented or retarded through humane treatment and minimization of stress to animals prior to slaughter.

PSE and DFD meat is **not unfit** for human consumption, but not well suited for cooking and frying (PSE loses excessive moisture and remains dry due to low water binding capacity while DFD meat remains tough and tasteless due to the lack of acidity).

Nevertheless, for meat processing purposes, PSE and DFD meat can still be utilized, preferably **blended** with normal meat. PSE meat can be added to meat products, where water losses are desirable, such as dry-fermented sausages, while DFD meat can be used for raw-cooked products (frankfurter type) where high water binding is required.

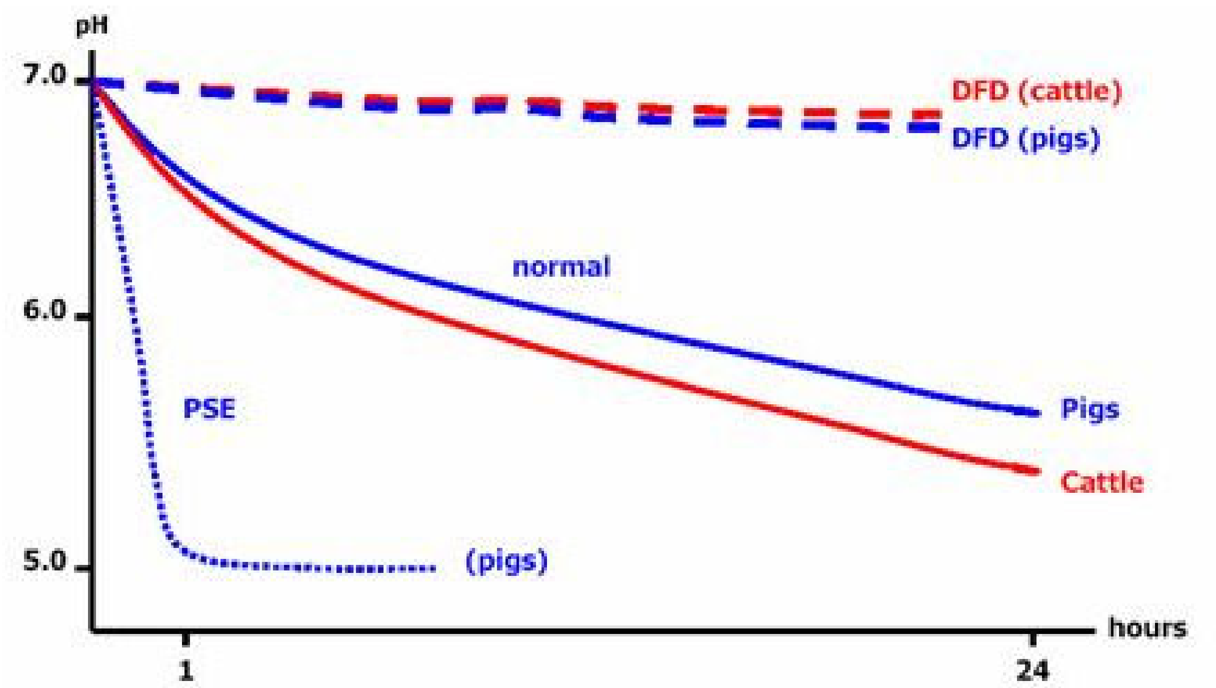


Fig. 3: Changes of pH

Meat colouring

The red pigment that provides the characteristic colour of meat is called **myoglobin**. Similar to the blood pigment haemoglobin it transports oxygen in the tissues of the live animal. Specifically, the myoglobin is the oxygen reserve for the muscle cells or muscle fibres. Oxygen is needed for the biochemical process that causes muscle contraction in the live animal. The greater the myoglobin concentration, the more intense the colour of the muscle. This difference in myoglobin concentration is the reason why there is often one muscle group lighter or darker than another in the same carcass.

Fig. 4: Fresh meat cut (beef) with intense red meat colour

Myoglobin concentration in muscles also differs among animal species. Beef has considerably more myoglobin than pork, veal or lamb, thus giving beef a more intense colour (Fig. 4). The maturity of the animal also influences pigment intensity, with older animals having darker pigmentation. The different myoglobin levels determine the curing capability of meat. As the red curing colour of meat results from a chemical reaction of myoglobin with the curing substance nitrite, the curing colour will be more intense where more muscle myoglobin is available (see "Curing", page 34).

Water holding capacity

The water holding capacity (WHC) of meat is one of the most important factors of meat quality both from the consumer and processor point of view. Muscle proteins are capable of holding many water molecules to their surface. As the muscle tissue develops acidity (decrease of pH) the water holding capacity decreases (Fig. 5, 429, 430).

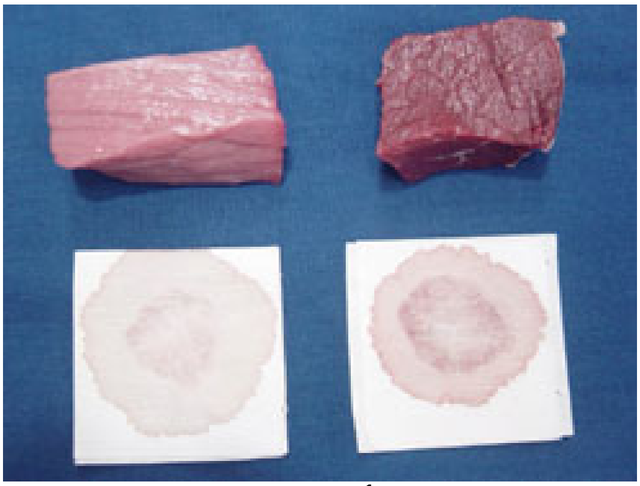


Fig. 5: Compression test[1], different water holding capacity of muscles. Left: Sample with low WHC. Right: Dark meat sample with good WHC (less water pressed out)

____

[1)] Compression instrument see page 325

Water bound to the muscle protein affects the eating and processing quality of the meat. To obtain good yields during further processing including cooking, the water holding capacity needs to be at a high level (except for uncooked fermented and/or dried products which need to lose water during processing, see page 115, 171).

Water holding capacity varies greatly among the muscles of the body and among animal species. It was found that beef has the greatest capacity to retain water, followed by pork, with poultry having the least.

Tenderness and flavour

Meat tenderness plays an important role, where entire pieces of meat are cooked, fried or barbecued. In these cases some types of meat, in particular beef, have to undergo a certain ripening or ageing period before cooking and consumption in order to achieve the necessary tenderness (Fig.6). In the fabrication of many processed meat products the toughness or tenderness of the meat used is of minor importance. Many meat products are composed of comminuted meat, a process where even previously tough meat is made palatable. Further processing of larger pieces of meat (e.g. raw or cooked hams) also results in good chewing quality as these products are cured and fermented or cured and cooked, which makes them tender.

Fig. 6: Aging / ripening of beef hind quarter in cooling room

The taste of meat is different for different animal species. However, it may sometimes be difficult to distinguish the species in certain food preparations. For instance, in some dishes pork and veal may taste similar and have the same chewing properties. Mutton and sometimes lamb has a characteristic taste and smell, which originates from the fat. Even small quantities of **fat**, e.g. inter- and intramuscular fat, may imprint this typical smell and taste on the meat, particularly of meat from old animals. **Feed** may also influence the taste of meat (e.g. fish meal). In addition, the **sex** of the animal may also give a special taste and smell to the meat. The most striking example is the pronounced urine-like smell when cooking old boar's meat. Meat fit for human consumption but with slightly untypical smell and flavour, which may not be suitable for meat dishes, can still be used for certain processed meat products. However, it should preferably be blended with “normal” meat to minimize the off-odour. Also intensive seasoning helps in this respect.

Fig. 7: Meat from different livestock species
Typical retail cuts

Beef top round slice

Pork rib chops from loin

Lamb ribs

Chicken leg

The typical desirable taste and odor of meat is to a great extend the result of the formation of **lactic acid** (resulting from glycogen breakdown in the muscle tissue) and organic compounds like aminoacids and di- and tripeptides broken down from the meat proteins.

In particular the aged (“matured”) meat obtains its characteristic taste from the breakdown to such substances. The “meaty” taste can be further enhanced by adding **monosodium glutamate (MSG)** (0.05-0.1%), which can reinforce the meat taste of certain products (see page 73). MSG is a frequently used ingredient in some meat dishes and processed meat products in particular in Asian countries.

Animal fats

Fatty tissues are a natural occurring part of the meat carcass. In the live organism, fatty tissues function as

- Energy deposits (store energy)
- Insulation against body temperature losses
- Protective padding in the skin and around organs, especially kidney and heart.

Fatty tissue (Fig. 8) is composed of cells, which like other tissue cells, have cell membranes, nucleus and cell matrix, the latter significantly reduced to provide space for **storing fat**. Fats, in the form of triglycerides, accumulate in the fat cells. Well fed animals accumulate large amounts of fat in the tissues. In periods of starvation or exhaustion, fat is gradually reduced from the fat cells.

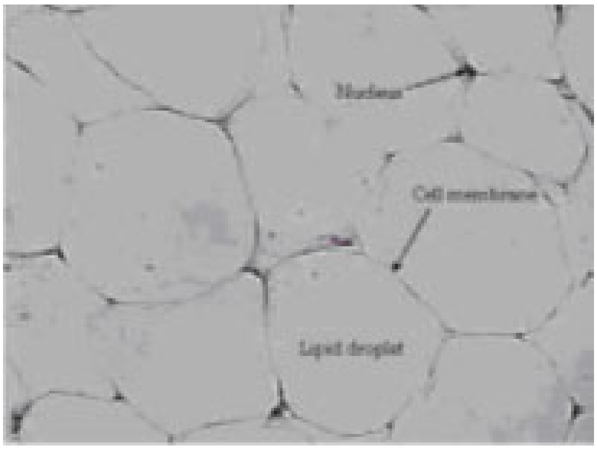


Fig. 8: Fatty tissue (fat cells filled with lipids)

In the animal body there are **subcutaneous fat deposits** (under the skin) (Fig. 10(a/b)) and Fig. 14(a)), fat **deposits surrounding organs** (e.g. kidney, heart) (Fig. 10(d) and Fig. 16(a)) or fat deposits between muscles (**intermuscular fat**, (Fig. 9(a)). Fat deposits between the muscle fibre bundles of a muscle are called **intramuscular fat** (Fig. 9(b)) and lead in higher accumulations to *marbling*. Marbling of muscle meat contributes to tenderness and flavour of meat. Many consumers prefer marbling of meat for steaks and other roasted meat dishes.

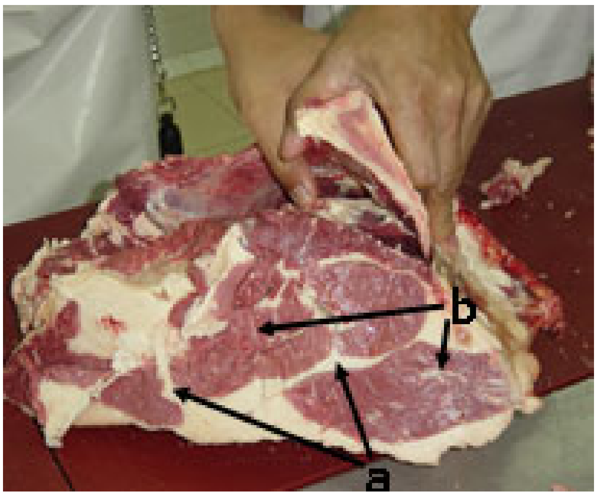


Fig. 9: Intermuscular fat (a) (around individual muscles) and intramuscular fat (b) (inside muscle tissue)

For *processed meat* products, fats are added to make products ***softer*** and also for ***taste*** and ***flavour improvement***. In order to make best use of animal fats, basic knowledge on their selection and proper utilization is essential.

Fatty tissues from certain animal species are better suited for meat product manufacture, fats from other species less or not suited at all. This is mainly for sensory reasons as taste and flavour of fat varies between animal species. Strong differences are also pronounced in older animals, with the well known example of fat from old sheep, which most consumers refuse. However, this aspect is to some extent subjective as consumers prefer the type of animal fat they are used to.

Availability also plays a role when fatty tissues are used for processing. Some animal species have higher quantities of fatty tissue (e.g. pigs), others lesser quantities (e.g. bovines) (Table 1). Pig fat is favoured in many regions for processing purposes. It is often readily available but and has a suitable tissue structure, composition and unpronounced taste which make it readily usable. Fresh pork fat is almost odour- and flavourless. Body fats from other animal species have good processing potential for the manufacture of meat products, but the addition of larger quantities is limited by availability and some undesirable taste properties.

Pork fat

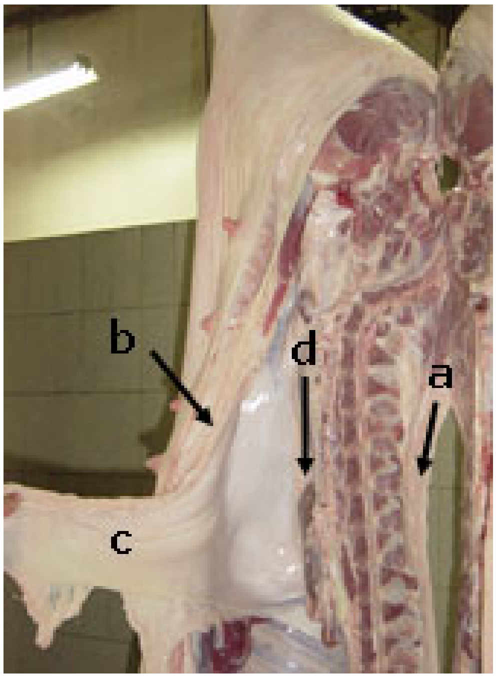


Fig. 10: Pork carcass with backfat (a), belly (b), leafe fat (c) and kidney fat (d)

The ***subcutaneous fats*** from pigs are the best suited and also most widely used in meat processing, e.g. **backfat** (Fig. 10(a), Fig. 12), **jowl fat** (Fig. 11(b), Fig. 12) and **belly** (Fig. 10(b) and Fig. 12). These fatty tissues are easily separated from other tissues and used as separate ingredients for meat products. Also the ***intermuscular fats*** occurring in certain locations in muscle tissues are used. They are either trimmed off or left connected (e.g. intermuscular fat in muscle tissue) and processed together with the muscle meat. Subcutaneous and intermuscular fats are also known as “body fats”. Another category are the ***depot-fats***, located in the animal body around internal organs. These fats can also be manually separated. In rare cases mesenterical (**intestinal**) fats of pigs are used for soft meat products (e.g. liver sausage), but only in small quantities as they cause untypical mouthfeel in final products. The **kidney fat** (Fig. 10(d)) and **leafe fat** (Fig. 10(c), Fig. 12) of pigs are not recommended for processed meat products due to their hardness and taint, but are used for lard production.

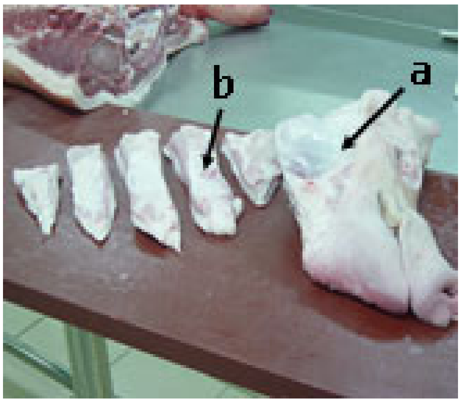


Fig. 11: Jowl fat removed from pig head (a) and cut into strips (b). Behind: Rest of pork carcass with back fat

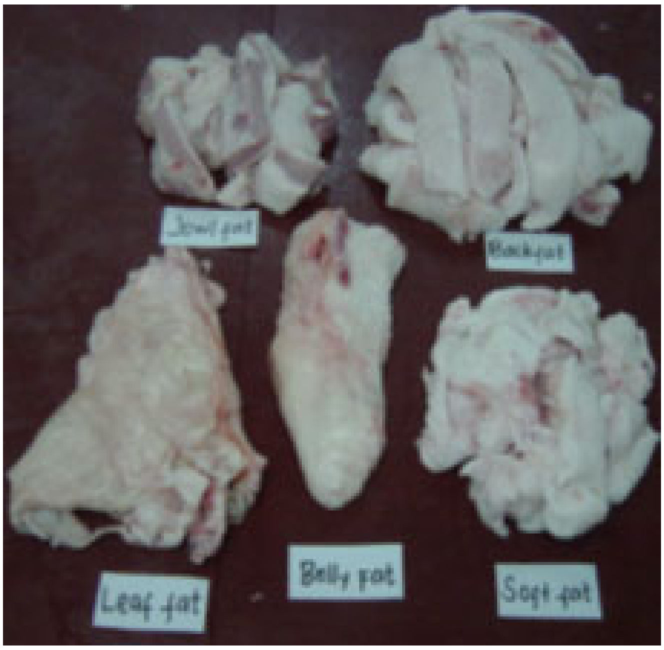


Fig. 12: All fatty tissues from the pork carcass: Jowl fat, back fat (above); leafe fat, belly and soft fat (below)

Beef fat

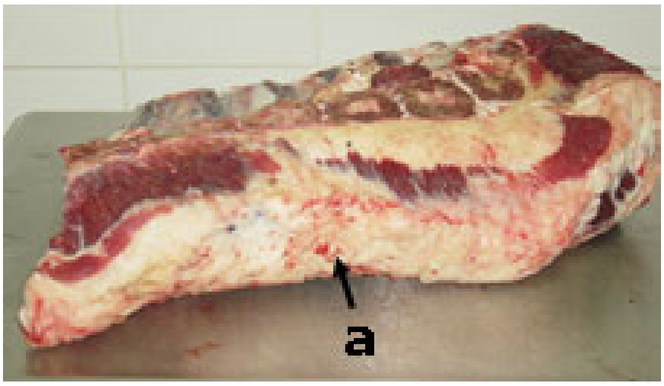


Fig. 13: Brisket fat (a) on beef cut (brisket)

Beef fat is considered less suitable for further processing than pork fat, due to its firmer texture, yellowish colour and more intensive flavour. When used for processing, preference is usually given to **brisket fat** (Fig. 13(a) and Fig. 14(b)) and other **body fats** preferably from younger animals. Such fats are used for specific processed beef products when pork fats are excluded for socio-cultural or religious reasons. Some tropical cattle breeds have a large subcutaneous fat depot in the shoulder region known as “hump”. Fat is the predominant tissue of the hump together with stabilizing connective tissue and muscle meat. The **hump tissue** (Fig. 15(a)) is often cut into slices and roasted/barbecued as a delicacy or used for processed products. **Buffalo fat** has a whiter colour than beef fat and is therefore well suited for processing. The limiting factor for utilization of beef/buffalo fat is its scarce availability, as beef/buffalo carcasses do not provide high quantities of body fats suitable for the manufacture of meat products such as frankfurters, bologna etc., where amounts of fatty tissues in the range of 20% are required. However, for the manufacture of products with a lower animal fat content, e.g. burgers, fresh sausages for frying etc., mixtures of beef and beef fat are well suited.

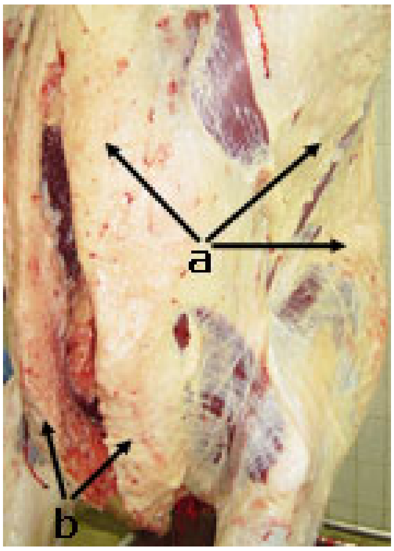


Fig.14: Beef carcass, front part with external subcutaneous fat (a) and brisket fat (b)

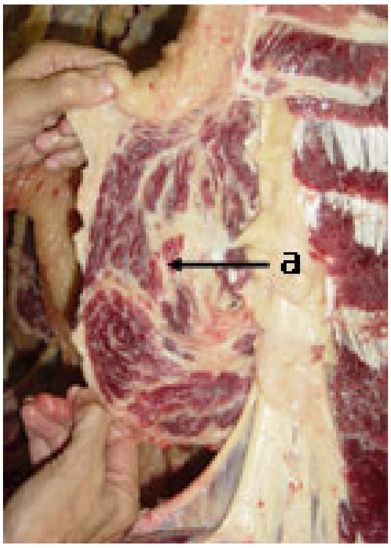


Fig. 15: Hump with fatty tissue (a) of tropical cattle

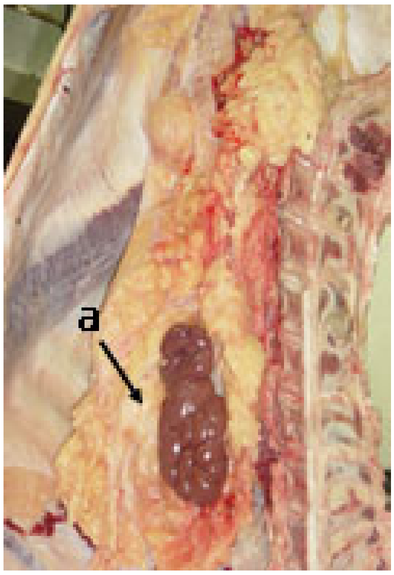


Fig. 16: Kidney fat (a) in beef carcass

Mutton fat of adult animals is for most consumers absolutely unsuitable for consumption due to its typical unpleasant flavour and taste. Fats from lamb are relatively neutral in taste and commonly eaten with lamb chops. Lamb fat can be used as a fat source when producing Halal meat products.

Fat from chicken

Chicken fat is neutral in taste and well suited as a fat component for pure chicken products. Chicken fat adheres as intermuscular fat to chicken muscle tissue and is processed without separating it from the lean meat (see page 56). However, the majority of chicken fat derives from chicken skin (Fig. 17, 84) with its high subcutaneous fat content. For processing, chicken skin is usually minced (see page 56) and further processed into a fat emulsion before being added during chopping.

Fig. 17: Chicken skin to be removed from cuts and used as fat ingredient

The nutritional value of meat and meat products

a. Proteins

The nutritional value of meat is essentially related to the content of high quality **protein**. High quality proteins are characterized by the content of **essential aminoacids** which cannot be synthesized by our body but must be supplied through our food. In this respect the food prepared from meat has an advantage over those of plant origin. There are vegetable proteins having a fairly high **biological value** (see page 431), for instance soy protein, the biological value of which is about 65% of that of meat. Soy protein concentrates are also very useful ingredients in many processed meat products, where they not only enhance the nutritional value but primarily the water binding and fat emulsifying capacity (see page 80).

The contractile proteins or myofibrillar proteins are quantitatively the most important (some 65%) and are also qualitatively important as they have the **highest biological value**. Connective tissues contain mainly collagen, which has a **low biological value**. Elastin is completely indigestible. Collagen is **digestible** but is devoid of the essential aminoacid tryptophan.

Blood proteins have a high content of tryptophan but are nevertheless of a lower biological value than meat due to their deficiency of the essential aminoacid isoleucine.

b. Fats

Animal **fats** are principally triglycerides. The major contribution of fat to the diet is energy or calories. The fat content in the animal carcass varies from 8 to about 20% (the latter only in pork, see table 1). The fatty acid composition of the fatty tissues is very different in different locations. External fat (“body fat”) is much softer than the internal fat surrounding organs due to a higher content of **unsaturated** fat in the external parts.

The unsaturated fatty acids (linoleic, linolenic and arachidonic acid) are physiologically and nutritionally important as they are necessary constituents of cell walls, mitochondria and other intensively active metabolic sites of the living organism. The human body cannot readily produce any of the above fatty acids, hence they have to be made available in the diet. Meat and meat products are relatively good sources, but in some plant sources such as cereals and seeds, linoleic acid is usually present at about 20 times the concentration found in meat.

In recent years it has been suggested that a high ratio of unsaturated / saturated fatty acids in the diet is desirable as this may lower the individual's susceptibility to cardiovascular diseases in general, and to coronary heart disease in particular. There is evidence to indicate that a diet which predominantly contains **relatively saturated fats** (such as those of meat) raises the level of **cholesterol** in the blood. To avoid possible health risks from the consumption of the meat, vulnerable groups should reduce the animal fat intake.

In this context, the **"hiding" of high fat contents** in some processed meat products can be a dietary problem. Improved processing equipment and techniques and/or new or refined ingredients has made it possible to produce meat products with relatively high fat contents, which may be difficult to recognize by consumers. In particular in products like meat loaves, frankfurter type sausages or liver pate, where meat and fat are finely comminuted and the fat particles are enclosed in protein structures, the fat is difficult to detect visibly. Fat contents of up to 40% may be hidden this way, which is profitable for the producer as fat is a relatively cheap raw material. For some consumer groups, such diets are not recommended. On the other hand, there are many physically active hard working people or undernourished people, in particular in the developing world, where meat products with higher fat content may be beneficial in certain circumstances, predominantly as energy sources.

Fig. 18: Meat loaves with different fat contents; Left lower fat (20%) and right high fat (35%)

c. Vitamins

Meat and meat products are excellent sources of the B-complex vitamins (see table 2). Lean pork is the best food source of Thiamine (vitamin B_1) with more than 1 mg / 100 g as compared to lean beef, which contains only about 1/10 of this amount. The daily requirement for humans of this rarely occurring vitamin is 1-1.5 mg. Plant food has no vitamin B_{12}, hence meat is a good source of this vitamin for children, as in their organisms deposits of B_{12} have to be established. On the other hand, meat is poor in the fat soluble vitamins A, D, E, K and vitamin C. However, internal organs, especially liver and kidney generally contain an appreciable percentage of vitamin A, C, D, E and K. Most of the vitamins in meat are relatively stable during cooking or processing, although substantial amounts may be leached out in the drippings or broth. The drip exuding from the cut surface of frozen meat upon thawing also contains an appreciable portion of B-vitamins. This indicates the importance of conserving these fractions by making use of them in some way, for example through direct processing of the frozen meat without previous thawing (which is possible in modern meat processing equipment). Thiamine (vitamin B_1) and to a lesser extent vitamin B_6 are heat-labile. These vitamins are partially destroyed during cooking and canning.

Table 2: Average content of vitamins in meat (micrograms per 100g)

Food	B_1	B_2	B_6	B_{12}	A	C
Beef, lean, fried	100	260	380	2.7	20	1
Pork, lean, fried	700	360	420	0.8	10	1
Lamb, lean, fried	105	280	150	2.6	45	1
Veal, lean, fried	70	350	305	1.8	10	1
Pork liver, fried	260	2200	570	18.7	18000	24

d. Minerals

The mineral contents of meat (shown as “ash” in table 1) include calcium, phosphorus, sodium, potassium, chlorine, magnesium with the level of each of these minerals above 0.1%, and trace elements such as iron, copper, zinc and many others. Blood, liver, kidney, other red organs and to a lesser extent lean meat, in particular beef are good sources of iron. Iron intake is important to combat anaemia, which particularly in developing countries is still widespread amongst children and pregnant women. Iron in meat has a higher bio-availability, better resorption and metabolism than iron in plant products.

PRINCIPLES OF MEAT PROCESSING TECHNOLOGY

MEAT PROCESSING TECHNOLOGY

Meat processing technology comprises the steps and procedures in the **manufacture of processed meat products**. Processed meat products, which include various different types and local/regional variations, are food of animal origin, which contribute valuable animal proteins to human diets. Animal tissues, in the first place *muscle meat* and *fat*, are the main ingredients, besides occasionally used other tissues such as *internal organs*, *skins* and *blood* or *ingredients of plant origin*.

All processed meat products have been in one way or another physically and/or chemically treated. These treatments go beyond the simple cutting of meat into meat cuts or meat pieces with subsequent cooking for meat dishes in order to make the meat palatable. Meat processing involves a wide range of **physical and chemical treatment methods**, normally combining a variety of methods. Meat processing technologies include:

- **Cutting/chopping/comminuting** (size reduction)
- **Mixing/tumbling**
- **Salting/curing**
- **Utilization of spices/non-meat additives**
- **Stuffing/filling into casings or other containers**
- **Fermentation and drying**
- **Heat treatment** (see separate chapter page 87)
- **Smoking**

EQUIPMENT USED IN MEAT PROCESSING

In modern meat processing, most of the processing steps can be mechanized. In fact, modern meat processing would not be possible without the utilization of specialized equipment. Such equipment is available for small-scale, medium-sized or large-scale operations. The major items of meat processing equipment needed to fabricate the most commonly known meat products are listed and briefly described hereunder.

Meat grinder (Mincer) (see also page 301)

A meat grinder is a machine used to force meat or meat trimmings by means of a feeding worm (auger) under pressure through a horizontally mounted cylinder (barrel). At the end of the barrel there is a cutting system consisting of star-shaped knives rotating with the feeding worm and stationary perforated discs (grinding plates). The perforations of the grinding plates normally range from 1 to 13mm. The meat is compressed by the rotating feeding auger, pushed through the cutting system and extrudes through the holes in the grinding plates after being cut by the revolving star knives. Simple equipment has only one star knife and grinder plate, but normally a series of plates and rotary knives is used. The degree of mincing is determined by the size of the holes in the last grinding plate. If frozen meat and meat rich in connective tissue is to be minced to small particles, it should be minced first through a coarse disc followed by a second operation to the desired size. Two different types of cutting systems are available, the “Enterprise System” and the “Unger System”:

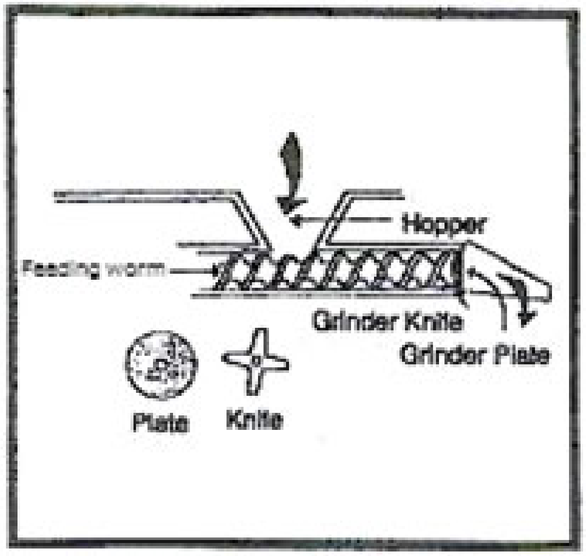


Fig. 19: Schematic drawing of grinder

- The “Enterprise System” (Fig. 19) is mainly used in smaller meat grinders with orifice diameters up to 98 mm and consists of one star knife, sharpened only on the side facing the disc, and one grinder plate. Hole diameters can vary from 13 to 5 mm.
- The “Unger System” (Fig. 20) is used in meat grinders with orifice diameters up to 440 mm and consists of the kidney plate, one or two star knives sharpened on both edges and one or two grinder plates.

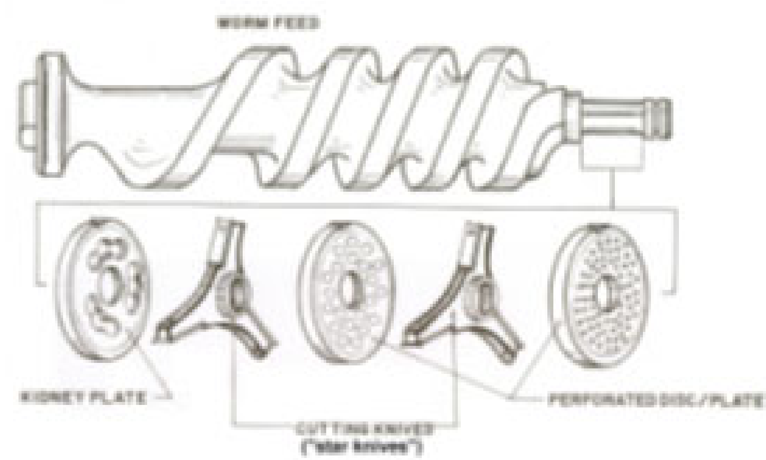


Fig. 20: Grinder: Worm feed (feeding worm / auger) and cutting set with plates and knives (system “Unger”)

For a final particle size above 8 mm the recommended setting is kidney plate – star knife – grinder plate. For a final particle size <8 mm the recommended setting is kidney plate – star knife – grinder plate (13 mm) – star knife – grinder plate (6 to 1 mm) (Fig. 21).

Fig. 21: Grinder plates of different hole size, star knives and spacer rings for tightening of cutting assembly

The smallest type of meat grinder is the **manual grinder** (Fig. 22) designed as a simple stuffing grinder, i.e. meat material is manually stuffed into the feeder. For all these small machines the Enterprise cutting system is used with one star knife and one grinder plate. These machines are very common everywhere in food processing but their throughput and production capacity is limited due to the small size and manual operation.

The intermediate size meat grinder, also designed as a **stuffing grinder**, has orifice diameters up to 98 mm. It is driven by a built-in single-phase electrical motor (250 V) and available as both a table and floor model. The meat is put onto the tray and continuously fed by hand into a vertical cylindrical hole leading to the feed auger. The meat or fat is forced by its own weight into the barrel with the rotating feed auger. This type of meat grinder is the most suitable for commercial small-scale operations. Some brands use the Enterprise cutting system, others the Unger system (Fig. 23, 24).

Fig. 22: Manual grinder

Fig. 23: Grinder as table model

Fig. 24: Grinder as floor model

Large **industrial meat grinders** are driven by a three-phase electrical motor (400 V) and equipped with the Unger cutting system. The orifice cylinder diameter of this type of grinder ranges from 114 - 400 mm. Industrial grinders are either designed as stuffing grinders with either tray or hopper or as an automatic mixing grinder. The automatic mixing grinder has a big hopper and the meat falls automatically onto the mixing blades and the feeding worm (auger). The mixing blades and feeding worm can be operated independently with mixing blades rotating in both directions but the feeding worm only towards the cutting set. Most of the industrial meat grinders are also equipped with a device for separating tendons, bone particles and cartilage.

Bowl cutter (bowl chopper) (see also page 303)

The bowl cutter (Fig. 25, 26, 28, 29) is the commonly used meat chopping equipment designed to produce small or very small ("finely comminuted") lean meat and fat particles. Bowl cutters consist of a horizontally revolving bowl and a set of curved knives rotating vertically on a horizontal axle at high speeds of up to 5,000 rpm. Many types and sizes exist with bowl volumes ranging from 10 to 2000 litres. The most useful size for small- to medium-size processing is 20 to 60 litres. In bigger models bowl and knife speed can be regulated by changing gears. Bowl cutters are equipped with a strong cover. This lid protects against accidents and its design plays a crucial role in the efficiency of the chopping process by routing the mixture flow. Number, shape, arrangement, and speed of knives are the main factors determining the performance of the cutter (see page 304). Bowl cutters should be equipped with a thermometer displaying the temperature of the meat mixture in the bowl during chopping.

Fig. 25: Small 20 litre bowl cutter, single-phase motor

Fig. 26: Bowl cutter assembled with 6 knives

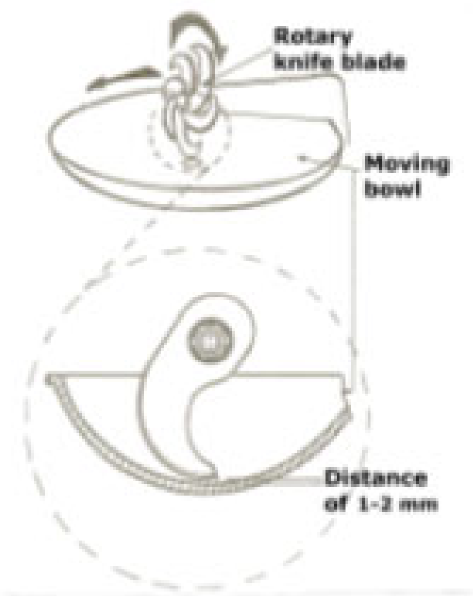


Fig. 27: Bowl cutter, schematic

Fig. 29: Bowl cutter–grinder combination (twin model) with bowl cutter (60 litres capacity) and meat grinder (114 mm orifice diameter)

Fig. 28: Bowl cutter filled with meat for chopping

Fig. 30: Vacuum cutter; lid can be hermetically closed for vacuum treatment of batter in the bowl

Modern large scale bowl cutters may have devices to operate under a vacuum (Fig. 30), which helps to improve colour and texture of the meat products by keeping oxygen out of the meat mixes and avoid air pockets. Cutter knives should be adjusted to a distance of 1-2 mm from the bowl (Fig. 27) for optimal cutting (check the manufacturers recommendations for each model). Most of the large and high-speed bowl cutters are equipped with mechanical discharger devices for emptying the cutter. The process of chopping in a bowl cutter is used for producing fine comminuted products such as frankfurters, bologna, liver sausage etc., and enables processors to offer a much wider range of products.

Filling machine ("sausage stuffer") (see also page 306)

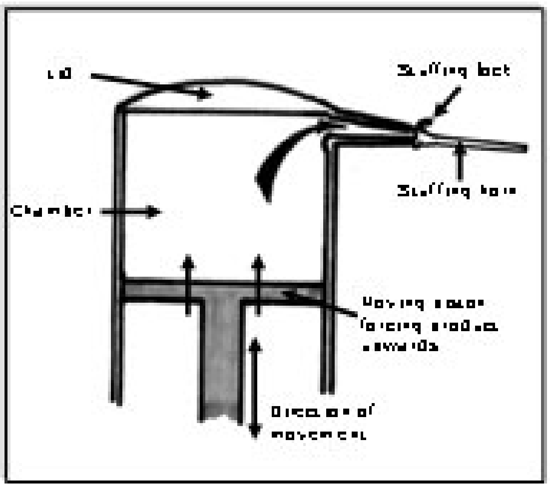


Fig. 31: Piston stuffer, schematic

These machines are used for filling all types of meat batter in containers such as casings, glass jars, cans etc. The most common type of filling machine in small and medium size operations is the piston type. A piston is moved (Fig. 31) inside a cylinder forcing the meat material through the filling nozzle (funnel, stuffing horn) into the containers. Piston stuffers are either attached to the filling table (Fig. 32; manual) or designed as floor models (Fig. 33; hydraulic). In small-scale operations manual stuffers are usually sufficient, sometimes even simple hand-held funnels are used (Fig. 412) to push meat mixes into casings.

Fig. 32: Manual piston stuffer (10 litres)

Fig. 33: Piston stuffer (20 litres) with different size filling funnels

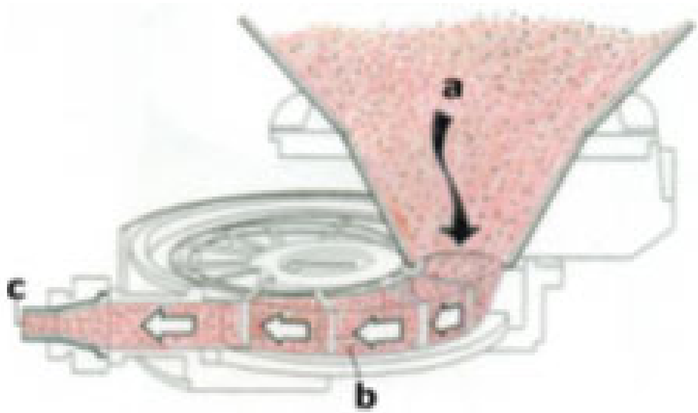


Fig. 34: Principle of continuous stuffer (can also be operated with vacuum)
a = Hopper (recipient for meat mix), b = Rotating transport segments for meat mix
c = to filling nozzle; pink colour = meat mix (transport flow)

Modern filling machines for larger operations are designed as continuous vacuum stuffers (Fig. 34). During the filling process a substantial part of the enclosed air is removed from the product, which helps to improve colour and texture of the finished products. These models are usually equipped with a portioning and twisting devise and have a casing grip devise attached for filling of ”shirred” (folded) uncut collagen and plastic casings. This type of continuous filling equipment is relatively expensive and are thus not used in small- to medium-size operations.

Clipping machine

Fig. 35: Manually operated sausage clipping machine with clip rails (left)

Clipping machines place small aluminium sealing clips on the sausage ends and replace the manual tying of sausages. They can be used for artificial or natural casings. Clipping machines can also be connected to filling machines. Such machines work with so called casing brakes, which are devices for slow release of the shirred casings from the filling horns ensuring tight filling. Then the filled casing segments are clipped in portions. So called double clipping machines place two clips next to each other, which ensures that the individual sausage portions remain clipped on both ends and easy separation of the sausage portions is possible. When using shirred casings (see page 263), the time consuming loading of pre-cut casings is no longer necessary. Wastage of casings can be reduced to a minimum by tight filling and leaving only as much casing for the sausage end as needed for the placing of the clips.

Clipping machines are mainly used in larger operations and in most cases operated by compressed air. For medium-scale operations manually operated hand clippers are available (Fig. 35).

Smokehouses (see also page 310)

Simple smokehouses are used for smoking only (Fig. 36, 37). In **traditional** and small-scale operations the most common methods of smoke generation include burning damp hardwood sawdust, heating dry sawdust or heating pieces of log. But technological progress has changed the **smoke generation** and application techniques. Methods used in **modern** meat processing include the following:

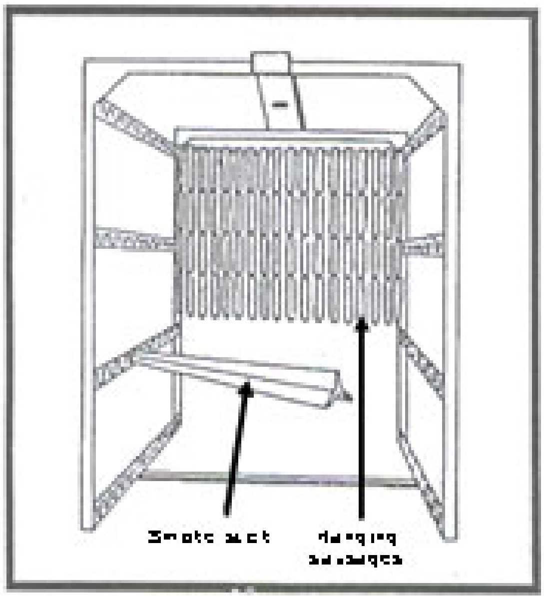


Fig. 36: Arrangement of sausages for smoking inside smokehouse, schematic

Fig. 37: Small-scale smokehouse (sawdust is placed on the smouldering tray)

Burning / smouldering of saw dust (Fig. 38)

In modern smokehouses (1), smoke generation takes place outside the smoking chamber in special smoke generators with electrical or gas ignition (4). Separate smoke generators allow better control of the quantity and temperature of the smoke produced. The sawdust or chip material (3) is moved from the receptacle to the burning zone (4) by a stirrer or shaker (3). It is ignited by means of an electrically heated plate or by gas flame. A smoke stripper, which is basically a cold water spray, can be placed in the initial part of the smoke pipe and serves to increase the purity of the smoke as undesirable substances are washed out. Smoke with a high degree of desirable smoke components can be obtained in the low temperature range of thermal destruction of saw dust beginning at around 230°C and not exceeding 400°C. The smoke is conveyed directly from the generator to the smoking chamber (Fig. 38(1), 41) via a smoke pipe (2). The burned sawdust is collected at the bottom (5).

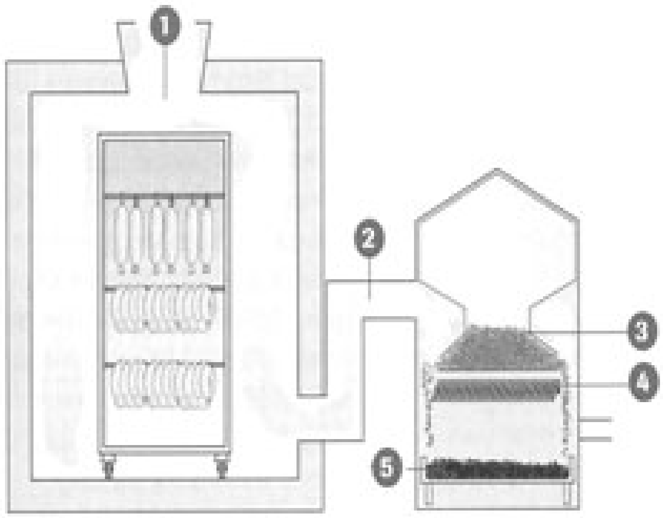


Fig. 38: Smokehouse with generator for sawdust smoldering

Smoke generation through friction (Fig. 39)

Timber (3), which is pressed (1) against a fast-rotating steel drum (4) results in pyrolysis of the wood in the favourable temperature range of 300°C to 400°C. The flameless, light, dense and aromatic smoke contains a large proportion of desirable smoking substances and a low proportion of tars. The smoke is conveyed (2) into the smoking chamber. The creation of smoke can be commenced and completed in a matter of seconds. The operation of this type of smoke generators is usually carried out in a discontinuous manner. The smoke quantity and quality can be regulated by changing the speed and time of rotation. As this type of smoke can be produced at relatively low temperatures, it does not carry high amounts of hazardous substances such as benzopyrene (see page 40).

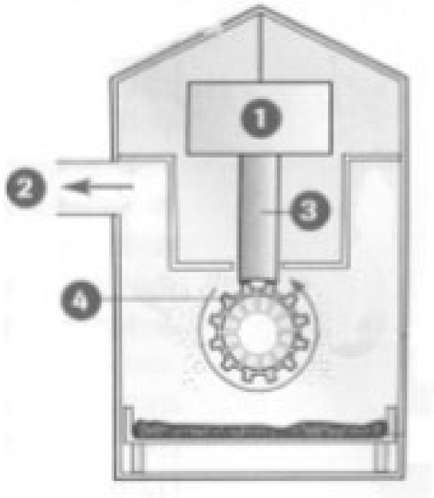


Fig. 39: Friction smoke generator

Smoke generation through steam (Fig. 40)

Overheated steam (3) at approximately 300°C is injected into a compact layer of sawdust (4), which causes thermal destruction of the wood and smoke is generated. This method allows the control of smoke generation temperature by choosing the adequate steam temperature. Impurities in the smoke caused by particles of tar or ash are minimal. The steam-smoke mixture condensates extremely quickly and intensively on the surface and inside the sausage products and produces the desired smoking colour and flavour. No connection to the chimney is required as smoke particles not entering the products settle down in the condensing steam. The condensed water is conducted to the effluent system. Other details of the system are: Hopper and conveyer for sawdust (1,2), smoke duct to smoking chamber (5), ashes (6).

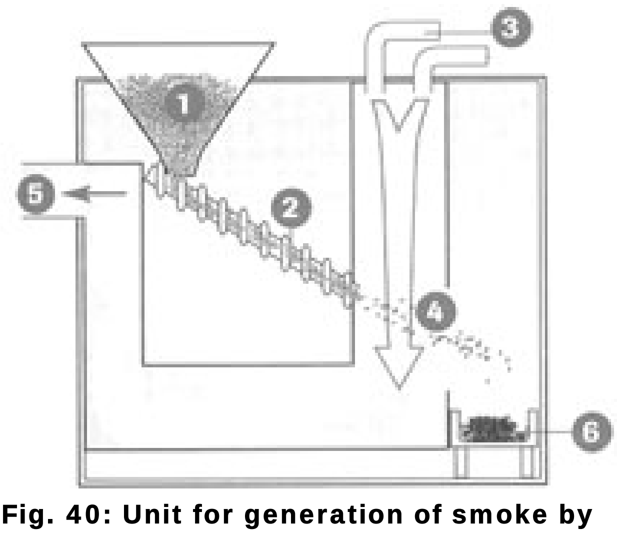


Fig. 40: Unit for generation of smoke by steam

Combined equipment

Modern facilities can combine smoking, cooking and cooling operations for meat products in one continuous process. By means of automatic stirring systems processing parameters such as smoke generation, temperature (up to 100°C) and relative humidity (up to 100%) required to dry, smoke, or steam-cook any type of product, can be pre-set. With additional refrigerated units installed in the smokehouse, it is also possible to use it as a fermenting/ripening room for the first crucial steps in production of fermented sausages or raw ham products, where air temperature and air humidity have to be accurately controlled (see page 123, 177).

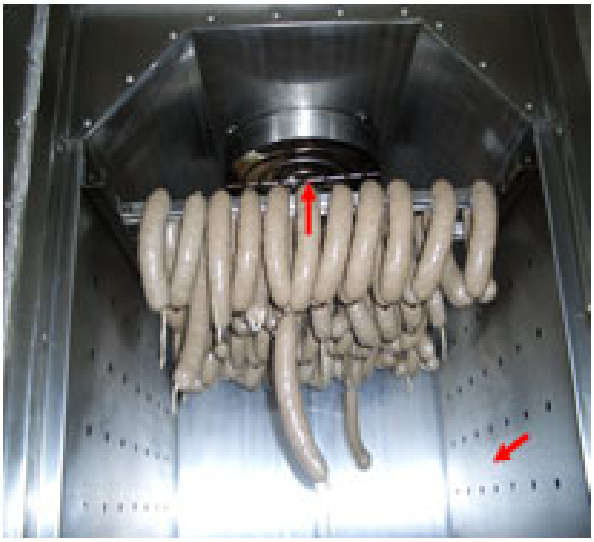


Fig. 41: Small smokehouse, inside view, air/smoke circulation forced by extraction fan on top (arrow) and re-circulated through openings in double jacket side wall (arrow)

Fig. 42: Smokehouse with sausages ready for smoking

Brine injector

This equipment serves for the injection of brine into meat. Brine is water containing dissolved salt and curing substances (nitrite) as well as additives such as phosphates, spices, sugar, carrageenan and/or soy proteins (see page 179). The injection is done by introducing pointed needles into the muscle tissue. Brine injection is mainly used for the various types of ham, bacon and other whole muscle products.

Brine injectors are available in different sizes from manually operated single-needle devices (Fig. 43, 44) for small-scale operations to semi-automated brine injectors with up to 32 needles and more (Fig. 45, 46). In large machines the quantity of brine injected into the fresh meat can be determined by pre-setting of pressure and speed. It is very important that all parts of the brine injectors are thoroughly cleaned after every working session and disinfected regularly. Before the injector is used again all hoses and needles should be rinsed with warm water as particles left in the system can block the needles. Absolute cleanliness is necessary as microorganisms remaining in the system would be injected deep into the meat pieces during the operation.

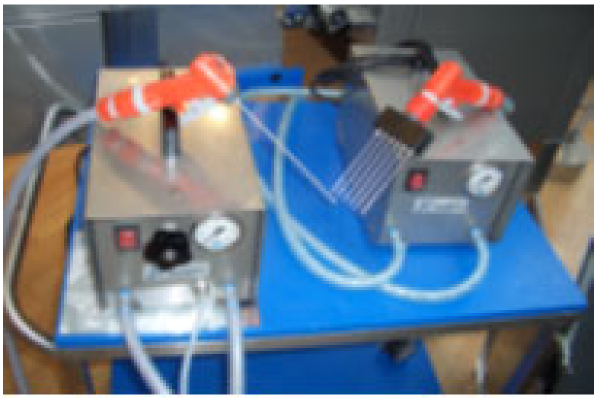


Fig. 43: Brine injectors, pump driven, manually operated, with single needle (left) and multi needle device (right)

Fig. 44: Manual pump type injector (left), syringe type injector (right)

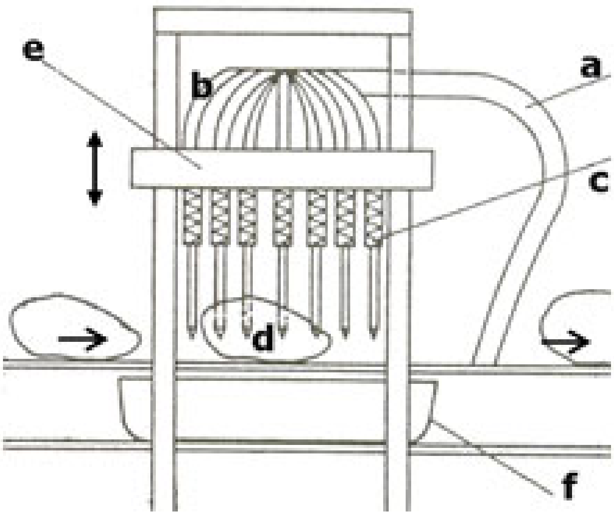


Fig. 45: Multi-needle injector, schematic a - Main brine supply pipe, b - Brine distribution pipe, c - Injection needle, d - Meat piece to be injected, e - Sliding needle holder, f - Excess brine collection pan

Fig. 46: Multi-needle injector, semi-automated

Tumbler or Massager

Tumblers (Fig. 47) are used for the processing of meat products such as whole-muscle or reconstituted hams. Such machines resemble in principle a drum concrete mixer. A rotating drum with steel paddles inside slowly moves the meat pieces thus causing a mechanical massaging effect. This mechanical process is assisted by the addition of salt and phosphates to achieve equal brine distribution and liberates muscular protein from the meat tissue (protein extraction). The semi-liquid protein substances join the meat pieces firmly together during later heat treatment (see page 184, 185). For hygienic reasons it is important to place the tumbler below 10^{o}C to avoid excessive microbial growth during lengthy tumbling times (more then 4 hours or even over night). In specific cases it is recommended that the tumbler should be operated refrigerated (Fig. 48, 49) or inside a cold room below -1°C, as these temperatures are best to extract as much soluble protein as possible from the muscle meat.

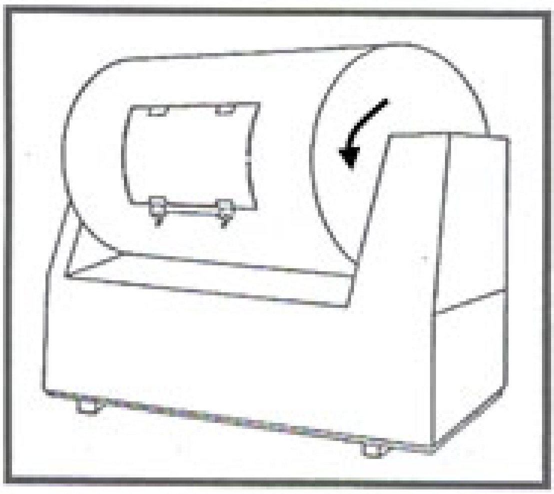


Fig. 47: Tumbler, schematic

Fig. 48: Tumbler with double jacket for refrigeration and vacuum pump / motor device

Fig. 49: Tumbler inside mobile refrigerated housing

Vacuum packaging machine

For vacuum packaging the meat product has to be placed into a vacuum bag (multi-layer synthetic bag, see page 270). Air is removed from the bag by means of the vacuum packaging machine (Fig. 50) and the bag then sealed (see page 273). Special vacuum packaging machines can operate with so called gas-flushing, where a mixture of gas is injected after evacuating the air. Such protective gas atmospheres inside the product package inhibit bacterial growth and stabilize the meat colour. The gas mixtures usually contain CO_2 and N_2 (see page 275).

Fig. 50: Vacuum packaging machine (table model)

Mixer / blender

Mixers are used to blend meat and spices, or coarse and finely chopped meat. The machine generally consists of a rectangular or round bottom vessel through which two parallel shafts operate (Fig. 51). Various paddles are mounted on those shafts to mix the meat. The mixer is discharged through tilting by 90 degrees. Some mixers are designed as vacuum mixers (Fig. 52), as the mixing under vacuum (exclusion of oxygen) has advantages for the development of desirable product colour and texture.

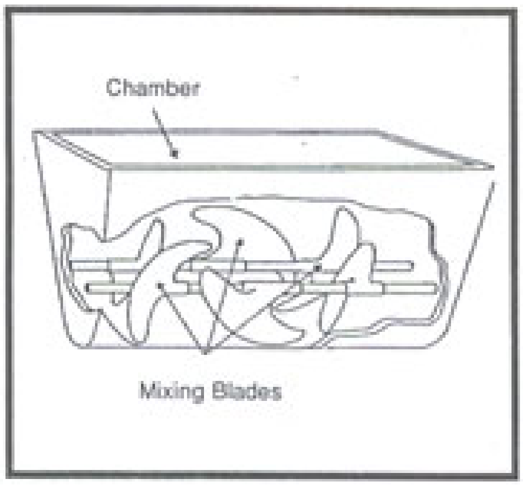


Fig. 51: Blender, schematic

Fig. 52: Blender with lid for hermetic closure for vacuum treatment; can be declined for emptying

Emulsifying machine (colloid mill)

The emulsifier (Fig. 53, 54) serves for the preparation of very fine meat emulsions. Its functional parts are a perforated plate, attached to which two edged blades are rotating (rotor blade) (Fig. 55). Next to the blades there is a centrifugal pump that forces the pre-ground meat through the perforated plate. Most emulsifiers are vertical units. Compared to the bowl cutter the emulsifier operates at much higher speed, producing a finer emulsion-like mix. The emulsifier is also perfectly suited to produce semi-processed products such as pig skin emulsions (see page 32).

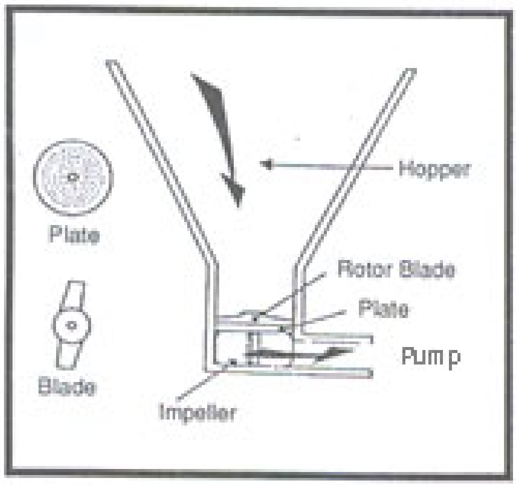


Fig. 53: Emulsifying machine, schematic

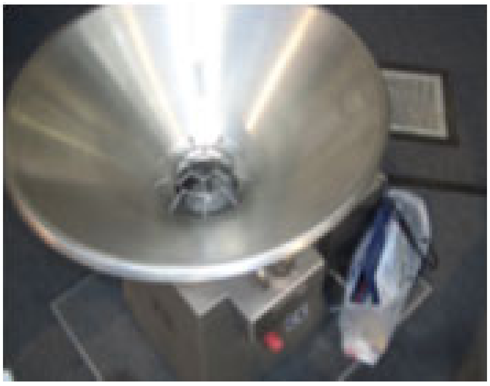


Fig. 54: Emulsifying machine (top down view)

Fig. 55: Emulsifying machine (plate and rotating blade)

Ice flaker

In these machines (Fig. 56) ice flakes are continuously produced from potable water. Ice is needed in meat processing for some types of meat products. Water, added in the form of ice, is an important ingredient in order to enhance protein solution (see page 128) and to keep the temperature of the meat batter low. Ice flakers with in-built UV-water-disinfection device are available for areas with unsafe water supply.

Fig. 56: Ice flaker with storage compartment

Frozen meat cutter

The purpose of cutting frozen meat blocks into smaller pieces is to make frozen meat suitable for immediate comminuting in grinders, bowl cutters etc. without previous thawing. There are two types of machines for the cutting of frozen meat blocks, working either with knives cutting in vertical direction (guillotine principle) or using rotating drums with attached sharp knives. In the guillotine-type machines a knife head is driven hydraulically and even the hardest frozen products can be cut into small pieces, either meat cubes or meat strips. Rotary frozen meat cutters (Fig. 57) operate according to the principle of carving out particles from the frozen meat blocks. The rotary drums can be equipped with knives capable of cutting out pieces of frozen meat from large fist-size to small chip-size.

Fig. 57: Frozen meat cutter with rotating round knives for cutting out pieces/chips from frozen meat blocks

MEAT PROCESSING TECHNOLOGIES – STANDARD PRACTICES

Meat processing technologies include on the one hand purely technical processes such as

- Cutting, chopping, comminuting
- Mixing, tumbling
- Stuffing/filling of semi-fabricated meat mixes into casings, synthetic films, cans etc.
- Heat treatment

On the other hand, chemical or biochemical processes, which often go together with the technical processes, are also part of meat processing technology such as

- Salting and curing
- Utilization of spices and additives
- Smoking
- Fermentation and drying

These processes are described hereunder and in the following chapters.

1. Cutting (reducing meat particle size)

There are five methods of mechanical meat cutting for which specialized machinery is used:

Mincing (grinding) of lean and fatty animal tissues (Fig. 58)
Larger pieces of soft edible animal tissues can be reduced in size by passing them through meat grinders. Some specially designed grinders can also cut frozen meat, others are equipped with devices to separate “hard” tissues such as tendons and bone particles from the “soft” tissues (minced muscle meat particles) (see page 18, 301).

Chopping animal tissues in bowl cutter (discontinuous process) (Fig. 59)
Bowl cutters are used to chop and mix fresh or frozen lean meat, fat (and/or edible offal, if required) together with water (often used in form of ice), functional ingredients (salt, curing agents, additives) and extenders (fillers and/or binders) (see page 20, 111, 137, 151, 157)

Fig. 58: Mincing of raw meat material for processed meat products in meat grinders

Fig. 59: Chopping of meat mixture in bowl cutter; lid opened after finalizing chopping, cutter knives visible

Chopping animal tissues in emulsifying machines (continuous process)
The animal tissues to be emulsified must be pre-mixed with all other raw materials, functional ingredients and seasonings and pre-cut using grinders or bowl cutters. Thereafter they are passed through emulsifiers (also called colloid mills) in order to achieve the desired build-up of a very finely chopped or emulsified meat mix (see page 30).

Frozen meat cutting
Boneless frozen meat blocks can be cut in slices, cubes or flakes by frozen meat cutters or flakers. The frozen meat particles (2-10 cm) can be directly chopped in bowl cutters without previous thawing thus avoiding drip losses, bacterial growth and discoloration which would happen during thawing (see page 31). For small operations the manual cutting of frozen meat using cleavers or axes is also possible.

Cutting of fatty tissues
Back fat is cut in cubes of 2-4 cm on specialized machines to facilitate the subsequent chopping in cutters/emulsifiers. In small-scale operations this process can be done manually.

2. Salting / curing

Salting – Salt (sodium chloride NaCl) adds to the **taste** of the final product. The content of salt in sausages, hams, corned beef and similar products is normally 1.5-3%. Solely common salt is used if the cooked products shall have a greyish or greyish-brown colour as for example steaks, meat balls or "white" sausages (see box page 33). For production of a red colour in meat products see "Curing" (page 34).

Chemical aspects of salting

The water **holding capacity** of meat can be increased with the addition of salt up to a concentration of about **5%** in lean meat and then decreases constantly. At a concentration of about 11% in the meat, the water binding capacity is back to the same level as in fresh unsalted meat.

Sodium chloride has only a very low capacity to destroy microorganisms, thus almost **no bacteriological effect**. Its **preserving power** is attributed to the capability to bind water and to deprive the meat of moisture. The water loosely bound to the protein molecules as well as "free" water will be attracted by the sodium and chloride ions causing a reduction of the water activity (a_w) (see page 323) of the product. This means that less water will be available and the environment will be less favourable for the growth of microorganisms. Bacteria do **not** grow at a water activity **below 0.91**, which corresponds to a solution of **15g NaCl/100 ml water** or about 15% salt in the product. These figures explain how salt has its preservative effect. Such salt concentrations (up to 15%) are too high for palatable food. However, for the preservation of natural casings this method is very useful

Heat treatment of meat salted with NaCl results in conversion of the red meat pigment **myoglobin** (Fe^{+2}) to the brown **metmyoglobin** (Fe^{+3}). The colour of such meat turns brown to grey (see Fig. 60, 61).

Besides adding to flavour and taste, salt also is an important functional ingredient in the meat industry, which assists in the extraction of soluble muscle proteins. This property is used for **water binding** and **texture** formation in certain meat products (see page 129, 184).

The **preservation** effect, which is microbial inhibition and extension of the shelf-life of meat products by salt in its concentrations used for food (on average 1.5-3% salt), is low. Meat processors should not rely too much on this effect (see box page 33) unless it is combined with other preservation methods such as reduction of moisture or heat treatment.

Curing – Consumers associate the majority of processed meat products like hams, bacon, and most sausages with an attractive pink or red colour after heat treatment. However experience shows that meat or meat mixes, after kitchen-style cooking or frying, turn brownish-grey or grey. In order to achieve the desired red or pink colour, meat or meat mixes are salted with common salt (**sodium chloride NaCl**), which contains a small quantity of the curing agent **sodium nitrite ($NaNO_2$).** Sodium nitrite has the ability to react with the red meat pigment to form the heat stable red curing colour (for details see box page 35, 68). Only very small amounts of the nitrite are needed for this purpose (Fig. 60, 61, 88).

Fig. 60: Pieces of cooked meat (pork) 4 pieces with common salt only (right) and 3 with common salt containing small amounts of nitrite (left)

Fig. 61: Two sausage cuts One produced with salt only (right) and the other with salt and small amounts of nitrite (left)

Nitrite can be safely used in tiny concentrations for food preservation and colouring purposes. Traces of nitrite are not poisonous. In addition to the reddening effect, they have a number of additional beneficial impacts (see below) so that the meat industries widely depend on this substance. Levels of 150 mg/kg in the meat product, which is 0.015%, are normally sufficient.

To reduce the risk of overdosing of nitrite salt, a safe approach is to make nitrite available only in a homogeneous mixture with common salt generally in the proportion **0.5% nitrite** and the balance of **sodium chloride (99.5%)**. This mixture is called **nitrite curing salt.** At a common dosage level of 1.5-3% added to the meat product, the desired salty flavour is achieved and at the same time the small amount of nitrite needed for the curing reaction is also provided. Due to the sensory limits of salt addition (salt contents of 4% are normally not exceeded), the amounts of nitrite are kept low accordingly.

Chemical and toxicological aspects of curing

In meat or meat mixes to be cured the nitrite curing salt must be evenly distributed (relevant techniques see page 37, 38, 39, 134, 173, 179)). During mixing the nitrite is brought in close contact with the muscle tissue and its red meat pigment, the myoglobin. Due to the acidification in meat after slaughter (see page 4), the pH of such meat or meat mixes is always below 7, which means slightly acidic. The acidity may be enhanced through curing accelerators such as ascorbic acid or erythorbate (see page 37, 68).

Nitrite **($NaNO_2$)**, or rather nitrogen oxide, NO, which is formed from nitrite in an acid environment, combines with **myoglobin** to form **nitrosomyoglobin**, a bright red compound. The nitrosomyoglobin is **heat stable** i.e. when the meat is heat treated the bright red colour remains. The addition of nitrite curing salt in quantities of approximately 2%, which is the usual salt level, generates a nitrite content in the meat products of approximately 150ppm (parts per million or 150 mg/kg). This nitrite content is **not toxic** for consumers. Upon reaction of the nitrite with the myoglobin (which is the genuine curing reaction), there will be on average a residual level of nitrite of 50-100ppm remaining in the product. In any case the amount of residual nitrite in the finished product should not exceed 125ppm. The maximum ingoing amount for processed meat products is normally up to 200mg/kg of product (Codex Alimentarius, 1991).

Apart from its poisoning potential (which is unlikely when using nitrite curing salt), there is a debate concerning the possible health hazards of nitrite curing as under certain conditions nitrite can form **nitrosamines**, some of which can be carcinogenic in the long term. However, nitrosamines can only be found in strongly cooked or fried meat products which were previously cured with nitrite. Fresh meat for cooking (see page 90) and fresh burgers or sausages for frying (see page 103) do usually not contain nitrite but salt only. Hence the risk of formation of nitrosamines does not exist in such products. One product, where such conditions may be met, is bacon. Keeping the residual nitrite content low in bacon minimizes the risk of formation of nitrosamines.

Sodium or potassium nitrate (Na/KNO_3) ("saltpetre") may also be used for curing but it is limited to certain dry cured products such as raw hams, which require long curing and aging periods. Nitrate must be broken down by bacteria to nitrite, which is the substance to react through its NO with the muscle pigment myoglobin. The bacterial process is rather slow and time consuming. As most products require an immediate curing effect, the nitrite is the substance of choice in most cases and there is little use for nitrate (see also page 119).

A great deal of research has been done with regard to the utilization of nitrite and it can be said that nitrite in meat products is safe if basic rules (see box page 35) are adhered to. Nitrite is now recognized a substance with multifunctional beneficial properties in meat processing:

- The primary purpose of nitrite is to create a **heat resistant red** colour in a chemical reaction with the muscle pigment, which makes cured meat products attractive for consumers.
- Nitrite has a certain **inhibitory effect on the growth of bacteria**. This effect is particularly pronounced in canned meat products which are usually stored without refrigeration, where small numbers of heat resistant bacteria may have survived but their growth is inhibited by the presence of nitrite (see also page 77).
- Nitrite has the potential of **attributing a specific desirable curing flavour** to cured products.
- In the presence of nitrite **fats are stabilized** and rancidity in meat products retarded i.e., an antioxidant effect.

Many attempts have been made to replace nitrite by other substances, which would bring about the same beneficial effects as listed above. Up to now no alternative substance has been found. As the above desirable effects are achieved with extremely low levels of nitrite, the substance can be considered safe from the health point of view. Currently the known advantages of nitrite outweigh the known risks.

Curing of chopped/comminuted meat mixtures

Curing is applied for most **chopped meat mixtures** or **sausage mixes** for which a reddish colour is desired. The curing agent nitrite is added in **dry form** as nitrite curing salt (Fig. 62). The reaction of nitrite with the red meat pigment starts **immediately**. Due to homogenous blending the meat pigments have instant contact with the nitrite. Higher temperatures during processing, e.g. "reddening" of raw-cooked type sausages at 50°C or scalding/cooking of other products at 70-80°C, accelerate the process.

Another accelerating or "catalytic" effect is the addition of **ascorbic acid**, which slightly lowers the pH of the meat mixture. However, the dosage of ascorbic acid must be low (0.05%), just to provide the slightly acid conditions for the reduction of $NaNO_2$ to NO. A pronounced reduction of the pH would negatively affect the water binding capacity of the product which is not desirable.

Fig. 62: Adding of nitrite curing salt during initial phase of meat mix fabrication

Curing of entire meat pieces

Besides the curing of chopped meat mixtures, **entire pieces of muscle meat** can be cured. However, due to size the curing substances cannot instantly react with the meat pigments as is the case in chopped meat mixes. Hence various curing techniques are applied.

The final products of curing entire meat pieces are either **cured raw fermented products** or **cured cooked products** (see page 98). The curing system to be used depends on the nature of the final product (uncooked or cooked). There are two systems for curing entire meat pieces, dry curing and wet curing ("pickling") and the type of the final product determines which system will used.

In **dry curing** a curing mix is prepared containing salt or nitrite curing salt, together with spices and other additives. The pieces of meat are rubbed with this curing mix (Fig. 63, 64, 214, 215) and packed in tanks. The curing mix gradually permeates into the meat, which can be a lengthy process ranging from several days to several weeks. For more details see page 173).

Dry curing is exclusively used for the fabrication of cured raw fermented products, in particular those with a long ripening period.

Fig. 63: Application of dry curing mix (curing salt, curing accelerators, spices) on fresh ham (pork leg)

Fig. 64: Ham is uniformly covered by curing mix

The second method of curing meat pieces is **wet curing**, also called **pickling**, which involves the application of **curing brine** to the meat. For the manufacture of the brine, curing salt and spices, and other additives if required are dissolved in water (see page 179). The meat cuts are packed in tanks and brine is added until all pieces are **completely covered** (Fig. 65). A temperature of +8 to +10°C for the curing room is recommended as lower temperatures may retard curing. For equal penetration of the brine, the meat is cured for periods ranging from several days to two weeks depending on the size of the cuts and curing conditions. After completion of the curing, ripening periods for the products follow for taste and flavour build-up (for more details see page 175).

Fig. 65: Wet curing

Wet curing by immersion of meat pieces in brine is primarily used for the fabrication of cured raw fermented products with shorter ripening periods.

An alternative and quick way of wet curing is to accelerate the diffusion of the curing substances by pumping brine into the meat tissue ("**injection curing**"). For this purpose brine injectors with perforated hollow needles are used. The injection of brine into the muscles can be done manually by using simple pumping devices (Fig. 43, 44, 66, 67). At the industrial level semi-automatic multi-needle brine injectors (Fig. 45, 46, 68) are used which achieve very even distribution of the curing ingredients and can reduce the curing period (equal distribution of the curing substances or "'resting period") to less than 48 hours.

Fig. 66: Manual brine injection using a large syringe

Fig. 67: Brine injection with a manual curing pump

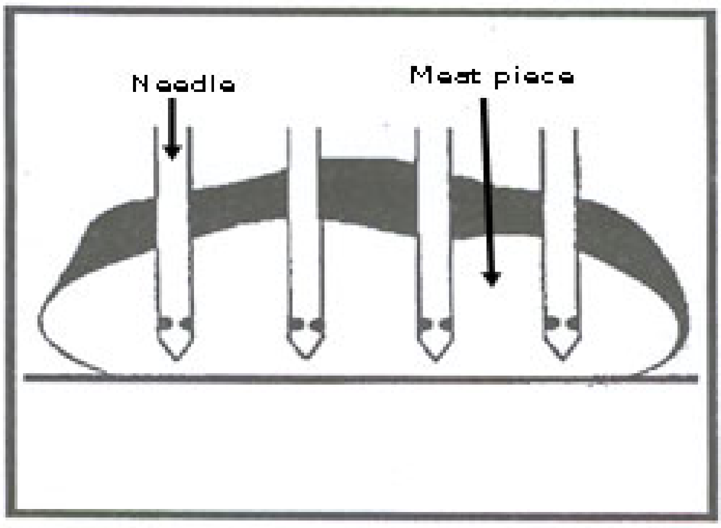


Fig. 68: Multi-needle brine injection (principle)

In addition, most injection cured meat pieces which are to be processed into cured-cooked products (such as cooked hams etc), are submitted to a tumbling process (see page 28, 184). Tumbling further accelerates the brine penetration throughout the meat prices and “resting periods” are not necessary.

Wet curing by brine injection is used for the fabrication of cured cooked products (see page 177).

3. Smoking

Smoke for treatment of meat products is produced from raw wood. Smoke is generated through the thermal destruction of the wood components **lignin** and **cellulose**. The thermal destruction sets free more than **1000** desirable or undesirable firm, liquid or gaseous components of wood.

These useful components contribute to the development of the following desirable effects on processed meat products:

- Meat preservation through aldehydes, phenols and acids (anti-microbial effect)
- Antioxidant impact through phenols and aldehydes (retarding fat oxidation)
- Smoke flavour through phenols, carbonyls and others (smoking taste)
- Smoke colour formation through carbonyls and aldehydes (attractive colour)
- Surface hardening of sausages/casings through aldehydes (in particular for more rigid structure of the casing)

The most known **undesirable effect** of smoking is the risk of **residues of benzopyrene** in smoked products which can be carcinogenic if the intake is in high doses over long periods. With normal eating habits, a carcinogenic risk is normally not associated with moderately smoked food such as smoked meat products.

Depending on the product, smoke is applied at different temperatures. There are two principal smoking techniques:

- Cold smoking
- Hot smoking

The principle of both methods is that the smoke infiltrates the outside layers of the product in order to develop flavour, colour and a certain preservation effect.

Cold Smoking – This is the traditional way of smoking of meat products and was primarily used for **meat preservation**. Nowadays it serves more for **flavour** and **colour formation**, for example in sausages made from precooked materials such as liver sausage and blood sausage (see page 153, 161).

The combination of cold smoking and drying/ripening can be applied to fermented sausages (see page 124) and salted or cured entire meat pieces (see page 176), in particular many raw ham products. In long-term ripened and dried hams, apart from providing colour and favour, the cold smoking has an important preservative effect as it prevents the **growth of moulds** on the meat surfaces.

The optimal temperature in "cold" smoking is 15 to 18°C (up to 26°C). Sawdust should be burned slowly with light smoke only and the meat hung not too close to the source of the smoke. Cold smoking is a long process which may take several days. It is not applied continuously, but in intervals of a few hours per day.

Hot Smoking – Hot smoking is carried out at temperatures of +60 to 80°C. The thermal destruction of the wood used for the smoking is normally not sufficient to produce these temperatures in the smoking chamber. Hence, **additional heat** has to be applied in the smoking chamber.

Fig. 69: Hotdogs are placed in the smokehouse for hot smoking (pale colour before smoking)

Fig. 70: After completion of the smoking process (brown-red colour after smoking, see also Fig. 42)

The relatively high temperatures in hot smoking assure a rapid colour and flavour development. The treatment period is kept relatively short in order to avoid excessive impact of the smoke (too strong smoke colour and flavour).

Hot smoking periods vary from not much longer than 10 minutes for sausages with a thin calibre such as frankfurters to up to one hour for sausages with a thick calibre such as bologna and ham sausage and products like bacon and cooked hams (see pages 142, 143).

Products and smoking – Cold smoking is used for fermented meat products (raw-cured ham, raw-fermented sausage) and precooked-cooked sausage (liver and blood sausages). Hot smoking is used for a range of raw-cooked sausages, bacon and cooked ham products. Smoke treatment can only be applied, if meat the products are filled in casings permeable to smoke (see page 248, 261). All natural casings are smoke permeable, as are cellulose or collagen basis synthetic casings.

Smoke permeable casings can also be treated using a new technology, where a liquid smoke solution is applied on the surface. This can be done by dipping in solution, showering (outside chamber) or atomization (spraying inside chamber). Polyamide or polyester based synthetic casings are not permeable to smoke. If smoke flavour is wanted for products in such casings, small quantities of suitable smoke flavour (dry or liquid) are added directly to the product mix during manufacture.

Production of liquid smoke

Liquid smoke can be used as an ingredient to sausages in smoke impermeable casings in order to achieve a certain degree of smoke flavour. As impermeable casings do not allow the penetration of gaseous smoke, liquid smoke can be added to the sausage mix during the manufacturing process. The starting point for the production of liquid smoke is natural smoke, generated by burning/smouldering wood under controlled temperatures with the input of an air supply. There are basically two different methods used for the subsequent processing of liquid smoke:

- direct condensation of natural wood smoke to liquid smoke
- penetration of the smoke into a carrier substance on the basis of water or oil and using this “smoked” carrier substance as an ingredient for meat products

SELECTION AND GRADING OF RAW MATERIALS FOR MEAT PROCESSING

The *two main components of processed meat products* are *animal muscle meat* and *animal fat*. Apart from pure muscle tissue, **muscle meat** (see page 2) also contains some connective tissue and inter- and intra-muscular fat, which determine the quality of muscle meat. **Animal fats** (see page 10) are of firmer or softer texture depending on their location in the animal body. In addition to the animal species, the texture of fats determines their processing quality. **Edible animal by-products** such as skin, internal organs and blood also play a role as raw materials for meat processing. By-products are not generally used; they are part of specific processed meat products (described in “Precooked-cooked meat products”, see page 149).

The first preparatory step for processing of meat into meat products is the product-oriented selection of raw animal materials, taking into account their quality and processing suitability and the characteristics of the meat products to be fabricated. Some meat products require lean meat without adhering fat or connective tissue, while others have a higher fat and/or connective tissue contents. Other products require firm animal fats, for others soft fats are better suited. Choosing appropriate raw materials is indispensable for efficient meat processing and is best done by visual **selection and grading** according to the tissue-specific properties.

Meat processors are advised to develop **enterprise-specific standards** of raw material composition for each meat product fabricated. The proper grading of raw materials, which needs skills and experience, has a decisive impact on the quality of the meat products and resulting revenues which can be generated.

For the needs of small to medium sized meat processing plants, simple grading schemes are described hereunder, with raw materials from pigs, cattle/buffaloes and other ruminants as well as poultry.

Selection and grading of manufacturing meat from pigs

The below proposal for selection and grading of pig meat refers to the utilization of the entire carcass for **meat processing**. Naturally, in many meat plants, valuable meat cuts may be excluded from further processing and marketed as **fresh meat**.

In these cases only the remaining carcass meat is used for **further processing**. Common cuts for fresh meat sales are tenderloin, loin, rump, the entire ham or parts of the ham (topside, silverside, knuckle) and parts of the neck and shoulder (Fig. 71, 72).

The proportion of carcass meat going into fresh meat sales or into further processing is decided by the operator on a case-by-case basis. If higher amounts of lean meat are required for further processing, more primal cut meat will be used for this purpose and vice versa.

Hereunder, a **grading scheme** for manufacturing-meat from pigs consisting of six grades is proposed (Fig. 73). This standard can be refined or simplified as determined by consumer demand.

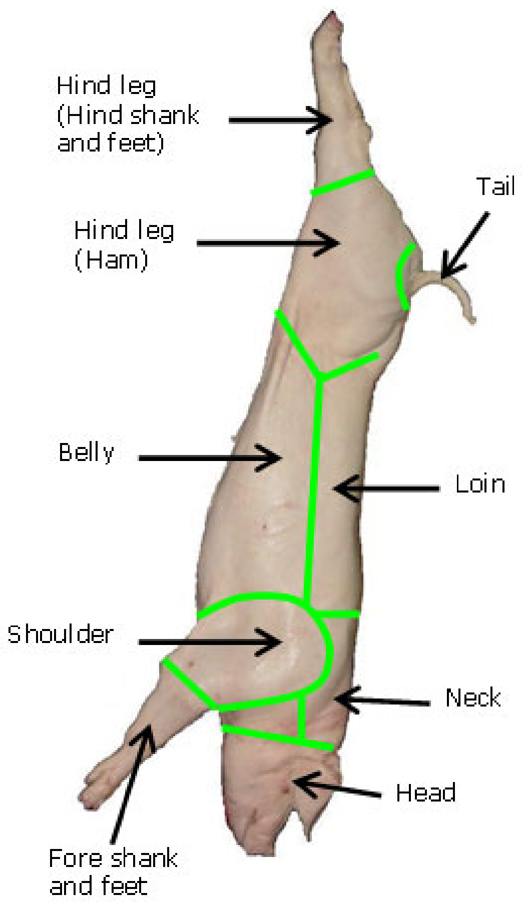
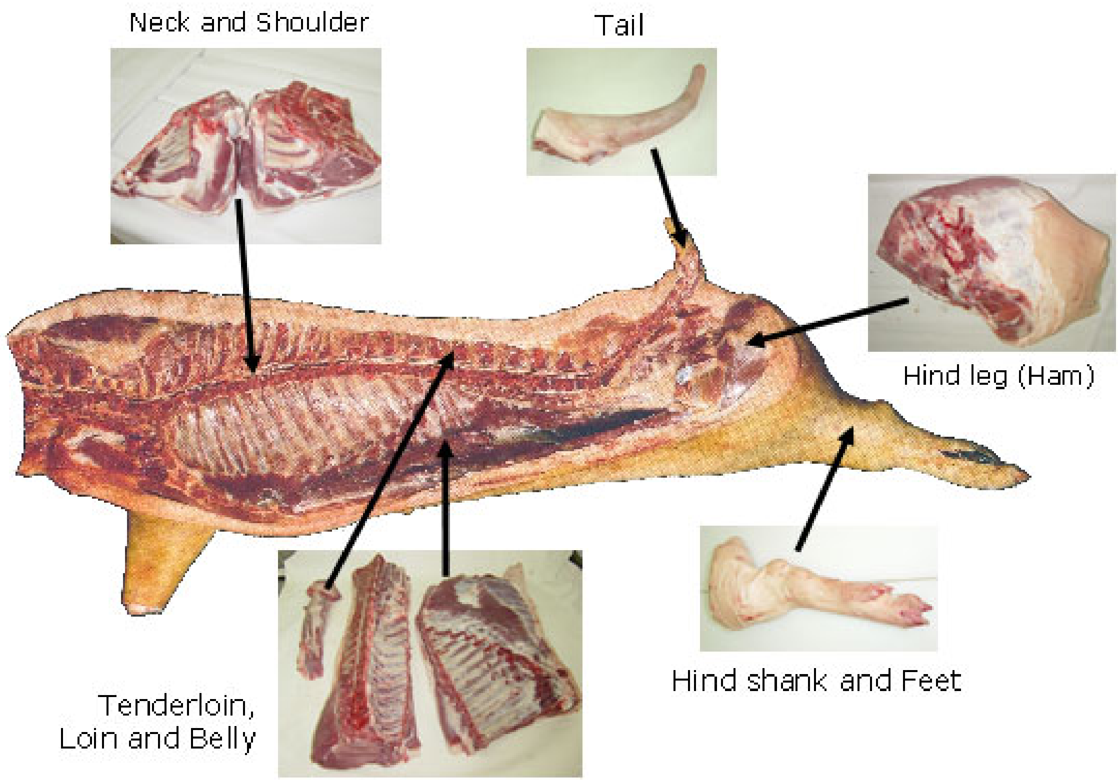


Fig. 71: Pork carcass schematic



Grade Pork 1 (P1)
Pig meat, all visible fats and connective tissues removed

Grade Pork 2 (P2)
Pig meat, 15-25% firm body fats, visible connective tissues removed

Grade Pork 3 (P3)
Pig meat, 10% visible firm and soft fats and some soft connective tissues

Grade Pork 4 (P4)
Pig fat, back fat (firm tissue)

Grade Pork 5 (P5)
Pig fat, body fats (soft tissue)

Grade Pork 6 (P6)
Pig skin, free of hair and fatty tissue

Fig. 73: Grading scheme for manufacturing-meat from pigs

GRADE Pork 1 (P1) **Lean muscle meat with all visible fat and connective tissues (hard and soft) removed**

This meat is derived from body parts with large muscle groups such as loin (loin, tenderloin), hind leg (topside, silverside, rump) and shoulder. P1 meat is obtained during the preparation of choice cuts, when portions are trimmed off from the cuts for fresh meat sales. Given the case that more of this P1 meat is needed for processing, some of the above mentioned cuts can be used completely for this purpose. Muscle groups with a high connective tissue content (neck, thin shoulder) are not considered suitable for P1. Grade *Pork 1* meat is used for whole muscle hams (raw-fermented, cured-cooked) and all products where the meat structure remains visible (coarse sausages, reconstituted hams).

GRADE Pork 2 (P2) **Muscle meats with some solid fats embedded and connective tissue removed**

This manufacturing-meat category mainly comes from the leaner parts of the belly (near the loin) and pieces trimmed off from the hind leg. The fat content of grade P2 meat should not exceed 25%. The embedded fatty tissue must be firm and dry, as this meat is normally used for coarse products where meat and fat particles remain visible and can be sensed during chewing. For the same reason all visible hard and soft connective tissues should be removed. Typical products are fresh sausages, dry fermented sausages and luncheon meat and, to a certain extend, reconstituted hams (see page 108, 117, 127, 183).

GRADE Pork 3 (P3) **Muscle meat trimmings with low fat content, but larger amounts of soft connective tissue**

The meat trimmings for grade P3 can originate from all body parts, but its main source is the front quarter. As these meat trimmings usually contain smaller or larger amounts of soft connective tissue, they are mainly used as raw material for finely-chopped meat mixes. The hard connective tissue should be removed. The embedded fatty tissue can be of soft or firm texture, but its content must not exceed 10 % to allow for preparation of lean batter for further processing (see chapter "Raw-cooked meat products" page 127).

GRADE Pork 4 (P4) **Pork back fat**

The fatty tissue derived during cutting of pork carcasses and preparation of choice cuts can be divided into soft and firm tissue. The firm and dry fat for grade P4 is exclusively from the fatty layer under the skin on the backside of the pork carcass, hence the name "back fat". Back fat is primarily used as the fat portion of raw-fermented sausages (see page 115) and for the manufacture of finely chopped meat mixes of the raw-cooked type (see page 127). For coarse fresh meat products, where usually P2 meat is taken, back fat in combination with meat P1 can be used instead, as with such a blend the same fat content as contained in P2 can be achieved.

GRADE Pork 5 (P5) **Soft fatty trimmings**

Apart from the firm fatty tissue (grade 4 pork), a variety of soft fatty tissues are obtained from the pork carcass. Because of their oily and wet appearance, they are unsuitable for manufacture of coarse products, but can be incorporated in finely chopped meat mixes of the raw-cooked type in quantities of up to 25% of the overall fat portion added (page 127). It can also be used as fatty material for some precooked-cooked products (page 149).

GRADE Pork 6 (P6) **Pork skin**

Pork skin is normally used as food unlike other animal skins which are used in leather production. As the skin is exposed to contamination during slaughtering and cutting, special attention must be given to obtain pork skin of good hygienic quality. On its outer side pork skin should be free of hair and other impurities and on the inner side the connected fatty tissue must be thoroughly removed. Pork skin is collagen rich and in precooked form a valuable material for the manufacture of some meat products of the precooked-cooked type (page 147). Occasionally pork skin is also used in raw form in processed meat products normally shredded to small particles and either used as an ice/pork skin emulsion or as dry granules. However, this is an application for large industries. Pork skin can also be used for gelatine production (page 70).

Selection and grading of manufacturing-meat from cattle

Similar to pork, valuable meat cuts (choice cuts) from beef are usually excluded from further processing and marketed as fresh meat. The most common fresh meat cuts are tenderloin, sirloin, topside, silverside, rump and parts of the neck and shoulder (Fig. 74, 75). The rest of the carcass meat as well as trimmings derived during the preparation of the above mentioned choice cuts are used as manufacturing-meat for all types of processed products.

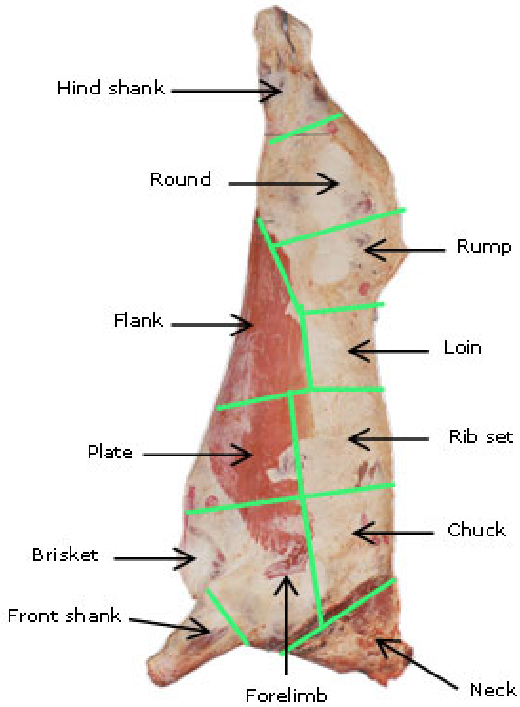


Fig. 74: Beef carcass schematic

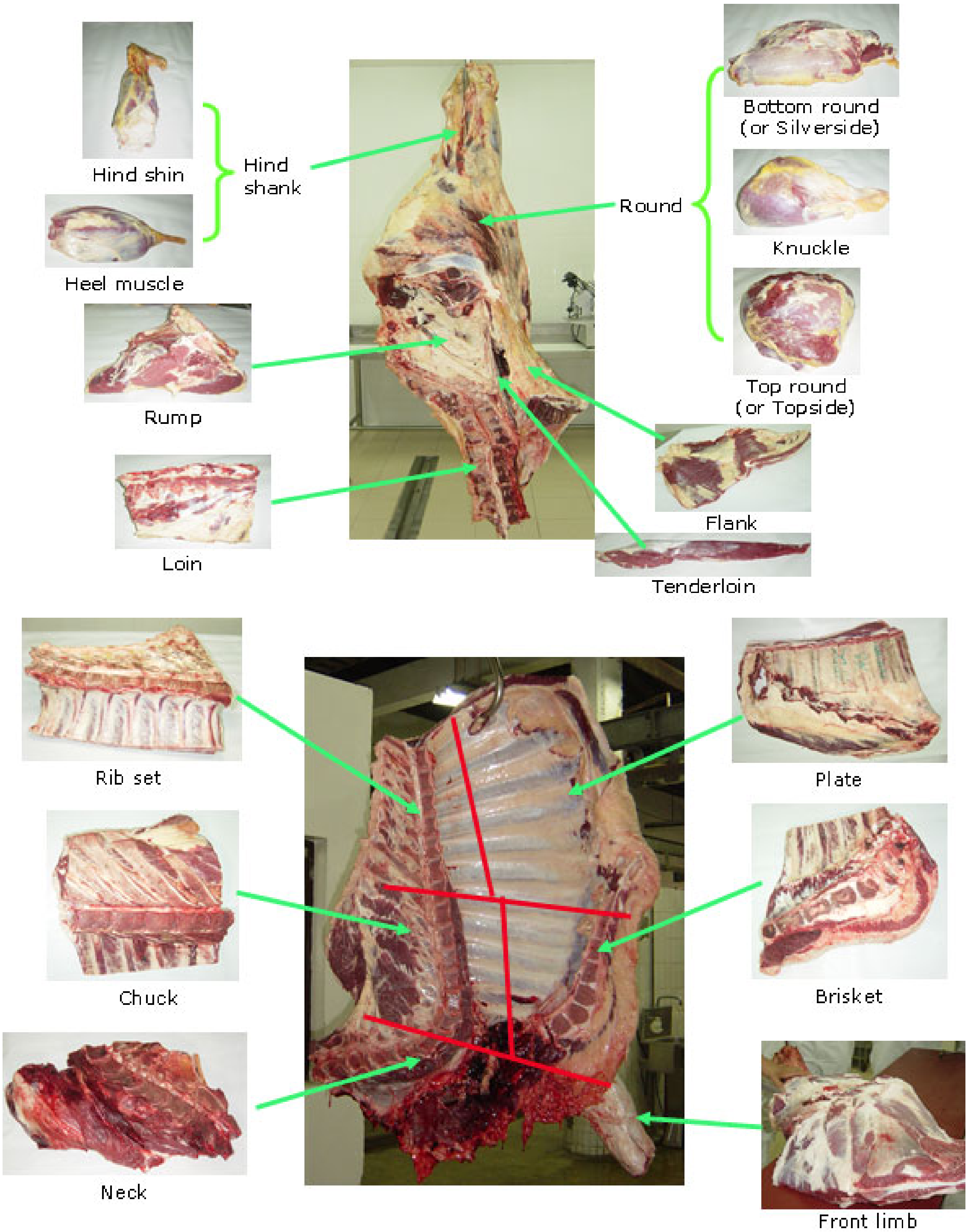


Fig. 75: Beef carcass and its cuts

The **functional properties** of beef are influenced to a large extend by the age of the animal. Meat from younger animals has a much higher water binding capacity than meat derived from a carcass of an older animal. For this reason meat from younger animals should be used for products requiring high binding and water holding capacity (see page 7) and meat from older animals is more suited for products undergoing a drying and fermentation process.

Similar to the grading scheme for pig meat, a simple scheme is proposed for the **selection and grading of beef**, which is considered suitable for small and medium operations. For beef, three grades of manufacturing meat (Fig. 76) are sufficient to cater for the needs of small to medium-size manufacturing. Beef fat and skin are usually not a raw material for meat processing.

Fig. 76: Grading scheme for manufacturing-meat from cattle / buffaloes

Grade Beef 1 (B1)
Lean beef without visible fat and connective tissue

Grade Buffalo 1
Lean buffalo meat without visible fat and connective tissue

Grade Beef 2 (B2)
Beef with less than 10 % (visible) connective tissue and less than 10 % fat

Grade Beef 3 (B3)
Beef trimmings with up to 20 % (visible) connective tissue and 20 % fat

The following grading scheme for beef is proposed:

GRADE Beef 1 (B1) **Lean muscle meat with all visible fat and connective tissue removed**

The meat is derived from the major muscles of the fore and hindquarter with the exception of shanks and belly muscles.

GRADE Beef 2 (B2) **Muscle meat trimmings with small quantities of connective tissue (<10%) and body fats (<10%)**

Meat parts used for this grade are mainly obtained as muscle trimmings from the manufacture of primal meat cuts and from smaller lean muscles which are not sold as special cuts.

GRADE Beef 3 (B3) **Muscle meat trimmings with connective tissue (<20%) and body fats (<20%)**

For this grade, small meat trimmings removed from bones during deboning, flanks and shanks are used. As this meat is relatively high in connective tissue and fat, it is only used for the manufacture of finely chopped meat mixes. It is not suitable for use as coarse parts in meat mixes due to its tough texture.

In some regions, in particular in Asia, **buffalo meat** plays a major role in the manufacture of meat products often replacing beef. The proposed grading scheme for manufacturing meat from **buffaloes** is the same as for beef (see Fig. 76).

In the above illustrations only grade 1 buffalo meat is shown. Grade 2 and 3 for buffalo is similar as indicated for Beef 2 and 3. Buffalo meat has excellent properties for further processing, in particular a pronounced red colour, good water binding capacity and typical flavour. Differences in texture compared to beef (buffalo meat may be slightly tougher) play no role in further processing. Buffalo meat differs slightly from beef in terms of:

- Colour: Buffalo meat has slightly darker red colour than beef (see Fig. 76), also processed meat products containing buffalo meat have a darker and more intensive red curing colour.
- Taste: Buffalo meat has a more pronounced meat flavour and taste.
- Texture: Buffalo meat cuts, upon ripening and aging, can be made sufficiently tender but remain with slightly stronger texture as compared to similar beef cuts.
- Fat content: Buffalo meat is usually leaner than beef and the colour of buffalo fat is white as compared to the yellowish fat colour in beef (see page 12).

Selection and grading of manufacturing-meat from poultry

In global meat production poultry meat is taking the second place after pork. Due to its widespread availability and popularity and its mostly very competitive production cost, poultry meat has an increasing share as a raw material in processed meat. Turkey and chicken meat is very suitable for further processing purposes.

Turkey meat, which has darker and brighter muscle components deriving from the same carcass is well suited for processed meat products. In some developed countries there are sizeable turkey meat industries, with outlets for processed turkey meat products, such as bologna/frankfurters/ham sausage type sausages, and cooked turkey hams. Such products are similar to the equivalent ones fabricated with beef and pork, but they are usually leaner.

Fig. 77: (Scheme): Turkey carcass and its cuts a / b leg (a=thigh, b= drumstick), c1 / c2

A widely practiced approach is to classify turkey carcasses in two grades. Grade A is top quality with no defects on the meat surface and general appearance. Entire frozen carcasses as retail goods belong to this category. Grade B is the lower category and this meat is usually taken for further processing. When producing turkey cuts (Fig. 77), those cuts not needed or suitable for fresh meat sales, can also go into further processing.

In developing countries, the production of **chicken meat** is by far more important than the production of turkey meat. Chicken meat can be produced industrially around population centres and it is in high demand, particularly where pork is not consumed for socio-cultural or religious reasons.

The most popular processed products from chicken meat are *chicken frankfurters*, *hotdogs*, *chicken hams* and the various breaded and fried products of the *chicken nugget type* (see Chapter: Processed products made from chicken meat, page 187).

For the production of meat from chicken for processing, the same principles apply as in the beef and pork sector. Either the entire carcass meat is used for further processing, or some of the cuts go in fresh meat sales and the remaining into the manufacture. Chicken carcasses are usually cut in **wings**, **legs** and **breast** (Fig. 78). Legs can be further subdivided into *thighs* and *drumsticks***.** The breast consists of the larger *superficial breast muscle* and the smaller profound breast muscle, the latter is also called "*filet*" (see Fig. 80, 84).

Fig. 78: Muscle meat of chicken carcass a / b leg (a=thigh, b= drumstick); c1 / c2 breast meat (c1=breast, c2=filet); d=wing

Examples for chicken cutting

<u>Industrial method</u>

In large industrial operations, chicken are usually cut in the hanging position. Carcasses are suspended by the neck on a conveyor and pass though working stations. At each station a specific cut is made and a certain part removed, until finally only the bone-carcass structure remains.

The following is a widely practiced industrial cutting method: First the skin is incised around the body above the legs (Fig. 79). Then the wings are loosened, by cutting between wings and carcass through the wing joint. Following minor incisions using a knife, the wings are pulled-off together with the breast meat. The legs are then pulled off the carcass and finally the fillets are removed (Fig. 80). Only the bone-carcass structure with neck remains.

Fig. 79: Cut-up in vertical position (industrial cutting)

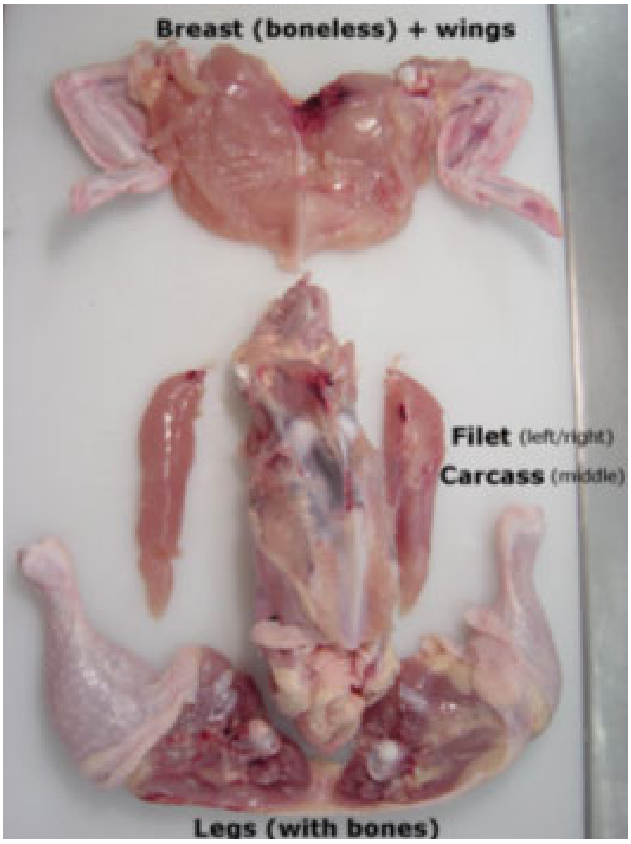


Fig. 80: Chicken parts in industrial cutting

Small-scale method

In small-scale operations more attention is usually paid to obtaining intact parts for individual sales. Conveyor systems are in most cases not available and therefore chicken carcasses are usually cut-up on a cutting board or table. Many different cutting styles have been developed. The following is one example.

First the chicken carcass is positioned on the cutting board with the breast muscle facing downwards. Then a deep cut is made just above the legs following the leg line (Fig. 81). The two carcass parts are pulled apart and the legs are separated with a knife by splitting the backbone. Next the wings are cut off through the lower wing joint (Fig. 82). If the breast and filets muscles are wanted separately, they are now removed from the upper carcass part and trimmed (Fig. 84).

Lean meat can now be trimmed off the carcass parts for further processing; skin and fat are also obtained.

Fig. 81: Cut-up in horizontal position (small-scale cutting)

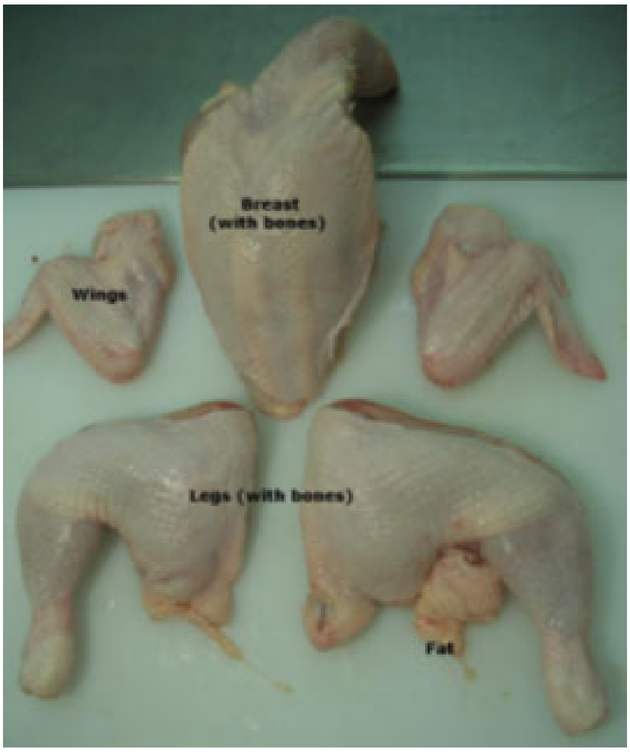


Fig. 82: Chicken parts in small-scale cutting

Grading of chicken meat for large operations

Chicken manufacturing-meat for larger processing operations is usually categorized in **four** different grades. The four grades of chicken meat are either used for **pure** chicken meat products or for **mixed** products. In **Halal** products made from red meat (beef, mutton), the fat portion may partially or fully be chicken skin.

Also in customary **mixed red meat products** (like frankfurter, bologna, breakfast sausages, luncheon meat, etc.) normally made of lean pork and beef or lean pork only, and pork fat, part of the lean pork may be substituted by lean chicken meat. This is usually done for cost-cutting reasons i.e. when cheaper chicken meat is available), but also to satisfy the growing demand for lower fat meat products.

The four grades are described below (Fig. 83):

GRADE Chicken 1 (CH1) **Chicken white muscle meat with visible fat, connective tissue and skin removed**

For this grade mainly breast and filet meat is used. As meat of this grade is used for reconstituted chicken hams and chicken sausages with visible coarse meat parts, all fat and skin must be removed from the lean meat.

GRADE Chicken 2 (CH2) **Chicken muscle meat with adhering subcutaneous and intermuscular fat**

Deboned and skinless meat from all chicken cuts (breast, legs, wings) can be used. This meat is usually ground or chopped during further processing. Smaller quantities of subcutaneous and intermuscular fat are usually not removed and incorporated in the final product.

GRADE Chicken 3 (CH3) **Chicken skin / fat**

Chicken skin is removed from the carcass or individual cuts and collected separately. Chicken skin has a high fat content and is ground prior to being added to processed meat products. Chicken fat serves as the fat portion in all-chicken processed meat products such as chicken frankfurters or chicken bologna. It can also be used as fat in lean beef or mutton products, such as Halal frankfurters etc. Chicken skin is added to meat products for the same purpose as pork fat in pork/beef products, namely to contribute to product flavour and softer product texture.

GRADE Chicken 4 (CH4) **Mechanically deboned chicken meat** (MDM)

This grade is manufactured in industrial chicken plants by mechanically separating remaining muscle tissue from the chicken carcasses after removing legs and wings and the breast muscles including skin. Chicken necks are also used for MDM. MDM contains muscle meat, connective tissue and some fat remaining on the bones after removing the meat cuts. MDM is a typical industrial product and not produced in small operations. However, it is available on the meat market and can be purchased by smaller producers as frozen blocks for further processing.

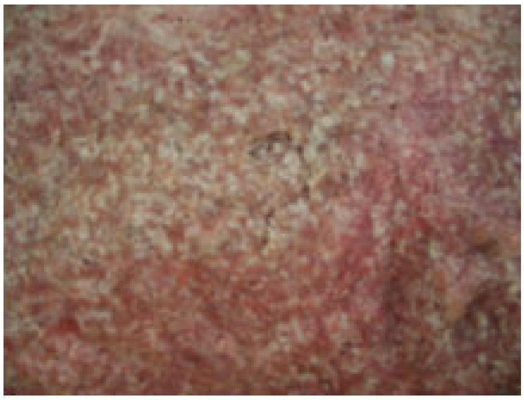
Chicken MDM is an ingredient for lower-cost meat products for partial substitution of the lean meat. However, MDM addition is limited as high amounts of chicken-MDM will affect the quality of products (deficiencies in texture and taste) and may in some countries result in products which are not in line with national food regulations.

Fig. 83: Grading scheme for chicken meat (industrial scale)

Grade Chicken 1 (CH1)
Breast meat

Grade Chicken 2 (CH2)
Chicken muscle meat with adhering subcutaneous and intermuscular fat

Grade Chicken 3 (CH3)
Chicken skin, ground
(below: from close range)



Grade Chicken 4 (CH4)
Frozen chicken MDM in plastic bags (below: from close range)

Grading of chicken meat for small operations

In small-scale operations, more emphasis is given to sales of fresh chicken parts. Therefore usually only three grades of processing meat are obtained (Fig. 84):

GRADE 1: Trimmed lean breast and filet muscle meat (light colour)

GRADE 2: Leg meat (darker colour) and trimmings from carcass

GRADE 3: Skin/fat

Fig. 84: Grading scheme for chicken meat (small-scale)

Grade Chicken 1 (small-scale)
(Breast and filet muscle)

Grade Chicken 2 (small-scale)
(Leg meat and trimmings)

Grade Chicken 3 (small-scale)
(Skin / fat)

NON-MEAT INGREDIENTS

Categories of non-meat ingredients

Along with the main components ***meat*** and animal ***fat***, a wide range of substances of ***non-meat origin*** are used as ingredients in processed meat products. Some of them are absolutely necessary, such as salt and spices. Others are used for specific products.

Fig. 85: Store room for non-meat ingredients

One way of categorizing non-meat ingredients is by source (Fig. 86). They are either

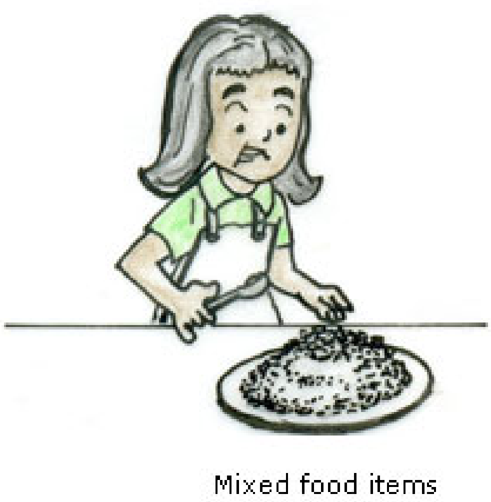
- **chemical substances** or
- of **plant origin** or
- of **animal origin** (examples see a, b and c on page 63).

Chemical substances Plant origin Animal origin

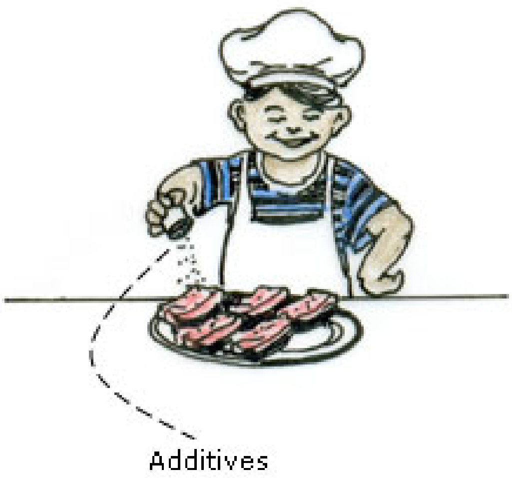
Fig. 86: Sources of non-meat ingredients

Other classification criteria for non-meat ingredients are, whether they are *additives* or *full foods* ("food by itself") or whether they have *functional* properties or not.

Additives (Fig. 87 right) are usually substances, which are not normally consumed as food by itself, but which are added to develop certain technological and quality characteristics (for examples salt, curing agents, spices, water binding and gelation enhancing substances). In contrast, vegetables, flours, eggs, etc. (Fig. 87 left) could be considered as full food ingredients.



Mixed food items



Additives

Most ingredients are **functional**, which describes their ability to introduce or improve certain quality characteristics. The functional properties of ingredients include their impact on:

- taste
- flavour
- appearance
- colour
- texture
- water binding
- counteracting fat separation
- preservation

Ingredients which are solely functional without any other effect such as filling or extending the volume of the product, are normally used in small amounts (e.g. common salt 1,5-3%, nitrite 0.01-0.02%, phosphates 0.05-0.5%, ascorbic acid 0.03%, isolated soy protein or non-fat dried milk proteins 2%) (Fig. 88, 89 right).

The criteria for the utilization of **functional** non-meat ingredients are:

- safe for consumers, and
- improve of processing technology and/or sensory quality of the products.

Fig. 88: Example of effect of functional ingredients

Meat loaf cut, left with curing colour, centre without colour, right with artificial colour

In contrast to the exclusively functional substances, there is another group of ingredients that are not primarily intended for change of appearance or quality improvements but serve to *add volume* to the meat products. They are called **meat extenders** and **fillers**. Their main purpose is to make meat products *lower-cost*. Meat extenders and fillers include cereals, legumes, vegetable, roots and tubers and are used in larger quantities, on average between 2 and 15% (Fig. 89 left and center).

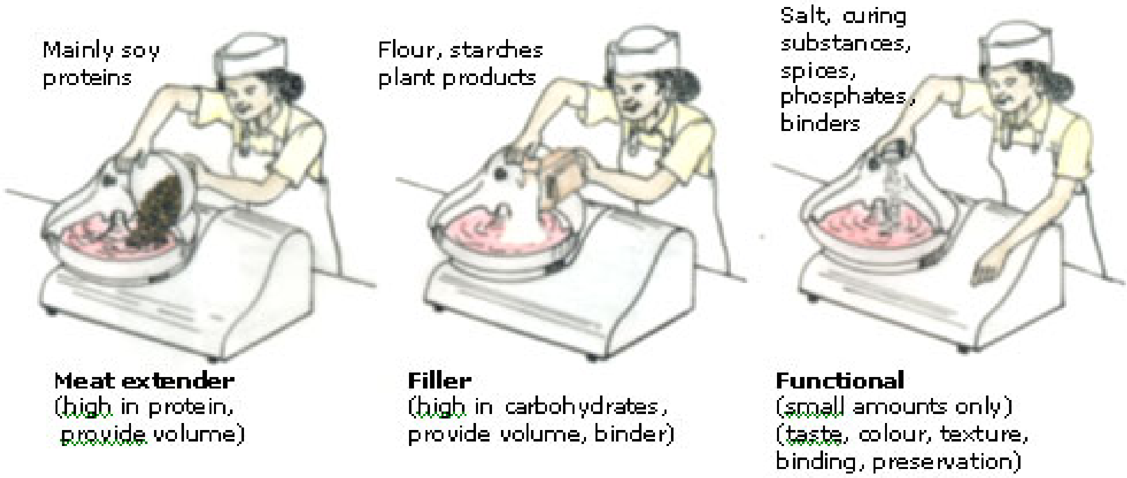


Fig. 89: Types of non-meat ingredients

Meat extenders are primarily plant ***proteins*** from legumes, with *soybeans* as the major source. ***TVP*** (Textured Vegetable Protein, see page 80) is the most common soy bean extender. These cheaper plant proteins ***"extend"*** the more expensive meat proteins, resulting in acceptable overall protein contents of lower cost meat products. Extenders are added in sizeable amounts that increase the bulk of the meat products, but this may also alter their quality. From animal protein sources, whole milk and eggs can be considered as meat extenders. In some countries, replacement of meat by fish is gaining popularity resulting in fish products which may be meat and fish mixes or entirely made of fish materials, e.g. "fish viennas", made using the same technology and process as viennas made of meat (Fig. 90).

Fig. 90: Fish sausage

Fillers are also mostly plant substances, low in protein and high in ***carbohydrates*** such as cereals, roots, tubers and vegetables and some refined products such as *starches* and *flours*. Pure meat products are very low in carbohydrates. Hence the addition of carbohydrate-rich substances is not an "extension" of the protein mix, but some new components ***"fill-up"*** the product volume. Apart from their volume-filling capacity, some fillers, in particular starches and flours, are also used for their capability to absorb extensive quantities of water.

Extenders and fillers are ***not*** standard ingredients in processed meats, in fact high quality products are often manufactured without them. But they are useful tools in ***cost reduction*** enabling the manufacture of lower-cost but still nutritive meat products. Such products are particularly suitable to supply valuable animal proteins in the diets of consumers who cannot regularly afford expensive meat and meat preparations (see page 195).

As another definition for specific non-meat ingredients, the term **binder** is used for substances of animal or plant origin, which have a significant high level of protein that serves for both ***water*** *and* ***fat binding***. Such substances include ***high-protein soy, wheat*** *and* ***milk products***, such as soy isolate, wheat gluten, milk protein (caseinate). They are not extenders in the first place due to the low quantities added (approx. 2%), but act through their high quality proteins that are instrumental in water binding and protein network structuring. On the other hand, some substances with little or no protein level, like ***starches*** and ***flours*** mentioned above under "fillers", can bind water and fat by means of physical entrapment and could also be considered "binders".

The above aspect illustrates that clear definitions in the wide range of non-meat ingredients are difficult to establish. While most substances have one ***dominating effect***, there are in many cases also desirable ***side effects*** that, however, complicate their clear grouping. Even those substances like textured vegetable protein/TVP, which are primarily intended for non-functional purposes, namely meat extension, have a water binding effect, which qualifies them also as moderately functional. Also soy isolates or dried milk powders, which are used as binders, also have a slight extension effect as the amounts added (approx. 2%) moderately increases the protein level. Most substances have double or even multiple effects.

Therefore, in order to provide an overview of the most common substances used as non-meat ingredients, they are listed hereunder according to their origin, namely *chemical* (a) or of *animal* (b) or *plant origin* (c):

a) Chemical substances used as ingredients

There are various chemical substances approved for the different kinds of food processing, but in the specific case of **meat processing** the number of approved chemical substances is rather limited in most countries. The following are of significance:

- ***Salt*** (for taste, impact on meat proteins, shelf-life)
- ***Nitrite*** (for curing colour, flavour, shelf-life)
- ***Ascorbic acid*** (to accelerate curing reaction)
- ***Phosphates*** (for protein structuring and water binding)
- ***Chemical preservatives*** (for shelf-life)
- ***Antioxidants*** (for flavour and shelf-life)
- ***Monosodium glutamate MSG*** (for enhancement of flavour)
- ***Food colouring substances*** (synthetic and of plant origin)

Chemical additives have exclusively functional properties, they are used in small amounts usually below 1% (with nitrate as low as 0.05%). Only salt is in the range of 2% (with up to 4% in some fermented dried products).

b) Non-meat ingredients of animal origin

Ingredients of animal origin are not commonly applied but may be useful for specific meat preparations. They all have functional properties (except whole milk), in particular improvement of water binding and prevention of fat separation during heat treatment. Apart from their functional properties, some of them can also be considered meat extenders, as mentioned below.

- ***Milk caseinate*** (90% protein; used in small quantities (2%); have functional water and fat binding properties)
- ***Whole milk*** or ***non-fat dried milk*** (=skim milk) (sometimes used in indigenous meat preparations as a protein extender)
- ***Gelatine*** (binding properties and meat extender)
- ***Blood plasma*** (predominantly binding properties)
- ***Eggs*** (extender and binding ingredient for meat pieces and fried sausages)
- ***Transglutaminase**** (exclusively binding properties)

c) Ingredients of plant origin

All ***spices*** (see page 83) are of plant origin. They are predominantly *functional* and used in small quantities to provide or add flavour and taste to meat products.

____

*) Natural substance in animal organisms, but now produced synthetically.

Another group of predominantly *functional* substances of plant origin with high protein content are used as ***binders*** (see page 80) to increase water binding and fat retention, in particular in intensively heat treated products (see page 158). The most commonly used substances are

- ***isolated soy protein*** (90% protein) and
- ***wheat gluten*** (80% protein)

and, less importantly, protein isolates from other legumes.

A third group of ingredients of plant origin are used as ***meat extenders*** (if rich in proteins) or ***fillers*** (if rich in carbohydrates) for meat product and sausage formulations. The purpose is to replace expensive meat for lower- or medium-grade products by cheaper ingredients of plant origin for cost reduction and volume increase.

Meat extenders / Plant products with high protein content are

- ***Soy flour*** (50% protein)
- ***Soy concentrate*** (70% protein)
- Other food legumes (***beans***, ***peas***, ***lentils***), used for special products only.

Fillers / Carbohydrate products with low protein content (usually added in quantities of 2%-15%, some of them – in particular roots and vegetable – up to 50%). These are the typical ***fillers***. Apart from cost reduction and adding to volume, some flours and starches belonging to this group of fillers also act to some extend as *binders*. This property serves important functions such as increasing water binding for more juiciness or fat binding for improved texture.

- ***Cereal flours*** from wheat, rice and corn
- ***Starches*** from wheat, rice, corn, potato and cassava
- ***Breadcrumbs***
- ***Rusk*** (derived by mixing and baking wheat flour)
- ***Cereals*** to be added without milling, e.g. rice, corn
- ***Roots*** and ***tubers***, e.g. cassava, sweet potato
- ***Vegetable*** and ***fruits***, e.g. onions, bell pepper, carrots, green vegetables, bananas
- ***Polysaccharides*** (Hydrocolloids)**:**
- ***Carrageenan*** (is the only hydrocolloid product of this group popular in meat processing, added in quantities of max. 1%, improves sliceability and cohesiveness). The substance can be considered both *binder* and *filler*.

Application of non-meat ingredients

For the application of ingredients listed above to meat products, various methods are deployed, depending upon the properties of the ingredient and the meat product. A **uniform distribution** is crucial for equal intensity of flavour, colour, texture or any other quality characteristic expected from the product.

Methods of application

a) During grinding

Chemical additives and smaller quantities of other fine or coarse non-meat ingredients or granulated substances (such as TVP) are easily incorporated in ground meat products by **mixing** them with the raw meat materials prior to grinding. In small scale operations, the mix of meat and non-meat ingredients is then simply passed through the grinder plates (Fig. 58). **Manual** or **mechanical blending** can be added if necessary. In larger industrial operations and for heavily extended products, ground meat materials, chemical additives and other non-meat ingredients are usually combined in a blender.

b) During chopping

In finely comminuted or chopped meats, non-meat ingredients are easily dispersed by **mixing** them with the rest of the batter in comminuting equipment (e.g. bowl cutter, see Fig. 62, 91, 92). Non-meat ingredients such as binders (isolated soy protein/ISP, milk caseinate) are preferably added in emulsion form (Fig. 95, 109), finely milled fillers (flours, starches) in dry form. In smaller calibre low-cost sausages such as hotdogs, also larger quantities of extenders (e.g. re-hydrated TVP) and coarse fillers (rusk, breadcrumbs, etc) are incorporated during the chopping process.

c) Application to non-comminuted meat

The addition of non-meat ingredients to larger meat pieces or intact muscles is more complex. **Injection** of ingredients as part of the curing brine, if they are water soluble or can be dispersed in water (salt, nitrite, spices, ascorbate, phosphates, soy products, Carrageenan), is the most rapid method of equal distribution (Fig. 63, 65, 66, 67, 93). The **surface application** of such dry substances (e.g. nitrite curing salt, spices) (see Fig. 63, 64, 94) or **immersion** of meat in salt/curing salt and flavouring solutions (Fig. 65) is another way of application, but requires days or weeks to diffuse throughout the muscle tissue.

Treatment before application

Finely milled ***fillers*** of plant origin (flours, starches) are added dry (Fig. 91, 251), coarse fillers such as breadcrumbs or rusk and cereals are usually re-hydrated. Granulated ***extenders*** of plant origin (TVP) are also re-hydrated before blending them to the product mix (Fig. 92). Some ***binders*** (e.g. milk caseinate, isolated soy protein) are either added as dry powder or as a fat/water/protein emulsion (see Fig. 109). Many manufacturers attribute better binding properties to prefabricated emulsions rather than using the dry powder. On the other hand, the preparation of an emulsion is labour-intensive and may be dispensable when using some highly effective comminuting equipment (e.g. colloid mill, high-speed cutter).

Fig. 91: Addition of filler / starches (dry) **in the bowl cutter**

Fig. 92: Addition of extender / soy concentrate (rehydrated) **during chopping**

Fig. 93: Application by injection of additives in watery solution; pump and injection needle for brine (see also Fig. 226)

Fig. 94: Application by surface treatment / dry salting

Important non-meat ingredients in meat processing and their properties

Key characteristics of non-meat ingredients used in the meat industries are provided below for guidance. They are listed by highlighting some of the most commonly used substances first with the rest roughly grouped in the order of frequency of use on meat processing.

Common salt (sodium chloride)
Levels used: 1.5 – 3.0%
Salt is the main agent used in meat processing and it contributes to basic taste characteristics of the final product. In processed meat products it usually ranges from 1.5 to 2.2%. Apart from improving the taste, salt in combination with water assists in opening up the structure of proteins (solubilises myofibrillar proteins). These proteins gel upon heating and by entrapping moisture and fats give form, structure and firmness to the finished product. Salt used at the above levels also improves the water holding capacity of meat (for more details see page 33, 147).

Seasonings (spices)
Seasonings are indispensable for the manufacture of processed meat products. Due to their importance and complexity they are described in a separate chapter (see page 83).

Water
Water is the main component of meat (up to 80% in lean meat). Therefore typically all meat products contain lower or higher amounts of “natural” water. Besides its “natural” presence, water is used in many processed meat products also as an ingredient. However, the assumption by some consumers that water is added to meat products only to increase product weight and manufacturers’ profits is incorrect. In fact, there are many types of meat products where the addition of water is needed ***for technical reasons*** (see page 133) or to ***compensate for cooking losses*** (see page 151).

The addition of water is essential during the manufacture of **raw-cooked meat batters** (meat loaves, frankfurter sausages etc). In this case water acts together with salt and phosphates to solubilize muscle proteins (see page 128), thus creating a strong protein network structure holding the product together after heat-treatment.

In the case of **precooked-cooked meat mixes**, water is added to compensate for the cooking loss, as precooking of raw meat materials generates cooking losses of approximately 30%. In order not to make the final products too dry, water losses are supplemented in the final meat mix. Care must be taken that no excess water is added, as this could lead to fat and jelly separation in the final product (see page 151).

Water is also needed as a ***substrate*** for curing substances or other non-meat ingredients and for ***re-hydration*** of meat extenders. For **cured-cooked products**, solutions of curing salt, which may also contain spices, phosphates and other ingredients, are injected into larger meat pieces for quick and equal distribution. In these cases the volume of the product will be increased by the injection of the curing brine, but will be reduced again during subsequent cooking. Technologies such as tumbling in combination with addition of phosphates and other substances make it possible to increase the yield further. Ideally, cooking losses are equivalent to the water previously injected. However, in the specific cases of cheaper cured-cooked reconstituted ham, tumbling in combination with addition of phosphates and binders (see page 69, 70, 71, 72, 184) can make it possible to retain higher amounts of water in the product.

Sodium Nitrite

Levels used: 0.01 – 0.03%

The addition of relatively small quantities of sodium nitrite produces the development of the desired colour "pickling red" in processed meat products. Without nitrite meat products turn grey in colour when heated. Of special importance for canned meat products is the potential of nitrite to inhibit microbial growth. Furthermore, it retards the oxidative rancidity by stabilizing fats. The common commercial form of nitrite is ***"nitrite curing salt"*** or "pickling salt", a mixture of 0.5 - 0.6% nitrite and 99.4 - 99.5% sodium chloride (see also page 34).

Ascorbic acid, sodium ascorbate, erythorbate

Level used: 0.03%

Ascorbic acid is perhaps better known as vitamin C. Its more stable salt form is sodium ascorbate or the chemically equivalent but cheaper sodium erythorbate. These so-called ***"cure accelerators"*** are used in curing-salt for processed meats because of their reducing properties. These substances accelerate the reaction of nitrite with the red muscle pigments resulting in the development of the red curing colour. Meat products to be heat-treated during manufacture instantly develop a uniform red colour, which can be intensified in the presence of cure accelerators. Similar reactions take place in non-heat-treated products such as raw-cured hams or sausages, but are considerably slower. Another effect of cure accelerators is that the chemical curing reactions will be more complete and hence less residual nitrite will be left in the product (for more details see page 37, 134, 137, 179).

Phosphates

Levels used: 0.05 – 0.5%

Phosphates have a wide application in the meat processing industry and improve binding and texture in processed meat products. They directly ***increase the water-holding capacity*** by raising the pH as their own pH is alkaline (above 7.0). Phosphates also stabilize the texture of meat products by ***increasing protein solubility*** in connection with salt and ***reduce lipid oxidation / rancidity*** and hence the occurrence of negative flavours. Phosphates have also shown the ability to ***reduce microbial growth***. The most common phosphates used in meat processing are:

Sodium tripoly-phosphate	**STPP**	**(pH 9.8)**
Sodium di-phosphate	**SDP**	**(pH 7.3)**

For meat preparations such as sausage mixes, where phosphates are added as dry powder, phosphates with moderate alkaline effect are preferred, in particular ***di-phosphates***. The usual dose is 0.03 % (see page 134). Di-phosphates are the most effective form of increasing water binding. However, di-phosphates have a low water solubility. Thus, for meat curing brines containing phosphates (see page 179), the more soluble ***poly-phosphates*** can be used.

Milk protein

Similar to isolated soy protein, **milk protein** (= milk caseinate) has the ability to interact with meat proteins or complement deficits in meat protein available in extended meat mixes. Due to the small amount required (2%) and its relatively high price, milk protein is primarily not a meat extender for volume increase but a functional ***binder*** to increase water holding and fat binding and reduce cooking losses. These properties can be used in all types of heat treated meat products (see page 160). Milk protein can impart a pale colour and soft texture to meat products, which is viewed as a disadvantage by some meat processors. In intensively heated products, this disadvantage is outweighed by the good binding properties and prevention of jelly and fat separation.

Fig. 95: Preparation of milk protein / water / animal fat emulsion

The levels of milk protein used should not exceed 2%. Milk protein (caseinate) is added to meat mixes as ***dry powder*** or as a ***prefabricated emulsion***. The emulsion is usually composed of milk protein/fatty tissue/water in ratios of 1:5:5 to 1:8:8. Emulsions can easily be made in the bowl cutter, where ingredients are mixed and emulsified under high-speed rotation (Fig. 95). The emulsifying process is supported by using hot water (80-100°C). **Skim milk** powder is dried defatted milk and is sometimes used in extended raw-cooked meat products (see page 127, 204). It can be considered an extender with binding properties.

Gelatine

Gelatine is an edible jelly composed of collagen proteins extracted from animal tissues (mainly skins, also bones) through boiling. Commercially available gelatine is a dry powder of various granule sizes, which is first dispersed in cold water and then completely ***solubilized in water of 50-60˚C***. The protein molecules of the gelatine absorb water and form a gel when cooling down. If meat pieces are mixed with the liquid gelatine, the cohesive properties, which are gradually strengthened with lowering the temperature, result in a solid, elastic and sliceable product (Fig. 96, 97).

Another technology sometimes practiced is to blend small amounts of ***dry gelatine*** with moist meat mixes. Here the gelatine will absorb the liquid surrounding the meat particles during heating and solidify during cooling down and hold the product together.

Fig. 96: Gelatine powder

Fig. 97: Meat products in gelatine

If commercial gelatine is not used, similar effects regarding water absorption and gelling can be achieved when using ***collagen rich animal tissues*** as part of the meat mixture, such as pork skin, skin from calf/cattle head and feet or other meat trimmings rich in connective tissue (with tendons, ligaments, fasciae etc.) (see page 166).

Blood proteins

Blood is not used everywhere for human food. Where its consumption is accepted, a great variety of meat products is possible, where whole blood is one of the major components (see page 161). If the solid parts (blood cells) are separated from the blood, the liquid fraction called **blood plasma** remains, which is rich in protein (8-9%). Some people even call this slightly yellowish fluid “liquid meat”. Such a protein solution can play a valuable role in meat processing.

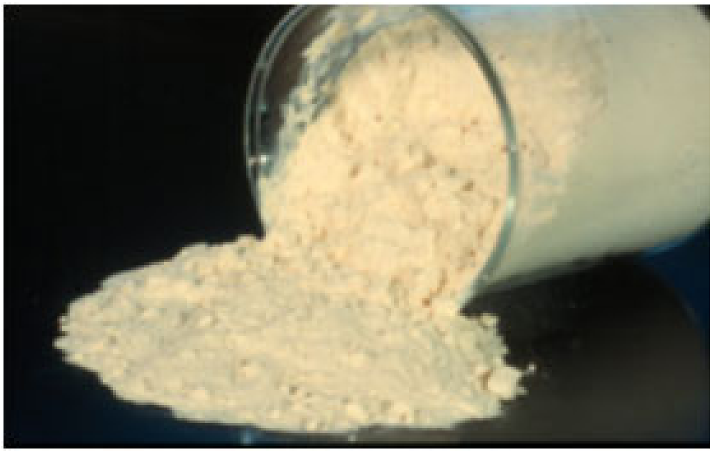


Fig. 98: Blood plasma, freeze-dried

In many locations, specialized enterprises produce blood plasma by centrifugation of hygienically obtained blood in slaughterhouses immediately after slaughter. Due to its hygienically sensitive nature the blood plasma is best frozen or freeze-dried (Fig. 98) immediately after centrifugation. Flakes of ***plasma ice*** are the ideal form for further processing in meat products. This form of plasma is particularly suitable for ***raw-cooked meat products*** (frankfurter, hot dog, meat loaves etc.), where water or ice has to be added (see page 133). If such water/ice is partly substituted by blood plasma the protein content of the product will be higher and the water binding capacity is increased. This is due to the good water binding of blood proteins, which is higher than that of meat proteins. Moreover, the ph of blood plasma is slightly alkaline (7.5-7.8), which is also beneficial for the water binding capacity.

Carrageenan

Carrageenan is a hydrocolloid (often known as “gum”) derived from aquatic plants (seaweed). Carrageenan is available as a refined powder (Fig. 99), which is water soluble and has strong ***water-binding and gelling*** properties. Upon cooling it forms an elastic gel which remains stable during refrigerated storage. Carrageenan, needed only in small quantities of up to 1% and added as a dry powder, can provide improved cooking yield and better sliceability and cohesiveness. It not only

Fig. 99: Carrageenan

increases the water retention in cooked hams or raw-cooked products, but also contributes to a desired stability and juiciness in products with reduced fat content (such as corned beef in jelly).

Transglutaminase

This is an enzyme needed in living animal organisms to repair lesions of body tissues and create stable structures by extensively cross-linking protein molecules. The recently introduced synthetic form of this substance develops similar effects in meat. It has the capacity to ***form bonds*** between superficial protein structures of individual smaller or larger muscle meat pieces. This effect can be used in various meat processing phases, from tumbling and reconstituting cooked hams to creating protein network structures in raw-cooked meat products (see page 127, 147, 184). The substance is expected to have an impact on specific meat processing technologies, for example, tumbling procedures could be considerably shortened or the utilization of phosphates and other binding substances in raw-cooked or cured-cooked products reduced or completely substituted. Even in raw-fermented sausages, consisting of a mix of coarsely chopped meat and fat particles (see page 115), the built-up of a firm cohesion of such particles during ripening can be strengthened by the presence of transglutaminase.

Vegetable oil

Vegetable oil can be used to ***replace animal fat***, in particular pork fat for Halal products. Vegetable oil can be considered a meat extender as it replaces part of the animal tissue. It also assumes the function of the animal fat to make the meat mix soft and juicy after heat treatment. Thus the oil has also functional properties. Vegetable oil is added in the same way as animal fat to comminuted meat batters (Fig. 100). It is important that the oil be cooled down (+1°C) before adding in order to keep the temperature of the meat mixes low. Best results can be achieved with vegetable oils displaying a pasty structure at this temperature.

Fig. 100: Adding vegetable oil to meat batter curing comminuting

Sugars
Levels used: 0.5 - 4.0 %
Sugars (sucrose[1], dextrose[2] or corn syrup) may be added to meat products to provide ***specific flavour*** and counteract salty taste, ***lower the a_w-value***, which may be important for dried and canned products, and act in dry fermented sausages (page 120) and raw hams (page 174) as a ***nutrient source for microbes***, which convert sugars into organic acids (lactic, acetic) resulting in souring. Substantial amounts of sugars are particularly common in Asian style traditional products (up to 8%, see page 214), where they are instrumental in lowering water activity a_w and extending the shelf-life. With the introduction of Western style products, this tradition continues in many places by using sugar for taste purposes, thereby altering taste and flavour as compared to the original products.

Flavour enhancer

These substances must not be confused with seasonings. They are intended to intensify flavour characteristics in specific meat preparations. Food proteins such as soy, milk or blood proteins or yeast extracts are partially hydrolyzed, i.e. broken down to simpler components (mainly peptides) which may have meat flavour or the property to strengthen meat flavours. One well known substance to strengthen meat flavour is **monosodium glutamate** (MSG). It is particularly popular in Asia where it is widely used in most meat dishes but also in many processed meat products (0.5% or higher).

Food colourings

Changing the colour of fresh and processed meats by ***means of food colourings*** is *not* common practice. The usual way of providing an attractive red colour to the great majority of processed meat products is by ***curing*** (see page 34). The principle of curing is not dyeing the product, but chemical reaction of the red muscle pigment with nitrite resulting in a stable red colour that does not change during heating and storage.

In certain circumstances, in particular in case of poor formulations with low muscle meat and therefore reduced muscle pigment contents, and supplemented by extenders and fillers of plant origin, manufacturers sometimes opt for the use of food colourings to ***intensify the product colour*** (Fig. 88, 101, 102).

————————

1) Sugar obtained from sugar cane or sugar beet
2) Sugar obtained by hydrolysis of starch, source of energy in living organisms

Food colourings may be derived from ***natural sources*** (e.g. orange-yellow beta-carotene from green plants, red oleoresin from paprika, red colour from red beet juice). Others are made ***synthetically*** (also beta-carotene derives now mainly from synthetic sources). Many of them are restricted for use only in particular food products. The debate over the safety of some substances, in particular the synthetic ones, is ongoing.

Some countries allow only limited utilization of food colourings for meat products. Some colourings not to be used for processed meat are, however, permitted for application on inedible sausage casings, which are not eaten with the sausage products. Apart from toxicological considerations, there are concerns that quality failures and hygienic shortcomings in processed meats could be masked using colorants.

In other countries, there seem to be less restrictions on the use of food colorants in the meat sector and colorants are readily available and applied. In meat processing, ***red*** and ***yellow*** colour types are preferred, with brand names such as “red blood”, “orange yellow” or “sunset yellow”. Ready-to-use solutions may be on the basis of tartrazine (E 102, yellow), cochineal extract (E 120, red) or carnoisine (E 122, red).

Apart from not posing immediate health risks, food colourings must meet a few ***technological requirements*** if applied in meat products. They need to be heat-stable to some extend, at least to endure pasteurization temperatures around 80°C. Colours should not change during exposure of the treated meat products to light or oxygen, nor should they be negatively affected through pH-changes.

Fig. 101: Addition of red food colourings during comminuting of batter for raw-cooked meat products

Fig. 102: Meat mixes with identical composition but different colorants

Preservatives

In meat processing, the preferable preservation methods are application of good slaughter, meat handling and processing hygiene and submission of semi- and fully-fabricated products to an uninterrupted cold chain. In complying with these requirements, bacterial counts in meat can be kept low and chemical preservatives are actually not needed.

Interestingly, traditional slaughtering and meat marketing, which still takes place without sophisticated slaughter facilities and without cooling, can reap satisfactory results. In this case, the factor time plays a major role. Animals are slaughtered during the cooler night time and the meat is marketed a few hours later, so that it arrives in the consumers' households before lunchtime for cooking. Due to the short periods of time elapsed between obtaining and preparing the meat, deterioration/spoilage does not occur and preservatives are not needed.

Unfortunately, it is a different story in today's mega-cities in developing countries, which are in many cases still supplied by traditional meat marketing methods. Inevitably, the distribution channels have become longer and the absence of cooling gives rise to an increased risk of meat deterioration and spoilage. In these conditions, meat handlers and processors may resort to chemical preservatives of dubious quality and safety.

Chemical preservatives are a sensitive issue, but can play an important and valuable role when properly applied during meat handling and processing in order to extend the shelf life of meat and meat products and reduce losses. Manufacturers may rely on the ***antimicrobial properties*** of such substances added and, trusting their good effect, neglect slaughter and processing hygiene and cold storage. In particular in tropical regions with a higher risk of meat spoilage, chemical preservatives are often used on a routine basis to keep bacterial growth at bay. Even worse, some manufacturers may chose substances, which in their views are "effective and cheap" to suppress bacterial growth, but which may be hazardous to human health, as they may produce toxic residues in meat. Such substances, no longer used on a widespread basis include for example *formalin*[1] or *borax*[2]. Some other compounds, known as "bleach" and chemically chlorine[3] or hydrogen peroxide[4], as they have the potential of whitening materials such as textiles, hair etc., have also been wrongly used for meat surface decontamination. The application of *antibiotics*[5] to animals before slaughter (e.g. sulfomethazine) or to the meat (e.g. nisin) has also been a continuing illegal practice for meat preservation. Another method, aiming at the improvement of the visual quality but with risks for consumers, is the treatment of minced meats with *sulphur dioxide*[6], which can reverse the dark unattractive colour of overstored products to bright-red.

____

[1) – 6)] See box page 76

Thanks to growing consumer awareness also in countries with less stringent sanitary controls, hazardous methods to extend the shelf-life of fresh and processed meat are gradually being phased out. By taking advantage of the highly sensitive analytical methods nowadays available, such illegal practices can be completely eliminated by official ***sanitary control measures***.

Malpractices in meat preservation

- Formalin or Formaldehyde is a strong disinfectant (see page 372); if illegally used to control bacterial growth on meat surfaces, it may get into the food chain, may cause kidney damage and is carcinogenic in the long term.
- Borax = Sodiumtetraborate, an ingredient in washing powders and used in paper and leather manufacture; is harmful by ingestion if illegally used for meat surface treatment or in meat mixes.
- Chlorine (Cl_2) is an effective disinfectant e.g. for drinking water (0.4-0.6 ppm), also sometimes used for microbial control of water for spin chillers in poultry slaughter (up to 20 ppm). "Bleach" which is calcium hypochlorite ($CaOCl_2$), reacts with water and releases chlorine ions, which may affect taste and create harmful residues.
- Hydrogen peroxide (H_2O_2), when applied to meat surfaces etc. it disintegrates into oxygen and water, whereby the oxygen develops the antimicrobial and bleaching effect. It causes colour changes on meat surfaces, sometimes used for bleaching cattle stomachs (tripes). Another substance used for bleaching tripes is Calcium carbonate ($CaCO_3$)
- Antibiotics such as nisin (= bacteriocin deriving from Strept. lactis bacteria), suppresses bacterial growth, used for some foods (dairy industries), but generally not allowed and discouraged for use in meat industries; or sulphamethazine used as an antibiotic in pigs with possible residues occurring in the meat.
- Sulphur dioxide, is widely legally used in food manufacturing (fruits, juices), but use in the meat sector discouraged or forbidden, as it would further add to the daily intake by consumers and, most importantly, it may make poor quality products open to adulteration. The substance has a notable effect on raw red meat, in particular on the hygienically very sensitive minced meat, as it can reverse dark brownish colours of over-stored products causing them to lighten and reddening in colour. Moreover, also the beginning bacterial spoilage can be masked through the substance's inhibitory effect on microorganisms.

Nevertheless, also in the meat sector a number of ***antimicrobial substances*** are used, which are very beneficial for product quality and safety.

Some common additives, primarily used for purposes such as reddening, binding or flavouring, also develop moderate antimicrobial effects, in particular **nitrite** (see page 35, 68) and **phosphate** (see page 68). Also the **common salt** has antimicrobial effects, in high concentrations direct, and in lower concentrations indirectly through reduced water activity (see page 33). However, these impacts alone cannot substitute strict meat hygiene and cooling, but are useful in combination with them.

Other chemical preservatives are also officially authorized in most countries and applied in specific hygienically sensitive situations in the meat sector. Amongst these specific chemical preservatives, organic acids such as **lactic**, **citric** or **acetic acids** are the most common. They are natural food components and therefore permitted in any type of food processing. They can reduce microbial growth on fresh meat surfaces, when sprayed on. For processed meat products they are less suitable as they will have a negative impact on water binding (produce low ph) and taste (sour). Sodium salts of the mentioned acids are better suited for meat products, in particular **sodium lactate** (approximately 1-1.5% added). Also **sodium acetate** or **di-acetate** are used, mostly in low concentrations in combination with sodium lactate.

Potassium sorbate is an effective mould inhibitor. It is only intended for dipping sausage casings (for dry sausages) and for surface treatment of dried meat (concentrations of 2%) to avoid mould growth during drying and storage. Addition to meat mixes is generally not allowed although it seems to be practiced in some places, but it should be discouraged because of possible health risks to consumers.

Para-hydroxybenzoates (PHB) are substances mainly used for preservation of certain pasteurized fish products (1% or less). It is also used as a preservative for meat products, mainly sausages. In some countries it is still officially allowed, but there is a tendency to prohibit it for meat due to residue problems. The same applies to **sodium benzoate** (less than 1%).

Antioxidants

Meat products are susceptible to rancidity, which is fat oxidation. Some commonly used meat processing ingredients moderately counteract oxidation, e.g. **nitrite**, **ascorbic acid**, **phosphates** and also some **spices**. Normally the presence of some of the above substances – nitrite, ascorbic acid/erythorbate and/or phosphates – will provide sufficient protection in the short term. For longer storage, the products should be *vacuum-packed*, *not exposed to light* and kept under *good refrigeration*, all measures, which can help to protect against oxidation. In industrial meat processing, additional chemicals antioxidants (such as

tocopherol/chemically equivalent to vitamin E) may be used in particular for products with high fat content.

Cereals, Legumes, Roots, Tubers and Vegetables

General

Unprocessed cereal grains, common legumes, vegetable, roots and tubers are sometimes used as ***fillers*** to increase volume and decrease costs. They are commonly used for *simple meat* ***preparations***, some of them being rural or ethnic specialities (see page 82, 213). ***Refined products*** of this group such as flours, starches and soy concentrates are used in the meat industry for simple ground products blended with the meat and also for more sophisticated products for ***filling*** *and* ***extension*** purposes. Lastly, some products from this group, processed with ***very high protein content*** (isolated soy protein, wheat gluten), are applied as water and fat ***binder*** mostly in raw-cooked products including canned products of this type.

Cereals

Maize is a common food crop, which can be used as **filler** in low-cost meat products. After harvesting, the grains are stripped from the cob and dried. These dried grains are milled and usually added as flour. In isolated cases they are added whole. Ground *maize bread* is also used as a cheap filler.

Wheat is usually added as flour (milled whole grain or grain with seed coat removed) as **filler**. A common filler product is *rusk*, which is flour mixed with water and little salt, baked and finally crushed. Rusk is a good agent to absorb water and contributes to a better binding in low-cost products. For similar applications, *breadcrumbs* may be used. Breadcrumbs are ground and roasted wheat bread particles, which have undergone two heat treatments (baking and roasting) and hence have a strong water absorption capacity.

Rice is a widespread stable food in developing countries, especially in Asia, and acts as good **filler** for low-cost meat products. If plain white rice is added (Fig. 103), it needs to be precooked or at least soaked in water. The high water absorption property has to be considered when formulating the recipe of the product. Rice can also be added as flour.

Fig. 103: Rice sausage

Food Legumes

The most important examples of this group are beans, peas, lentils, cow-peas and chick-peas. ***Whole seeds*** are used only for certain indigenous products. Care must be taken that the legumes are free of impurities (dirt, sand, insects etc). They are usually soaked in salted water for 1 to 2 hours prior to processing. Products with whole seeds should undergo immediate heat treatment at the processors level in order to avoid possible product spoilage caused by enzymatic reactions if stored without heat treatment.

Apart from the indigenous sector, legumes are used in meat processing in ***refined form***. The most common and most valued legume products derive from soy beans. A variety of **soy protein** products are used as **extenders** in processed meats. The most important are the following:

Soy grits (pressed dehulled and de-oiled soy beans) or ***soy flour***, finely ground, contain 50 percent protein. It is used in meat loaves and minced meat products to add protein and help hold the meat juices. Its main limitation is taste ("beany") and texture of the final product. Amounts to be added vary, but should not exceed 5% (dry).

Fig. 104: Textured vegetable protein (TVP)

Fig. 105: TVP containing colorants

Fig. 106: Isolated soy protein

Soy concentrate, contains about 70 percent protein. It may be used in flour or granular form for finely comminuted meat products. If its structure is changed to granular form to duplicate the texture of ground meat, it is called *textured vegetable protein* (***TVP***) (Fig. 104, 105, 107). Soy concentrates are almost neutral in taste and cause much less "beany" flavour in processed meats than soy flour. Amounts to be added to heavily extended products may be as high as 15% (dry) for hamburger type goods and up to 6% (dry) for raw-cooked goods. Before processing, re-hydration at a ratio of 1:3 is needed.

Soy isolate, contains 90 percent protein. It is the only soy product that functions like meat (it interacts with meat protein) in forming protein network structures and binding water and fat. It is particularly useful in "weak" formulations, where the meat protein content is low. Soy isolate is usually applied in quantities around 2% and is a **binder** (Fig. 106, 107).

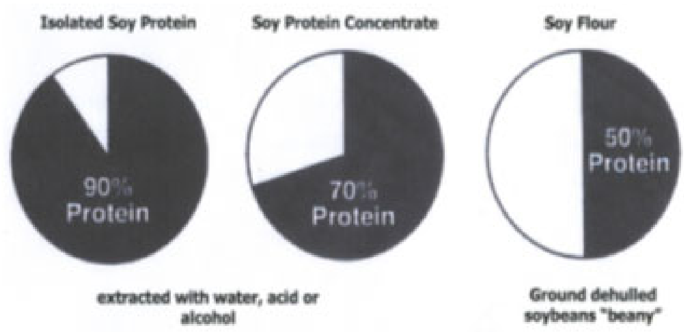


Fig. 107: Characteristics of different soy protein

For soy protein isolates fat/water/soy protein solution (gels) can be fabricated and these gels are added to the meat mixes (Fig. 109).

Soy concentrate may be texturized by extrusion and heating to produce a meat-like texture (Fig. 108). If the necessary flavour (chicken or beef or pork) is added, such products serve as ***meat supplements***.


Fig. 108: TVP shaped as meat-like structures, re-hydrated

Fig. 109: Production steps for soy protein emulsion


Composition of protein emulsion (water, vegetable oil, soy isolate)


Final protein emulsion

Roots and Tubers

Roots and tuber crops originate from swollen roots or underground stems of plants, in which large quantities of starch are stored. They present a major source of calories for rural populations in developing countries. The most common types in Asia and sub-Saharan Africa are cassava (manioc), cocoyams (taro and tania) and sweet potato. In some areas the Irish potato was also successfully introduced.

Cassava (manioc) can be added as an extender to processed meat products in different forms. Precautions should be taken during the selection of fresh cassava as raw material as some cassava varieties can contain high levels of toxic components (cyanide). For this reason, the use of the bitter variety is discouraged.

Fresh – The fresh cassava is peeled by hand. Fresh and peeled cassava tubers can be stored refrigerated for 2 to 4 days if kept in fresh, slightly salted water. The peeled tubers are washed with fresh water and cut in smaller pieces. These pieces can then be minced through the 8 mm disc of a grinder or grated/rasped by hand (Fig. 110).

Fig. 110: Fresh cassava: unpeeled (on top), peeled (right), peeled and grated (left)

Flour – Cassava flour, which is dried and milled cassava, can be a cheap alternative to the more expensive and often imported wheat and maize flour and used in a similar way, either added as powder (page 202) or further processed into a product like rusk.

Starch – In rural processing cassava starch is made from fresh peeled cassava, which is washed, grated and put into baskets for de-watering. The starch is derived by sedimentation in the water.

Gari – The cassava mash (low in protein, high in fibres) remaining from cassava starch production can be stir-fried until granules are formed. This product can now be stored in a dry and cool place and is a good and low-cost extender for all types of cooked meals and fresh sausages (Fig. 111).

Fig. 111: Gari derived from cassava

Sweet potato, Irish potato will be added mainly fresh and peeled. The preparation is similar to the one for fresh cassava. Potatoes are an ideal supplement to cassava as fillers for simple meat preparation as the taste of the final product is refined. Fresh and peeled potatoes can be stored refrigerated for 2 to 4 days if kept in fresh, slightly salted water.

Vegetables and Fruits (Fig. 112)
Onions present a well-suited filler and act as seasoning in fresh or precooked-cooked meat products. Due to the high water content and often very high microbial load the processed products must be prepared and consumed immediately or is cooked and refrigerated.

Banana or Plantain (green fruits) can also be added to precooked-cooked sausage mixtures and fit surprisingly well into the taste of the final products. Together with cassava and potato up to 50 % of the meat can be replaced in a blood sausage. Banana and plantain need to be washed prior to peeling. After peeling, the fingers are cut into small dices and added to the mixture. They are always added raw as cooking would destroy the structure.

Fig. 112: Typical ingredients of plant origin as fillers for simple indigenous meat mixtures

Above: some greens
Below: green banana as sold in fresh market (left), peeled and cut (right)

Above left to right:
Red and green bell pepper, garlic
Below left to right:
Sweet potato, cassava, carrots, onions
(all cut and / or peeled)

SEASONINGS USED IN MEAT PROCESSING

Seasonings are normally parts of plants which flavour food. The trade in and the processing of spices has developed into an important support industry for food processing enterprises in order to meet consumer preferences. Mixtures of seasonings were developed in order to serve as flavouring agents for various meat products. *Natural spices, herbs and vegetable* bulbs are the main groups of seasonings and are described hereunder.

Natural spices

The term "natural spices" includes dried rootstocks, barks, flowers or their parts and fruits or seeds of different plants. The most important natural spices used in processed meat products are **pepper**, **paprika**, **nutmeg**, **mace**, **cloves**, **ginger**, **cinnamon**, **cardamom**, **chilli**, **coriander**, **cumin** and **pimento**. The most common natural spice in sausage making is pepper. Spices are mainly used in the ground form with particle sizes from 0.1 to 1 mm.

Herbs

Herbs are dried leaves of plants grown in temperate climates. The major herbs used in processed meat products are **basil**, **celery**, **marjoram**, **oregano**, **rosemary** and **thyme**.

Vegetable bulbs

The main natural seasonings originating from vegetable bulbs and used in processed meat products are **onions** and **garlic**.

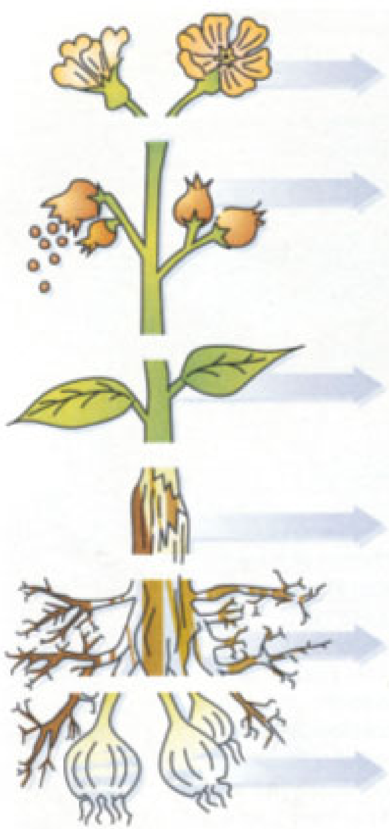


Fig. 113: Origin of natural spices

Extracts

Natural spices are often **contaminated** with high numbers of microorganisms, in particular spores, due to their production process. This may become a problem for the stability of the meat products. The microbial load of spices can be reduced by **irradiation** or **fumigation**. Such treatments are not allowed everywhere. Another option is the use of spices extracts. **Extracts** are produced by separating the flavour-intensive fractions through physico-chemical procedures (e.g. steam distillation) which results in germ-free flavouring substances. Extracts are preferably used in viscous liquid or oily form. Due to the absence of microorganisms, extracts are specifically recommended for the production of microbiologically sensitive processed meat products, such as cured-cooked hams or cured-cooked beef cuts.

Procession and handling

Most spices used in meat processing are milled or ground. The milling method used affects the quality of the spices. Spices are normally cold-milled at low temperatures. The raw spices are deep-frozen thus avoiding the loss of oleoresins, aqua-resins and essential oils, which are the active flavour components.

- Spices (whole or ground, natural or extractives) should always be kept in a **cool**, **dark** and **dry place**.
- They must be stored in tightly **sealed containers** or bags to avoid loss of flavour.
- For processing purposes, spices should only be removed from the storage container using a **spice spoon**. Under no circumstances should spices be removed by hand as the adhering moisture and germs will lead to contamination, loss of flavour and clotting of the dry mixes.
- For all production, spices should be **added by exact weight** in order to standardize flavour and taste of the product.
- Products, which are consumed hot should be spiced **mildly**, as in the hot product higher amount of flavouring agents (oleoresins, aqua-resins and essential oils) will be released.
- If spices are added to a product mix under high temperature, the seasoning should be **strong**. In case of cold consumption of this product less spice will be released and taste and flavour will be weak if there is not enough seasoning.

Table 3: Common Seasonings used in processed meats

Description and origin	Uses (in gram per 1 kilo of product)
A. ***SPICES***	
Black / white pepper Fruits seed	Used in a variety (almost all) meat products 1–2.5 g / 1 kg.
Paprika (Fruit seed)	Used in frankfurters, minced specialties and other products. Sometimes used as a colouring agent. 1-5 g / 1 kg.
Chilli (Fruit seed)	For spicy products
Pimento (Fruit seed)	It has an aroma similar to a mixture of nutmeg, cinnamon and cloves. Used in a variety of sausage products. Sometimes used as a partial replacement for black pepper in frankfurters and some smoked products. 0.3-3.0 g / kg
Mace (Flower)	Used in liver sausages, frankfurters and bologna and similar. 0.4-1.0 g / kg
Ginger (Rhizome) (Root)	Used in frankfurters and similar products. 0.3-0.5 g / kg
Nutmeg (Fruit seed)	Used in bologna and minced ham sausages, frankfurters, liver sausage and gelatinous meat mixes. 0.3-1.0 g / kg
Clove (Flower)	Used in bologna, gelatinous meat mixes and in blood and liver sausage. 0.3-0.5 g / kg
Cinnamon (Bark)	Astringent and sweet, used in some countries in mortadella and bologna sausage. 0.1-0.2 g / kg
B. ***AROMATIC SEEDS***	
Cardamom	Rapid loss of aromatic constituents during storage. Used in liver sausage and gelatinous meat mixes. 0.3-5.0 g / kg
Celery seed	Used in fresh pork sausages. 0.3-2.0 g / kg
Coriander seed	Contains about 13% of fatty matter and a trace of tannin. It is used in frankfurters, minced ham, luncheon meat. 0.3-1.0 g / kg
Cumin	Used for meat specialties with distinct flavour. 0.2-0.3 g / kg
C. ***CONDIMENTAL HERBS***	
Marjoram **Thyme**	Used in liver and white raw-cooked sausages and gelatinous meat mixes. 0.5-2.0 g / kg
D. ***CONDIMENTAL VEGETAB.***	
Onion (Bulb)	Used in liver sausage, gelatinous meat mixes, meat loaves. Sometimes replace garlic. 2.0-10.0 g / kg
Garlic (Bulb)	Used in many types of raw-cooked sausages. 0.1-0.2 g /kg

Fig. 114: Selected seasonings used in meat processing

White, black and green peppercorns

Ground coriander and coriander seeds

Ground and whole nutmeg

Ground mace and

Ground allspice and allspice berries

Cinnamon stick, quills and ground

Cayenne pepper

Whole and ground cloves

HEAT TREATMENT OF MEAT PRODUCTS

Heat treatment of processed 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.

Fig. 115: Large calibre sausages treated in hot water in cooking vat

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).

Fig. 116: Cured-cooked hams. Cooking by immersion in hot water in cooking vat

Fig. 117: Meat loaves before heat treatment (in this case **baking**)

Fig. 118: Meat loaf after heat treatment (core temp. +72°C)

Fig. 119: Meat loaf with firm texture and pink colour after heat treatment

Fig. 120: Large calibre sausage upon heat treatment (core temp. +70.3°C) (see also table 8, page 142)

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**

Fig. 121: Precooked lean meat (left) **and fat** (right) **for processing of "precooked-cooked meat products"**

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).

Fig. 122: Fresh sausages before heat treatment

Fig. 123: Fresh sausages after heat treatment

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)

Recommended minimum safe internal temperatures	
Poultry (dark meat)	80°C
Poultry (light meat)	71°C
Ground poultry	74-80°C
Ground beef and all types of pork	71°C
Beef/veal/lamb steaks and chops (medium-rare)	63°C

Heating parameters for 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.

____

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

Fig. 124: Hurdle technology

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

High temperature:	*Heat treatment*
Low temperature:	*Cooling, freezing*
Water activity (a_w):	*Drying, salt, sugar, fat*
Acidity (pH):	*Acidification*
Redox potential:	*Decrease oxygen (vacuum, ascorbate)*
Preservatives:	*Sorbate, nitrite etc.*
Competitive flora:	*Fermentation (only applicable for non-heat-treated products)*

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^{o}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 (10^5) microorganisms per gram
Treatment temperature 65^{o}C
Decimal reduction time 6 sec

$$10^5 \xrightarrow{\text{6 sec}} 10^4 \xrightarrow{\text{6 sec}} 10^3 \xrightarrow{\text{6 sec}} 10^2 \xrightarrow{\text{6 sec}} 10^1 \xrightarrow{\text{6 sec}} 10^0 \quad = \mathbf{30\ sec}$$

(In this example the temperature impact of **30 seconds** at 65°C is needed for the elimination of the microbial load of originally 10^5/g).

Table 4: Examples for heat resistance/ decimal reduction times of selected microorganisms (experimental results from various sources)

Vegetative organisms	50°C	55°C	60°C	65°C	70°C	75°C	80°C
E. coli	4-7 min						
Salmonella ssp. (average)				0.02-0.25 min	1.2 sec		
Salmonella typhimurium				0.06 min			
Salmonella senftenberg*				0.8-1 min			
Salmonella typhi						1 sec	
Mycobacterium tuberculosis				12-18 sec		5 sec	
Listeria monocytogenes			5-8 min		0.1-0.3 min		
Staph. aureus				0.2-2 min			2 sec
Campylobacter	1.1 min						
Enterobacter						3 sec	
Lactobacillus spp.				0.5-1 min			
Spoilage bacteria, yeasts, moulds				0.5-3 min			
Bacterial spores	**100°C**	**105°C**	**110°C**	**121°C**			
Bacillus spp.	0.1-0.5 min						
Bacillus cereus	5 sec			0.5 sec			
Bacillus anthracis	15 min						
Bacillus stearothermophilus			<300 min	4-5 min			
Cl. botulinum type E	0.01 min	<1 sec					
Cl. botulinum spp.	50 min			0.1-0.2 min			
Cl. sporogenes				0.1-1.5 min			

* = 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.

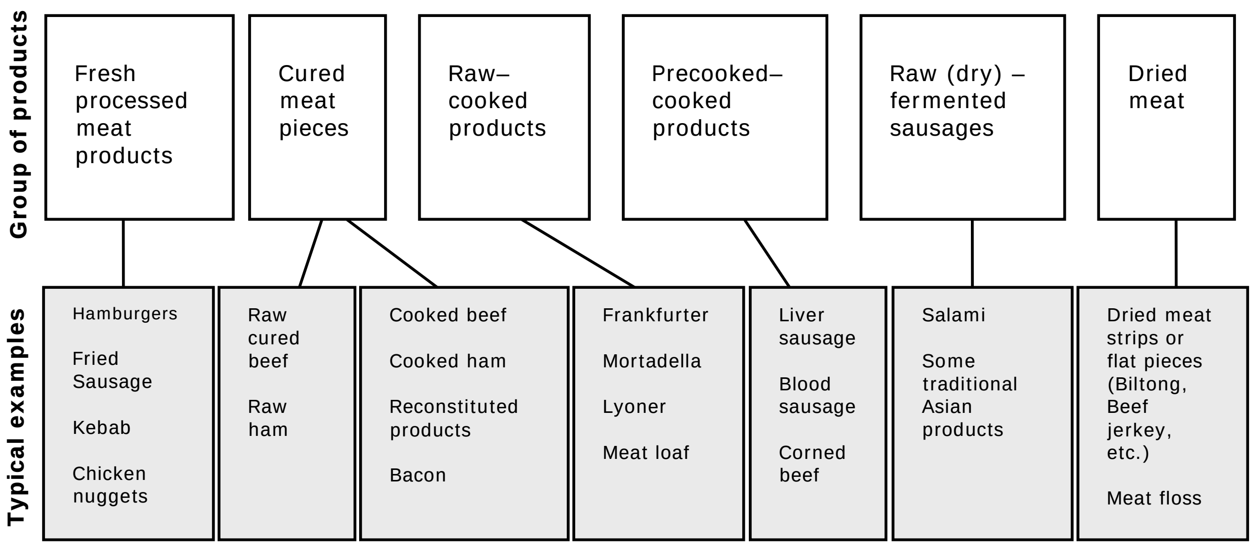
The above data on heat resistance of microorganisms clearly demonstrate the importance of accurately applying heat treatment temperatures and times recommended for specific meat products. So called **undercooking**, which means that recommended temperature/time parameter were not reached, must be avoided. 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:

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

Fig. 126: Fried fresh sausages (left) **and beef patties** (right)

Fig. 127: Chicken nuggets

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.


Fig. 128: Cured-raw ham


Fig. 129: Cured-cooked products

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.


Fig. 130: Viennas, hotdogs


Fig. 131: Sausages and meat loaf of the raw-cooked type

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 **precooking 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 precooking 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).

Fig. 132: Blood sausage

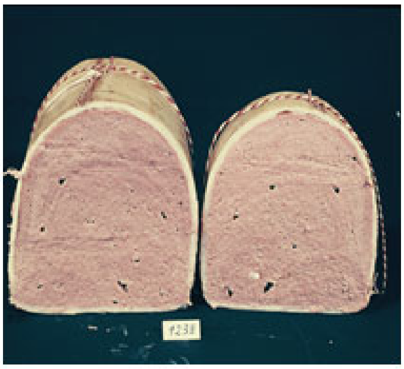


Fig. 133: Liver pate

Fig. 134: Corned beef in cans

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).

Fig. 135: Raw-fermented sausages

Fig. 136: Naem, a fermented product from South-East Asia

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.

Fig. 137: Biltong from Southern Africa

Fig. 138: Meat floss (beef, chicken, pork) from East and SE-Asia

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.

Fig. 139: Frying sausages and burgers, fresh, above; fried immediately before consumption, below

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

Step 2: Grinding / blending of burger mix

Step 3: Moulding burgers

Step 4: Frozen burgers

Step 5: Burgers fried for consumption

Fig. 140: Manufacture of burgers

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.

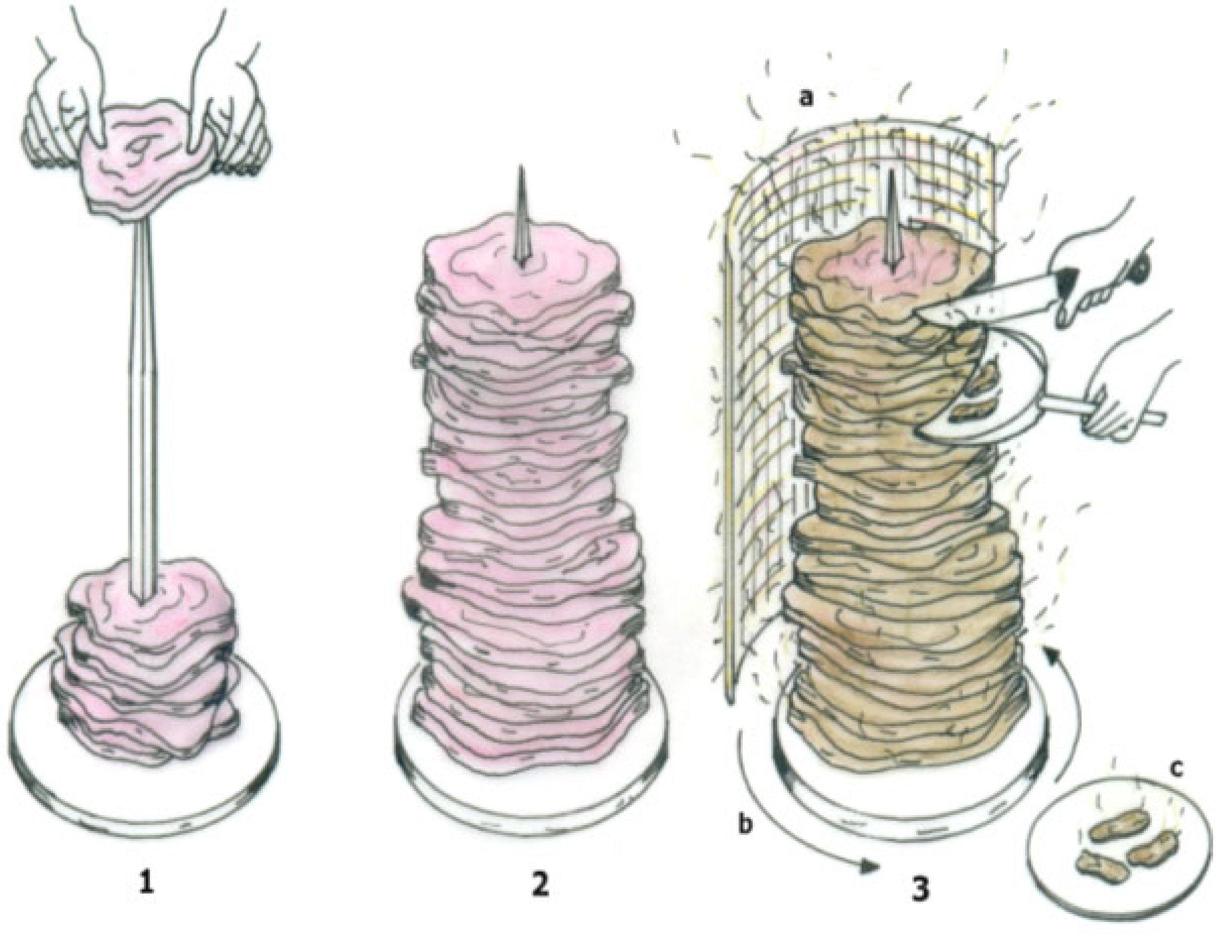


Fig. 141: Arranging meat slices on a kebab skewer and trimming off meat pieces from the skewer for consumption.
1 = Loading skewer with marinated meat slices
2 = Skewer ready for exposure to heat
3 = Skewer during heat treatment, fully cooked outer portions being trimmed off
a = heating device (charcoal, 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.

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.

Fig. 143: Fresh sausages in different casings being fried

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.

Fig. 144: Production steps for coarsely chopped fresh sausages

Step 1: Material composition
Left: back fat, middle: salt (above) and spices (below), right: lean meat with adhering fat and without coarse connective tissue

Step 2: Mixing of ingredients

Step 3: Grinding of mixture

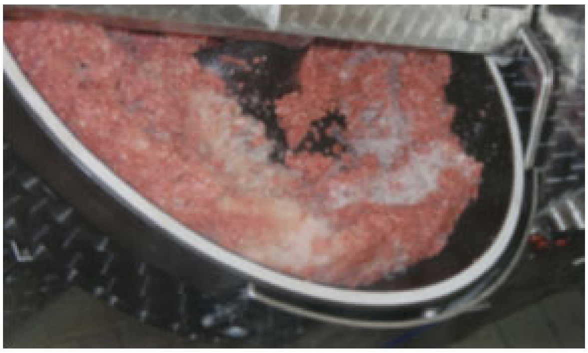
Step 4: Casing preparation (soaking and rinsing natural pig casings)

Step 5: Sausage stuffing (manual stuffer)

Step 6: Portioning and twisting

Step 7: Final fresh product

Fig. 145: Production steps for finely chopped fresh sausages



Step 1: Lean meat and ice are mixed

Step 2: Salt and spices are added

Step 3: Extenders are added

Step 4: Fatty tissue is incorporated

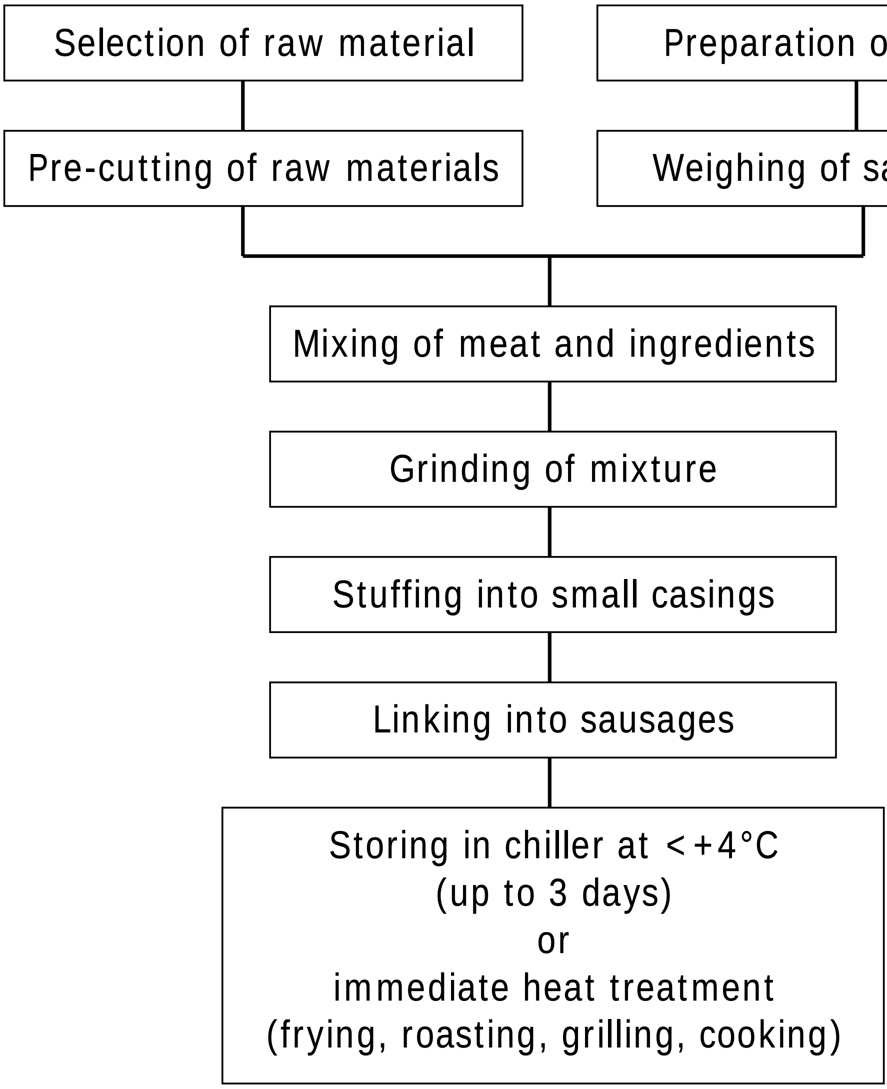
Step 5: After stuffing, the sausages are linked and twisted

Step 6: Packaging of fresh sausages in consumer portions (vacuum packs)

Storage and preparation for consumption

Fresh sausages are highly perishable products and subject to fast microbial spoilage and oxidative rancidity. They should be heat-treated and consumed **as soon as possible** after production, or must be stored immediately under refrigeration. Their maximum storage life is normally three days at +4°C or below. If the product is deep-frozen at -18°C, the storage life can be extended up to three months. However, one difficulty associated with frozen storage is the oxidative rancidity. Storage in vacuum bags can prevent the fast onset of rancidity.

Fig. 146: Production diagram of fresh coarse sausage



Processing of local low-cost fresh sausages

Low-cost variations of fresh sausages are widely available. In these variations, available vegetables and other fresh plant ingredients and their derivates (bell pepper, bread crumbs, soy concentrates/textured vegetable protein, potato, fresh cassava, dried cassava flakes, rusk, etc) are used as **extenders**. Small amounts of **binders** such as starches and flours are also common in some of the products. More details on extenders, fillers and binders see in Chapter “Non-meat ingredients” page 59.

In cases where smaller or larger quantities of **fresh vegetables** and other fresh plant ingredients are incorporated, special pre-treatment of these non-meat materials must be carried out. Onions and garlic must be thoroughly peeled; bell pepper must be washed and all seeds and stem parts must be removed; fresh cassava and potatoes must be washed and peeled. All components are cut into uniform small pieces and mixed with meat and spices. For a good degree of blending of such fresh plant/vegetable extenders the mixes containing all ingredients are minced 3-5 mm before stuffing them into available casings.

Fig. 147: Vegetable extenders and material mix

Step 1: Fresh extenders of plant origin: cassava, onions, garlic, bell pepper, potatoes, carrots (from left)

Step 2: Material mix with fresh extenders; left: lean meat with spices and salt, middle to right: garlic, bell pepper, cassava, carrots, onions

These low-cost variations vary widely in their composition but are easy to manufacture, even in basic kitchen-style facilities. Under such basic conditions, production should take place without delay after slaughtering and cutting. The produced goods should be cooked and consumed immediately or stored in chillers or freezers after stuffing. In general, products containing fresh extenders have a shorter storage life than products with derivate extenders. If natural casings derived from the same slaughtering are used for filling, they must also undergo rapid and hygienic processing (see page 252).

Fig. 148: Village manufacture of fresh beef sausages in East Africa

RAW-FERMENTED SAUSAGES

Definition

Raw-fermented sausages receive their characteristic properties (tangy flavour, in most cases chewy texture, intense red curing colour) through **fermentation processes**, which are generated through physical and chemical conditions created in raw meat mixes filled into casings. Typical raw-fermented sausages are **uncooked meat products** and consist of coarse **mixtures of lean meats and fatty tissues** combined with salts, nitrite (curing agent), sugars and spices as non-meat ingredients. In most products, uniform fat particles can clearly be distinguished as white spots embedded in dark-red lean meat, with particle sizes varying between 2-12mm depending on the product. In addition to fermentation, **ripening phases** combined with moisture reduction are necessary to build-up the typical flavour and texture of the final product. The need for moisture reduction requires the utilization of **water-vapour permeable casings** (see page 249, 261, 263). The products are not subjected to any heat treatment during processing and are in most cases distributed and consumed raw.

Fig. 149: Raw fermented sausage products of different calibres and degrees of chopping

Biochemical processes in manufacture

Raw-fermented sausage products have been developed and produced for centuries in regions with moderate climates around the world. Traditionally, the fabrication took place during the cold season, as relatively low temperatures are required for fermentation, drying and ripening. At the end of the ripening phase, raw-fermented sausages, also known as "**dry sausages**", are considered **shelf-stable** even under higher temperatures. A sub-group of raw-fermented sausages are the semi-dry and/or spreadable products. Principles of manufacture of these semi-dry products are discussed at the end of the chapter.

In the past, when cooling facilities were not readily available, their shelf-stability made raw-fermented sausages very popular as an animal protein reserve for food security purposes. Nowadays, these products are fermented, dried and ripened in artificially climatized rooms or chambers and can therefore also be fabricated during warmer seasons and even in tropical climates.

In the specific case of raw-fermented sausages, **fermentation** refers to the breakdown of carbohydrates ("sugars") present in meat mixtures, mainly to lactic acid. Traditionally processors of raw-fermented sausages relied on the action of fermentation bacteria, naturally present in the meat contaminating flora. Relatively low temperatures (around 20°C) are instrumental in stimulating the growth of the desired **fermentation flora**, while the growth of the **spoilage bacteria** is suppressed. Conditions for spoilage bacteria become gradually more unfavourable, as the fermentation bacteria produce acids resulting in the decline of the pH-values in the product. The development of the desired fermentation flora also contributes to the **typical taste**, **appearance** and **texture** of raw-fermented sausages. An additional measure to control spoilage bacteria in the product is the controlled decrease of moisture (reduction of a_w) during fermentation and ripening. Spoilage bacteria need higher a_w values than acid producing bacteria (see page 324).

These biological processes in raw-fermented sausages constitute a rare example where microbial activity can be useful. Another example is raw fermented ham. However, this biological process can get out of control, for example if temperatures in fermentation or ripening chambers are too high or if the contaminating flora is excessively numerous with an overwhelming share of spoilage bacteria. In such cases, fermentation bacteria will not sufficiently develop and the product spoils. This risk is minimized by the use of **fermentation and ripening chambers** with controlled air temperature and humidity favourable for fermentation and drying (Fig. 150, 151). The second measure is the use of **selected fermenting bacteria** (commercially produced microbial starter cultures), which are added to the sausage mix and develop the desired fermentation processes, until moisture contents reached are low enough to stop fermentation.

Raw-fermented sausages depend not only on fermentation to achieve the desired texture and flavour, but during their long ripening periods other biochemical and physical factors become increasingly important. Natural **fat alterations** (rancidity) take place and produce strong flavours. This process can be substantially slowed down by selecting suitable raw fat materials (preferably fresh pork back fat) and applying relatively low ripening and climatization parameters (e.g. 20°C and 75-80% rel. humidity). Prolonged ripening and drying also leads to **low moisture contents** with the consequence of more **concentrated flavour component** and **firmer sausage texture**. The water content of finished raw-fermented sausages is always below 35%, in many cases even less than 30%. This corresponds to an a_w of 0.90 and below and makes the product shelf-stable. Under moderate climatic conditions and storage (e.g. 20°C and 70-75% relative humidity), the products have a prolonged shelf life of over one year.

Raw-fermented sausages have **moderate acidity** with pH-values in the range of 5.0 to 5.5. Some manufacturers still rely on their typical meat plant flora to initiate the fermentation process. The use of **starter cultures** has the big advantage that the initial biological process can be controlled/directed and growth of spoilage bacteria is reduced. Raw-fermented sausages may be produced with or without **smoking**. Un-smoked products are called "**air-dried**". The **ripening** and **drying periods** are determined by the sausage formulation and casing diameter. Ripening periods can amount up to 90 days, but most raw-fermented sausages are finished within 3-4 weeks. Typical examples for dry sausages with more or less prolonged ripening periods are the various types of salamis (Hungarian, Italian, Central European, Spanish chorizo) (Fig. 152).

Fig. 150: Recently filled raw-fermented sausage being transferred to ripening chamber

Fig. 151: Raw-fermented sausage after 10 days in ripening chamber

Principles of manufacture (recipes page 394 – 399)

The manufacture of raw-fermented sausages at the small to medium scale meat industry level is outlined hereunder. These sectors often lack a full range of comminuting equipment and in particular equipment for accurate climatization during fermentation and ripening and therefore face more **technological** challenges than larger, well equipped industries.

Raw materials

The processing of raw-fermented sausages is dominated by biological and biochemical processes and raw meat materials of **excellent hygienic quality** are a precondition for the correct functioning of such processes. Lean meat from a variety of **animal sources** such as cattle, pigs, horses, donkeys, camels, sheep or goats can be used. The lean meat can be from older adult animals, as water content and water holding capacity of such meat is lower, which supports the necessary drying processes during fermentation and ripening. All meat used must be chilled for some time to reach its **lowest ph-values**. Beef meat should have pH-values at 5.4-5.5, pork meat 5.7-5.8. All lean meats for raw-fermented sausages need extra **careful trimming** of sinews and softer inter-muscular fatty tissue. Remaining sinews will remain tough and are not desired by consumers.

In most products fresh chilled **pork backfat** is used as it is firm and dry and remains stable without pronounced rancidity even after prolonged ripening periods. Softer inter-muscular fatty tissue should not be used as it cannot be chopped to clearly defined particles and would result in somewhat blurred unclear appearance of slices of the final products. Soft fat also increases the risk of early rancidity. If fats from other species of slaughter animals are used, only firm body fats should be considered (see page 10, 46).

Importance of bacteria

Bacterial starter cultures have a variety of functions including:

- Boosting acidity (decreasing pH)
- Intensify the curing colour (acid environment catalyses curing reaction)
- Counteract rancidity of fats (due to enzymatic impacts)
- Development of flavour and taste
- Texture improvement of ripened products (by supporting formation of protein gel in sausage mixes).

Over the years, mainly bacteria belonging to the groups of *Lactobacillus, Pediococcus, Staphylococcus and Streptococcus* have been identified and cultivated for **commercial starter cultures**, as they proved to provide the best results in terms of producing lactic acid, developing ripening flavour, and are generally harmless in terms of product spoilage and impact on consumers' health. Depending on the desired taste, texture and appearance of the product, **specific cultures** are selected. The use of Lactobacillus results in fast acidification to lower pH-values, the use of Pediococcus leads to slower and milder acidification. Selected Staphylococcus strains cause a speedy reduction of nitrite, stable curing colour and reduced risk of fat rancidity, especially in products fabricated with Glucono-delta-Lacton (GdL, see page 120).

In most cases **mixtures** from different strains are used in order to achieve the best product specific results, for example in sausages with normal diameters (35-70 mm) an even mixture of Lactobacillus and Staphylococcus can be used to achieve the product-typical flavour, texture and taste. In sausages with of larger diameter (70-100 mm), the starter culture mixture normally contains a lower amount of Lactobacillus and a higher portion of Staphylococcus, as these products need more time to reach microbial growth inhibiting moisture contents. The strong potential of Staphylococcus to stabilize curing colour and fats is helpful in this context.

Importance of salt, curing agents and sugars

One of the main targets during fermentation and ripening of raw-fermented sausages is the **reduction of their water content**. The moisture to be reduced is exclusively from the muscle meat which has a water content of around 80%. The addition of **salt** lowers the a_w value of the mix by absorbing water, which presents an initial hurdle for unwanted bacteria. Furthermore, in the presence of salt, salt-soluble proteins are extracted from the small lean meat particles after grinding and chopping. These solubilized or gelatinous proteins act like an adhesive between the interfaces of lean meat and fat particles in the meat mix. The result is an **increasingly firm structure** with progressive ripening and drying of the products. The average quantity of salt added to raw-fermented sausages should be between 26-30 g/kg (2.6-3.0%) but not below 26 g/kg (2.6%). It should be noted that the salt content in percent in the final products will always be higher than in the initial mix, as these products lose a substantial amount of water. Salt contents in final products can be from 3 - 4.5% depending on the initial salting.

In raw-fermented sausages, salt is also used as a carrier for the curing agent, normally **sodium nitrite.** This curing agent is not only responsible for the development of a typical **red cured meat colour**, but also has **bacterial growth inhibiting properties**, especially on some pathogenic bacteria (see page 68). In raw-fermented sausages with a slow decrease of pH-values and prolonged ripening periods, **nitrate** can also be used as a curing substance. The use of both, nitrite and nitrate results in similar colour and taste. The main difference is that nitrate must first be reduced to nitrite by bacteria, which is a time-consuming process and hence only applicable to long-term ripened products. The slowly progressing acidity in such sausages allows the bacterial breakdown of nitrate to nitrite. The following reduction of nitrite to nitrogen oxide (NO), which is the substance effective in the curing reaction, is a relatively fast chemical process (principles of curing see page 34). The use of nitrate, mixed with nitrite is favoured by some processors as it is associated with better colour and flavour.

From the technical point of view, the purpose of adding **sugars** is to facilitate and strengthen the fermentation by bacteria. Provision of a sweet flavour to counteract acidity in the final product is normally not intended. The bacterial breakdown of sugars results in the accumulation of lactic acid and in a low pH-value (acidification) as well as the development of a typical flavour. In order to support this process, lactic acid producing bacteria (starter cultures such as lactobacillus or pediococcus, see page 118) can be added to the sausage mix. Simple sugars such as dextrose or fructose support an early drop in pH-values as they are easily broken down by bacterial action. The breakdown of lactose is slower and takes longer. Often a mixture of different sugars is used. Another sugar-based additive is **GdL** (Glucono-delta-Lactone), which accelerates and intensifies the acidification process by reacting to glucono-acid in the presence of water (muscle tissue water). It is preferably used in semi-dry and/or spreadable products, which are not for long-term ripening and storage, but for consumption within a short period after production.

Production methods

As a rule of the thumb, raw-fermented sausages are fabricated with 20-35% fatty tissue and 65-80% lean meat, from one or more than one animal species, e.g. beef and pork or pork only or beef only. Other variations are also possible. If **fatty tissue** other than pork back fat is used the percentages for the fat are usually lower. The **techniques of comminuting** of meat and fat for raw-fermented sausages differ from other meat products. Raw-fermented sausages may be composed of coarse, medium or tiny meat and fat particles (Fig. 152). The **degree of chopping** can be visualized by the size of the fat particles in the final product. Some traditional Mediterranean (Italian, Spanish, French, etc.) salamis are chopped coarsely (6-12mm), but the majority of raw-fermented sausages are chopped moderately (2-5mm). Only a

Fig. 152: Different degrees of chopping (different fat particle size)

few semi-dry and/or spreadable products are finely chopped (see Fig. 158).

In small to medium-sized processing, there are two methods of manufacture of raw-fermented sausage mixes, which basically differ by the method of comminution of the raw materials. Applying a simple comminuting method, only **meat grinders** are used to prepare the sausage mixes. In more advanced techniques **meat grinders** and **bowl cutters** are used.

<u>Method 1:</u> In small-scale operations with only **meat grinding equipment** available, production is restricted to ground sausage mixes. The lean meat needs to be thoroughly chilled (+1°C) or even slightly frozen. The fat portion should be cut into small and uniform dices (10-20 mm, domino chip size) and frozen (-12°C) in order to obtain clearly and evenly cut particles in the initial chopping of the sausage mix. Clearly cut particles of firm solid fat also avoid greasing of the casing from inside, which would make drying more difficult. Firstly, part of the lean meat is minced 3-5mm (approx. 30%) and the remaining lean meat is cut into small pieces (20-50 mm). The chilled meat pieces and frozen fat dices are thoroughly mixed with all additives (curing salt, sugars, starter cultures, spices, etc), before the minced meat portion is added and incorporated in the mixture. The entire mixture is now passed through the meat grinder (disc size 3-6 mm), packed into the sausage stuffer and stuffed into casings. Delays leading to warming up of the mixture need to be avoided as this would result in greasing during the stuffing.

For the stuffing, natural or artificial casings can be used. Typical natural casings, depending on the desired sausage diameter, are those derived from the small intestines of pigs, sheep, cattle or horses. Artificial casings used are fibrous or collagen casings. One important requirement for casings used for raw-fermented sausages is to closely adhere to the sausage mix not only after filling but also during the drying period when sausages shrink. The casings used must be water vapour permeable, otherwise no drying during fermentation and ripening can take place and the products would spoil. The required conditions are met by natural casings, and fibrous and collagen casings (see page 249).

<u>Method 2:</u> With a **bowl cutter** available, a different technology can be applied. With this method 50% of the lean meat material is minced (3 mm) and kept at 1°C. The remaining 50% of the lean meat is cut into pieces of 30-50 mm diameter and slightly frozen (-10°C). As per method 1, the fat is cut into small dices (preferably 10-20 mm, domino chip size) and also frozen (-12°C). Firstly, the large pieces of frozen lean meat are chopped. If starter cultures are used, they must be added at this stage. After several rounds of the frozen lean meat in the bowl cutter, the

frozen fat is added together with the spices and sugars and chopping is continued at a medium speed until the fat has reached the desired particle size. Then the minced chilled meat is added under low chopper speed until an even distribution is achieved. In the next step, the nitrite curing salt is added and mixed at low speed for at least 6-8 rounds until a final temperature of around -5°C is reached. This mix temperature should not be exceeded in order to avoid the greasing of the interior of the filling funnel and casings.

When lean beef and pork is used for the above raw-fermented sausage fabrication, the beef should be chosen for the 50% lean meat portion to be minced, while the pork portion is preferably used frozen.

The sausage mix is packed into the sausage stuffer and stuffed into the casings as firmly as possible to avoid air pockets. Excessive air inside the casing will discolour the meat and reduce the shelf life of the sausage (Fig. 153). Selected natural or artificial casings can be used as above.

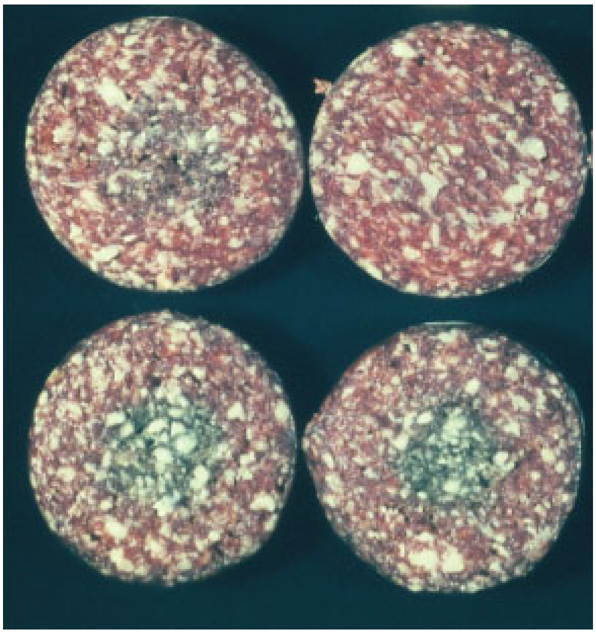


Fig. 153: Air pockets caused by loose stuffing. Discoloration caused by enclosed air. Above right tightly stuffed, no discoloration

Drying / ripening

The freshly filled sausages are subjected to the crucial part of their manufacturing process, namely **fermentation**, **drying** and **ripening**. To this purpose they are transferred to either a climatized room or a modern combined smoking/drying chamber. Directly after stuffing, the sausage mix is still in the temperature range below zero (below freezing point). It is therefore advisable to include a **tempering period** of three hours at moderate room temperature before the sausages are transferred to the drying/ripening chamber (Fig. 150).

The immediate goal is to allow **moisture** release from the sausages and to initiate the fermentation processes, e.g. to provide proper growth conditions for the fermentation bacteria. A high relative humidity at the outset of the drying operation, which keeps sausage casings wet and soft, and the gradual lowering of the air humidity in the advanced stages of the process are the key factors to enable the moisture to migrate from the interior of the sausage to the outer layer.

Temperatures and **air humidity** inside the drying/ripening chambers need to be adjusted carefully to support the ripening/drying process. The temperatures in the ripening chamber are initially kept at +22°C and are slowly reduced to +19°C. The relative humidity decreases gradually from typical values of 92-94% on the first day to 82-84% before the sausages are transferred to the ripening/storage room. During ripening the temperature is maintained at <16°C at a relative humidity of 75-78%. These physical parameters are applied to ensure controlled bacterial fermentation resulting in lowering of pH to 4.9 – 5.4 and controlled gradual dehydration resulting in remaining moisture content in finished raw-fermented sausages as low as 30%. The duration of the drying/ripening process mainly depends on the diameter of sausages and type of sugars and starter cultures used (Table 6, see also page 320, 322).

If the humidity is kept **too high**, excessive surface moisture is retained usually resulting in increased bacterial growth on the surface, thus forming a slimy layer. If humidity is **reduced too fast** especially in the early stages of the process, a hard and dry crust is formed at the outer layer of the sausage. This crust is unable to adjust to the reducing diameter caused by continuous loss of moisture and as a result cracks will appear in the centre of the product (Fig. 154).

Fig. 154: Raw-fermented sausage. Crack in centre as a consequence of excessively fast drying

In the first phase of drying, the **red cured meat colour** is built up in the previously grey sausage mix. The curing colour progresses from the centre of sausage to the outer region. Fermentation processes start practically from the point of transfer of the sausages into the drying/ripening chamber. The **duration of the fermentation** varies depending on the calibre of the sausages, particle size of the mix, temperature and ingredients. In a typical raw-fermented sausage (particle size 3 mm, stuffed in casing of calibre 65, where a sugar mix and starter culture mix is used), the lowest pH-values should normally be reached within 5-6 days. The typical flavour and texture of the products are developed after completing fermentation and ripening (Fig. 157).

One problem during the ripening period can be **mould and yeast growth** on the sausage casings, even under substantially decreased

Fig. 155: Undesirable mould growth

Fig. 156: Desirable mould growth. Casing surface inoculated with mould starter culture (below), without mould growth (above)

humidity. If these occur they can be brushed off and reoccurrence or further growth can be stopped by exposure of the sausages to smoke. Early (day 3-5) application of **cold smoke** at temperatures below +22°C as an additional preservation measure is highly recommended. Of course, smoking is also intended to contribute to flavour and taste. Sausages are smoked from several hours to several days or even weeks according to their diameter and type of product.

One specific group of raw-fermented sausages are the "**air-dried**" type, as they do not undergo smoking. The air-drying combined with prolonged ripening periods produces a typical yeasty-cheesy flavour, which is often intensified by intended mould-growth on the casing surfaces. Not all moulds are suitable. Some species are even capable of producing poisonous substances, which may penetrate into the sausages (see page 359). There are several **cultures of selected moulds** (e.g. Penicillium) available, which serve as starter cultures for desirable mould growth. A watery suspension of such moulds can be applied onto the surface of the sausages. This suspension of moulds will adhere to the casing surface and grow over the course of the ripening period to a thin white-coloured mould overlay. These microorganisms are harmless from the health point of view but provide typical appearance and flavour to the sausages (Fig. 156).

Table 6: Raw-fermented sausages of different calibres
Normal fermentation process assisted by starter cultures

Sausages 75 mm diameter						Sausage 40 mm diameter				
Day	Rel. humidity in %	Temp °C	a_w	pH		Day	Rel. humidity in %	Temp °C	a_w	pH
01	92	23	0.95	5.80		01	92	22	0.95	5.80
02	92	23	0.95	5.70		02	91	22	0.94	5.70
03	91	22	0.94	5.40		03	90	22	0.93	5.40
04	90	21	0.93	5.20		04	88	20	0.91	5.10
05	89	21	0.92	5.00		05	87	20	0.90	5.00
06	88	20	0.91	4.90		06	86	20	0.89	4.90
07	87	20	0.90	4.80		07	85	20	0.88	4.80
08	86	20	0.89	4.80		08	84	19	0.87	4.85
09	85	19	0.88	4.85		09	83	19	0.86	4.85
10	84	19	0.87	4.90		10	82	18	0.85	4.90
11	83	19	0.86	4.90		11	80	18	0.83	4.90
12	82	18	0.85	4.95		12	78	18	0.81	4.95
13	81	18	0.84	4.95		13	76	17	0.80	5.00
14	80	18	0.83	5.00		14	76	17	0.79	5.00
15	80	17	0.82	5.00		15	76	17	0.79	5.05
16	78	17	0.81	5.05		16	76	17	0.78	5.05

Rel. humidity, Temperature } in ripening chamber a_w, pH } in products

Semi-dry sausages

These products (Fig. 158) are produced by **forced rapid fermentation**. Certain starter cultures (Staphylococcus for speedy reduction of nitrite, stable colour) are used in combination with GdL (Glucono-delta-Lacton). This boosts the growth of the desired bacterial flora (lactic acid bacteria) and drops the pH-value fast, resulting in the rapid formation of a protein gel and firm structure of the sausage, which allows slicing and cutting at an early stage. The initial fermentation and ripening period takes place at slightly higher temperatures (+24-26°C) than used for long-time ripened sausages and rarely exceeds 4-7 days. The low pH of 4.8 to 5.4 also supports the fast release of meat tissue water from the sausage, but because of the short production period, the final moisture content will not go below **40%**. The shelf life of such sausages is surprisingly long, up to one month, due to the accumulation of acids and smoke compounds. These products rarely spoil even in ambient temperatures but they may develop excessive acidity, hence **climatized** (<+18°C) or **refrigerated storage** is recommended, in particular in subtropical and tropical countries. Acidity in semi-dry raw-fermented sausages is relatively pronounced, which makes such products less attractive to consumer groups not familiar with acid foods. But they are popular in Europe (“Cervelats”, “Mettwurst”) or in North America (“Summer sausage"). The product name "summer sausage" was coined due to the fact that this product's fabrication was possible by forced fermentation during the warm season and not only in winter.

A special type in the group of semi-dry sausages are the **spreadable raw-fermented sausages**. As the name implies, these products are designed to remain soft so that they can be used as a sandwich spread. For their production the same combination of starter cultures and GdL is used, but for a different reason. The formation of protein gel must be achieved rapidly before the final mechanical chopping step. The onset of gel formation must already develop in the semi-processed sausage mix and is destroyed again by additional chopping in order to retain a soft and creamy texture in the final product. For these products, softer fatty tissues can be used as they will further facilitate the spreadable texture.

Fig. 157: Raw-fermented sausages. Long ripening period (50 days)

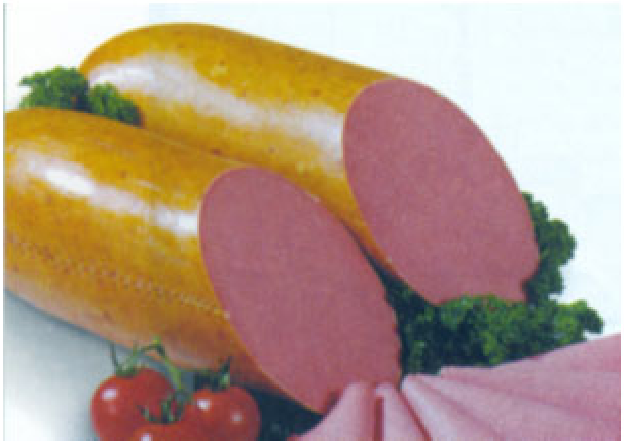


Fig. 158: Semi-dry fermented sausages. Short ripening period (10 days)

RAW-COOKED MEAT PRODUCTS

Definition: The product components *muscle meat, fat* and *non-meat ingredients*, are processed raw ("**raw**"=uncooked) by comminuting and mixing in a first phase. The resulting viscous mix/batter, upon portioning in sausages or otherwise, is thereafter submitted to heat treatment or "**cooking**", in order to obtain a firm-elastic texture typical for ready-to-eat raw-cooked products and to achieve palatability and a certain degree of bacterial stability.

Raw-cooked meat products are mostly manufactured and marketed as *sausages* in small to larger calibre casings, but are also available as *meat loaves*, *meat balls* or as *canned products* (Fig. 159). Raw-cooked meat products are a very specific group as **their processing technology is different** from all other processed meat products. The utilization of comminuting equipment such as grinders and bowl cutters is essential in their manufacture, in specific cases also emulsion mills (see page 18, 20, 30).

These specific meat products originated more than 100 years ago from Europe and many variations are now popular in most parts of the world. In fact, in many countries the raw-cooked meat products account for 50% or more of all further processed meats on the market.

The most common are the small-calibre "Frankfurters" and "Vienna sausage" and the large calibre "Bologna" and "Lyoner". They all belong to the group of "all-meat" ***classical raw-cooked meat products***, made from muscle meat, animal fat and water/ice as the main components and small amounts of necessary non-meat ingredients (recipes page 400 – 408). Others can be classified as ***extended raw-cooked meat products*** as they contain higher amounts of low-cost non-meat ingredients mostly of plant origin for cost-reduction. Some typical representatives of this group are "hotdogs" or "luncheon meat" (page 210, recipes page 410 – 412).

Fig. 159: Various raw-cooked meat products. Frankfurter and hungarian (left), sausage in large calibre casing (bologna and ham sausage, right), meat loaf (centre), canned products (frankfurter and luncheon meat, left, behind)

Classical raw-cooked

products (recipes page 400 – 408)

These are products of relatively high quality and good nutritional value as they contain meat and fat as the main components and water as the major non-meat ingredient. Ingredients of plant origin, if any, are used in small quantities and do not serve as an extender but as binders, e.g. soy isolate (approx. 2% added) (see page 80).

In contrast to the classical raw-cooked products, extended raw-cooked meat products are of inferior quality as they contain higher quantities of extenders and fillers of plant origin (see page 64). These products are described on page 199.

Principles of manufacture

1 **Extract and dissolve solid muscle proteins** through physical (chopping) and chemical (salting) treatment of lean meat and blending with water (Fig 160, 161).

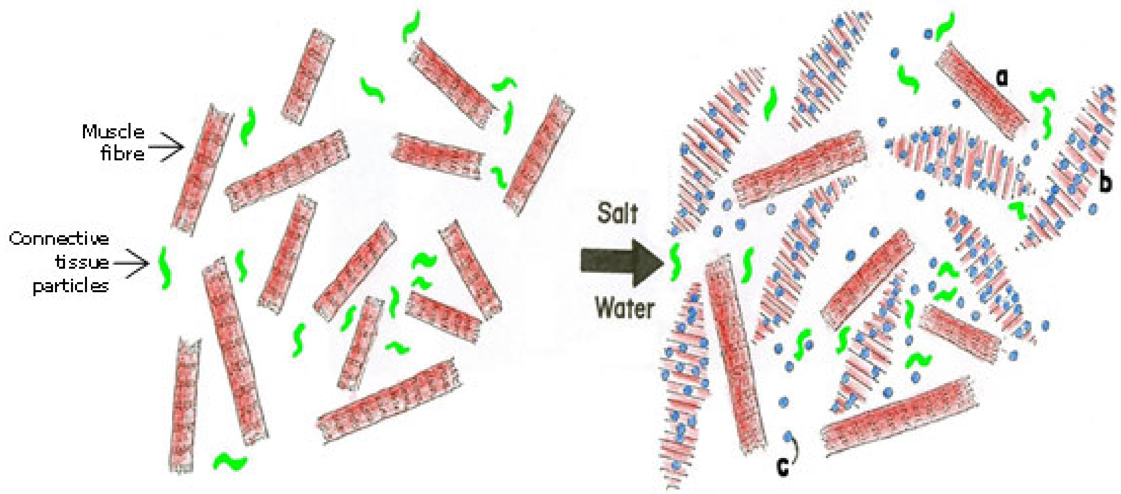


Fig. 160: Condition after dry chopping (see page 136). Muscle fibre fragments (red) and connective tissue particles (green) present in mix

Fig. 161: Condition after adding salt and water. Most muscle fibre fragments swell through water incorporation (blue) and become gelatinous or solubilized (b), some muscle fibre fragments (a) and connective tissue particles (green) remain unchanged. Water droplets may also be loosely bound between the fragments (blue) (c)

2 **Establish a network structure of liquid or gelatinous muscle proteins** in the meat batter capable of surrounding and enclosing small particles of fat and binding water (Fig. 162).

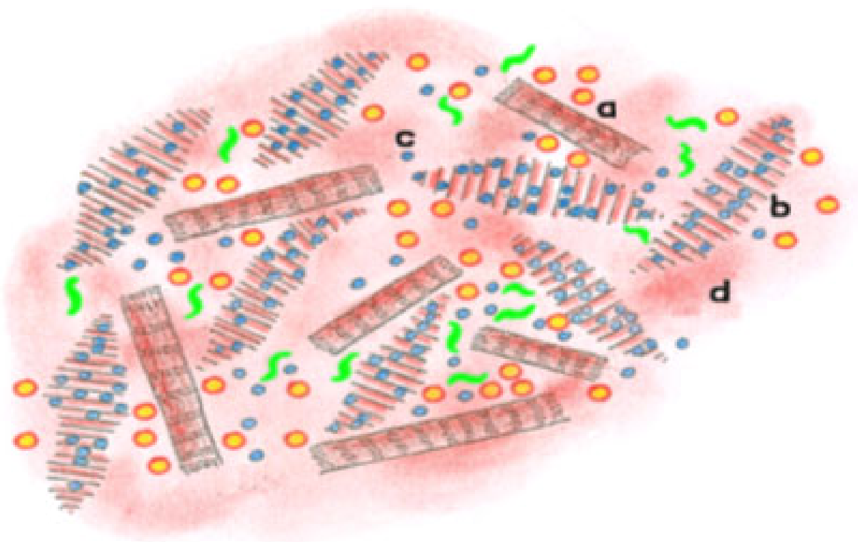


Fig. 162: Condition after comminuting and addition of fat. Network structure of gelatinous (b) or liquid (d) muscle fibre proteins (dark red areas) established, fat particles (yellow) coated by protein (bright red). Connective tissue (green) and some muscle fibre fragments (a) unchanged. Water droplets (blue, c) incorporated in protein network

3 **Stabilise the muscle protein network through heat coagulation** by "cooking". Core temperature of products should be not lower than 70°-72°C (Fig. 163).

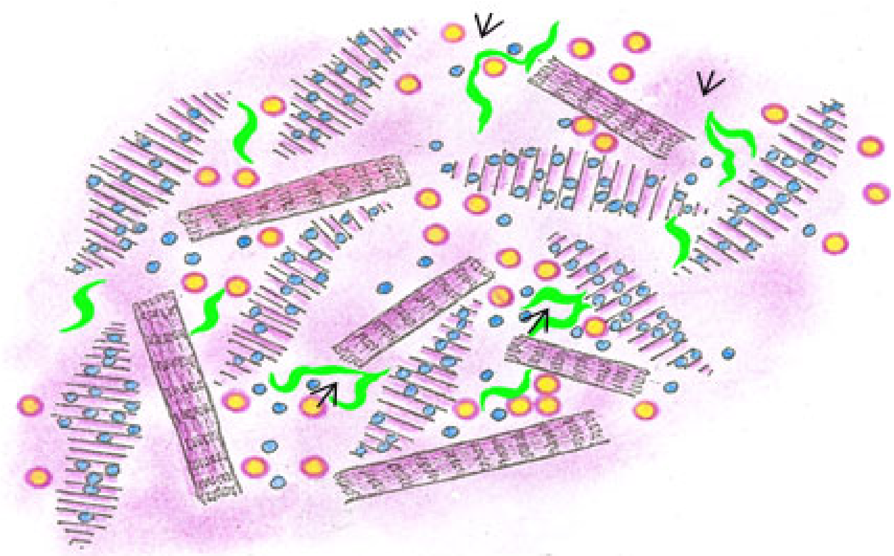


Fig. 163: Condition after heat treatment: Protein network structure becomes rigid and firm elastic (purple areas) through protein coagulation / denaturation. Connective tissue particles (green) swell in size and become softer, may interlink (arrows) if large amounts present

4 **Cool products** down through immersion in cold water or cold water spray immediately after cooking, pass quickly temperature range from +40°C - +20°C, store in refrigerated rooms (Fig. 164, 178, 181, 182).

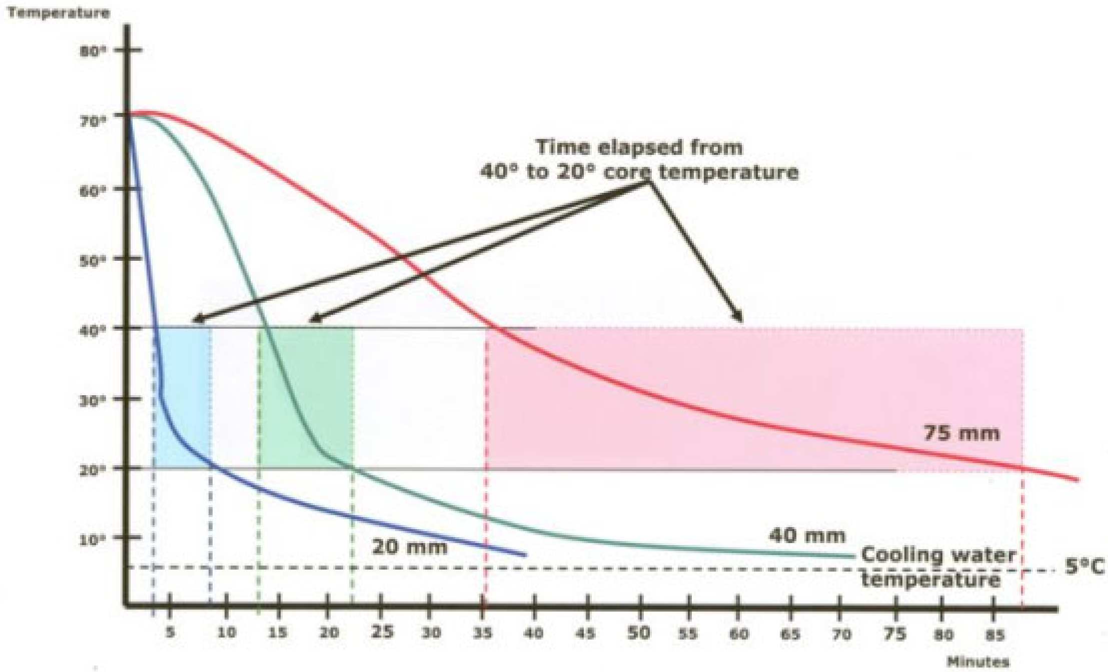


Fig. 164: Cooling in ice water (+5°C) of sausages of different calibre (20 mm, 40 mm, 75 mm). Decrease in core temperature depends on calibre of sausage and temperature of cooling water

These are the essential steps in the processing technology for all types of raw-cooked meat products. If instead of **classical raw-cooked products** specific types of **extended raw-cooked meat products** are manufactured, the incorporation of the extenders and fillers chosen takes place at phase 2. Examples for extended raw-cooked products are Hotdogs or Luncheon meat. Composition and technology used are described on page 204, and 210.

For **phase 1 and 2** of the manufacture of raw-cooked products it is essential that only **raw** (uncooked) **lean meat and fat** are used, as pre-cooked materials would not produce the necessary effects of protein solution, protein network building and increased binding of water. Protein solution and network building as shown in Fig. 160 to 163 is achieved through a combination of effects:

- Mechanical cutting/chopping/comminuting of the muscle tissue resulting in the release and extraction of muscle proteins out of the muscle cells.
- Solution of part of the released previously solid muscle proteins in the water/salt mix added.

- Enhancement of the transition of solid muscle proteins to the gelatinous or liquid phase in the presence of phosphates (see page 68) or other suitable substances such as citrates.

At **phase 3** the necessary **heat treatment** is applied. Through adequate heat treatment of the batter (see page 129, 144) filled in sausage casings, cans, or portioned otherwise (e.g. meat loaves, meat balls), the heat coagulation of the liquid or gelatinous proteins in the viscous batter is effected forming a firm cross-linked network structure. This results in a rigid firm-elastic texture of the final product.

For the above reasons the term **"raw-cooked"** is used for this type of products as in the **first phase "raw"** processing and in the **second phase "cooked"** processing is taking place.

Raw material and additives - preparatory steps for processing

Lean meat is the principle raw material for classical raw-cooked meat products. It provides the muscle proteins, which play an important role in the processing technology of raw-cooked products. The lean meat component comprises mainly chilled ***beef*** and/or ***pork***, but also ***poultry meat*** (turkey, chicken) is becoming increasingly popular for this purpose. Other meats like ***mutton*** and **venison** are less suitable and not commonly used. The same applies to muscular ***slaughter by-products*** such as heart, diaphragm and oesophagus.

Lean meat is used in quantities of 30-50% referred to the overall amount of batter for raw-cooked products. Beef forequarters are an important source of lean meat. As most of the lean meat will be finely chopped, also smaller meat pieces (trimmings) obtained during meat cutting can be used (see page 46, 50). Visible fats and hard connective tissues should be removed from the lean parts. The lean meat must be thoroughly refrigerated (+4°C or lower, except in case of processing "pre-rigor" meat, see page 135). In order to quickly achieve a homogeneous batter, the chilled lean meat is pre-minced (3mm grinder disc) prior to comminuting in the bowl cutter.

Note: The lean meat should have a relatively high pH, preferably in the range of 5.7-5.9, as such meat has a better **water binding (**also called **water holding) capacity** (WBC/WHC) (see page 7). Chilled meat reaches its lowest pH after 24 hours and thereafter there will be a slight pH-increase, which is favourable for the WBC. Hence it is recommended to use chilled lean meat, in particular beef, three days after slaughter. If frozen lean meat is used, this meat should not be thawed prior to chopping, as thawing will substantially reduce its WBC.

Frozen lean meat should be “tempered”, i.e. raising the temperature to make it softer, but keeping it below the freezing point (-1 - 5°C). It can then be placed frozen into the bowl chopper (upon manual pre-cutting or with frozen meat cutters, see page 31).

Beef, in particular from younger animals, has the best WBC. Good WBC is important to bind the amount of up to 30% of **water**, which is usually added to the batter to improve texture and palatability of the final products (see page 133). Moreover, the lean meat itself has a water content of 70%, which also must be kept bound. The binding of all this water must remain stable in the sausage mix also during heat treatment, which is the hardest challenge for the water retention capacity. Low WBC results in loss of liquid during cooking visible as an accumulation of jelly under the sausage casing, inside cans etc. (Fig. 165).

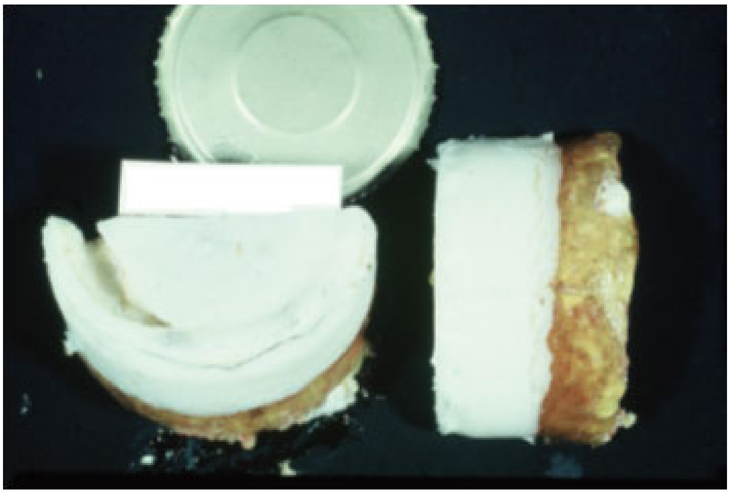


Fig. 165: Canned product with separation of jelly and fat

Apart from the water, the meat batter must also retain the **fat** added. It is again the function of the proteins to keep the comminuted fat droplets dispersed in the batter also during heat treatment (Fig. 163 and 165).

Fat, mainly chilled pork fat, but also chicken, beef or lamb fat or vegetable oil, is used in quantities of 15-30%. Not all animal fats are suitable for this purpose, as some would make the batter too “grainy” (kidney fat) and others too soft (intestinal fat). Back, belly and jowl fat (pork), skin (poultry) and to some extend intermuscular fat (beef) are suitable. Beef fat is generally inferior to pork and chicken fat and should only be used if pure beef products are to be fabricated (see page 12, 43).

Fat is an indispensable ingredient in classical raw-cooked meat products because they make products softer and more palatable and support desirable flavour. In order to achieve a good quality product with typical taste and texture, preferably fresh chilled fats should be used (see page 10). Fats from long cold storage, in particular frozen fats, are less suitable, as they tend to become rancid. Fats should be free of hard connective tissue. The chilled fats are pre-minced (3mm grinder plate) for good immediate distribution in the batter. If vegetable oil is used instead of animal fats, this oil should be chilled but must remain liquid or viscous (Fig. 100).

Other animal tissues

Animal by-products of the non-muscular type, such as internal organs, are not used for raw-cooked products. The only exception is animal skin. Poultry skin, which has a high fat content, can be used as pork fat replacement or as the entire fat component, in particular in pure poultry products. Pork and cattle/veal skin do not contain fat, but connective tissue. Pork skin becomes gelatinous upon cooking and comminuting, and has the property to bind some water and produce a sticky elastic texture. It can be blended to the batter, and this mixture develops good cohesiveness upon heat treatment and cooling. Pork skin is an economic source of protein (nutritionally inferior to muscle protein) and may be used for lower quality and lower cost raw-cooked products (see page 47).

In contrast to all other raw materials for this type of products, pork skin is often added pre-cooked, as pre-cooked pork skin is soft enough to be sufficiently comminuted by the equipment used. Pre-cooking also reduces the high bacterial content of pork skins. In some cases raw-frozen pork skin is finely chopped with ice flakes and added. Poultry skin, used for specific products as a carrier of larger quantities of fat, is used uncooked.

Water is added in quantities of approximately 15-35%. It makes products juicy and easily chewable. Water is not primarily used as “filler” in raw/cooked meat products. It is absolutely necessary as a **carrier** and **solvent** for the muscle proteins**.** Water together with salt and phosphates, which enforce the process, is indispensable for the desired extraction and water binding of the muscle proteins (see Fig. 161). As the protein extraction is best under low temperatures, water is often added frozen as ice to keep the temperature of the meat batter low. Low temperatures are also needed to avoid excessive rise of temperature in the area close to the fast rotating bowl chopper knives. Excessive temperatures there would spoil the ability of affected proteins in water binding and gelation. For quick and even distribution (in order to achieve an instant cooling effect in all parts of the chopping bowl), small-size ice flakes should be used or ice blocks should be crushed into small pieces before being added to the batter.

Fig. 166: Ice flakes

Additives and spices (salt, phosphates, ascorbic acid, various ground spices) are used in dry-powder form and must be stored in a cool and dry place in closed containers and frequently checked for impurities. These additives are used in smaller quantities and need to be accurately weighed to avoid under- or overdosage.

Salt and/or nitrite curing salt serve for salty flavour, solution of muscle proteins and curing colour. Approximately 2% is normally applied (see page 67, 68).

Phosphates assist in solubilizing muscle proteins. Approximately 0.3% is normally used (see page 69).

Ascorbic acid acts as a catalyst in the curing process. Approximately 0.05 – 0.1% is normally used (see page 68).

<u>Note</u>: In the process of chopping, the curing substances get homogeneously blended to the batter so that equal curing is secured. In order to accelerate this curing process, ascorbic acid (or sodium ascorbate or sodium erythorbate) is added to boost the reaction of myoglobin with curing salt (see page 35, 37). Ascorbic acid reacts instantly upon contact with the nitrite. In order to avoid a premature reaction before the nitrite is homogeneously distributed in the batter (which would result in unequal curing), it is recommended to add the ascorbic acid in the final phase of the comminuting process.

Spices may vary, but pepper (in combination with salt) forms the basis for a raw-cooked product seasoning mixture. Other spices are supplementary and are chosen according to the type of the product and local preferences (see page 85, table 3).

Additional measures for proper cohesiveness and water binding

The protein network in the final batter will be the more complete and functional as more meat protein is used in the mixture. To further facilitate the formation of the protein network, where the meat content is low, the following measures can be taken:

- Addition of small amounts of proteins (approx. 2% of dry substance) mainly originating from soy beans (isolated soy protein) or derived from milk (milk protein, caseinate) or blood (plasma protein) can be added. They increase the amount of available proteins resulting in more comprehensive protein network structures (see chapter “Non meat ingredients” page 69, 71, 80).

- Lean beef taken from the carcass up to 6 hours after slaughter or pork up to one hour after slaughter ("pre-rigor meat") is still high in pH (approx. 6,5) and contains natural phosphate (ATP) which develops the same effect as synthetic phosphates which are commonly used. This method is not frequently practised as in most cases pre-rigor beef is not readily available. Where pre-rigor meat can be made available (e.g. where slaughter and further processing operations are carried out in the same meat plant), this method should be considered.

Table 7: Typical composition of some raw-cooked sausages
(for definition of raw meat materials see page 45 and 49)

Ingredients %	Beef frankfurter		Mixed frankfurter		Pork frankfurter	Vienna	Bologna
	1	2	1	2			
Meats							
• Beef I and II	35.0	30.0	25.0	20.0	--	30.0	25.0
• Pork II	--	--	20.0	20.0	35.0	20.0	--
• Beef fatty trimmings (III)	33.0	20.	--	4.0	--	--	--
• Pork fatty trimmings (III)	--	--	5.0	5.0	5.0	4.0	4
• Beef fatty tissues	6.0	10.0	--	--	--	--	--
• Other by-products	--	--	7.0	8.0	--	--	--
Other ingredients							
• Ice water	21.0	16.0	23.0	22.0	25.0	28.0	24.0
• Meat extenders	2.0	3.0	3.5	3.0	3.0	3.5	3.0
• Phosphates	0.3	0.4	0.4	0.3	0.3	0.5	0.5
Curing ingredients							
• Nitrite salt	1.6	1.8	1.8	1.8	1.8	2.0	2.0
• Sugar	0.5	0.2	0.4	0.2	0.3	0.6	0.3
• Glutamate	0.15	0.2	0.2	0.2	0.2	0.2	0.2
Seasonings							
• Pepper	0.12	0.13	0.3	0.2	0.2	0.4	0.35
• Coriander	0.08	0.1	0.1	0.1	--	0.3	0.15
• Nutmeg	--	--	0.1	0.1	0.1	--	--
• Sage	0.05	0.05	--	0.05	--	--	--
• Cinnamon	0.05	0.05	--	0.05	--	--	--
• Fresh garlic	0.05	0.02	0.1	--	--	--	0.35
• Clove	--	--	0.05	--	0.05	--	--
• Mace	0.1	0.05	--	0.1	--	0.2	0.15
• Ginger	--	--	0.05	--	0.05	0.3	--

Technological procedures

Meat processing techniques changed over the years following improved equipment designs and performances. The methods described below take into account the performance of the equipment expected to be accessible to small or medium scale meat processors in developing countries. The following processing steps achieve satisfactory final products:

The chopping process (Fig. 167)

Step 1 : The lean meat portion is pre-minced and kept chilled (0˚C).
Step 2 : The lean meat is placed in the bowl cutter with the salt and additives for the whole batch. The mixture is chopped for 5-10 rounds without ice. This step is called "dry-chopping".
Step 3 : Ice is added and the chopping continued at fast bowl chopper speed until the ice is evenly incorporated and a "sticky" lean batter is achieved. Now also the spices are added.
Step 4 : The fat (pre-minced and chilled) is added and the mixture chopped at high speed until a homogeneous batter made of lean and fatty tissues is achieved.
Step 5 : The final temperature of the batter should not exceed +12°C

The extraction of muscle proteins can be **further enhanced** and a uniform distribution of all components in the mixture accelerated by:

- Sharp bowl chopper knives, high rotation speed (up to 7000 rpm)
- Specific knife shapes (cutting angles, etc., see Fig. 396)
- Increased number of knives (up to 8)
- Specific knife positioning for improved cutting sequence
- Passing the batter through emulsifying machines[1] (see page 30).

Not all raw-cooked products are entirely made of finely chopped batter. Many products are made of a mixture of **finely chopped** batter and **coarse** meat pieces. The coarse meat material can be cut by hand (strips of meat with 1-2 cm diameter) or pre-minced (5-8 mm hole size in grinder disc). It is usually pre-salted and spiced before incorporated in the finely chopped batter. Bigger meat pieces are separately cured (preferably in curing brine over 24 hours) and should be manually massaged or tumbled to extract protein from the surface of the meat pieces, which after heat treatment, makes the coarse pieces adhere firmly to the surrounding batter (see Fig. 168).

____

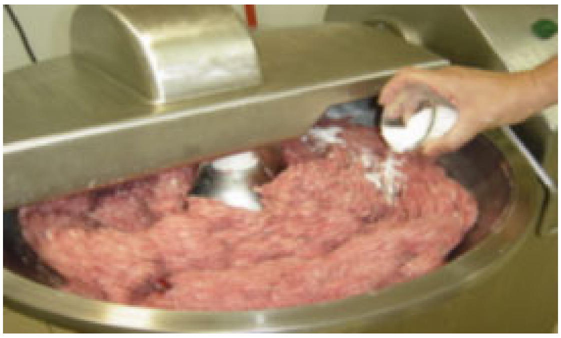
1) As this operation is accompanied by a certain temperature increase, the temperature of the batter produced in the bowl cutter should remain below 10°C prior to passing the batter through the emulsifying machine.

Fig. 167: Production steps for finely chopped batter

Typical composition of finely chopped product: Ice, fat (above), beef, pork (below)

Additives and spices: Phosphate, ascorbic acid (above), garlic, spices (middle), curing salt (below)

Step 1: Mincing of meat and fat (3 mm grinder disc)



Step 2: Dry-chopping of lean meat, curing salt and phosphates

Step 3: Ice is added to the dry-chopped lean meat

Step 4: Fat is added to the lean batter

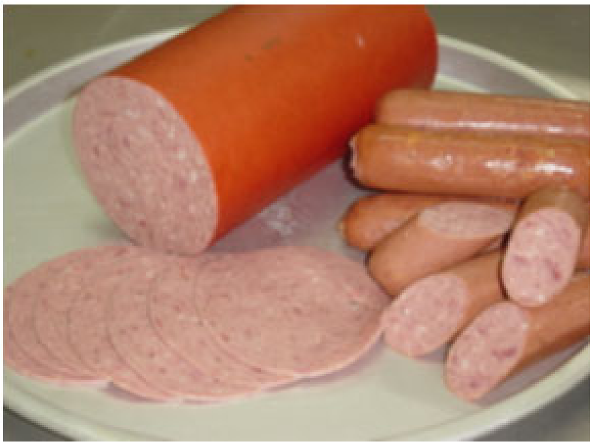
Step 5: The mixture is finely chopped until +12°C is reached

Fig. 168: Production steps for raw-cooked products with coarse meat ingredients

Meat and spices for coarse sausage type

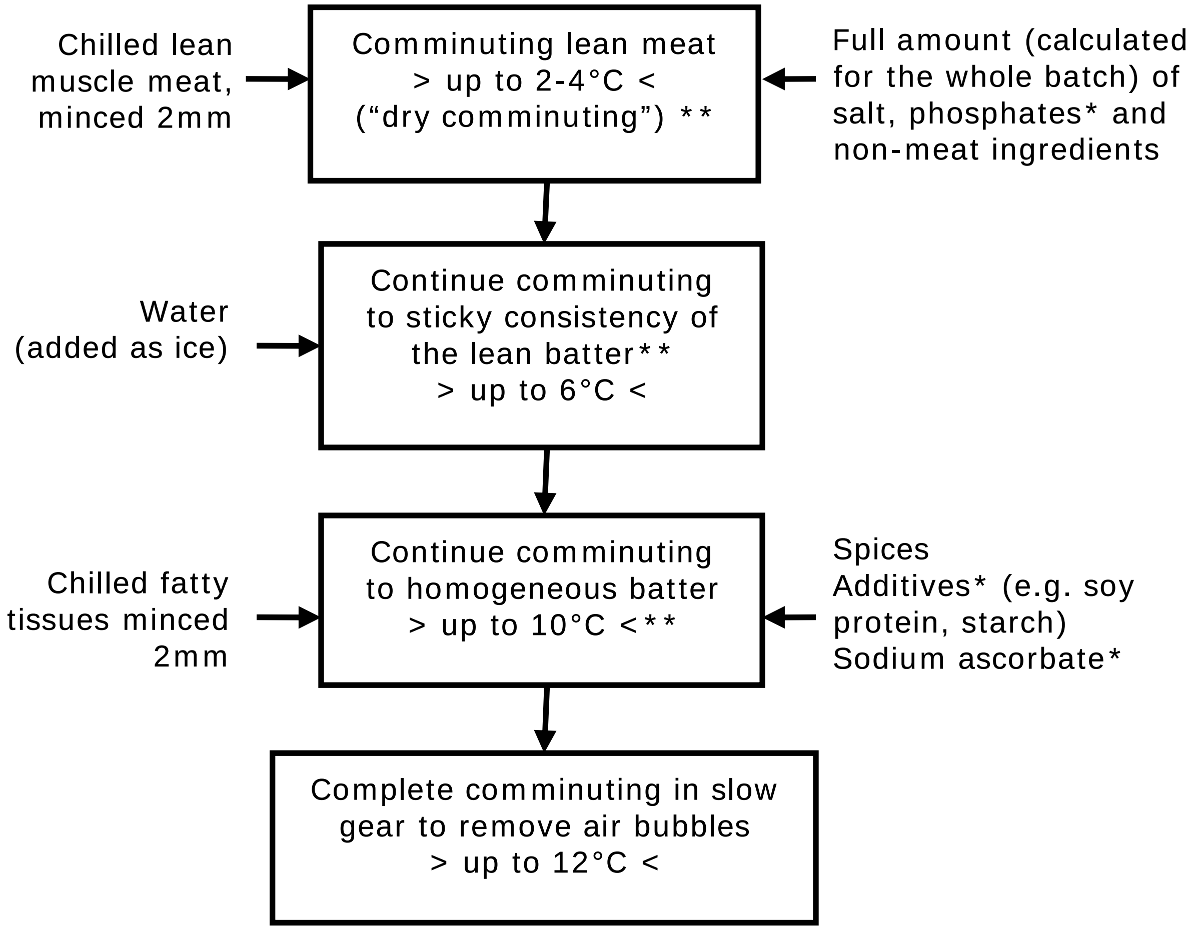
Step 1: Mincing of meats to be added to finely chopped batter for coarse sausage

Step 2: Coarse material is added to finely chopped batter (above). Final mixture after a few rounds in the bowl cutter (below)



Step 3: Coarse sausage (final product). Coarse particles embedded in finely chopped basic matrix

Fig. 169: Production flow for finely chopped batter



* These substances are useful but optional ingredients. They are not absolutely necessary, but widely used.

** The separate production steps indicated are recommended for small-scale operations where highly efficient bowl cutters may not be available. In industrial processing with modern equipment, “dry comminuting” is not needed. Comminuting can be started with lean meat and approximately $^{2}/_{3}$ of the ice, the rest of the ice is added together with the fat in order to achieve an additional cooling effect.

Filling the product mixture into casings or other containers

The product mixture is usually filled into casings (Fig. 170, 172) or other containers (Fig. 413, 415). Casings can be natural or made of different materials and are available in different shapes and calibres. Most casings require pre-treatment before being used (see chapter “Casings” page 249).

Fig. 170: Filling of product mixture into a long strand of natural hog casings

Fig. 171: Sausages (linked and twisted to size) are put on a stick for smoking

Fig. 172: Product is filled into an individual casing of larger calibre

Fig. 173: The sausage end is sealed using a metal clip

The product mixture can be manually filled into casings using a simple funnel (Fig. 412), but even in small-scale meat processing operations simple filling machines (piston stuffers, see page 22, 306) are commonly used. Before and during filling the following aspects are of specific importance:

- The filling machine must be clean and properly assembled (check piston gasket, attach funnel suitable for the calibre of the casing = rule of thumb: diameter of funnel to be $^{2}/_{3}$ of casing)
- The mixture must be placed tightly in the cylinder. Large enclosures of air must be avoided as they will burst during filling and produce loosely filled casings or lead to air pockets in final products.
- Casings should be filled to their maximum capacity to avoid surface wrinkles in the final product.

Sausages of smaller calibres are filled into longer strands of natural (mostly sheep) or collagen casings. These strands are divided into portions by manually or mechanically[1] twisting (Fig. 171) or tying with a string (Fig. 320). Sausages of bigger calibres are stuffed into individually cut casings. Both ends are tied with a string or sealed with a metal clip (Fig. 173).

____

[1)] Modern filling machines have automatic portioning devices to be adjusted for portioning individual sausages in the desired length.

Using the filling machine, portions of the product mixture can also be filled in cans and glass jars. Meat loaf moulds are usually filled by hand.

The period between producing the batter and filling it into casings, cans, moulds etc. should be kept as short as possible. In the batter, even under relatively low temperatures, acid producing microorganisms can develop. The result is the lowering of the pH and reduction of the water binding capacity (WBC) in the batter.

Methods of heat treatment

In order to achieve

- firm texture
- intensive curing colour
- microbiological stability for cold storage and
- palatability for consumption

Raw-cooked products undergo specific heat treatments as the final processing step, which vary according to the type of products. The most complex heat treatment is applied to sausages. For sausages, after filling in casings, a combination of **heat treatments,** usually carried out in three steps (***reddening***, ***smoking***, ***cooking***) is applied. In most small and medium scale operations simple individual machinery (smoke house, cooking vat) suffices. In larger operations more sophisticated equipment (computerized smoking/cooking chambers) is used.

The following describes a typical procedure for sausages undergoing all three steps using simple equipment:

Reddening: After filling, the sausages are hung on sticks in a way that they do not touch each other, thus allowing for air circulation around the individual pieces. The sticks are transferred to the pre-heated smokehouse and exposed to **modest heat treatment** (hot air) in a first phase **without smoke** at approximately +50^{o}C. At this temperature the curing process in the product mixture is accelerated and completed (visible as a change in colour from grey to red, see Fig 42 and 70) within a relatively short time depending on the calibre of the sausages (from 15 minutes for calibre 22 to one hour for calibre 90). The presence of cure accelerators (ascorbic acid, sodium ascorbate) in the batter enhances this curing reaction.

Fig. 174: All sausages are spread on a stick allowing smoke to circulate around each individual piece

Fig. 175: Fully loaded smokehouse

Fig. 176: After smoking is completed the sausages must have a uniform attractive colour

Fig. 177: Cooking process of raw-cooked sausages

Fig. 178: Immersion cooling: The smoked and cooked products are cooled down in cold water

<u>Note</u>: Many raw-cooked sausage products undergo hot smoking after the reddening phase (see page 41), where the curing reaction is completed. When raw-cooked products are not smoked, sufficient temperature and time must be provided for the reddening. For sausages in impermeable casings of coated cellulose or synthetic materials or meat loaves in moulds, good reddening results are achieved when sausages or meat loaves are stored for 1-2 hours after filling at ambient temperatures.

During this phase the curing process is initiated and will be completed during the heating up in the subsequent cooking process in hot water. If a smoking/cooking chamber is used, reddening is done under controlled conditions at +45-50°C for 30 to 45 minutes before cooking.

Note: For the vast majority of raw-cooked sausages nitrite curing salt is used to achieve an appealing red cured meat colour. Some local specialities are fabricated with common salt only and consequently display a greyish colour (Fig. 179, 180). One example is the "white sausage". "White products" are normally consumed fresh right after production and are not subjected to reddening or smoking.

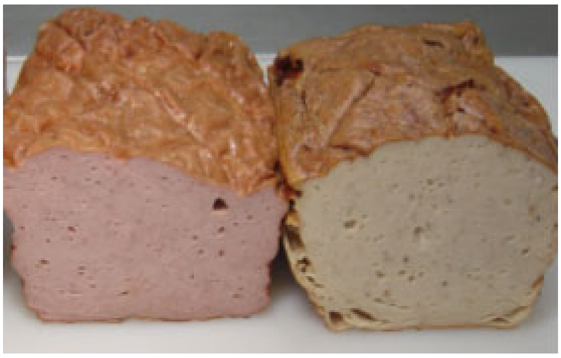


Fig. 179: Meat loaf left: with nitrite curing salt
Meat loaf right: with common salt only

Fig. 180: White sausages:
Left: after stuffing (raw meat mix)
Right: after cooking (greyish), ready for consumption

Hot-smoking: After the sausages to be smoked have gone through reddening and developed a red curing colour, the process of hot smoking is initiated. In small and medium scale operations sawdust and open gas flames or electrical heating are used to generate the smoke. Besides these simple smoking facilities, more advanced methods are also available (see page 24, 41, Fig. 174, 175, 176).

The sawdust should originate from untreated wood (preferably hard wood) and must be free of any impurities. Care must be taken that the smoke is developed through smouldering. Open flames must be avoided. Raw-cooked sausages are **hot-smoked** at temperatures of +65 to 70°C until a desired product colour is achieved (30-60 minutes). As the smoking is carried out at relatively high temperatures, it can be considered part of the overall heat treatment of the product.

Note: The main purpose of sausage smoking is to provide a smoke flavour colour. The aspect of product preservation is only secondary. Smoking with gaseous smoke is only applicable, when sausages are filled in smoke-permeable casings (natural, cellulose or collagen casings). In some advanced smoking/cooking chambers "smoking" can also be carried out by spraying liquid smoke particles onto the product during cooking.

Alternatively, raw-cooked sausage products in smoke impermeable casings can also be produced with smoke flavour. In this case liquid smoke flavour is added to the batter during chopping to achieve the desired flavour (see page 42).

Cooking: After the hot-smoking is completed or for un-smoked products after the reddening phase was initiated, the sausages are taken for further heat treatment ("**cooking**", "**scalding**") in order to achieve complete protein coagulation. In small and medium scale operations the sausages are transferred to a cooking vat and submerged in hot water of +74° to +80°C for a certain period of time (see table 8, Fig. 115, 177) until a core temperature of at least +72°C is achieved. As a rule of thumb for products exposed to moist heat, **1 minute** of heat treatment at +70°C **per 1 mm** of sausage diameter is required (e.g. cal. 60 needs 60 min.).

During the cooking process all products must be covered by hot water to avoid discolouration and partial undercooking. A floating grill can be used. When a smoking/cooking chamber is used, the sausages remain in the chamber after smoking and cooking is done by applying steam or water vapour saturated hot air[1]. Cooking is essential and indispensable for all raw-cooked meat products to build up a strong complete **network of coagulated protein** (see page 129) and make the products "elastic". It also **reduces the bacterial load** (see page 95) present in the raw batter. The following facts are important to note:

- Core temperatures of +65°C would be sufficient to achieve the required texture through protein coagulation. However, for hygienic reasons and in order to eliminate a major part of the micro-organisms present in the batter, core temperatures of +70° to +72°C must be reached.
- Core temperatures up to +78°C are recommended for production in tropical countries in view of the ambient hot environment during handling and transport.
- Core temperatures above +78°C should be avoided as this would negatively affect the texture of the products (atypical soft).

____

1) Steam can either be injected into the chamber from an outside source (steam generator) or can be produced inside the chamber. In this case water is introduced into a container inside the chamber and heated up.

Note: It must be kept in mind that even after intensive cooking such sausages are only germ-reduced but not germ-free. They must always be stored refrigerated (≤4°C).

Table 8: Parameter for reddening, smoking and cooking

	Reddening			Smoking			Cooking		
	Humidity	Temperature	Period	Humidity	Temperature	Period	Humidity	Temperature	Period
Frankfurter type sausages 20/22mm	60%	45-50°C	30 min	80 %	65-70°C	30-45 min	100 %	74-80°C	10 min
Smoked sausages 32-40 mm	60%	45-50°C	45 min	80 %	65-70°C	45-60 min	100 %	74-80°C	30 min
Smoked sausage of Bologna/Lyoner type 70-90 mm	60%	45-50°C	60 min	80 %	65-70°C	45-60 min	100 %	74-80°C	60 min
Meat loaf (2 kg loaf) (baking in oven)	--	ambient	1 - 2 hours	--	--	--	--	150°C	180 min

In addition to moderately heated raw-cooked products, some of this group are also suitable for sterilization in hermetically sealed containers. These products can be stored without refrigeration. For more details see page 277.

Cooling of cooked products

After sufficient heat treatment was applied to the sausages to achieve the desired texture, colour and flavour, care must be taken to quickly reduce the product temperature through cooling. Products should never be kept or stored in the temperature range of +20°C to +40° (see Fig. 164) as this would stimulate the growth of remaining bacteria/spores. The rapid cooling is practically achieved by immersing the products in a container of cold water (Fig. 181) or in modern cooking chambers by showering with cold water (Fig. 182). After dropping the product temperature and superficial drying of the sausage surfaces, the products must be immediately transferred into chillers where they can be stored for a few days to a few weeks depending on the type of product (see page 87, 93).

Fig. 181: Immersion cooling (ice water)

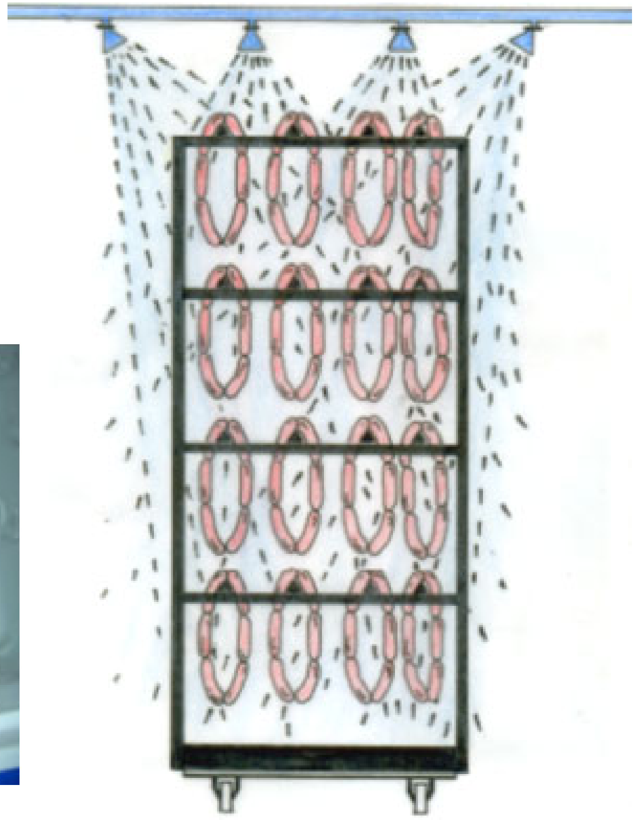


Fig. 182: Shower cooling

Mode of consumption

Raw-cooked sausages of smaller diameters such as frankfurters, hotdogs or Viennas are mainly consumed hot. They are heated up immediately before consumption. These small calibre sausages are mostly filled in edible casings (natural casings derived from sheep or collagen casings, page 245) and the edible casings are consumed as part of the product.

Larger calibre sausages are mainly eaten cold on sandwiches. The casings are removed and the sausage is cut into thin slices.

Raw-cooked products others than sausages

Apart from using casings the batter can also be filled into containers such as tin cans or glass jars for subsequent sterilization, resulting in **canned products** of the raw-cooked type (for more details see chapter on "Canning" page 277). The use of special moulds (Fig. 415) is also common for baking in ovens or in hot air. Such finished products are called **meat loaves** (Fig. 117, 118, 119, 179). The batter can also be shaped as **meat balls** (Fig. 237), which are directly submerged into hot water. Meat balls are popular as ingredients for soups.

Theory of formation of "raw-cooked" meat mixes

The main components of meat mixes for raw-cooked meat products are **animal protein**, **animal fat** and **water**. For raw-cooked meat mixes it is essential that fat and water components are evenly dispersed as tiny droplets and are kept stabilized in a finely comminuted protein mass ("protein matrix") (Fig. 162, 163). Keeping the fat and water droplets "stabilized" in the protein matrix means to prevent their confluescence to larger drops. In order to achieve this target, specific conditions must be met with regard to raw material selection (see page 131), comminuting equipment and techniques (see page 20, 30, 299) and mix temperatures not to exceed during comminuting (see page 136).

Through the comminuting process, the tiny lengthy structures of the muscle fibers (identical with "muscle cells", see Fig. 1) are cut into a multitude of small fragments (Fig. 160). As a result the three types of proteins present in the muscle tissue are set free (Fig. 161). These are

- connective tissue proteins, mostly **collagen,** deriving from cell membranes and intercellular tissue,
- water-soluble soft **sarcoplasmatic** proteins from inside the muscle cells,
- **myofibrillar** proteins, which are solid protein chains (responsible for muscle contraction) inside the muscle cells composed of actin and myosin proteins.

Myofibrillar (***actin*** and ***myosin***) **proteins** play a decisive role in formation of raw-cooked meat mixes. Extracted from the muscle cells by comminuting the muscle tissue, these proteins are capable of ***absorbing water*** and ***swelling in volume***. Myofibrillar proteins are ***"salt-soluble"***, which means that in the presence of salt (NaCl) and water, they can be transferred from the solid to a gelatinous or liquid phase. This does not mean that all myofibrillar proteins present in the mixture are subject to gelation or are fully solubilized. The degree of gelation or solubilization depends on the amount of salt available, intensity of comminuting, pH of the meat and the processing temperature (see page 128, 129). Hence the mix contains different structural phases of myofibrillar proteins:

- one fraction are muscle cell fragments with unchanged solid myofibrillar proteins,
- other myofibrillar proteins are swollen through uptake of water and
- a substantial part of the myofibrillar proteins become gelatinous once fully solubilized through the impact of salt and water.

This situation indicates that raw-cooked meat mixes are not true emulsions, although products of this group are sometimes described as **"emulsion-type sausages"**. The mixture of protein, fat and water is better characterized by the term **"batter"** rather than "emulsion".

Fig. 183: Close-up view of a homogeneous meat mixture ("batter")

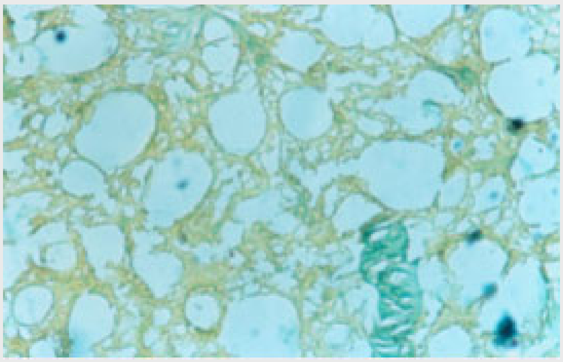


Fig. 184: Microscopic view of a meat mixture. Protein structure network (light green) surrounding enclosures of fat and water (light blue). Also visible are connective tissue particles (dark green)

The batter achieved by comminuting is defined as an **aqueous protein phase ("matrix"), where small fat globules are dispersed**. The fat globules are immobilized in the matrix and their convalescence prevented by two mechanisms:

- Liquid myofibrillar proteins, through physical forces, have the tendency of surrounding ("coating") the fat globules with a protein film and stabilize them.
- The fat globules are entrapped and immobilized in the viscous protein matrix. During heat treatment the solid or viscous fat globules become liquid. The fat globules are held in place by the protein matrix, which during the same heating process, changes from viscous to solid, the protein structures become denaturated or coagulated. As a result, the fat globules are held finely dispersed and their convalescence is prevented in the generated rigid protein network.

The water is held in the protein matrix as a result of the comminution process either

- firmly bound to proteins or
- similar as in the case of the fat globules, entrapped and kept in its place upon protein denaturation in the rigid protein network structure.

The muscle meat used as raw material plays an important role in the **water-holding capacity** of the batter. Water retention is significantly influenced by the pH-value of the lean meat (see page 4, 131). The higher the pH, the stronger the water retention (see page 7). Natural phosphates (ATP) present in muscle meat during a certain period after slaughter (see page 135) or synthetic phosphates added during batter fabrication (see page 69) have the effect of splitting the acto-myosin complex, which contributes to a significant increase of the water holding capacity of the myofibrillar proteins.

PRECOOKED-COOKED MEAT PRODUCTS

Definition

As the name implies, there are two heat treatment procedures involved in the manufacture of precooked-cooked products. The *first heat treatment* is the **precooking of** most of the **raw meat materials** at temperatures below 100°C, usually in the range of 80°C. The *second heat treatment* is the **cooking of the finished product mix** at the end of the processing stage. This second heat treatment is carried out either at *pasteurization temperatures* (around 80°C) for sausages filled in natural and artificial casings resulting in a limited shelf-life and the need for refrigeration. At *sterilization temperatures* (above 100°C) canned products are filled in glass jars, tin or aluminium cans or similar, have extended shelf-life and do not require refrigeration. Precooked-cooked meat products are not only distinguished from the other categories of processed meat products by precooking most of 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. 185, 186).

Fig. 185: Typical precooked-cooked products. Liver sausage (left), blood sausage (centre) and gelatinous meat mix (right)

The raw meat materials used for precooked-cooked products are **lower-grade muscle trimmings, fatty tissues, head meat**, **animal feet**, **animal skin**, **blood**, **liver** and **other edible slaughter by-products**.

Precooked-cooked meat products contain mixes of those animal tissues which are generally of good nutritive value.

Fig. 186: Typical precooked-cooked products in glass jars. Liver sausages (left), gelatinous meat mix (centre) and blood sausage (right)

The processing to precooked-cooked products results in attractive and palatable varieties of animal food items. In many formulations, precooked-cooked products also contain cereals and other plant materials, depending on local availability and consumption habits.

General principles of manufacture

The animal tissues for precooked-cooked products are heat treated (“**precooked**”) prior to their further processing. The precooking is done for the following reasons: Precooking facilitates the **removal of soft animal tissues** (muscle meat, fat, connective tissue) from bones of heads, feet etc. and makes tissues such as skin softer and better to handle for the processing steps to follow. In addition, precooking substantially **reduces the bacterial content** of the mentioned raw materials. These raw materials (skin, trimmings, heads, feet etc.) often have relatively high bacterial loads as they are more exposed to contamination during slaughtering and meat handling than muscle meat. Hence not only the second heat treatment but also the precooking is crucial for the shelf life of the final products. Remaining hairs on skin, feet and heads should be carefully removed before precooking.

The raw materials of animal origin used for precooked-cooked products are all highly perishable. Therefore meat processors should not only rely on the germ-reducing effect of the two heat treatments, but must also obtain and process these materials under **good hygienic conditions**. Internal organs must be trimmed and cleaned thoroughly immediately after slaughter. Product manufacture should start immediately after preparing the animal tissues for further processing in order to obtain fresh flavour and taste in the final products.

The fact that all ingredients of animal origin were subject to **precooking** applied to the initial fabrication of precooked-cooked meat products. In modern meat processing, modifications in processing technology were introduced regarding the use of blood and liver. **Liver** (for liver sausage) and **blood** (for blood sausage) are added *uncooked* (**raw**) to the mixtures, with the aim of improving fat- and water-binding ability in processed liver products and colour in processed blood products. The addition of raw liver and raw blood requires very careful hygienic handling of these materials before processing in order to keep their microbial load low.

Precooking periods depend on the nature and size of the carcass part, age of the animal and desired characteristics of the final product. As the precooking times for most of the animal tissues differ, they have to be cooked separately. Raw materials with bones and rich in connective (collagen) tissue, such as pig heads, tails and feet are cooked until the soft tissue can be easily manually separated from the bones. Pig skin (with meat, fat and hairs carefully removed) is only partially cooked until soft enough to be ground in the mincer. Over-cooking should be avoided, as it would make tissues too soft. The **precooking temperatures** must be carefully balanced and should be kept in the range of +80°C to +90°C, with tissue core temperatures not exceeding +65°C. The precooking also results in **weight losses** (cooking losses; up to 30%) of the heat treated animal tissue. The cooking loss is often compensated by adding equivalent amounts of water or hot meat broth (deriving from precooking in the cooking vat) to the final mixture. The addition of cooking broth will also enrich the taste of the final product. National regulations need to be observed regarding the amount of broth added.

Combined equipment for precooking and comminuting

A new and advanced technology for precooked-cooked meat products is the utilization of "**cooker-choppers**". These are bowl choppers with a steam heating device covering the bowl from below and a double jacket for steam injection in parts of the lid. Low pressure steam is injected, which heats up the chopper bowl and the lid and allows the precooking of raw materials directly in the bowl. This way, precooking and comminuting can be done simultaneously in one process, which, apart from time saving, has the advantage of avoiding cooking losses from the raw materials. As in all heat treatments, process water, proteins, fats and minerals will be cooked out from the raw materials. But unlike in cooking vats or cooking chambers, these substances are not wasted but remain in their full amount in the product mix in the cutter bowl. This contributes favourably to flavour and nutritional value of the final products. By regulating the steam supply, precooking periods and temperatures can be adjusted as in conventional manufacture. In the specific case of liver or blood products, liver or blood is added raw after the precooking phase similarly to conventional manufacture. Cooker cutters are technically complicated and relatively expensive and are mainly applied in industrial scale meat processing.

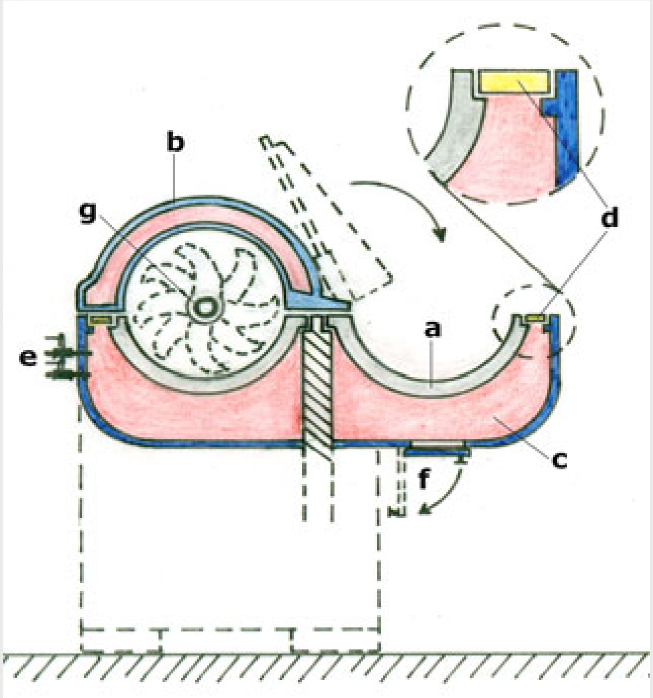


Fig. 187: Schematic drawing of cooker-chopper (cross section)
Steam injection in chopper lid and in space below chopper bowl (pink colour).
a = chopper bowl
b = chopper lid
c = steam container below chopper bowl
d = plastic washer between rotating bowl and stationary steam container (to prevent escape of steam)
e = steam inlet
f = opening for cleaning
g = chopper knife

According to the ingredients used, five types of precooked-cooked sausage products can be distinguished:

Liver sausage
Blood sausage
Cooked gelatinous meat mixes
Cereal sausage
Corned beef

Fig. 188: Some raw materials used in precooked-cooked products


Pork belly, soft tissues, meat bones


Pork skin, heads and feet


Fresh (raw) blood


Fresh (raw) liver, lungs, heart


Lower-grade muscle meat/beef (for corned beef etc.)


Lower-grade muscle meat / beef (for corned beef) from close range

The choice of animal tissues and quantities to be used depends on the type of precooked-cooked meat product to be manufactured (Fig. 188). For **liver sausage** or **liver pate products**, which are ground to finely comminuted mixtures, the amount of fatty tissues is usually high while connective tissues should be reduced. This is because these foods are commonly used as sandwich spreads and should be soft. **Blood sausage products** should be rich in connective tissues (e.g. addition of animal skin and utilization of meat from heads and feet) in order to obtain a gelatinous texture of the final product. Similarly also for **gelatinous meat mixes**, animal parts with high connective tissue content are needed. These latter two types of precooked-cooked products can be cut in slices when cold, which is the usual form of preparation for consumption. For **Corned beef** lean beef is the main ingredient and only for lower qualities also second grade beef with some adhering fat and connective tissue may be used. For **cereal sausages** there are no firm rules but local habits and preferences apply.

Liver sausage / liver pate products (recipes page 418, 419)

Liver sausages or liver pate are amongst the most popular precooked-cooked products. The basic product mix may be composed of precooked lean meat trimmings (see page 45), softer or firmer fatty tissues preferably from pigs (body fats such as jowls, belly fat or back fat; internal fats such as kidney fat or intestinal/mesenterial fat, see page 11) and for low cost products other soft animal tissues (for example hearts, lungs, spleen, tripes, Fig. 188). At least 10% and a maximum 35% liver is added as the major and typical component and provides the name for this meat product and contributes to its unique flavour and taste. Liver contents of more than 35% are unusual and could result in a bitter taste in final products. The main types of liver products are the **coarse-mixed** type and the **fine-comminuted** ("**emulsion-like**") type, but also combinations of the two types (**fine-comminuted basic mix** with **integrated coarse particles**) exist.

Animal tissues used and their origin

The correct **treatment of the fresh livers** plays an important role for the quality of the final products and should be effected immediately after slaughtering. All white bile ducts and large blood vessels as well as the liver lymphnodes should be cut out. The trimmed livers should be rinsed in cold water to wash out remaining bile content in order to remove bitter taste. This procedure is also needed for those livers which cannot be used instantly for further processing but must be stored refrigerated or frozen.

Pork liver as well as **soft fatty tissues from the pork carcass** have proven to be particularly well suited to achieve the desired texture and taste in liver sausage/liver pate products. Moreover, there are no significant differences in the processing suitability of the various types of pork fatty tissues for finely comminuted liver products. For coarse liver products it is preferable to use the firmer body fats.

Where local and cultural traditions demand meat from other animal species, pork meat materials can be replaced by meats deriving from **bovines, small ruminants and poultry** (including large birds with high meat yield such as ostriches). In particular chicken liver has proven to be a suitable replacement for pork liver. Up to a certain extend **vegetable oils** can be used as pork fat substitute. The manufacturing techniques remain basically the same, no matter from which animal species the raw materials derive.

Coarse-mixed liver products

This type of liver sausage can be manufactured in a simple way even in small operations as only meat grinding and filling equipment and a cooking vat (see page 244) is required. The animal tissues are **precooked** as soon as possible after slaughtering to retain the fresh taste and flavour. Then the precooked materials are cut in smaller pieces and **mixed** with the fresh[1] liver and all other ingredients such as common salt[2] and spices. Usually also vegetables (mostly peeled and blanched onions) are added. The mixture is then coarsely **minced** by using a meat grinder with a perforated disc with holes of the desired size (3-6mm) (Fig. 189).

After mincing, the coarse mix is portioned. The most popular way of portioning is to fill the coarse mix in natural or artificial **casings** of medium to larger diameters (Fig. 189). The coarse mix can also be filled in **glass jars** or **cans** for heat sterilization (see Fig. 189, 195). After filling, the **second heat treatment** takes place.

---

1) In the case of coarse-mixed products liver can also be added blanched or precooked instead of fresh as no fat and water binding properties are required. Precooked liver will keep the bacterial load of the mix at a lower level.

2) In the coarse-mixed type liver sausage products usually common salt is used, hence a curing reaction does not take place and the colour of the final products remains grey.

In *smaller operations*, coarse-mixed **liver sausages** are heat-treated (pasteurized) in hot water in an open cooking vat. To prevent bursting in case of using **natural casings** (see Fig. 192), the water temperature in the cooking vat must be kept below +85°C. However, a core product temperature of +74°C must be achieved. For tropical regions, **synthetic casings** may be better suited as the cooking can be done more intensively even in boiling water including higher core temperatures above +74°C. The cooking time also depends on the calibre of the sausages. As a rule of thumb, one minute cooking time per mm diameter is recommended, which means that sausages of calibre 60 (60mm diameter) have to be cooked for 60 minutes (one hour). In *larger industrial operations*, heat treatment is not done in an open water bath, but by using steaming chambers or by passing the goods through steam conveyer cookers.

Fig. 189: Production steps for coarse liver sausage

Step 1: Preparation of raw materials: fresh (raw) liver (right), precooked lean and fatty tissue (left) and fried onions (centre)

Step 2: Manual pre-mixing of raw materials, spices and salt

Step 3: Mincing of mix through a perforated disc (3 mm)

Step 4: Stuffing of mixture into natural casings

Coarse liver sausage mix in different formats: (natural casings, artificial

After cooking the immediate **cooling** of the products has to be initiated. In most cases this is done by submerging the hot liver sausages in cold running water with a temperature below +12°C to initiate a fast drop of temperature in the product. In tropical countries the use of ice water is recommended. Sausages in artificial casings can be cooled down completely in cold water and directly transferred to the cold room for storage. Sausages in natural casings are also initially cooled down in cold water until a core temperature below +20°C is achieved. They are then transferred to the cold room for complete cooling down. Excessive cooling in cold water would extract flavour and also soften the natural casings. If smoking is intended it should be only done after the sausages have been chilled completely. For coarse-mixed liver sausages in natural casings **cold smoke** (below +20°C) is applied for flavour, taste and preservation (see page 41). Sausages with wider calibres are usually consumed cold as sausage spreads. Sausages with smaller calibres are sometimes also fried and consumed hot.

Fine emulsion-like liver sausage and liver pate

As a first step in the manufacture of fine emulsion-like liver sausage/liver pate, **fresh cold liver**[1] with its high protein network building potential is **chopped** in the bowl cutter (Fig. 190) with all the **nitrite curing salt**[2] calculated for the whole batch until a fine batter with a light pink colour is achieved. Sodium ascorbate (0.05%) can also be added to further enhance the curing reaction (see page 37, 68). If sugar is part of the recipe, it should also be added here to counteract any possible bitter taste originating from the liver. The liver batter is then transferred to the chiller and usually kept overnight for processing the next day. This resting period facilitates the development of a desired curing colour and further extraction of protein.

In the next step, **hot** (65°C) **pre-cooked meat materials** (mixture of trimmings of lean meat, fatty tissues, often also head meat and other soft tissues) are first minced (8-13mm) and placed in the bowl cutter. Hot **meat broth** (to compensate for the cooking loss of the pre-cooked materials) and optionally emulsifying agents[3] are added and the mixture is chopped until a fine structure is achieved.

---

1) The processing suitability of frozen liver is similar to fresh liver. But it should be noted that trimming and washing immediately after slaughter and before freezing is required.

2) In this specific case the blood pigment haemoglobin, present in larger quantities in the fresh liver tissue, is cured.

3) Emulsifying agents serve to enhance the emulsifying properties of liver. For fresh sausages specific mono– and di–glycerides are available. If the sausage mix is to be used for canned sterilized products, glycerides are not suitable and milk protein (2%) is used instead.

Fig. 190: Pre-chopping of raw liver (with curing salt). This batter is added later to the precooked hot meat materials (see Fig. 191)

Fig. 191: Addition of chilled liver batter: The liver batter is added to hot precooked and pre-chopped meat materials in the bowl cutter. Bowl cutter is kept rotating in low gear.

When the mixture reaches a temperature between 45°C and 60°C, the cold **pre-chopped liver** and all **spices** are added (Fig. 191) and the mixture is chopped to its final degree. Thereafter the mixture is ready for stuffing. The type of liver sausage mix or liver pate is usually **filled** in plastic casings or larger diameter natural casings. During filling, the temperature must be kept above +35°C to avoid possible fat separation at this stage, below +35°C fat starts to solidify.

The subsequent second heat treatment should be carried out **without delay** after fabrication of the product mix to minimize hygienic hazards. By keeping the batter or filled casings and cans over a prolonged period uncooked, strong microbial growth and enzymatic activities can start and will rapidly deteriorate the products resulting predominantly in an unpleasant acidic taste. This is due to the elevated temperature of the mix, which can contain significant numbers of microorganisms, in particular because some of the ingredients (liver, non-meat additives) were incorporated without precooking.

The fine emulsion-like liver sausage type is consumed cold as a sausage spread. As local specialties, finely chopped liver sausage may contain non-meat ingredients such as onions, mushrooms, special herbs and in particular cream/milk. Such products are called “liver patė” (Fig. 196).

Texture building in fine emulsion-like liver products

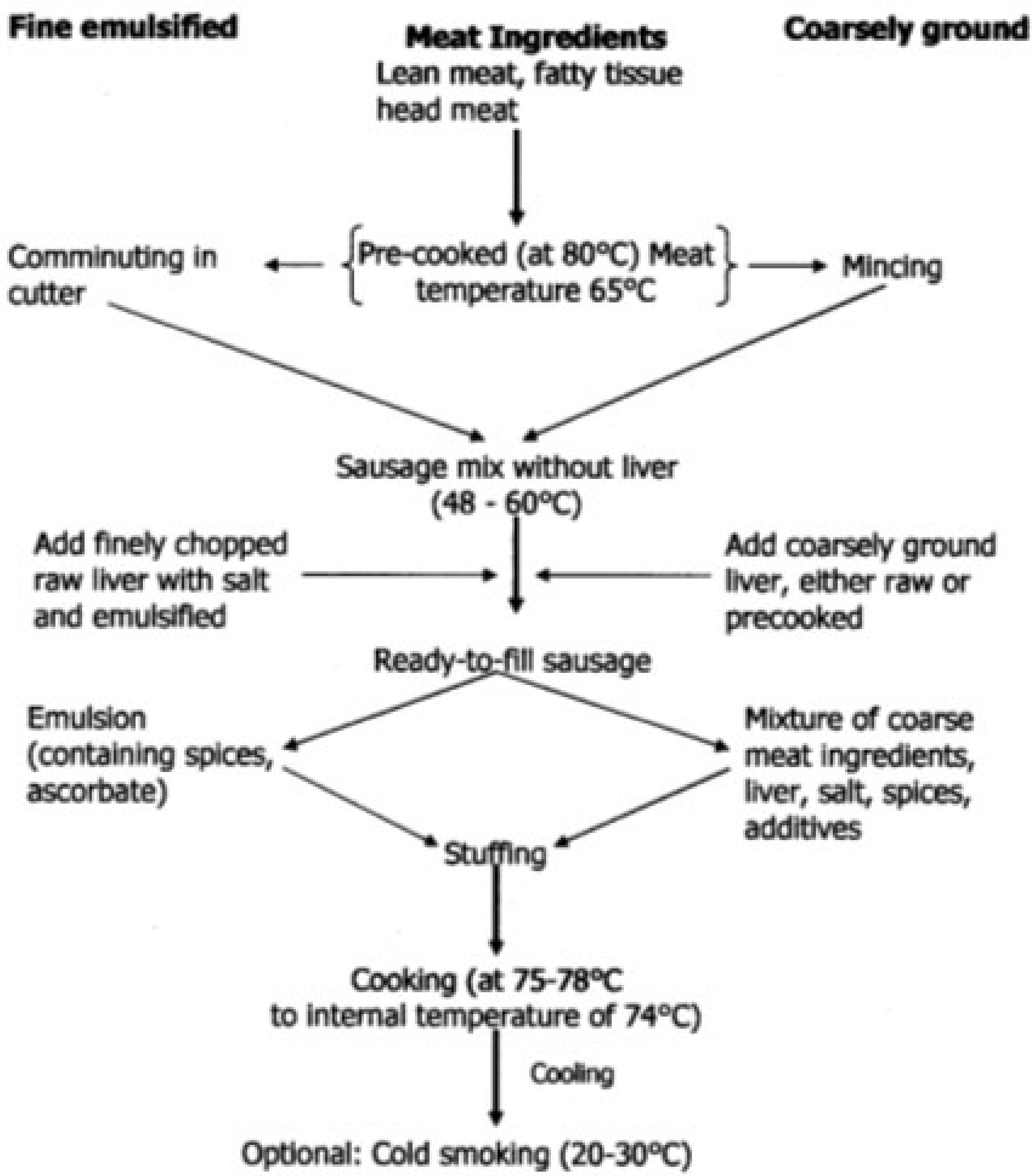
The finished liver sausage or liver pate products have a soft creamy texture and are spreadable on sandwiches, crackers etc. They are fabricated from finely comminuted mixes of lean and fatty animal tissues and liver. Because of the complexity of the raw materials used, these finely comminuted mixes are not true emulsions, hence the term **"emulsion-like"** is used. It appears that the fat particles in the mix are not equally and completely coated by protein, which would be the characteristic pattern of an emulsion. It is believed that part of the liver proteins in the comminuted batter form a protein network structure, where fat particles are embedded. Upon heat coagulation of the proteins the network becomes more rigid and the fat particles are held in place, as long as enough liver protein – in combination with salt and water – is available for network building. The subsequent cooling of the final products changes the consistency of the fats from liquid to firm and completely immobilizes them in the product. If fat separation did not take place during the heat treatment, it can no longer happen in the cooled product. It has been experimentally established that increasing fat contents from 10% to 40% in the finely comminuted mixes require increasing liver contents from 20% to 35% to avoid fat separation during cooking to a core temperature +74°C.

Fine emulsion-like liver sausage with course ingredients

In order to achieve this kind of product, **coarse liver and/or meat particles** of 2-6 mm size are added to the fine emulsion-like basic liver sausage mix. The liver particles can be added raw or cooked, the meat particles always cooked. The addition of the coarse ingredients takes place at the final stage of the fabrication of the fine emulsion-like mix (Fig. 192).

Fig. 192: Fine liver sausage with coarse ingredients

Fig. 193: Production diagram for liver sausages



Impact of heat treatment on product quality

Fine emulsion-like liver sausages without or with coarse ingredients are usually **filled** in natural or synthetic casings of medium diameter. They are **cooked** in a cooking vat or cooking chamber at around 78°C. At temperatures >84°C natural casings may break. The core temperature to be reached is 74°C. Products in plastic casings are rapidly cooled in cold running water. In tropical countries the use of ice water is recommended. Also emulsion-like liver sausages in natural casings are initially cooled down in cold water until a core temperature below +20 is achieved. They are then transferred to the cold room for completely cooling down. Smoking will be only done after the sausages have been chilled completely at a temperature not exceeding +20°C.

The **three types** of liver sausage (*fine emulsion-like*, *partly coarse-mixed*, *fully coarse-mixed*) are basically fabricated with the same raw materials and undergo similar heat treatments. The chopping methods applied are different which eventually lead to different textures and variations in appearance and taste in the final products.

Liver sausages and liver pate generally have a medium to high **fat content**, which is needed to achieve the desired spreadable products. However, sausages containing more than 45% fatty tissue give an extremely fatty impression in taste and appearance and may not be accepted by many consumers from the nutrition point of view (see also page 15). Moreover, fat may separate during heat treatment (see Fig. 194), which spoils product appearance. To avoid such failures, fat has to be reduced. A simple butcher trick is addition of water if the fine liver sausage batter appears to break (visible fat separation during chopping). Water seems to interfere in the emulsion-like structures with the result that fat gets more firmly bound and fat separation can be reduced. Products containing 30-40% fatty tissue (preferably pork jowls and bellies) have a pleasant meat-liver flavour. At high fat levels, care must always be taken to avoid fat separation. When adding less than 25% fatty tissue, products start getting dry but still have acceptable meat-liver flavour.

Fig. 194: Liver sausage with high fat content. Due to high fat content the sausage mix destabilizes during heat treatment resulting in fat separation (right)

The *fine emulsion-like type* (Fig. 196) is well suited for **canned sterilized products**, as the fat is embedded in a protein network structure derived from the liver proteins and will not easily separate during heat treatment even at high temperatures. Addition of milk proteins (2%) (see page 63, 69) also assists in keeping the mix stable during sterilization. The average liver content in finely comminuted products is 20%, which usually provides sufficient fat binding capacity. During sterilization fat separation may occur in products with 20% liver content. This can be solved by reducing the fat content. Also the *coarse liver sausage mixes* (Fig. 195) can be used for canned sterilized products. In these products fat separation, and possibly also jelly separation, is unavoidable and accepted by consumers.

Fresh liver contents in all sterilized liver products should not exceed 20%, because liver is very heat sensitive and higher contents would lead to unpleasant bitter taste. Similarly, fat contents in sterilized goods should be kept lower than in cooked (pasteurized) goods, as higher temperatures provoke more fat separation.

Fig. 195: Coarse liver sausage mix in glass jar (sterilized product)

Fig. 196: Emulsion-like liver pat ė in sealable plastic container (sterilized product)

Blood sausage / blood products (recipes page 420, 421)

Approx. 10 litres of blood are obtained from one bovine during slaughter and approx. 3 litres per pig. This blood with its 20% protein content is a **valuable source of animal protein** and is used in many parts of the world as a raw material for processed meat products. A large variety of food products have been developed which contain blood as one of the main components. During manufacture of these products, blood is mixed with other ingredients such as animal tissues of different origin, cereals, vegetables, salt and spices. For socio-cultural reasons there are some restrictions where blood is not used as food, for example in Halal products. In many developing countries blood is often wasted due to low-standard slaughter facilities and practices, although its consumption is permitted. Improvements in this field could significantly increase the collection and use of blood and contribute to an increased supply of valuable animal proteins to needy consumers.

Blood as a raw material

In principle, blood from all livestock can be used for the manufacture of blood food products. In most cases **pig blood** is preferred for further processed goods as it provides the best colour and taste, but also **cattle blood** can be a suitable raw material. Fresh blood with its high water content and pH over 7.0 (7.3-7.5) favours bacterial growth leading to spoilage and must be collected in the most hygienic way during slaughtering. It should either be used immediately or kept under refrigeration (below +3°C). In some instances, also **blood from small ruminants and poultry** is collected for human consumption and used for a variety of blood products. In the process of bleeding poultry, and small ruminants, contamination is more likely to occur than in pigs and cattle. Therefore special care has to be taken during collection and such blood should be treated immediately.


Fig. 197: Fresh, stirred blood

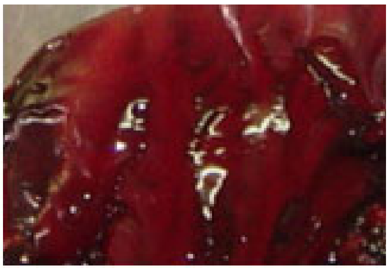


Fig. 198: Coagulated blood (not stirred)


Fig. 199: Fibrin, stirred out

Basic blood-based products

In East and South East Asia, blood collected at slaughter places is commonly used as an ingredient for soups and meat and vegetable dishes. In these cases the blood is allowed to **coagulate** immediately after bleeding. The viscous mass is cooked as soon as possible either in special blood pans or even in containers suspended in hot water. Through the cooking a great deal of the remaining liquid fraction of the blood is separated and the resulting **solid product** of dark brown to black colour is used as a food ingredient.

Blood sausages

Unlike the above simple application of blood, blood sausages are fabricated as mixtures of **raw un-coagulated blood** and other food ingredients (meat, fats and non-meat ingredients) filled into casings with subsequent heat treatment. For most of these blood sausages a firm to strong-elastic texture is required. Blood added in its liquid form is well suited to achieving such a texture. Blood coagulation during heat treatment of the mixes filled in casings, cans etc. contributes to a firm structure. These mixes must undergo heat treatment immediately after filling or portioning to make the final products palatable and safe from the hygienic point of view.

Blood to be used for this type of further processing **must be kept liquid** after collection at point of slaughter. This can simply be achieved by immediate intensive manual or mechanical **stirring** of the blood from the moment of collection in a container. This way, the blood protein fraction fibrinogen, which is an indispensable factor in the biological blood clotting reaction for stopping the blood flow in wounds, is transformed into fibrin and separated as solid fibrin fibres. As a result, the remaining blood stays liquid (Fig. 197, 198, 199). Another way of preventing blood from coagulating is the addition of **anticoagulant chemicals** (2% sodium citrate or sodium phosphate solutions). The advantage of using anticoagulants is that the protein substance fibrinogen is not converted into fibrin and remains integrated in the blood as a valuable liquid protein fraction.

<u>Traditional blood sausages</u>
These products have a blood content of between 5-30 % and also contain precooked materials such as cheaper meat parts, often with high collagen content and edible slaughter by-products such as kidneys and spleen.

In one type of traditional blood sausages, only blood and precooked edible carcass parts such as pork skin, head meat and meat derived from cooked bones are used. No non-meat ingredients/meat extenders are added except **common salt** and **dried herbs** and **spices** for flavour improvement. All components for the product are mixed together, ground to the desired size in a meat grinder, filled into natural casings and subjected to heat treatment. The natural casings may derive from the slaughter animal. One typical example for this group of blood sausages is the South American **Morcilla** (see page 219), which is popular for traditional BBQ's. In English speaking countries traditional blood sausages are known as **Black Pudding** (Fig. 201).

Other local variations of blood sausages have been developed over the centuries using low-cost raw materials of plant origin such as cereals and/or vegetables as ingredients (Fig. 202) replacing the more expensive meat. In some Asian countries a mixture of **blood, flour, cooked pieces of pig feet and spices** is stuffed into casings and fried before consumption. In Ireland the **black pudding** contains oats. In Southern Germany **farm blood sausages** (Fig. 202) can contain a mixture of roasted bread and onions. In a product found in East Africa the **blood** is mixed with **fermented milk** and sometimes with ground **cassava** and other **vegetables**.

Fig. 200: Typical blood sausage composition

Precooked meat trimmings with high collagen content (left), fresh (raw) blood (right), onions and garlic (centre)

Mixing of precooked materials with fresh blood and extenders before mincing

Fig. 201: Black pudding

Central European blood sausages

Blood sausage varieties in Central Europe (Fig. 202 centre) usually contain 10 to 20% blood, pork skin, lean meat and back fat. All meat raw materials used in the manufacture are **previously cooked**, with the exception of fatty tissues, which are only briefly **scalded**, and of course the blood, which is always added **raw** (uncooked) (Fig. 200). While the traditional blood sausages contain common salt and are dark brown to black in colour, modern Central European blood sausages are known for their bright red shiny colour. This appearance together with a typical flavour is best achieved by using pig blood. The red colour is obtained by adding **nitrite curing salt** to the blood.

The blood is usually **pre-salted** with nitrite curing salt immediately after collection, which is the traditional method to achieve an attractive red colour in the final product. Pre-salting also has the advantage of presenting a significant hurdle for bacterial growth in the fresh blood during storage under refrigeration. Care must be taken that the pre-salted blood is not added to the precooked materials at temperatures above +45°C, as this could destabilize the curing reaction. Curing enhancing substances such as ascorbic acid should only be added at the end of the mixing process as this supports the formation of a stable red colour. Recent studies suggest that the utilization of fresh **unsalted** blood in blood sausage manufacture and addition of nitrite curing salt in the final stages of the mixing process, can still lead to a shiny red colour in the final product.

In order to create the desired **firm-elastic texture** in the final products, the liquid blood is mixed with precooked pork skin, which is rich (up to 30%) in connective tissue/collagen and has a strong gel-forming capacity. Pork skin should be fat-free and preferably from younger animals, as they have softer and more elastic skin. The **blood/pork skin mix**, usually in a proportion of 1:2, is the basic matrix for this type of blood sausage. In small-scale manufacturing a meat grinder can be sufficient to prepare the matrix. In this case the precooked pork skin is mixed with the pre-salted blood and minced through the 3mm disc. The use of a bowl cutter has the advantage that the precooked pork skin and raw blood can be intensively chopped, which results in a very homogenous blood/skin-mixture. In practice, before starting the chopping, the hot precooked pork skin (+65°C) is coarsely minced, transferred into the cutter bowl and chopped with some hot meat soup (fat-free liquid remaining from pre-cooking). As soon as a temperature below +45°C is reached, the blood is incorporated and the chopping process completed. The temperature of the final mix should be between +30 and +40°C.

Fig. 202: Blood sausage mix in natural casings: Traditional blood-cereal mix (left), European blood sausage (centre), farm-style blood sausages (right)

These **blood/pork skin mixes** are combined with portions of precooked coarse meat and fat particles. Precooked lean meat pieces (mostly cured prior to cooking to achieve an attractive red colour) are cut into cubes or stripes. The raw fatty tissue is diced (<5mm) and briefly scalded in hot water (+95°C) to remove greasy layers from the surface and harden the connective tissue structure inside the dices. This will prevent grease extraction during cooking as well as blood infiltration. Lean meat particles are rinsed with hot water in order to remove all greasy surface layers and to achieve good binding with the blood/pork skin mix. The meat pieces and fat dices are mixed with spices and some salt and incorporated in the blood/pork skin mix. After filling into casings (for attractive presentation larger calibre natural casings are preferred over synthetic casings) (Fig. 202, 203). The products are cooked at <**84°C** to avoid casing rupture. Core temperatures of +**75°C** are recommended for sufficient microbial stability. Due to their firm-elastic texture the chilled products can easily be sliced and are mainly consumed cold. Blood sausage mixes can also be sterilized resulting in shelf-stable products (Fig. 204).

Fig. 203: Blood sausage (above) and gelatinous meat mix in synthetic casings

Fig. 204: Blood sausage (right) and gelatinous meat mix (left), sterilized in glass jars

Cooked gelatinous meat mixes

The **low-cost variety** of this cooked meat/by-product specialty uses high-collagen meat sources similar to the collagen-rich mixtures of ingredients as used for blood sausages, but without adding blood (Fig. 203, 204). These products usually contain higher amounts of head trimmings (including skins, snouts and pork under-lips), veal and pork feet, tongues and other animal tissues according to local preferences. All raw materials are precooked to some degree, depending on the nature of each individual tissue. After cooking, they are cut into small pieces or ground, salted and seasoned. The uniformly blended mixes are filled in casings of larger diameters (natural or synthetic) and subsequently cooked. As natural casings only endure cooking temperatures of up to **+84°C**, but on the other hand the core temperatures should be in the

Fig. 205: Low cost product (mainly pig head meat) filled in pig stomach

Fig. 206: High quality product (lean cured ham pieces in jelly) in synthetic casing

range of +**74°C**, cooking times in large casings are relatively long. As a rule of the thumb, one minute cooking time should be considered per one mm diameter.

The characteristic of the ready-to-eat products is the gelatinous texture (Fig. 205, 206). The jelly, which holds the mix together, is derived from the **collagen-rich raw materials** used. Cooking such tissues releases and solubilizes part of the collagen, which solidifies upon cooling of the products. Moreover, the jelly-rich water, in which the individual raw materials were cooked, is a valuable ingredient to improve the binding properties and the flavour of the products. For this reason, the jelly-rich water is concentrated by boiling and added to the mixes in this form.

High quality variations of gelatinous meat mixes are also on the market and contain larger portions of **lean meat**. Some of them even fulfil the criteria of dietary meat products with low fat content (less than 10%). The lean meat is usually first treated with nitrite curing salt for an attractive red colour and later precooked. The precooked meat pieces are diced and rinsed with hot water to remove all smaller particles and fatty layers, which would limit the binding of the final mix (Fig. 206).

The lean meat used for this high-quality variety does not contain sufficient collagen to produce the required jelly. In some more traditional products, ground precooked pork skin is used as a collagen source, but provides a turbid jelly. In order to achieve the desired “elastic” gelatinous structure and obtain a clear appearance of the jelly, in industrial applications **gelatine powder**, dissolved in hot potable water is used, replacing the precooked ground pork skin. In some recipes pieces of vegetables (e.g. carrots) are added, which are embedded in the gelatinous matrix in a similar way as the meat pieces and provide an attractive product appearance.

Cereal sausage

For this type of precooked-cooked sausages sizeable quantities of various **non-meat ingredients** such as breadcrumbs, rusk (flours mixed with water, baked and crushed), rice, sweet and Irish potatoes, cassava, plantain, etc. are used (see page 64, 78, 81). With the exception of breadcrumbs or rusk, all other plant ingredients are precooked. They are incorporated into a **basic mixture of pre-cooked lower value animal parts** deriving from animal heads and feet, bone scraps and any other edible tissues. Also liver or blood may be added thus making those cereal sausages to some extent similar to either the liver or blood sausage variety.

Cereal sausages in Europe originate from a time when meat as a raw material for sausage production was relatively expensive and hardly affordable by the bulk of the population. Hence products were created with cereals mostly combined with edible slaughter by-products to keep the cost low (Fig. 207). From **poor peoples' food** some of these products have now become **local delicacies** and achieve relatively high prices. They are also seen as contributing to more balanced diets, if they are low in fat and high in fibre.


Fig. 207: Cereal sausage

Nevertheless, for developing countries with population segments who may find it difficult to afford expensive meat products, these traditional formulas offer a good opportunity to provide access to and increase consumption of animal proteins at **low cost** for all. The methods of production are simple. Meat/cereal mixes are prepared similar to the usual methods for low-cost cooked gelatinous meat mixes. If blood or liver is used, all these ingredients are usually added precooked, unlike the technology used for blood or liver sausages where blood and liver are mostly used raw (see page 150).

Corned beef varieties *(recipes page 415 – 417)*

Corned beef with jelly

Corned beef with jelly is produced from **cured pre-cooked beef**. The pre-cooked lean beef should be shredded in order to maintain the fibrous structure of the muscle tissue to some extent. This shredding is done in bowl cutters with a specific shredding device in the form of blunt knives. Cutter knives fitted in the reverse way to avoid sharp cutting of the tissues and operated in slow gear can also serve for this purpose.

Typically for corned beef with jelly a certain quantity of **liquid**, which is usually the cooking broth of the lean meat, is added to the shredded lean meat. This cooking broth may have been concentrated by boiling or enriched with gelatine. Normally only the quantity equivalent to the loss of meat juice is replaced that had been cooked out during the precooking of the raw meat.

Before adding the liquid, the shredded precooked beef is mixed with spices and additives. The aim is to achieve a **juicy soft texture** of the final product. For this purpose, the mix is filled either in synthetic casings (Fig. 208) and pasteurized (cooked below +100°C to core temperatures of +74°C) or filled in cans and sterilized (Fig. 209) (e.g. as fully preserved products, see page 288).

There are **high quality** products on the market with lean beef only as raw material (Fig. 208, 209). For **lower price** products beef or buffalo meat trimmings are used with higher fat and connective tissue content, some also contain meat extenders (red coloured TVP, approx. 5%) (Fig. 105, 211, 212).

Fig. 208: Corned beef with jelly, in casing (Europe)

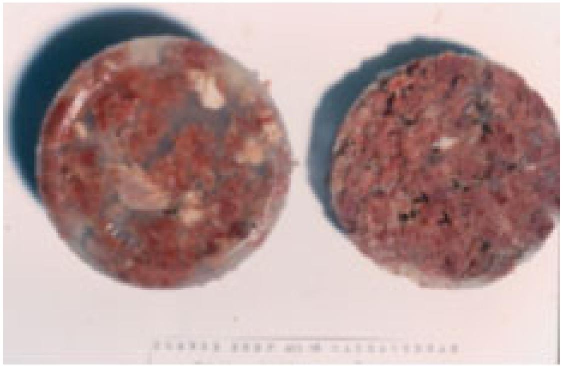


Fig. 209: Corned beef with jelly (high amounts of jelly)

Classical Corned beef

The classical corned beef was originally a **by-product of meat extract production**. More than one century ago, before refrigeration was available, the only way of utilizing the surplus beef from Latin-America and other regions of the Southern hemisphere for shipments to Europe, was to produce meat extract. Meat extract is a viscose concentrated protein-mineral paste obtained by evaporating the process water (cooking broth) of beef. Meat extract is shelf-stable and can be shipped over long periods at ambient temperatures. It is a useful ingredient for seasoning and protein enrichment of meat dishes.

Fig. 210: Classical corned beef in typically shaped cans. Right: open can showing product

The remaining product of the meat extract production was the **cooked beef**, where part of the proteins and minerals had been extracted, but which still was a valuable food in terms of protein content. With the development of the food canning technology, this cooked beef was filled into cans and heat sterilized. The result is the **classical corned beef**. Thus, besides the meat extract, another shelf-stable and attractive meat product was obtained, that could also be shipped without refrigeration to consumers in Europe. Canned classical corned beef is still a popular product worldwide.

The **manufacture** of classical corned beef is simple. The raw material is lean beef of lower grades, usually from cows. In industrial plants the precooking of the beef takes place in continuous cooking lines. Visible connective and fatty tissue is separated from the precooked beef. The remaining lean precooked meat is mixed with spices and curing salt and coarsely minced. This mix is filled into the typically shaped corned beef cans (Fig. 210, 211) and sterilized. The product quality is not significantly affected by high temperatures, hence the sterilized products, for safety reasons (long transport and storage at high temperatures!) should reach F-values of 12. F-value is the measurement for the intensity of the heat sterilization (see chapter “Canning” page 289).

There is one interesting feature in the manufacture of classical Corned beef. In industrial corned beef lines it is not possible to treat the raw beef with curing substances before cooking, as it would interfere in the meat extract production. Nitrite curing salt is only added to the final precooked mix before filling it in cans, and one would expect a grey product after sterilization. Nevertheless, the final products achieve a slight pink colour. Obviously there is still some myoglobin available that was not destroyed by the precooking and reacts with the nitrite.

Fig. 211: Classical corned beef (left) and low cost corned beef (right)

Fig. 212: Low cost corned beef upon removal from the can

CURED MEAT CUTS

Entire pieces of muscle meat and reconstituted products

Curing is the treatment of muscle meat with **common salt** (NaCl) and **sodium nitrite**[1] ($NaNO_2$). It is applied in the manufacture of sausages or similar products, but also for larger pieces of meat selected for cured meat specialities. In the past, when refrigeration was not commonly available, curing was mainly applied to extend the storage life of entire pieces of muscle meat by using the preserving effects of common salt (in high concentrations) and to a lesser extent sodium nitrite. In modern meat processing, this aspect is less important as more efficient meat preservation methods, in particular cooling and freezing, are available. Curing is now mainly applied to achieve a pink-red colour as well as a typical flavour and taste in processed meat products (see page 36, 68).

Fig. 213: Cured-raw pork loin ("coppa"), left, and cured-cooked pork loin ("smoked loin"), right

Cured meat cuts made of **entire** pieces of muscle meat, constitute a specific group of meat products. The opposite are **comminuted** cured meat products, to which sausages and similar preparations belong (see relevant chapters page 115, 127, 149). In principle, the cured meat cuts can be sub-divided into two groups, **cured-raw meats** and **cured-cooked meats** (Fig. 213).

For ***cured-raw meats***, usually entire muscle groups in their anatomical connection are used. Typical examples are whole pork hind legs or parts of hind legs (topside, silverside, round), pork loins and bellies, beef briskets and/or cuts from beef hindquarter. In some regions mutton legs, ostrich breasts and game meat cuts are also produced as cured meat cuts.

---
1) Sodium or potassium nitrate ($NaNO_3$/KNO_3) are alternative curing substances but generally not needed and not recommended for the usual processing methods, if sodium nitrite is available (see page 35, 119).

For ***cured-cooked* meats**, similar meat cuts as mentioned above and smaller meat pieces can be used as raw material. These pieces vary in size and can be much smaller than individual muscles. After curing (in most cases combined with tumbling, see page 28), the pieces are joined together in special containers (moulds) and/or casings prior to cooking to “reconstituted meat” (see page 178).

The curing for both groups, **cured-raw** and **cured-cooked**, is in principle similar: Small amounts of nitrite, either as dry salt or as salt solution in water, have to be brought in close contact with the muscle tissue in order to effect the curing reaction with the muscle pigment myoglobin (for details on curing techniques see page 37).

The decisive difference between the two groups of cured meats is:

- **Cured-raw meats** *do not undergo any heat treatment* during the manufacturing process and need to be kept in controlled climatized conditions during their entire processing period which comprises curing, fermentation and ripening. During this period a decrease of the moisture content is achieved resulting in a moderate drying effect of the meat. Fermentation and ripening processes take place simultaneously with the drying and make the products palatable.

- **Cured-cooked meats**, after the curing process of the raw muscle meat, *always undergo heat treatment*, either at pasteurization or sterilization temperatures, to achieve the desired palatability. Moisture losses would make the products dry and are therefore not desirable.

Cured-raw meat

For cured-raw meat, fresh meat of **good hygienic quality** should be used, as this aspect has a crucial impact on the long shelf-life and typical flavour of the final products. The fresh meat selected for cured-raw products should have a low pH, as **lower pH-values** result in lower water binding capacity, thus allowing for adequate release of water (drying) during the fermentation and ripening phase. If the meat remains in the high pH range and retains high moisture content, it would spoil during the prolonged ripening phase. pH-values below 5.6 in the selected fresh lean pork and even lower for beef are recommended. Meat from older animals is equally suitable due to its decreased water holding capacity.

Raw-cured meat cuts are not submitted to any heat treatment and consumed raw. The exception is Jinhua ham (page 174), which Chinese consumers prefer to boil in soups or similar, but it can equally be eaten raw.

Curing and ripening

Products under this category are manufactured by **applying curing salt** (combination of 99.5% common salt and 0.5% sodium nitrite) either dry or in solution or in a combination of both (see page 173, 174). After the curing, specific processes of **fermentation**, **drying** and **ripening** take place in the meat. The duration depends on the size of the meat pieces and the type of products, but lasts usually between three to six months. For some raw ham specialties the process can take up to 24 months.

a) Dry curing

Dry-salting is the traditional favoured method for raw-cured meat. Meat cuts (entire pieces of muscle meat) are **rubbed with curing salt** (see Fig. 63, 64, 214). Thereafter these meat pieces are **packed in curing tanks** and **piled** on top of each other with layers of curing salt between them and stored at low temperatures (0 to +4^{o}C). The curing salt **infiltrates** the meat tissue and at the same time liquid from the meat tissue is **extracted** by the salt surrounding the meat. The liquid accumulates at the bottom of the curing container. Sometimes, this liquid covers the lower piles of meat pieces and contributes an additional curing and flavouring effect, in other cases this liquid is drained out. Due to the weight of the rubbed meat cuts, the pressure within the pile is higher at the bottom of the container. This results in faster liquid loss and salt infiltration. For equal distribution (uniform exchange

Fig. 214: Rubbing with salt for dry curing

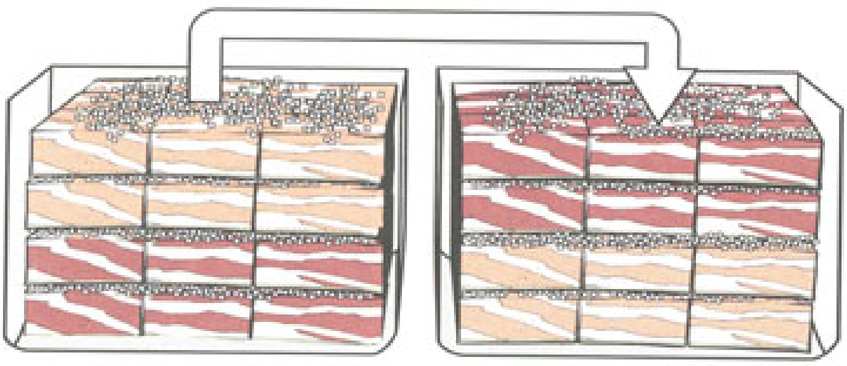


Fig. 215: Dry-salting. Periodic re-arrangement of meat piles

process) re-piling and adding of dry curing salt should be carried out every seven days with the lower piles up and the upper ones down (see Fig. 215).

Depending on the size of the meat cuts, the **curing process** alone can last up to several weeks for equal penetration of the meat cuts with curing salt. At temperatures of about +4^{o}C, a pork shoulder takes about two weeks, a leg of pork about four weeks. The same curing periods apply to beef cuts of comparable size. In all dry-curing methods the meat should be covered to protect it from the air. The liquid, which may develop in the first few days, when the salt extracts the juice from the meat, can be removed, but additional smaller amounts of dry curing mix must than be sprinkled over the meat cuts. If the liquid is left at the bottom of the container, care should be taken that re-piling is done more frequently (see Fig. 215).

In combination with the dry curing salt, also **spices** and **sugars** for flavouring and **sodium ascorbate** for enhancement of a typical curing colour (pickling-red) are used simultaneously. The use of ascorbic acid (instead of sodium ascorbate) in curing mixes and/or brines is discouraged as it could lead to a violent chemical reaction with the nitrite, especially when dissolved in water together with nitrite. The result would be fast nitrite breakdown and loss of its functional property.

As exception to the common technology of using curing salt (containing nitrite or nitrate, or a mixture of both, see also page 119), some well-known traditional cured-raw ham products (e.g. *"Parma Ham"* and *"San Daniele Ham"* in Italy, *"Jinhua Ham"* in China *"Jamon Serrano"* in Spain, *"Jambon Savoie"* in France, or *"Virginia Ham"* in US) are fabricated without nitrite using **common salt** only. For these products carefully selected pork hind legs with bone are used. Although no nitrite is used, a stable red colour is achieved in these cured-raw ham products. This red colour derives from the natural meat colour intensified by the drying and ripening process, in some instances traces of nitrite and nitrate in salt and spices may also contribute.

b) Dry-Wet curing

This method is also sometimes practiced in order to **facilitate a standardized curing process** in bigger meat cuts of slightly different size in one curing container. The meat cuts are dry-salted as usual and piled up layer by layer in the curing containers. The liquid extracted from the meat tissue by salt accumulates at the bottom of the curing container and is topped up to reach to upper piles by separately prepared brine, usually with 15-20% curing salt concentration. The brine must be checked periodically for density and salt concentration and replenished as necessary to assure even curing. The curing brine can also contain spices for enhanced flavour and sodium ascorbate to further stabilize the curing colour. After 5-7 days the meat cuts are re-piled and covered again by the curing brine. As a rule of the thumb, the curing time for the biggest meat cut is 2 days per kg of its weight at a brine/meat ratio of 1:2. This is followed by a drying/ripening phase.

Fast curing with additional brine injection
For some raw-cured products smaller amounts of curing brine are injected directly into the muscle tissue to accelerate the curing process. This technique significantly shortens curing periods, as curing substances migrate in both directions, from outside to inside and from central to less central parts. But because of the accelerated process, the curing flavour remains less intensive and texture of these products remains softer then in products applying dry or dry-wet curing. The shelf life is also reduced significantly and most products are kept refrigerated. Typical products of this fast-cured type are **cured/smoked pork loin** and **breakfast ham** (low price raw ham). Fast curing with injection of curing brine will therefore remain the method of choice for **rapid turnover cured-cooked meat products** only.

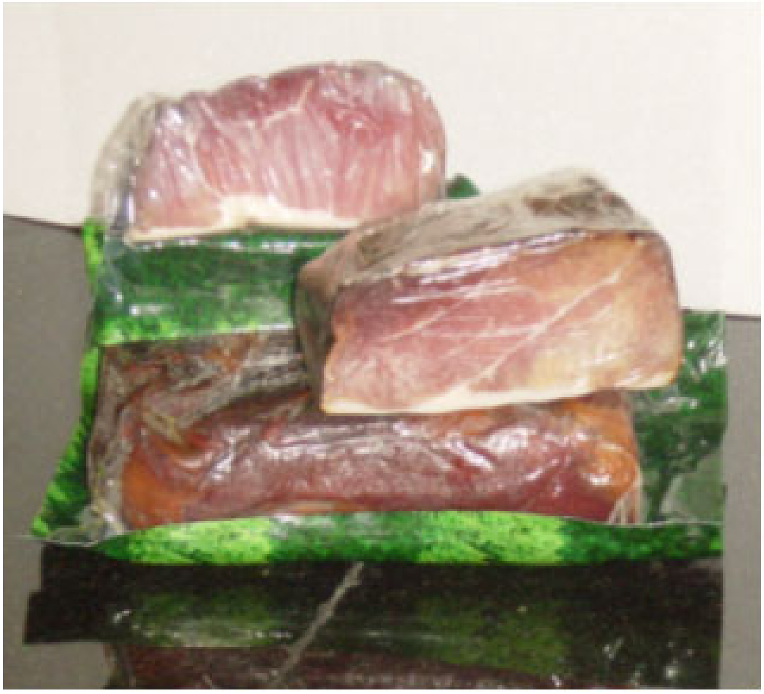


Fig. 216: Quick cured-raw breakfast ham
Vacuum packed to stop weight loss

c) Ripening and fermentation of cured-raw meat products

After the curing period, a **ripening** (maturing) and **fermentation period** is required for the full development of the typical flavour of raw-cured meat products. At the start of the ripening period, all curing salt is removed from the meat surfaces and the meat cuts are either spread on trays or hung on sticks in refrigerated rooms at initial temperatures between +2 and +5°C (Fig. 217). During this phase the cured meat cuts develop the typical flavour, colour and texture. In the course of the ripening period, temperatures are gradually increased, but should not exceed +12°C. Ripening is a very slow process and can take up to several months for specific products. Throughout the entire process (curing, ripening, fermentation) the meat looses a significant portion of its water content. This process starts during curing, when salt penetrates the meat in exchange for moisture, and is continued during ripening, when moisture from the meat evaporates and dry partially. At the end of the ripening phase the salt concentration should reach ≥4.5% (a_W 0.96) as this ensures a microbiologically stable product. Hams dried and fermented in natural or climatized air are called **"air dried hams"** (Fig. 218, 219). **Air dried beef** is a very tasty product and attracts high prices (Fig. 221)

Fig. 217: Drying and ripening stage of cured-raw hams (suspended in ripening room after completion of curing)

For *"Parma Ham", "San Daniele Ham"* and "*Jamon Serrano"*, the whole process including curing, drying, fermentation and ripening leading to the product ready for consumption can take up to 24 months. Process periods (curing, drying, fermentation and ripening) for *other* raw-cured products see table 9.

d) Smoking

For many of the larger raw-cured meat cuts and depending on the region it is common to apply short sequences of **cold smoke** (around 20°C) (see page 41) during the ripening stage, especially in regions with wet and/or cold climate. The high air humidity in these regions increases the risk of mould growth on the meat surfaces, which can be prevented by the antimicrobial effect of smoke. This category of products is called **"smoked raw hams"** (Fig. 220).

Table 9: Treatment for raw fermented products

	Curing period temp	Post-curing period	Optional cold smoke	Ripening, fermentation, drying
Pork leg (Ham) dry cured	15-30 days 4-8°C	3-5 days 8-12°C	5-30 days 12-18°C	Normally up to 9 months (Parma etc. up to 24 months) (water content in muscle tissue ~62%); +2 to +5°C, later higher
Smaller meat pieces dry cured	4-10 days 4-10°C	1-3 days 8-12°C		Few days to few weeks (water content in muscle tissue 67% and above); +4 to +10°C, later higher

Fig. 218: Well ripened ham, bone-in, air dried

Fig. 220: Raw ham, heavily smoked

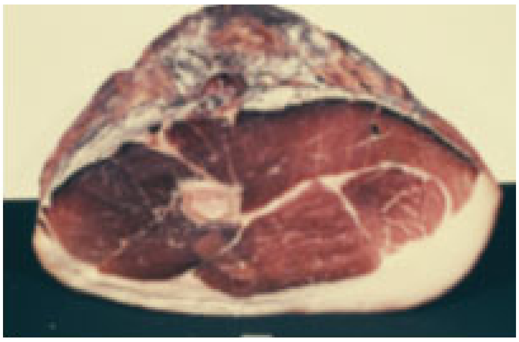


Fig. 219: Well ripened ham, bone-in, air-dried

Fig. 221: Beef, dry cured, rectangular shaped through pressure during curing and fermentation, ripening period several months, surface layer edible yeasts

Cured-cooked meat products (recipes page 422 – 423)

Raw meat material used for cured-cooked meat products is mainly pork derived from hind leg, shoulder or loin. In some regions, lean muscle meat from other species (here mainly from beef carcasses, Fig. 231) may also be processed to local cured-cooked specialties. In some regions cured-cooked beef tongue is a delicacy. Meat from younger animals with **higher pH values** is preferred (for pork pH above 5.6, preferably 5.8-6.0). Higher pH values are associated with better water binding capacity. Contrary to cured-raw products, where low pH-values are desirable to boost moisture decrease, high pH-values are desirable for cured-cooked products to retain the full moisture content.

For high quality products and regional delicacies, **entire pieces of muscle meat** (Fig. 226, 230) are cured and cooked. These meat pieces may consist of defined muscle groups, such as ham or large back muscle. Medium quality cured-cooked meat products are normally **reconstituted** (Fig. 228, 231) from smaller size lean muscle parts, which are cured and tumbled (see page 184), tightly filled in special containers and cooked (Fig. 413, 414). For the low-cost market so-called **"re-formed"** products have become popular. For these products, small muscle pieces and lean trimmings are mixed with brine (water, salt, binders, extenders, etc., see page 180). The mixture is tumbled, stuffed into casings or cans and heat treated. The individual processes are described below. The meat temperature should ideally be kept below +4°C during the curing process.

Fig. 222: pH – measurement in ham

Processing Technology

There are slight differences in the processing technology of cured-cooked products, mainly depending on the size of the meat parts used for product manufacture. Curing brine is administered in all products. This is usually done by brine injection.

Even distribution of the injected brine is achieved by treating the injected meat pieces in a meat tumbler (Fig. 28, 228). When no tumbler is available, "resting periods" (see page 182, 185) for the meat pieces are needed.

When meat pieces are too small for brine injection, they are transferred untreated into the tumbler together with an adequate amount of curing brine, which will be absorbed into the meat tissue through the massaging effect of the tumbling.

Preparation and application of curing brines

An essential part of cured-cooked meat processing is the **use of curing brine**. For some products, curing brine is partly injected directly into the meat tissue and partly used in solution in which the injected meat cuts are submerged prior to cooking. In re-constituted cured-cooked meat products, a mixture of meat pieces, trimmings and curing brine (often enriched with additives for increased binding) is subjected to tumbling. All these curing brines have different compositions and salt concentrations.

Table 10: Injection of curing brine

Cooked cured	
Concentration % (curing salt)	Volume % (injected brine)
8-14	15-20

All curing brines contain **nitrite curing salt** dissolved in potable water. The recommended ***salt concentration*** in brines for cured-cooked meat pieces is 8-14%. **Seasonings** are also often added to a brine to impart a uniform flavour in the final product. Here liquid spice extracts (page 84) are best suited as solid spice particles can cause blockage of injection needles. Other common additives in the curing brine solution are **cure accelerators** and **phosphates**. The common cure accelerator used in cured-cooked meat products is ***sodium ascorbate***. The use of ascorbic acid must be avoided (page 174). Sodium ascorbate (0.1-0.2%) should only be added to the curing brine immediately before application, as otherwise the substance could initiate a premature breakdown of the nitrite.

Other additives used in small amounts include **sugars**. In only mildly pasteurized products sugar might cause undesirable acidity during prolonged product storage, due to active Lactobacillus bacteria. The addition of ***phosphates***, especially in combination with salt, increases the water binding capacity of raw meat and contributes to improved texture in the final product after heat treatment (see Fig. 230). In low-cost products with increased yield (reconstituted hams), additional non-meat additives can be used, such as **isolated soy protein**, and **modified starches**. In these rather complicated curing brines, care must be taken that all additives are completely dissolved and evenly distributed.

Table 11: Approximate addition to curing brines for injection[1]
(referring to 15-25% brine injection)

Additives	% in brine
Curing salt	8 - 14
Phosphate	1 - 3
Sodium ascorbate	0.15 - 0.20
Isolated soy protein	4 - 6
Sugar	1 - 4
Gelatine	1 - 2
Carrageenan	0.5 - 2
Modified starches	1.5 - 3
Glutamate	0.2 - 0.3

The following sequence is commonly recommended for the successful preparation of curing brines (Fig. 223, 224, 225):

- Firstly phosphates are dissolved by continuous stirring
- Secondly isolated soy protein is added and dissolved
- Then salt is added and dissolved followed by carbohydrates (sugars), gelatine and carrageenan
- Lastly modified starches and cure accelerators are dissolved

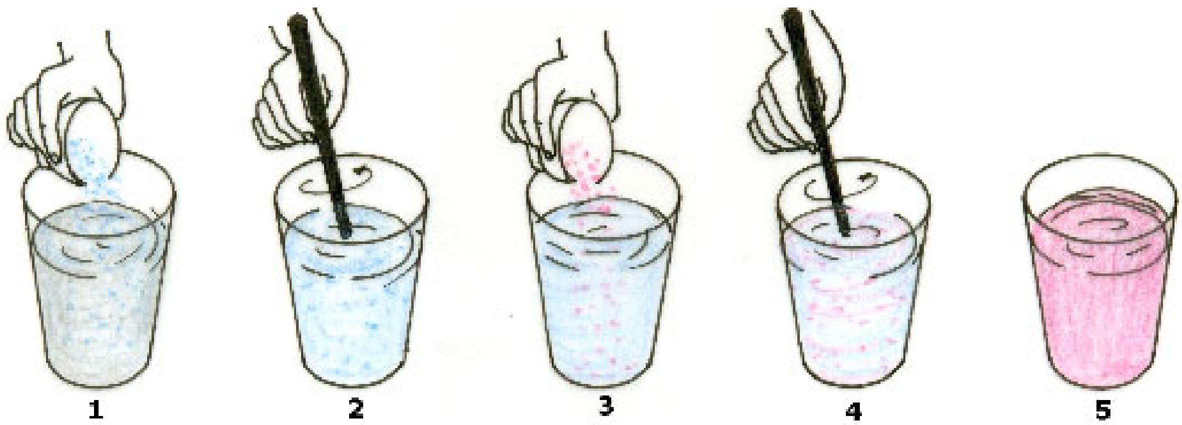


Fig. 223: Preparation of common curing brine (containing curing salt and phosphate)
Correct order of dissolving components
1 = Add phosphates first, 2 = Stir and dissolve, 3 = Add nitrite curing salt,
4 = Stir and dissolve, spice extracts can be added at this stage,
5 = Brine ready for application

1) There may be variations involving a wider range than indicated in table 11 depending on local processing techniques and national regulations.

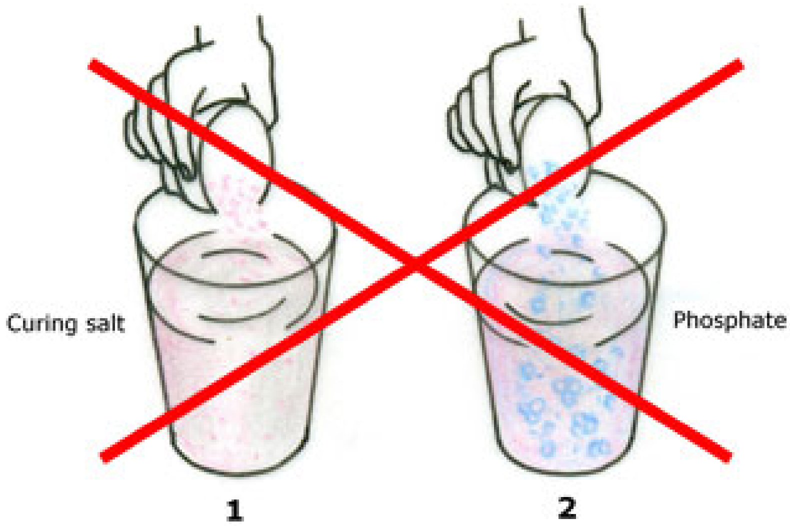


Fig. 224: Wrong order of dissolving components for curing brine (leads to clotted phosphate) (phosphate must be dissolved first!)

Fig. 225: Correct order of dissolving ingredients in complex brines
1 = phosphate, 2 = isolated soy protein, 3 = curing salt, sugar, gelatine and carrageenan, 4 = modified starches and sodium ascorbate

To reduce bacterial contamination of the cured meat, particularly through injection, curing brines must be **hygienically** prepared and handled. For example in case of poor hygienic water quality, the water used for the curing brines should be boiled and thoroughly chilled again before application. This can be achieved by either cooling the potable water in the cold room, or by direct addition of ice (use of ice water). When using ice, care must be taken that it has completely melted prior to injection of the curing brine. Large portions of remaining solid ice, into which no salt penetrates, would result in too high a salt concentration in the liquid part of the brine. The temperature of meat and brine should not exceed +4°C. One important additional benefit of such low temperatures is the increased amount of protein going into solution, thus contributing to improved water holding and reduced cooking loss of the final products.

Whole muscle products

Curing brine injection (see page 39) is the method of choice for a fast curing process of large meat cuts (entire pieces of muscle meat) to be processed through curing and subsequent heat treatment. The curing brine solutions are injected into the muscle tissue by using either manually operated **curing brine pumps** with a single or multi-needle device (Fig. 226) or automatic **multi-needle brine injectors** (see page 27, 39). The curing brine injection should take place in small quantities and repeatedly in various different spots of the muscle tissue. Injection of huge quantities of brine in one or few isolated spots would cause ruptures of the meat tissue and substantial loss of brine. Usually 15-20 % of brine (by volume) having a salt concentration 10-14 % are injected into. Both parameters need to be carefully balanced in order to achieve the desired salt concentration in the final product, which are normally between 1.8% and 2.4%, depending on the product type.


Fig. 226: Manual brine injection

The **equipment used** for the curing brine injection (pump, hoses, needles) must be thoroughly cleaned and periodically disinfected to prevent the transfer of microbial contamination from dirty equipment into the meat.

Excessive pressure during brine injection or the injection of larger quantities of brine into one spot must be avoided, as both would damage the meat tissues. Muscle pumping, even if done properly, may still result in unequal distribution of the brine throughout the meat cuts. For this reason the curing is usually completed by immersing the meat in curing brine of the same composition as the one injected (“resting period”). This method has the advantage that losses of injected curing brine are replenished.

The “**resting time**” for products, which are not tumbled, should be 24-48 hours under refrigeration. This will further enhance the uniform distribution of salt and curing substances and ensure the development of an attractive red curing colour throughout the meat cuts prior to cooking.

If tumbling equipment (see page 28, 184) is available, the immersion of the meat in brine (“resting period”) is not necessary. In this case, the drip-off of brine lost during injection is added to the tumbler and will be reabsorbed by the muscle tissue during tumbling.

The curing colour is further stabilized during the first phase of the subsequent heat treatment, while passing through the temperature range of 30-50°C. Large cured meat cuts (e.g. boned pork legs) can be kept in the desired shape by tightly binding them with layers of string. In recent years this labour-intensive method has been increasingly replaced by using **expandable nets**. These more traditional products are often **hot-smoked** prior to cooking in steam. Alternatively, the meat cuts can also be tightly pressed into ham moulds, round or square (Fig. 414), or stuffed into heat resistant plastic bags or casings and cooked (Fig. 227).

Fig. 227: Filling meat pieces in casing and putting in mould before cooking

Reconstituted meat products of the cured-cooked type

Cured-cooked meat products can also be produced from **smaller muscles or muscle parts** (Fig. 228, 229). These smaller size meat pieces are usually derived from meat cutting and grading operations. The main purpose of these procedures is cost reduction, as carcass parts can be more profitably utilized. The most common source is pork meat, mainly hind legs, shoulders or loins are de-boned and dissected. The dissection enables grading according to lean and fat, dark or bright meat colour and even according to the pH of individual muscle tissues.

The selected smaller muscles or muscle parts undergo preparatory **treatments**. Care must be taken that all fat and connective tissue layers are removed from the meat surface. These undesired tissues are either removed manually or by using electrical “skinning” machines. The lean surfaces of the muscle pieces should be **incised** by knife, as this, in combination with the application of curing brine, facilitates the release of liquefied muscle protein, which in turn coagulates during heat treatment and makes the meat pieces stick firmly together.

In the next step, the smaller muscles or muscle parts are injected with curing brine and subjected to a resting phase of 24-48 hours. **Cure accelerators, phosphates**, and **spices** are added to the curing brine as described in sub-chapter “Whole muscle products” (page 182). The cured meat pieces are then tightly pressed into ham moulds and cooked. To facilitate the necessary firm coherence of the meat pieces, some meat processors sprinkle small quantities of gelatine powder onto the meat surfaces to be bonded together.

The release of liquefied muscle protein in particular on the surfaces of meat pieces can be further enhanced by subjecting the brine-injected or brine-infiltrated meat pieces to **tumbling**. Tumbling is the mechanical treatment in special equipment, either in rotating drums with fixed massaging humps or in fixed drums with rotating massaging arms (see also page 28 and Fig. 228). Tumbling takes place at temperatures of <4°C (-5 to -8°C is best) for several hours (up to 24 hours) (Fig. 229). Tumbling or massaging followed by **heat treatment** allows the meat processor to reconstitute larger and uniformly shaped cured-cooked meat products from smaller meat pieces of different sizes and shapes. At the industrial scale large quantities of such products are manufactured.

Fig. 228: Tumbling of pork pieces, brine added to tumbler

Fig. 229: Pieces of pork after tumbling

Apart from the above processed goods the use of a tumbler enables production of low-cost cured-cooked products. Lean meat pieces and trimmings from all parts of the carcass are coarsely ground, placed in the tumbler together with the desired quantity of curing brine and tumbled/mixed. Such products very often contain non-meat additives for cost reduction and improvement of the binding and water holding capacity of the mixture, such as **soy protein** (isolate), **hydrocolloids** (carrageenan), **gelatine**, **transglutaminase**, etc. (see page 71, 80).

In general, in order to facilitate a timely and uniform tumbling/curing process, larger meat pieces are **brine-injected** prior to tumbling, while smaller pieces can go uncured directly into the tumbler. Care must be taken that the correct quantity and concentration of **curing brine** is added. Amounts and concentrations of brines must be carefully balanced in order to maintain the targeted salt content of the final product, which should be in the range of 2% (see also table 12).

Table 12: Treatment for cooked cured products

	Brine injection	Treatment after injection	Heat treatment of products in containers (moulds, foils, etc.)
Entire meat pieces	Brine 15-20 % by volume with a a salt conc. of 10-14% Temperature 0°C	Resting period for penetration of curing salts (12-26 hours, 0-4°C), with or without tumbling	Water/steam Temperature 70-75°C Internal temp 70 (72) alternatively: hot smoke for bacon, pork chops
Small pieces to be reconstituted	Brine by 15-20 volume % with a a salt conc.. of 10-16% Temperature 0°C	Tumbling for equal distribution of all ingredients, 8-12 hours (15 min. tumbling, 15 minutes rest) (0-4°C or below)	Water/steam Temperature 70-75°C Internal temperature 70°C (72)

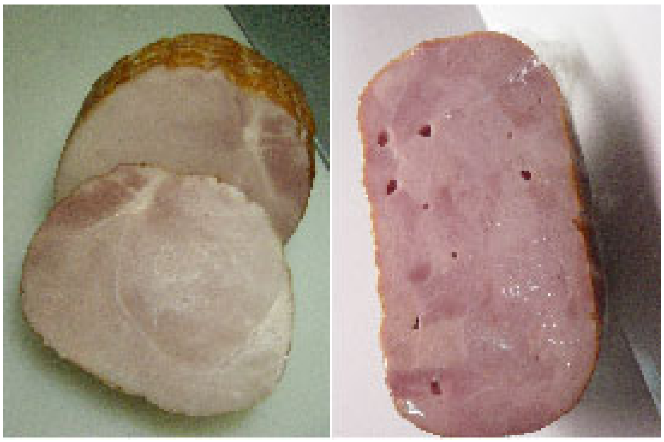


Fig. 230: Entire cooked ham (left) and tumbled reconstituted cooked ham (right)

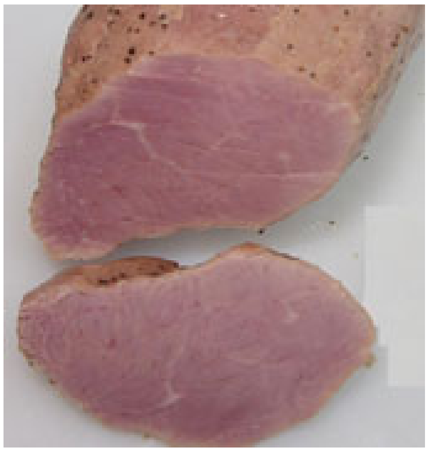


Fig. 231: Beef ham as a cured-cooked product, made of one entire piece of muscle

PROCESSED PRODUCTS MADE OF CHICKEN MEAT

Chicken sausages

Sausages containing meat mixes including chicken meat

Chicken meat is often used to partly substitute the more expensive red meats in meat products especially of the raw-cooked type such as luncheon meat, bologna or hotdogs. In such cases the chicken meat percentage can vary substantially. As a good manufacturing practice, the percentage of chicken meat should be indicated for consumer information, as such products are normally perceived as pork or beef products, not containing chicken meat. Also some liver sausages can contain larger quantities of chicken meat. These products are commonly labelled as “Chicken Liver Sausage”, although in many cases the liver and animal fats derive from pork.

Sausages and other products with 100% chicken meat

Besides the use of chicken meat in mixed red meat products, there are many well established and popular products which contain chicken meat only. When processed chicken and turkey meat products were introduced on a broader scale a few decades ago, traditional red meat recipes where simply modified and red muscle meat was replaced by poultry meat and pork fat by fat rich chicken skin. For these poultry products such as chicken frankfurter, chicken bologna etc., non-meat ingredients and the processing technologies remain basically the same as for the corresponding processed red meat products. Manufacturers even endeavour to make chicken and turkey sausages similar to red meat sausages in taste and flavour, but point out the health benefits of poultry products (low fat, low cholesterol, see table 1 on page 2).

Chicken frankfurter and **chicken bologna** are finely comminuted products, which can be considered as **raw-cooked products** (see page 127). Lean chicken meat provides the proteins and chicken skin replaces the fat to be finely dispersed in the sausage batter. Filled in small casings (18-22mm), this typical raw-cooked sausage mix is the basis for chicken frankfurters (Fig. 232), when filled in larger casings (40-60mm), for chicken bologna (Fig. 233). The mix also serves as the basis for products where coarse chicken meat (either diced or ground) is blended with batter and filled in casings of 60-80mm or cans. These products may be named chicken or turkey ham sausage, chicken or turkey roll etc. (Fig. 236). **Chicken meat balls**, a product in high demand in the Asian

region, are also of the same category. They are manufactured based on the method used for traditional meat balls from red meat (Fig. 237).
Another chicken meat product, which resembles the cooked hams made from pork in both manufacture and appearance is called **chicken ham** (raw meat material may come from all parts of the chicken carcass) or **chicken breast** (in this case only chicken breast parts should be used). The meat material is tumbled together with brine containing curing salt, phosphates and spices, and either pasteurized when filled in casings or moulds (Fig. 234) or sterilized when filled in cans. For canned and sterilized chicken products see Fig. 238 and 239.

Fig. 232: Chicken frankfurter

Fig. 233: Chicken bologna

Fig. 234: Chicken ham

Fig. 235: Turkey ham

Fig. 236: Chicken roll

Fig. 237: Chicken meat balls
Steamed (left) and oil fried (right)

Other chicken meat products

Coated / breaded products

In addition to chicken sausages, the chicken meat industry also developed new products, which contributed significantly to meeting the global increase in demand for poultry meat. These can be compared to a few examples from the red meat and fish sector, e.g. breaded and fried meat slices of pork or mutton known as “Escalope” or “Wiener Schnitzel” and in the fish sector as “fish fingers”. The characteristic of such products is the coating of meat surfaces with flour, fat/flour mixes and/or breadcrumbs etc. In the poultry sector, similar products include **chicken nuggets** (ground meat mix), **chicken sticks** or **fingers** (muscle strips) or **chicken schnitzel** (breast muscle slices).

After the meat or meat mix is portioned, each portion is *pre-dusted* by applying a thin layer of dry flour on the meat surface. This serves to firmly absorb the *batter* and the *breading* in the following steps of the processing. Battering consist of dipping the meat pieces in a semi-liquid mixture of oil, eggs, water and spices. Breading is the coating with flour, fat/flour mixes and/or breadcrumbs. The final step in this process is heat treatment to stabilize the coatings on the meat surface. This short heat treatment in *hot fat/oil* (approx. +175°C) as part of the processing must be seen as a pre-treatment only and does not cook the product. The final heat treatment is carried out by the consumer right before eating.

In large chicken industries, the above processes have been automated by using continuous processing lines. This industrial level processing mainly focuses on comminuted and reconstituted meat parts, in some cases mechanically deboned meat (MDM) is used for cost reduction. Some examples of industrially manufactured chicken products are shown in Fig. 240 to 243.

Fig. 238: Canned chicken frankfurters

Fig. 239: Canned chicken chunks in different gravies

Fig. 240: Chicken nuggets, small size

Fig. 241: Chicken wings with bones

Fig. 242: Chicken drumsticks (below), Chicken nuggets, large size (above)

Fig. 243: Chicken 'tocino' raw (left) and fried (right). Philippines delicacies with high sugar content

Even though the large poultry firms dominate the markets, there is still scope for small manufacturers to produce and successfully market similar products of high quality standards using manual processing methods. Examples of technologies and products suitable for the small-scale sector are:

Chicken burgers, chicken longganisa

These two products are easily made from spiced ground chicken / poultry meat mixes. The mixture for the burgers is portioned into the desired weight and shaped using a hand-held moulding device (Fig. 245). The longganisas are also portioned and rolled into plastic wrapping.

Fig. 244: Raw material (ground chicken meat)

Fig. 245: Moulding chicken burgers

Fig. 246: Chicken burgers, left fresh, right fried

Fig. 247: Skinless chicken longganisa, made of ground meat, left frozen / fresh, right fried

Chicken nuggets

Also **chicken nuggets** can be manufactured at the small-scale level and a simple method is shown below (Fig. 248).

Fig. 248: Small-scale manufacture of chicken nuggets

(a) Ground chicken meat with salt and spices, to be frozen for chicken nuggets manufacture

(b) Raw chicken nuggets cut-out from frozen block

(c) Materials for pre-dusting (left) and coating with egg batter (right)

(d) Coated for frying

(e) Arrangement for coating and frying of nuggets

The meat selected for the chicken nuggets is mixed with spices, salt and herbs and ground to the desired particle size (1-5 mm). The ground mixture is spread in a tray to the desired thickness covered with plastic foil and frozen. After freezing the nuggets are cut out and breaded (Fig. 248 a-e).

Methods of processing **chicken filets** (to chicken fingers) and of **chicken wings** (to spicy marinated products) are shown in Fig. 249 and 250.

Fig. 249: Method for pre-dusting, battering and breading of chicken filets

Fig. 250: Marinating chicken wings for fried products

MEAT PRODUCTS WITH HIGH LEVELS OF EXTENDERS AND FILLERS

Introduction

Meat extenders are non-meat substances with substantial protein content, whereas ***fillers*** are high in carbohydrates (see page 60). Meat extenders and fillers are primarily used with the objective of making meat products ***lower-cost***. In the upmarket sector there was traditionally less demand for highly extended products as their sensory properties could not fully match "full-meat" products. However, much progress has been made in recent years in improving the sensory qualities of extended meat products by using better balanced spice mixtures or other suitable additives of plant origin such as flavouring herbs (parsley, oregano, rosemary, leeks) or bulbs, roots and tubers (onions, garlic, ginger, raddish). These facts make the low-cost market more attractive and may contribute to its further development.

Interestingly, in recent years also in the upmarket sector some ***new developments*** regarding increased utilization of non-meat additives can be noted. In this case it is not based on price considerations but on health-consciousness of consumers. New additives (coming from dairy, bakery and other food industries) have recently been introduced into the meat sector, with the intention of promoting the production of "healthy" food. Some of these additives are advertised with the potential to increase the ***fibre***[1] content (dietary fibre fortification) of meat products (e.g. wheat, bamboo, cotton seed, red beet, chicory). Also functional properties are attributed to the fibre additives (see page 60), in particular binding of water and creating a creamy product texture.

Fig. 251: Addition of non-meat ingredients (example: starches)

---

[1] see footnote page 196

Other additives are recommended to increase the level of certain ***minerals***[1] in meat products (fortified iron, magnesium enriched, calcium improved). Some of these additives are by no means cheap "fillers" and may even increase the costs of the products. Specific target groups of consumers are prepared to pay for these relatively high-priced "wellness-products", which are gaining increased market share.

In countries with low purchasing power, some meat processors intend to **reduce their production costs** by adding disproportionately high amounts of cheap extenders and fillers (e.g. flours, starches, breadcrumbs, soy concentrate, MDM, also water) to meat products.

More ***transparency*** is needed in this part of the meat sector, particularly in developing countries, where relevant food regulations are often incomplete or poorly applied. Such transparency can be best achieved by greater public access to information on the safe use of non-meat extenders and fillers. Proper labelling is therefore a key area to be addressed by national food control authorities.

In addition to *extenders* and *fillers* of non-meat origin, mechanically separated cheaper materials from animal carcasses also known as ***mechanically deboned meats (MDM)*** are widely used in meat processing. This refers in particular to poultry meat[2] (chicken, turkey). The use of such materials, separated as the remaining meat on bones, certainly contributes to the integration of all edible parts from carcasses into the food chain without wastage of valuable animal proteins. However, MDM must be hygienically generated and processed and its incorporation as raw material for meat products should be well balanced.

---

1) Additives containing fibre, minerals etc. have **prebiotic** properties, which assist the organism in creating favourable conditions for good health. It must not be confused with additives with **probiotic** properties, where living bacteria (mostly Lactobacillus strains) are added, e.g. to yoghurt and more recently also to fermented meat products such as dry fermented sausages. It is believed that the microorganisms have a direct positive impact on the human digestive system.

2) Mechanically separated meat from cattle, sheep and goat is not currently produced because of possible BSE-risk.

Traditional extended meat products

Various flours are primarily used in extended traditional meat products from ***Asia***. One well known example is **'Moo-Yoh'** (Fig. 252).

Fig. 252: Moo-yoh

This is the Thai name for a product popular in Thailand and some other South-East Asian countries. The roduct is manufactured using raw-cooked technology (see page 127) by finely chopping all ingredients with ice. It is composed of pork (85-90%), sugar (1.5%), fish sauce, common salt and pepper (each 1%), and flour (5-10%) is used as a filler. Due to the high flour content air bubbles are produced during the cooking, which are characteristic for Moo-Yoh. Moo-Yoh has a grey to whitish colour (Fig. 252).

In ***Africa*** the main traditional meat processing methods are meat salting, drying and smoking. In the past these three methods allowed semi-nomadic or nomadic herdsmen to preserve meat from livestock or game in higher temperatures. Such traditional products were later developed into biltong, kilishi, etc. (see page 237, 241).

The manufacture of **mixtures** containing cereals, mainly beans, grains and/or cassava (manioc) with meat, fat, blood, internal organs and even milk, falls in the category of extended products (see also page 112). Such products can on the one hand be considered as processed meats, on the other hand they are related to kitchen style cooking, as these mixtures are usually consumed as part of the meals immediately after preparation. In recent years some of these traditional cooking mixes have been commercially produced in cans and used as food supplies with extended shelf life for emergency situations, for remote regions and for refugee camps. These mixed meat/plant products offer a convenient outlet for otherwise highly perishable animal products and are nutritious, particularly due to the animal protein. The content of extenders may be high, in some cases exceeding the content of animal tissues.

More advanced processing methods were imported into Africa over the years from other parts of the world. The preparation of meat/plant mixes as fillings for samozas (dough pouch with filling) and spring rolls originated in Asia while the preparation of coarse and fine breakfast sausages (see below)and meat rolls were introduced from Europe.

In ***Europe*** there are a number of extended traditional meat products, mostly based on adding cereals to mixes of meat, fat, blood, pork skin or other carcass parts with high connective tissue content. Typical examples are the French “pate de champagne” and “boudin de bretagne”; the Scandinavian “blodpolse” and “blodkorv”; the Irish “black pudding”; the German “gruetzwurst” and “pfaelzer saumagen”; the Spanish “morcilla de calabaza” and “morcilla sencilla de arroz”, the Polish “kiszka kaszana wyborowa” and “kiszka kaszana gryczana”. All these belong to the group of pre-cooked-cooked meat products (see page 149).

The ***breakfast sausage*** is another highly extended meat product. These sausages can be categorized as raw-cooked sausages, but are sold in fresh or frozen form and heat treated in restaurants or by the consumer directly at home. One common composition is approx. 60% animal tissue (meat, fats), 15% water, 25% extenders and fillers (wheat flour, rusk, corn starch) (Fig. 253).

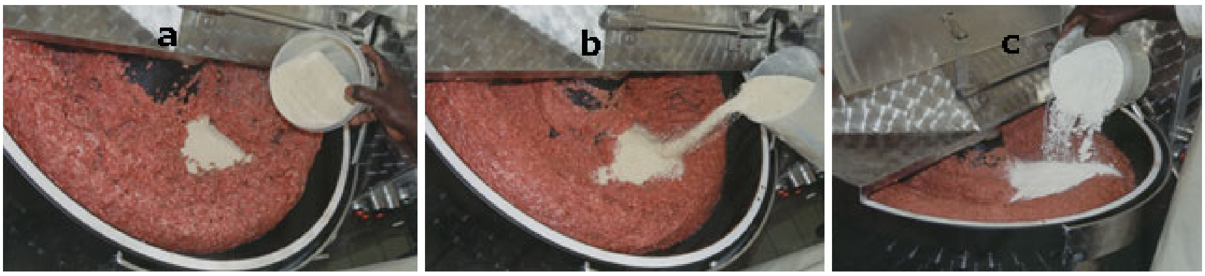


Fig. 253: Breakfast sausage
Sequence of adding ingredients to lean meat batter:
(a) salt, phosphate, spices, (b) rusk, (c) flours and starches

The most typical extended European meat product on the market is the lower quality type ***Italian Mortadella*** (Fig. 254). Its fabrication follows the principles of raw-cooked meat products, with meat, animal fats and water as basic raw materials and extenders. The meat component does usually not only include lean meat, but also offals such as spleen, oesophagus and sometimes even udder. Smaller fat dices are also often embedded in the batter in combination with green peas, pistaccio nuts or black peppers. The fillers used are usually starches and flours. The cohesiveness of the mortadella is achieved partly by the network of muscle proteins (see page 129), but to a certain extend also through the stickiness of the fillers. Mortadella is stuffed in large calibre casings (up to 200 mm). In order not to expose the outer zone of the sausage too long time to excessive temperatures, a special heat treatment (**delta-t**

cooking) is required. In the delta-t method, the heat treatment usually starts with water temperatures of +60°C. This temperature is maintained until the core temperature in the sausage has reached +35°C. From then on the water temperature is raised continuously, always maintaining a certain difference with the core temperature (usually 25°C) until the final water ("cooking") temperature (in this example +78°C) is reached. The heat treatment is continued at this water temperature until a core temperature of +68°C is reached in the product (see page 444).

Most mortadella products are to a certain extend shelf stable at moderate ambient temperatures due to the long heat treatment and the low a_w achieved by the high share of extenders. They are often stored without refrigeration. Although mortadella is considered a low cost product, it has an attractive appearance and taste and is now considered a delicacy.

Fig. 254: Mortadella

Extended Western style meat products *(A, B, C, D below)*

The groups of *fresh* (page 103), *raw-cooked* (page 127) and *precooked-cooked* meat products (page 149) of comminuted Western style meat products are well suited for replacing part of the expensive meat by cheaper meat extenders and fillers. These practices, dictated by the need to produce ***lower cost products***, are much more common in developing regions because of the lower purchasing power. In the past few decades Western style meat products have been introduced in the meat sector of most developing regions. Western style products such as frankfurters, cooked ham, luncheon meat etc. often rapidly overtake the production and sales the traditional indigenous meat products.

Inevitably, there is the ***risk of exaggerated and unprofessional application*** of extenders and fillers. The basic rule should be that meat products with elevated amounts of extenders and fillers should be marketed as low-cost, but must still be ***recognizable as typical meat preparations*** and clearly labelled as to composition and nutrient content. Within the existing framework of experience, ***guidelines*** are given hereunder on extender and filler utilization. The ***cost*** of the individual extenders, which may widely vary from country to country, plays an important role in the economics of producing extended meat products. Extender and filler utilization can reduce the cost of full meat products by ***10-30%***. These figures refer to moderately extended products, which still maintain the characteristics of processed meat. Where consumers are used to extended products, it is the experience of meat processors that the majority of consumers ***prefer*** slight to medium extended meat products over full-meat products. The situation is different in countries where high quality standards prevail. Here consumers usually even ***dislike*** relatively small amounts of extenders.

Apart from the overall quantity of extenders and fillers to be added, the ***right proportion*** of substances has to be used that give products a more granular texture (e.g. breadcrumbs, coarse TVP, page 64, 80) and those that provide a more soft texture (starches, flours, fibre products, page 79, 80, 81). Also the proportion of substances with higher water absorption capacity (“fillers” such as starches, flours or fibres) and lower water absorption capacity (“extenders” such as soy products or other legumes) has to be established. There are a number of product formulas available taking the above aspects into account, but they normally have to be tailored to local consumer tastes and needs.

Hereunder, selected groups of Western style meat products and their suitable extenders and fillers are discussed (see also chapter: NON-MEAT INGREDIENTS, page 59). For comparison, the common formulas of such not extended products are listed in Annex I “Recipes”.

Extenders, fillers and binders suitable for heavily extended meat products:

Extenders (definition see page 61):

Soy concentrate (70% protein) is available as a flour-like product. In coarse granular form it is called TVP (Textured Vegetable Protein). It can be added re-hydrated for meat product manufacture at a re-hydration ratio of 1:3.

Fillers (definition see page 62):

Cereal flours from wheat, rice and corn
Added dry

Starches from potato, corn, wheat, rice
Added dry

Whole grains of rice
Added cooked

Breadcrumbs, rusk
Added dry, in isolated cases also re-hydrated

Cellulose fibres derived from bamboo and other plants
Added re-hydrated, re-hydration rate 1:9

Other fillers (e.g. *vegetable*) are dealt with in chapter: Non-meat ingredients (page 59).

Binders (definition see page 62):

Most binders (e.g. *isolated soy protein*, *milk protein*) used in non-extended and extended raw-cooked sausages do not serve for volume increase.

The binding substance *carrageenan* (page 71) can provide significant volume increase as it is highly water absorbent. Its positive role is mainly in the manufacture of coarse products such as burgers or coarse skinless sausage products and in cooked hams. It may also be of use for improved cohesiveness in the case of high extender utilization in raw-cooked products.

A. Fresh coarsely ground meat products - extended

Hamburgers (Burgers)

Fig. 255: TVP of different granulation and colour

Burger products are ***simple mixtures of ground meats***, including the *traditional hamburger* consisting of pure beef only without any extender or binder and with low fat content. The name *burger* is used for all kinds of simple mixtures of ground meat and animal fats (beef, pork, poultry meat, fish, or mixes of several). Burgers have always been considered suitable for using meat extenders even in high quantities, as no stringent requirements for product cohesiveness or colour exist. In industrial meat processing of burger patties the most commonly used extender is soy concentrate in medium to coarse granular shape as **TVP** (page 80). When rehydrated it has a meat-like texture. TVP in its dry form should be of slightly smaller particle size than the ground lean meat (3-5 mm disc), as the granules increase in size upon re-hydration.

Moderately extended burger products are softer and juicier and have a pleasant but not too intensive meat flavour. Full-meat products often have a tougher texture and in some cases the meat flavour might be too dominant. In burgers relatively large amounts of up to 15% **TVP** (re-hydrated) are tolerated even by quality-conscious consumers. But when TVP contents are in the range of 30% (re-hydrated), this causes almost complete loss of meat flavour and makes products dry.

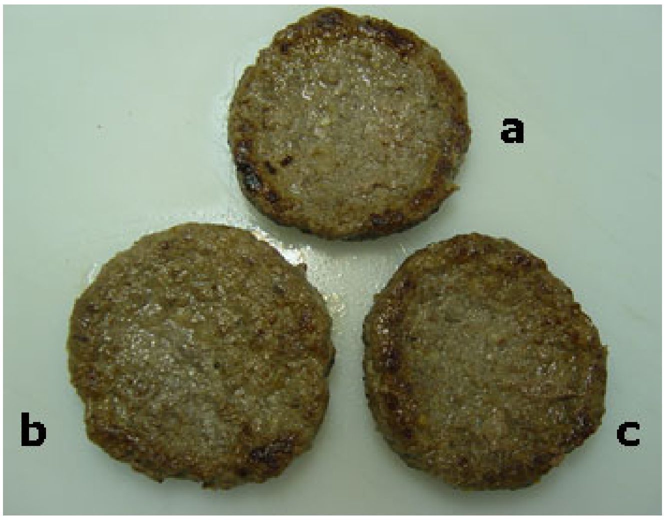


Fig. 256: Burger patties, cooked, (a) with meat only, (b) with TVP and cassava, (c) with TVP. Up to a certain level no sensory differences

In some low-cost burger formulations ***breadcrumbs, cassava***, ***potato***, or ***rice*** are used as fillers, often in combination with TVP as extender. In regions where most consumers are used to extended meat products, hamburgers with 7.5% TVP, or 7.5% TVP plus up to 10% cassava starch were still rated equal to full-meat burgers in consumer acceptability tests. Products with cassava starch also showed reduced cooking losses. Also the addition of ***carrageenan*** in low doses (0.5%) to low-cost burgers contributes to higher yield and less cooking losses without altering the sensory attributes.

Cellulose fibre additives, such as bamboo and potato fibres are also increasingly used for burger type products, mostly in combination with extenders such as TVP. Moderate quantities up to 2.0% (dry) facilitate a smoother mouth-feel, as long as enough water for re-hydration is added. Instead of TVP some regional recipes use fibres (up to 2.0% dry) together with potato (mix of fresh pieces, flakes and flour) and water as extenders for burgers. In this case the re-hydration potential of fibres of 1:9 can be helpful in absorbing most of the excess water.

Chicken burgers

Due to recent consumer concerns about red meat, chicken burgers have become more popular, in particular in the fast-food market. Top quality products are preferably made of leg meat, which is juicier than breast meat and without significant quantities of extenders or fillers (Fig. 246).

For lower-cost products, substantial amounts of extenders and fillers are common and are basically the *same as for* ***red meat burgers*** described above. In addition, some manufacturers incorporate certain levels of mechanically deboned chicken meat (***MDM***) (page 196) in the mix. Chicken burgers are of pale colour and ***food colouring*** (page 73) may also be used but is not a general practice.

Extended chicken burgers, like all other burgers, are usually moulded fresh and stored and distributed frozen. Alternatively, burger mixtures can be stuffed into artificial casings of a desired diameter (65-90 mm), frozen and sliced to individual patties of desired thickness (5-10 mm).

Meat balls (coarse)

Coarse meat balls have a similar composition as burgers and are mainly added to and consumed with soups. The round-shaped mixture (30-40 mm diameter) is stabilized when the meat balls are cooked in water or steamed. The additional heat treatment differentiates the meat balls from burgers (sold uncooked) and also limits the amount of extenders. Meat balls need a more cohesive texture, hence the extender content is usually kept lower than in burgers, but fillers in particular ***starches*** and ***flours*** are used at high levels. Due to the heat treatment (cooking/steaming) of the meat balls, high amounts of extenders would result in an atypically pale colour and lead to loss of meat flavour.

The moderate use of ***cellulose fibres*** as a filler for coarse meat balls can be useful as these fibres re-hydrate at a ratio 1:9. However, excessive use of cellulose fibres in meat balls results in dry “sandy” products, as much of the water absorbed is probably lost during cooking. Coarse meat balls are sometimes also extended with green and red ***vegetables***, such as parsley, carrots and bell pepper. Apart from the slight extending effect, smaller particles of such colourful ingredients can make the usually grey-coloured meat balls more attractive (Fig. 237).

Meat rolls, ground kebabs

Also meat rolls (meat mixes in a cylindrical shape) and ground kebabs (see page 106) are made as extended products. Some of them are sold **frozen raw** and others are **heat treated** prior to marketing. Production processes and the selection of suitable extenders, fillers and binders are based on the same technologies as ground burgers and ground meat balls.

B. Raw–cooked meat products - extended

Raw-cooked meat products made of finely comminuted meat batter (see page 127) are particularly well suited to incorporate certain amounts of extenders and fillers for cost reduction and are always used in combination with binders. The most commonly used *binders* are isolated soy protein (***ISP***) and milk protein (***caseinate***), both usually added as water/fat/protein emulsion (see page 69, 80). In typical extended western-style products, especially in larger calibres used for cold cuts, only ***flours*** and ***starches*** are used as *fillers* and to a rather limited extent also ***cellulose fibres***. TVP is not used as its light-brown colour and granules would show in slices of cold cuts. Similarly also small calibre sausages such as extended hotdogs or frankfurters are mostly fabricated using this technology and composition.

In less demanding markets, where mainly ***low-cost hot dogs*** are the most common extended products, several other *extenders* and *fillers*, often combined with flours and starches, are used. If available, soy concentrate (***TVP***) is the preferred extender, due to its standard quality, user-friendly properties and relatively high protein addition to the product. In many places, manufacturers have resorted to other, readily available and cheaper fillers for low-cost hot dogs such as breadcrumbs, rusk, gari, cassava and boiled rice (see page 64, 78, 81).

Phosphates (see page 69), are particularly useful common additives for raw-cooked meat products. They assist in the development of comprehensive protein network structures. In this respect some **fillers** will develop complementary functions, for example some starches (e.g. potato starch) start absorbing increasing amounts of moisture at the temperature range of 50-70°C, at which some of the loosely bound water is expelled from the protein structure networks. Hence, liquid purge can be decreased or avoided.

Negative effects of extenders and fillers can arise when excessive doses are applied, particularly in terms of appearance, cohesiveness and taste. Limitations have been indicated for the individual products discussed hereunder, but consumer expectations vary widely.

Hot dogs, Vienna sausages

Both sausage types are of a small-calibre, i.e. characterized to be filled in narrow (18-22mm) casings. Hot dogs usually contain ***high amounts*** of extenders. In contrast, in demanding markets, Vienna sausages are known as ***pure*** meat/fat products. In many places around the world this quality pattern is not strictly adopted and various extenders and fillers are used, always in combination with binders.

Naturally, these products cannot be extended up to such levels possible for burgers. The addition of up to 3% (re-hydrated) ***TVP*** as extender combined with up to 2.5% ***starch*** as filler with binding potential[1] will improve the cohesiveness and results in reasonable products ***not very different*** from full-meat products. Levels of TVP up to 6% (re-hydrated) result in ***less "meaty"*** products and demanding consumers may dislike them. But even levels of up to 10% (re-hydrated) TVP could be acceptable to certain consumer groups, in particular when sold at a lower price and consumed as part of a sandwich or in soups.

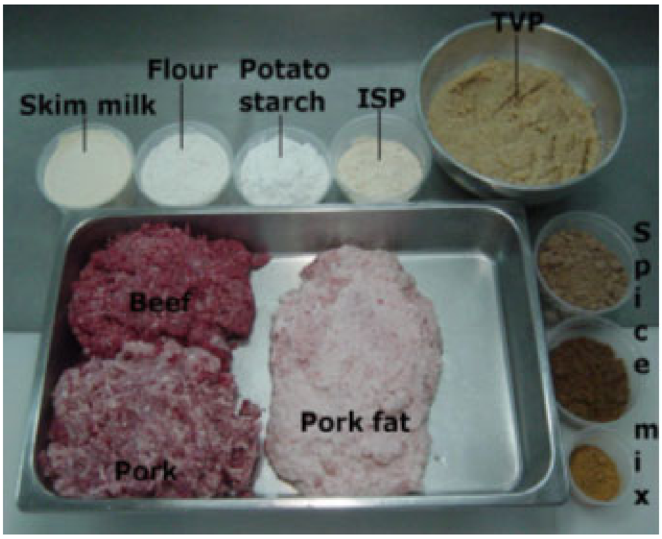


Fig. 257: Raw materials for extended

Fig. 258: Extended hotdogs (no colorant). Colour pale, for more attractive appearance food colouring is commonly used (see also Fig. 260, 265)

When using ***cellulose fibres*** (see page 195) in combination with TVP and starches/flours/skim milk, only moderate quantities of such fibre products (not exceeding 2.5%) should be applied. This is due to the fact that the cellulose fillers are re-hydrated at a ratio of 1:9, which means that 200 g dry powder (= 2% of a 10 kg batch of sausage mix) result in a wet mass of 1800 g in the 10 kg sausage mix. During the heat treatments (reddening, smoking, cooking) of these small-calibre sausages, part of this water may be released, leading to dry "sandy" final products. For the same reason, TVP, which is also a re-hydrated ingredient, should be reduced in quantity, when used in combination with cellulose fibres.

---

1) Potato starch is the most common, followed by corn starch, sometimes cassava starch is used.

Chicken viennas, Chicken hotdogs

Poultry products in small-calibre casings are recently in highly ***demand*** as snacks or whole meal foods particularly in regions where for cultural or religious reasons beef and/or pork are not eaten (Fig. 259, 260). In such products, the fat component also derived from chicken in the form of the fat-rich chicken skin. Alternatively vegetable oil may be used. From the socio-cultural point of view filling the sausage mix into removable cellulose casings does not raise any concerns regarding the animal tissues involved. Many of the regions with preference for chicken sausages are in the developing world with low purchasing power. Hence addition of extenders and fillers is widespread.

For better quality products mainly chicken leg meat is used. In ***low-cost*** formulations the major or entire part of lean meat derives from mechanically deboned chicken (or turkey) meat (***MDM***). Mechanically deboned chicken meat is not entirely lean but contains on average 20% fat, therefore quantities of fat-rich chicken skin or replacement vegetable oils need to be adjusted. The binding capacity of chicken meat is only slightly inferior to beef or pork. Therefore the application of extenders and fillers is possible in practically the ***same way*** as for beef/pork hotdogs and viennas.

Up to 3% (re-hydrated) ***TVP*** as extender combined with 2.5% ***starch*** results in attractive chicken sausages. ***Vegetable oil*** as a fat component produces slightly juicier products than ***chicken skin*** added as the fat component (non-extended formula see Annex I, page 402). More intensive meat flavour can be achieved by replacing some of the lean chicken meat with lean beef. However, this option can be considered only if consumers accept beef and local regulations permit certain amounts of red meat in food labelled as chicken meat products.

Chicken meat is very pale and higher amounts of extenders will also have an additional adverse effect on good product colour. In many countries it is common practice to use ***food colourings*** (red or red and yellow type combined) to give the products a more attractive appearance (Fig. 260, 265).

In some countries, highly extended chicken hotdogs are produced in order to cater for consumers with very limited purchasing power. Formulations with more than 20% of extenders and fillers (mainly ***TVP***, balanced amounts of ***breadcrumbs***, ***flours*** and ***starches***), up to 25% ***water*** and ”lean” chicken meat (***MDM***) in the range of 30% and fats (fat-rich chicken skin, vegetable oil) in the range of 20% are common. In such mixtures, the meat protein network cannot integrate the whole amount of extenders, fat and water (see page 127). The absorptive functions of the fillers play the major role to limit fat and water separation in these cases. This can usually be managed to a satisfactory level, but sensory properties (taste, texture) remain ***atypical*** in meat products.

Fig. 259: Raw materials for extended chicken vs pork/beef hotdogs. Above left chicken skin/chicken meat. Above right pork fat/lean beef, centre TVP

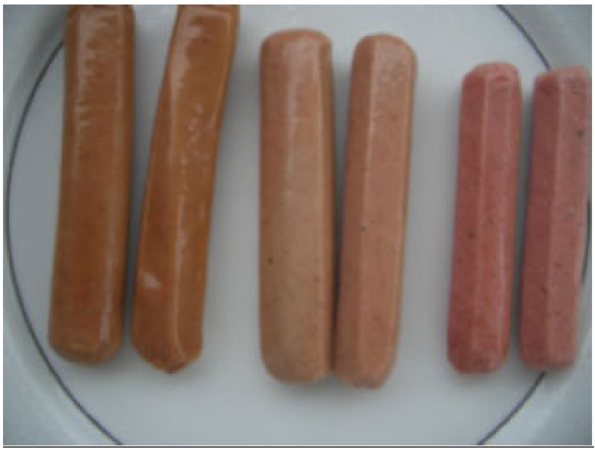


Fig. 260: Extended chicken viennas (cellulose casings removed). Left smoked, centre unsmoked, right unsmoked with food colouring

In Fig. 261 the **different manufacturing stages** of such a heavily extended product are shown. During the first stages the quality of the semi-fabricated product remains high. At the stage of adding the bulk of the extenders, which is instrumental for lowering the product price, the drop in quality occurs. (In order to clearly demonstrate the different stages of the batter, the batter was filled into wider casings than those normally used for hotdogs. All samples were heat-treated.)

For reasons of cost reduction, the quality decrease particularly from step d) to e) (Fig. 261) is unavoidable, but such products can still play a vital role in ***basic animal protein supply*** for low-income population groups, as long as they are made available at a low and affordable price. The animal protein content may still be kept in the range of 7-8%. To improve the sensory quality of such products, parts of their cheapest ingredient, which are the breadcrumbs (besides the water), can be replaced by other cheap locally available foods such as *cassava* (*starch, gari*) or *rice (flour, boiled)*. This contributes to softer texture and better taste.

The *processing* ***technology*** will also contribute to the improvement of heavily extended meat products. In particular coarse extender particles should be further reduced in size. Sharp and efficient bowl cutter knives are essential (page 304). After chopping all ingredients in the bowl cutter, passing the mixture through colloid mills (page 30) will further promote the better integration and binding of all extender and filler materials.

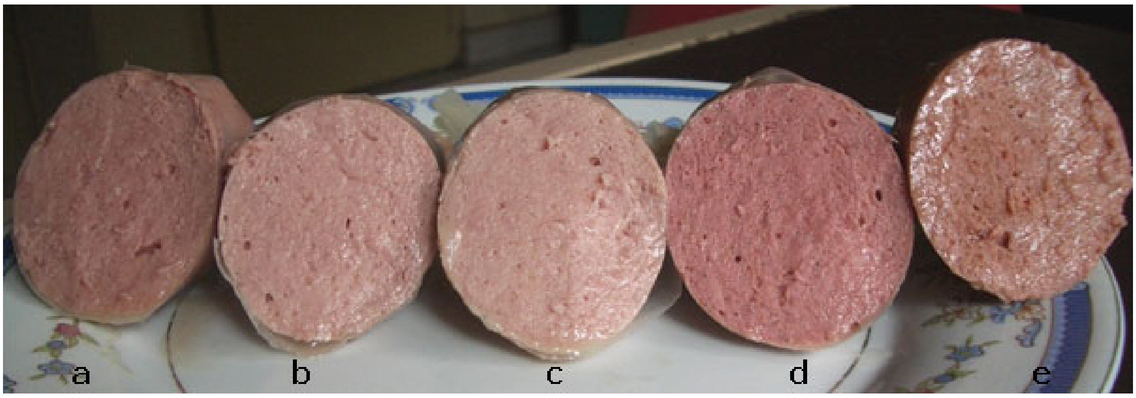


Fig. 261: Different stages of production of highly extended chicken raw-cooked product.

a) **Mix of lean meat, phosphate, salt and water**. Compact texture, pink colour, no purge of fat and water.
b) **Addition of binders** (isolated soy protein, milk protein). Texture remains compact, colour becomes significantly paler.
c) **Addition of fat** (chicken skin). Texture becomes slightly softer, colour slightly paler.
d) **Addition of starch and flour, some vegetable oil and artificial colouring.** Colour turns pink but not like typical curing colour, texture softer but still good.
e) **Addition of high amounts (15%) TVP and breadcrumbs.** Significant change in colour to brownish-yellowish, water exudation, change in taste towards only slightly meat-like.

Larger-calibre sausages of the raw-cooked type

There are different product names for larger calibre raw-cooked sausages depending on their origin, size and sensory properties (appearance, colour, taste etc.). Products such as ***Lyonese*** or ***Bologna*** are finely comminuted and stuffed in casings of 40-80 mm diameter; ***Polony*** can contain some coarse material and is stuffed in casings of 30-40 mm diameter. Often the name “Salami” is also used around the world for a more coarse product, but this may be misleading as this definition has been used for centuries for the European type dry-fermented sausages (see page 115).

The large-calibre products contain *basic* ***sausage mixes*** (lean meat, fat and water) manufactured with the same technology and raw materials used for hot dogs. They share the same characteristic protein network structure (see page 127) and the typical firm-elastic texture. Similarly to extended hotdogs, this protein network is often supported by an emulsion made with isolated soy protein (ISP) or milk protein (caseinate) (page 69, 80) and has the capability to embed and keep in place not only fat and water droplets but also particles deriving from non-meat additives. In these types of products, the addition of ***extenders*** (e.g. soy concentrates) and ***fillers*** (e.g. starches, flours, cellulose fibres) must be carefully balanced and overdoses avoided in order to retain meat products characteristics as much as possible (Fig. 261, 262, 263, 265).

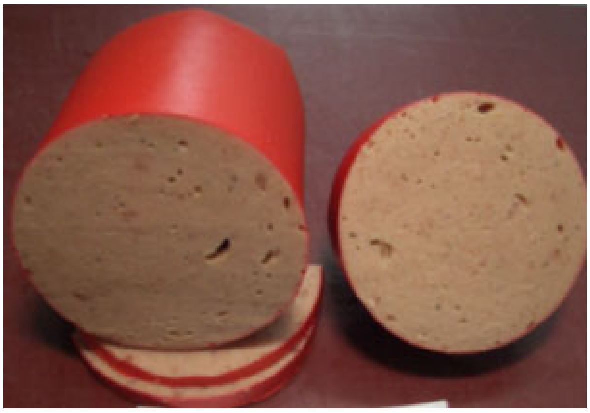


Fig. 262: Extended bologna
Good appearance and cohesiveness

Fig. 263: Highly extended bologna type sausage Excessive levels of extenders and insufficiently comminuted, visible coarse TVP particles

Moreover, an effective ***comminuting technology*** (use of a higher number of chopper knives, additional use of colloid mill for the fine batter component of the sausage mix) is crucial for larger calibre extended products, as for their consumption they are usually cut up into thin slices. In these slices any deficiencies in colour or cohesiveness become rapidly apparent and can be easily detected. Lumps of excess extender would be visible and also result in separation of fat and/or jelly after cooking and insufficient texture combined with dry and coarse mouth-feel. Therefore extender and filler quantities in large diameter sausages are usually kept more moderate than in hotdogs (Fig. 262, 263).

Experience shows that for satisfactory large-calibre raw-cooked sausages the overall level of extenders and fillers ***in dry form*** should not exceed ***10%*** and an adequate proportion of various filler, extender and binder substances is helpful (see page 204). As some substances with high re-

Fig. 264: Large-calibre raw-cooked sausage with higher (centre) and lower (right) levels of rice grains and with rice flour (left)

Fig. 265: Colouring of heavily extended product. Use of food colorant (left)

hydration ratios (e.g. TVP, cellulose fibres) are used, the dry extender level should be kept slightly below the 10% mark to avoid excessive overall extender contents. In Asia, precooked rice (Fig. 264) is used not only in hotdog type products, but also for medium-calibre raw-cooked sausages, as ***rice grains*** have strong cohesive properties. In order to make the rice grains less visible in slices of larger calibre sausages, colloid mills are very useful in the manufacturing process.

The addition of small quantities of carcass parts rich in connective tissue, such as ***pork skin***, ***tendons*** or ***gelatine*** (product derived from skin or bones) in the recipe will also facilitate efforts to make products with high quantities of extenders and fillers appear more acceptable. Connective tissue proteins swell and take up water and enter a gelatinous phase upon heating. This helps product components to stick firmly together after the process of cooking and cooling is completed.

Luncheon meat

Luncheon meat is known worldwide as a ***canned product*** (Fig. 266). (see page 127). The product mixes are in principle similar to the ones used for the above described extended sausages of the raw-cooked type. But while those are usually manufactured from pork and/or beef, luncheon meat may also contain other meat types. Cheap luncheon meat products often contain mechanically deboned meat (***MDM***), mostly from chicken, as part of the lean meat ingredients.

Fig. 266: Luncheon Meat

Canned luncheon meat, also in its cheapest versions, should not show excessive separation of water and/or fat after sterilization. Therefore, absorbing non-meat ingredients are used such as ***starches***, ***flours***, ***soy proteins*** (concentrate and isolate) and also ***carrageenan***.

C. Cooked ham

In its ***original manufacture***, cooked ham is made of one large piece of meat or few combined entire muscles (see page 182, 183). It does not undergo any comminuting process and is traditionally produced without any extender or filler. No yield is expected from such products as the curing brine injected will be lost again during cooking.

In moderately priced industrial cooked hams made of one large piece of meat or few combined entire muscles, the yield is usually increased using modified fillers and binders in the curing brine, which allow retention of some of the injected brine even after cooking. These products still meet the expectations of quality-conscious consumers but enable manufacturers to reduce costs and adjust the pricing.

Reconstituted cooked hams (see page 183) are produced in large quantities. These products are made of muscle meat, which is trimmed, cut or ground into medium to small chunks and reshaped to resemble an entire larger piece of meat. In such products modified soluble ***binders*** including isolated soy protein, gelatine, carrageenan and modified starches (Fig. 225) with a high binding capacity have become popular production ingredients. Before reconstitution through heat coagulation, curing salt, spices and substances assisting in water-binding (commonly phosphates and optionally the mentioned binders, see pages 69-72, 80, 180) are injected or mixed into the lean meat components and the entire mix is mechanically treated by tumbling (see page 184).

Insoluble extenders or fillers in dry powder form (flours, starches) or re-hydrated (TVP, cellulose fibres) are not suitable as they would hamper the reconstitution process which is based on “gluing” together the individual muscle particles by means of heat-coagulated protein (see page 184). Hence the main filling substance for cost reduction used for cooked hams is ***water***. As cooked ham is made of *pure muscle meat*, the water binding capacity is relatively high. The water absorption is further increased by the *tumbling process*, which releases additional amounts of myofibrillar protein with strong water binding capacity. The utilization of *phosphates*, *soy isolates* etc. strengthens this process further. Such products can achieve yields up to 150% and are, with corresponding pricing, affordable also for low-income consumers.

Maximum water retention can be achieved, if, in addition to the above treatments, ***carrageenan*** is used as a binder. Carrageenan powder (see page 71) dissolved in hot water, has the potential to absorb and hold moisture and significantly reduces cooking losses. Tests revealed 4% cooking loss with 1g carrageenan per kg meat mixture, 1.8% with 2.5 g/kg and very low 0.5% with 5 g/kg. Use of carrageenan up to 5g/kg ham gives a neutral taste.

The ***transglutaminase*** products recently introduced in the food sector are particularly efficient in cooked ham as their main function is strengthening the linkages between proteins (see page 72). Small quantities (0.1%) dissolved in the curing brine injected or added to the mix in the tumbler are sufficient to significantly improve cohesion between the meat pieces.

D. Corned beef

There are two groups of Corned beef

- ***Original Corned beef*** fabricated from cooked beef only and canned/sterilized (see page 169).
- ***Corned beef with jelly***, fabricated from beef and gelatinous substances such as gelatine or carrageenan or carcass parts with high connective tissue content (skin, tendons) and small amounts of water added, filled in casings and pasteurized or filled in cans and sterilized (see page 168). In particular carrageenan is a popular ingredient for corned beef in jelly, as it forms a gelatinous matrix, which can absorb substantial amounts of water. This jelly remains stable also at higher storage temperatures, where gelatine jelly could become liquid.

Although *corned beef with jelly* is considered the extended low cost version, many people prefer this product over the *original corned beef*, which is, due to the intensive cooking and sterilizing, dry and not particularly tasty. In contrast, corned beef with jelly is due to its gelatinous texture much juicier and suitable spices contribute to good flavour and taste, in particular when products were processed with moderate heat treatment (pasteurized). In sterilized products product quality can also be maintained.

A small up-market niche exists in Europe where *corned beef with jelly* is produced with such a high quality and firm jelly texture, that it is usually sold and consumed as cold cuts.

In some countries, ***low-cost corned beef in jelly*** is produced, which however still has a satisfactory protein content due to the fact, that the lean meat content is still relatively high and the extending substances (TVP) also contain protein (Fig. 267).

Fig. 267: Corned beef in jelly

TRADITIONAL / ETHNIC MEAT PRODUCTS

Introduction

Meat plays an important role as a high protein food in most cultures and societies. The situation is different when it comes to further processing of meat to meat products. **South-East** and **East Asia**, and in particular China, have a rich tradition in further processing of meat dating back several thousands of years. **Europe** is also famous for a great variety of processed meat products. In both regions the desire for variations in taste and flavour, but also the need of producing food with a longer shelf-life than the fresh meat, was the reason for deviating from consuming heat treated meat only and exploring new processing methods.

The other regions took a different approach. In **Africa**, the requirement for longer shelf-life was met by ***drying the meat***, whereby besides simple sun drying (see page 224) other quite attractive products such as ***Biltong*** or ***Kilishi*** (see page 237, 241) emerged. A harsh meat processing method practised in West Africa is the ***hot smoking*** of large pieces of fresh meat or of entire eviscerated carcasses of small mammals or poultry in dense smoke and at high temperatures. This is basically done for meat preservation purposes, as the smoking reduces the moisture content of meat and the smoke substances add to the preservation effect. However, meat treated this way is of reduced sensory quality. Apart from drying and smoking, the only traditional meat products popular in Africa are ***mixtures of meat with vegetables*** (see page 113). This kind of processing was not so much for taste variations, but owing to the lack of sufficient quantities of meat, which was tackled by “diluting” meat with plant products. This way lower-cost, but still protein-rich extended meat preparations where achieved. Some of these products also had a longer shelf-life if they were properly heat treated immediately after production.

In **South and Central America** and in **South Pacific countries** no significant own traditions existed in the meat sector and European meat manufacturing traditions were adopted initially. However, afterwards some specific developments took place in large meat producing and consuming areas in particular in South-America, where a number of local products became very popular for meat barbecues (see page 219).

Asia

The tradition of meat processing in Asia, especially in China, is much older than in Europe. From China, the manufacture of raw-fermented hams is known (called ***Jinhua hams***), which are similar to the European raw-fermented hams of the Parma (Italy) or Serrano type (Spain) (see page 176). Apart from the hams, other traditional Chinese or Asian processed meat products are completely different from the European ones. Most traditional Asian meat products are fermented for extension of their shelf-life and achievement of desired flavour and taste. The typical characteristic of most products is the utilization of *sugar* as an ingredient. This is practised for the following reasons:

- Achievement of slightly to moderately sweet taste commonly desired in Asia.
- Lowering of the water activity a_w in the presence of sugar and improvement of bacterial stability.
- Only in case of fermented products: Enhancement of fermentation processes, as sugars serve as “food” for fermentation bacteria (see page 120).

The most popular product available throughout East and South East Asia is the ***Chinese Sausage***, locally called *kunchiang, yuen chang or lup-cheong* (Fig. 268, 269, 270, formulation see page 424). It is not a raw-fermented product and the utilization of sugar serves only for taste and low water activity. Fresh raw pork and pork fat are the principal ingredients. The pork fat must be solid, preferably back fat, in some cases also jowl fat, and is prepared by cutting it into small cubes. The lean meat, preferably from the hind quarter with tendons and fat removed, is ground through a 2 mm plate. Non-meat ingredients include curing salt, sugar, pepper, garlic and optionally some Chinese seasonings including cinnamon, ginger, soy sauce (1-6%) and Chinese rice wine (1.5-3.5%). Sugar contents may vary from 1.4% in the cooler north of China to 4% in central China to 6% in the hot southern areas adjacent to South-East Asian countries, where similar products with high sugar content are fabricated. In some places, customers require sugar contents of more than 10%. The higher the sugar content the better the microbial stability due to the lowering of the water activity (a_w). Fat contents vary from 30-65%. Some cheap variations of Chinese sausage may also contain starch and food colouring.

The sausage mix is filled into pig casings or more recently also into collagen casings (page 263). Chinese sausages are neither fermented nor ripened. They are dried products and their flavour results basically from the ingredients used. The drying is different to all other comparable meat products. The products are subjected in a first stage of two days to temperatures of approximately 60°C, usually produced by charcoal (alternatively wood and electricity) and in a second stage of 2-3 days at approx. 50°C. The internal temperature in the sausages must not exceed 50°C. Dry heat and **not** smoke is essential in Chinese sausage manufacture.

Fig. 268: Chinese meat products
(Chinese sausages and flat flavoured meat pieces)

Fig. 269: Chinese sausages
(different sizes and recipes)

Fig. 270: Typical view of East Asian food market

Chinese style sausages are never spread or sliced for sandwiches or eaten directly. They are usually cut in small pieces and **always cooked** before eating, sometimes steamed with rice, noodles or other dishes, giving them the characteristic flavour. The same applies to the Chinese Jinhua ham (see above), which is usually used as a soup ingredient.

Apart from the classical Chinese sausages made of pork meat and fat, there is also the option of replacing some of the meat and fat by approx. 20% ***pork liver***. Manufacture and consumption are the same as above.

Spleen-liver sausage (Fig. 271) is a unique product of South-East Asia. It does not contain meat nor fat but the offals, liver and spleen only, which are minced together with 10% garlic, possibly also with 1% rice and salt and spices. The mix is filled in small or large cattle casings and dried at room temperature. Heat treatment during manufacture does not take place. The high garlic content prevents spoilage during the drying phase. The products remain soft for up to seven days and are eaten raw or fried. After seven days the sausages are dry and can be stored over longer periods.

Fig. 271: Spleen-liver sausage

Fig. 272: Herb sausage

Herb sausage (Isaan sausage) (Fig. 272, recipe page 426/427)) is a product from North-East Thailand with a very typical taste due to its herb components. Coarsely ground pork plus 20% fatty tissue are mixed with seasonings (amongst them garlic, soy and fish sauce, chilli paste, shrimp paste, glutamate) and herbs such as lemon grass and bergamot leaves. The mix is filled in small natural casings (pig casings) and fried for consumption.

Fig. 273: Longganiza
shaping skinless longganisa

Longganisa (Fig. 273, recipe page 384) is a product from the Philippines based on the Chinese tradition. The products are made of ground pork meat and fat, cured and seasoned with a typical sweet taste. They are filled in fresh/dried pig casings, artificial casings or formed into sausage using plastic paper/paperlyne (skinless longganisa). It is usually consumed fried except for one variety that is fermented for a few days, but mostly also fried for consumption.

For the manufacture of ***flossy shredded pork*** (Fig. 274) meat pieces cut along the grain are boiled for four hours and then dried at 60°C in a pan by stirring and pounding the content until the meat desintegrates into its muscle fibre bundles (see page 2). In larger operations specific pounding machines have been developed. During drying 1% sugar, 1% seasoning sauce and 1% salt are added. The final product looks like a bundle of wool and is used as an ingredient for soups, rice dishes etc.

Fig. 274: Flossy shredded pork

A fermented product popular in many South East Asian countries either as snack or ingredient for Asian style meals is ***Naem*** (Fig. 275, 276). It is a mix of minced lean raw pork, precooked pork skin cut into long thin strips and cooked rice at a ratio of 2:1:1. Apart from salt and pepper, generous amounts of ground fresh garlic are added. Traditionally small portions of the mix were wrapped in banana leaves. Now it is mostly filled in strong transparent synthetic casings (approx. 35 mm). The products are left at room temperature, where immediate fermentation starts through bacteria producing lactic acid, thus suppressing spoilage bacteria present. The antimicrobial effect of garlic also helps to maintain microbiological stability despite the high ambient temperatures. The

Fig. 275: Raw materials for Naem

Fig. 276: Naem packed in banana leaves and plastic bags

synthetic casings used can have tiny perforations to let the gas which is produced during fermentation escape. Alternatively two not perforated synthetic casings, one inside the other, are used, which resist the pressure of the gas produced. Naem is ready for consumption from the third day of fermentation. It can be kept under ambient temperatures for up to five days, after that it should be refrigerated to slow down the fermentation, which, if continued at high temperature, would make the products too sour.

Another traditional Asian meat product on the basis of pork is ***Moo-yoh*** (see page 197).

A popular non-pork traditional Asian and North African meat product is ***Pastirma*** (see page 238).

Europe

Meat processing in Europe started centuries ago with the manufacture of shelf-stable fermented meat products. Examples are raw-fermented hams such as the air-dried ***Parma hams*** (Italy) and ***Jamon Serrano*** (Spain) or the heavily cold-smoked ***Black Forest*** and ***Guestphalia hams*** (Germany) (see page 176). Examples for dry-fermented sausages are the ***Hungarian*** or ***Italian Salami*** or ***Spanish Chorizo*** containing pork only or other ***European dry fermented sausages*** made of lean beef and pork mixes and pork fat (see page 115). Similar to hams, dry fermented sausages from southern Europe are mostly air-dried, while the ones from Central and Northern Europe are in many cases cold-smoked. The time-consuming manufacture of raw fermented hams and sausages was done mainly in the cooler winter season to avoid spoilage and to take advantage of optimal climatic conditions for curing, drying and fermentation (see page 116).

Apart from the dry fermented products, meat mixes were developed to be consumed immediately after fabrication. These included minced meat products similar to ***burgers*** (see page 105) and ***fried sausages*** (see page 108), some of them with vegetable ingredients or special spices. Precooked-cooked products were also popular, which can contain internal organs in addition to meat and fat such as ***liver sausages*** and ***blood sausages*** (see pages 154, 161) and vegetable or grains such as ***black pudding*** (see page 164).

More than one century ago the technology for the manufacture of ***raw-cooked products*** (see page 127) was invented in Germany. This technique was based on the principle that lean raw meat, when finely chopped, is capable of absorbing water and develop a protein network structure (see page 128), which coagulates and solidifies upon moderate heat treatment above 60C. Comminuting the lean meat was originally done manually using large curved knives or by shredding and battering the meat. With the emergence of comminuting equipment such as bowl cutters and emulsion mills the technology for raw-cooked products was refined and improved. Products of this group, like ***hotdogs***, ***viennas***, ***lyoner*** or ***meat loaves*** (see Fig. 159) are now produced in large quantities in most countries and have become the most consumed processed meats worldwide.

South-America

In large meat producing countries, in particular in Argentina, some local products have been developed. As part of barbecues a type of sausage is used called ***Chorizo criollo***, which is a fresh sausage for frying unlike the Spanish chorizo, which is a raw-fermented product. The chorizo criollo is usually composed of ground pork (75%), beef (20%) and pork fat (5%). Additives include salt, sugar, garlic, red wine, nutmeg, ground pepper and pepper in grains. The mix is filled in pork casings and is for immediate consumption after frying.

A composition entailing more pork fat and beef than for the chorizo criollo is used for the manufacture of a raw-fermented sausage called ***Salame*** (Fig. 277) (approx. 53 % pork, 33% beef and 14% pork fat). The other ingredients are similar to the chorizo criollo including stuffing in pig casings. Salame is a fast ripened product (approx. 10 days). Ripening and fermentation usually take place in cool rooms.

Fig. 277: Argentine salame

Another speciality used for barbecues is a blood and offal sausage called ***Morcilla***. These sausages often contain pork (approx. 11%), pork skin (66%), pork fat (10%), liver (8%), tongue (5%), milk, common salt and as seasonings pepper, garlic, oregano and green and white onions. Blood is added in quantities of 30 litres referred to 100 kg of the sausage mix.

MEAT DRYING

Introduction

In physical terms, drying is the lowering of the water activity a_w (see page 324) in meat and meat products. Water activity is the measure of free unbound water available for microbial growth. Microorganisms need certain amounts of free water for growth, and their growth is halted below defined minimum levels of moisture. Minimum levels vary from species to species of microorganisms.

Meat drying is not a clearly defined technology. Drying may be done for the single purpose of dehydrating fresh meat for extension of storage, but it may also be one of various processing steps during the manufacture of specific meat products.

The manufacture of *fermented meat products,* such as **raw hams** or **dry sausages** (see page 115, 173), is an example, where drying is one processing component amongst several others. To have an extended shelf life, fermented products need to lose moisture during their fermentation, they are dehydrated or "dried" to a certain extend. Drying and fermentation must go hand in hand to achieve the desired flavour and shelf life. The drying of such products is mostly done in climatized chambers with exact temperature and humidity parameters. Drying under natural conditions is increasingly rare. Another example is the drying of meat preparations in ovens with temperatures in the range of 70-80°C, to become fast-dried products such as **beef sticks** formed of ground, salted and flavoured meat. Furthermore, for a number of indigenous meat products, moderate drying is part of the manufacturing technique with the aim of lowering the water activity (a_w), thus curbing microbial growth. A good example is the **Chinese Sausage**. This product becomes shelf-stable through various a_w-lowering measures, namely its relatively high fat content and use of certain additives including a high sugar content, in combination with drying and light smoking at temperatures of +50-60°C (see page 214). Other dried Chinese products commonly found in open markets are the flat

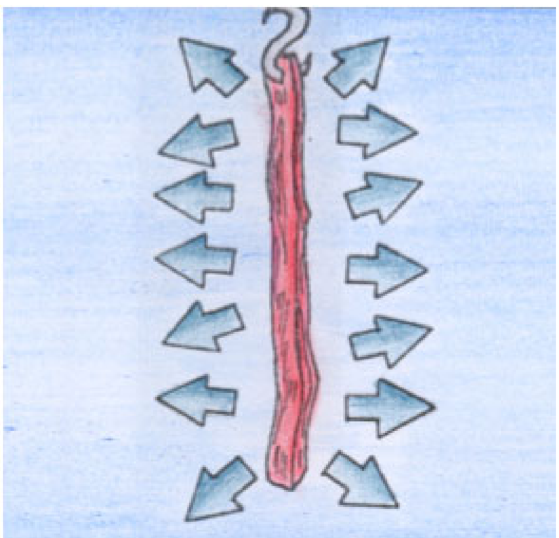


Fig. 278: Dehydration of meat
Evaporation of tissue fluid out of a flat piece of meat

flavoured meat pieces (Fig. 270). The meat is rubbed with a mixture of sugar, salt and spices and subsequently exposed to heat for drying. The heat is generated by charcoal fire or in hot air ovens.

Besides such more complex drying techniques, the simple ***dehydration*** or ***drying of lean meat*** under **natural conditions** has been practised for centuries. It is still a popular method in many developing countries, in particular where no cold chain is available. It is predominantly carried out for meat preservation, based on the experience that dehydrated meat will not spoil easily. Pieces of meat are cut to a specific uniform shape that permits the gradual and equal drying of whole batches of meat. Physically, the reduction of the moisture content is achieved by continuous migration of water from the deeper layers of the meat to its peripheral zone and the evaporation from there into the air (Fig. 278).

Continuous evaporation and weight losses during drying cause changes of the **shape** of the meat through shrinkage. The meat pieces become smaller, thinner and to some degree wrinkled and darker in **colour**. The **texture** also changes from soft to firm to hard.

The fact that dried meat is no longer comparable to fresh meat in terms of appearance and sensory and processing properties, has to be weighed against the significant extension of the shelf-life (see page 233). Under certain circumstances, in particular in the absence of refrigeration, these disadvantages have to be accepted particularly where the alternative might be loss of the valuable meat by spoilage. Most **nutritional properties** of meat, in particular the protein content, remain unchanged through drying.

Types of meat suitable for drying

Meat drying is a simple but efficient food preservation activity. Dried meat can be stored under ambient temperatures for many months. Due to the low water content, microbial spoilage of the muscle proteins can be safely prevented. However, deterioration of adhering fatty tissue through rancidity cannot be stopped. It is therefore advisable to use lean meat only. ***Beef*** and ***buffalo meat*** as well as ***goat*** and certain ***game meats*** (deer, antelopes) are best suited. The same applies to meat of livestock used in some regions for meat production, such as ***camels*** or ***yaks***. The suitability of ***mutton*** is ranked slightly lower. ***Pork***, even from very lean muscle parts, is less suitable, as it contains higher amounts of intermuscular and mostly invisible intramuscular (within the muscle cells) fat, which is prone to oxidation and hence turns quickly rancid.

Preparation of meat for drying

The meat is exposed to the open air and intermittent solar radiation and quickly loses substantial amounts of its tissue moisture. The drying process will be faster the shorter the distance from the centre of the meat piece to its surface. In order to accelerate the drying process in particular from the inner layers of the meat, it is therefore common practice to cut the meat in ***narrow strips*** or in ***flat pieces*** (Fig. 279, 280, 281).

Recommended shapes for meat pieces to be dried are:

- strips with a rectangular cross-section of 1 x 1 cm
- flat- or leaf-shaped pieces with cross-sections of 0,5cm x 3 to 5cm.

Fig. 279: Cutting of meat in lengthy strips (approx. 1-2 cm width)

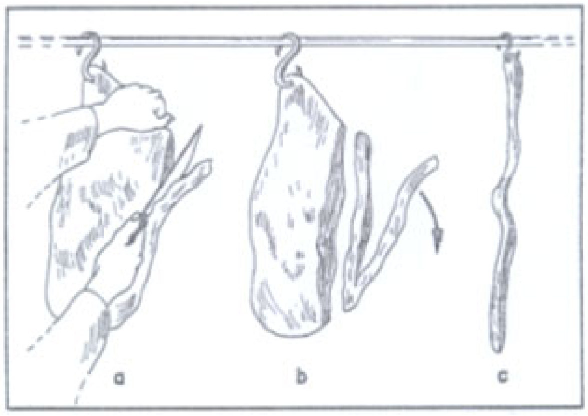


Fig. 280: Special cutting technique to obtain long meat strips for suspension

Fig. 281: Cutting of meat in flat pieces in preparation for drying

In large thick meat pieces, the moisture content in the centre would remain high for too long and, given the high ambient temperatures, could easily lead to microbial ***spoilage***, as microorganisms still would find good conditions for growth. Hence flat meat pieces should always be used for successful drying. Spoilage through chemical reactions can occur when fat turns rancid. Adhering visible fatty tissues need therefore to be carefully trimmed off from the lean meat in order not to limit the shelf life of dried meat.

Meat drying techniques

For the traditional drying of meat, the natural conditions ***sunshine*** and ***air circulation*** are used. Two drying techniques can be distinguished with both using prevailing natural conditions but differing in the impact of the solar energy. These techniques are called ***sun drying*** and ***solar drying*** and are described hereunder.

Sun drying

The basic traditional drying method is called ***sun drying***, characterized by direct solar radiation and natural air circulation on the product. Meat pieces are cut into strips or flat leaf-shaped pieces as described above. They are then ***suspended*** in the open air or ***spread*** on drying trays made of fibre or wire mesh with a wooden or metallic frame (Fig. 282 - 285). For sun drying, in particular for the suspension method, the meat is sometimes ***dipped in salt solution*** (approx. 14% common salt). This helps to limit microbial growth on the meat surfaces and protects to some extend against insects.

The sun drying method is known to have certain disadvantages, such as exposure to ***contamination*** from sources such as dirt, wind, rain, insects, rodents and birds. Quality deficiencies, such as changes in colour, off-flavours, foreign contaminating substances such as dirt and sand and even high surface microbial contamination may occur. Heavy microbial contamination can affect the meat after rehydration, when sufficient moisture for renewed bacterial growth is available, as this will lead to product deterioration and even possible food poisoning.

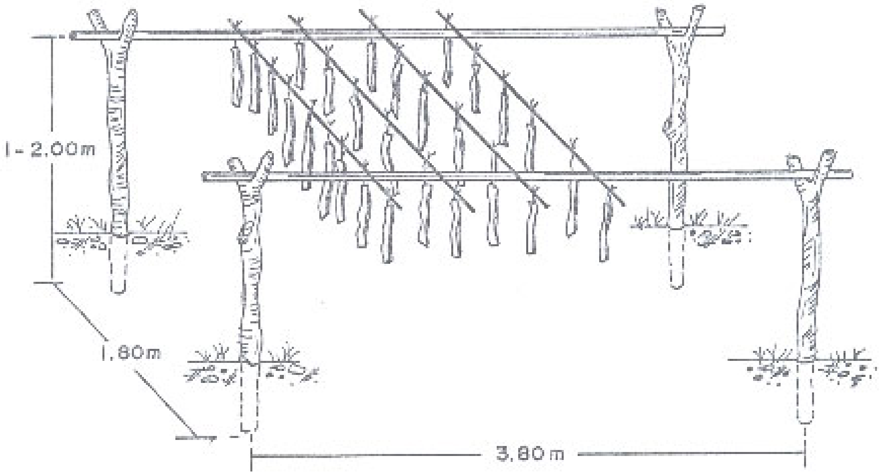


Fig. 282: Set-up for simple sun drying

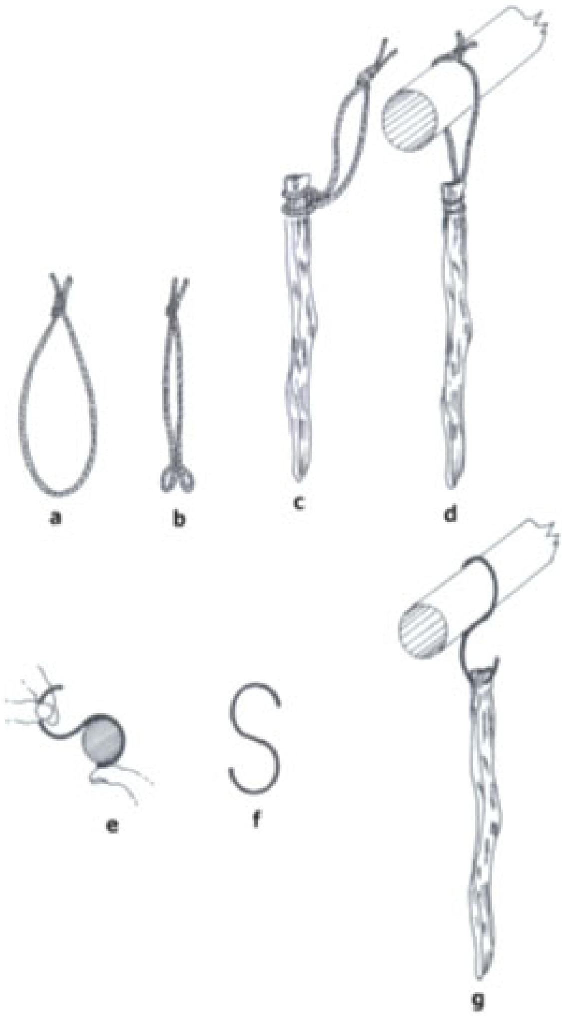


Fig. 283: Suspending meat strips on strings (a-d) or hooks (e-g)

Fig. 284: Sun drying by suspension practised in a rural setting.

Fig. 285: Sun drying by exposing flat meat pieces on drying trays

The *sun drying* method can be done at the domestic or farm level for quick and uncomplicated preservation for example of surplus meat which cannot be consumed immediately or stored properly. Possible contamination can be limited at the small-scale level, as these operations are easy to manage and supervise. For relatively small pieces of meat the drying process can be completed in the course of one day by starting in the morning. If the drying cannot be finished in the lapse of 8-10 hours, which is usually the case with meat pieces of a thickness >1 cm, the meat should be stored overnight in a safe and dry place and exposed the following morning again to the sun.

Solar drying

For larger-scale or commercial meat drying operations in rural settings, improved approaches have been developed using **solar drying**. In contrast to sun drying, where the meat is exposed directly to the sun, the solar drying method uses indirect solar radiation. The principle of the solar drying technique is to collect solar energy by heating-up the air volume in ***solar collectors*** and conduct the hot air from the collector to an attached enclosure, the ***meat drying chamber*** (Fig. 286, 287). Here the products to be dried are laid out.

In this closed system, consisting of a solar collector and a meat drying chamber, without direct exposure of the meat to the environment, meat drying is more hygienic as there is no secondary contamination of the products through rain, dust, insects, rodents or birds. The products are dried by hot air only. There is no direct impact of solar radiation (sunshine) on the product. The solar energy produces hot air in the solar collectors. Increasing the temperature in a given volume of air decreases the relative air humidity and increases the water absorption capacity of the air. A steady stream of hot air into the drying chamber circulating through and over the meat pieces results in continuous and efficient dehydration.

Construction of solar dryers

Solar dryers are composed of two essential parts, the *solar collector* and the *drying chamber*. Both are simple constructions and can be built everywhere using locally available materials such as timber, brick, metal plates and transparent plastic sheets. Two examples of solar dryer design – *tunnel dryer* and *multi-collector dryer* - are provided hereunder.

In the ***tunnel dryer***, the shape of the solar collector is tunnel-like to provide enough surface area for the absorption of the solar radiation. For the capacity of the drying chamber of 50-100 kg of goods the length of the collector should be 10-15 meters (see Fig. 286, 287 and table 13).

Fig. 286: Tunnel dryer. Lower cost option

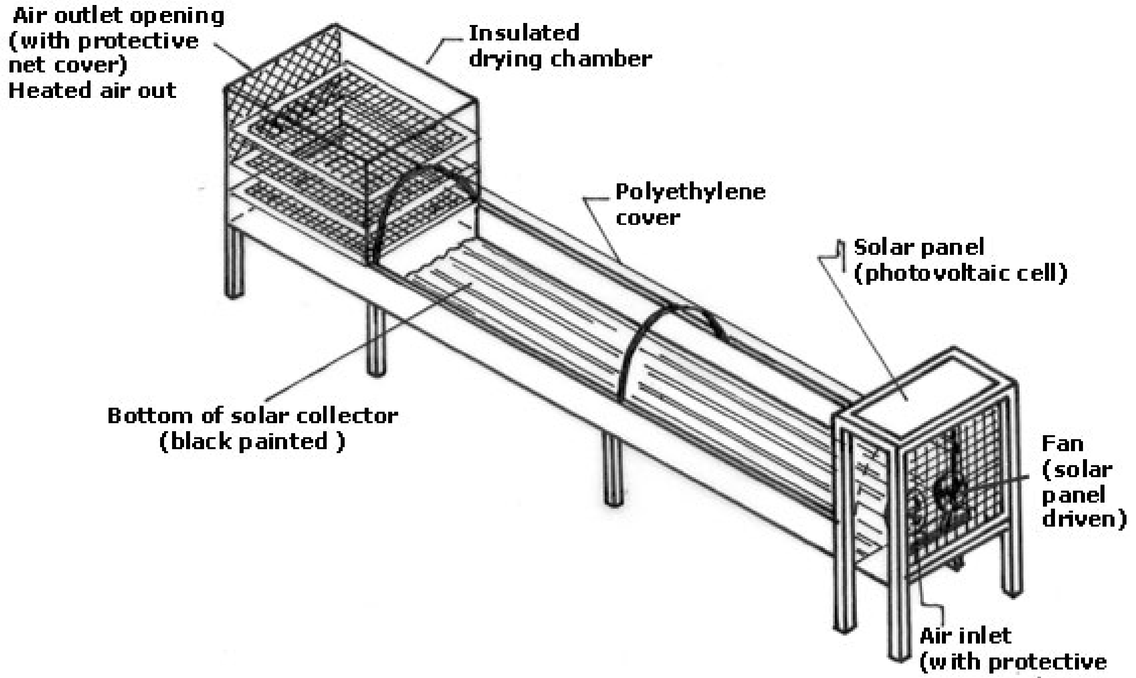


Fig. 287: Tunnel dryer. Higher cost option

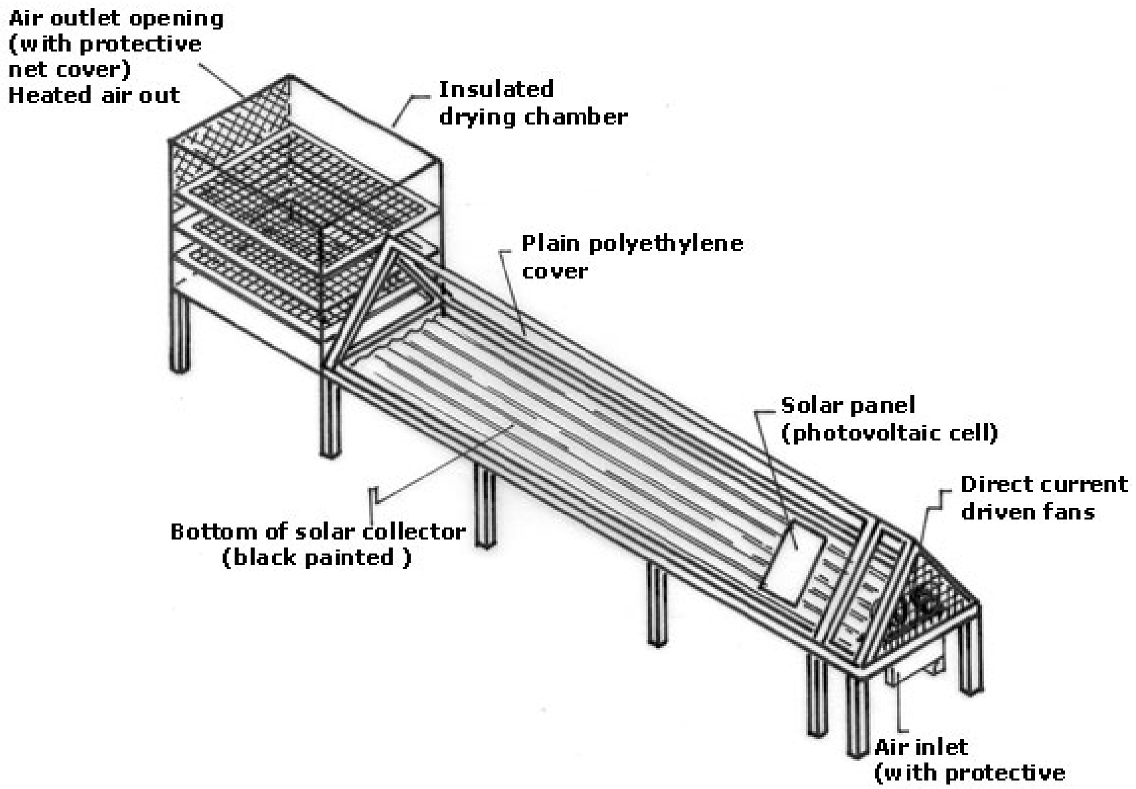


Table 13: Materials for two tunnel dryers (example)

Parameter	Type 1 (Fig. 286, 291) Lower cost construction	Type 2 (Fig. 287, 293) Higher cost construction
Tunnel (= collector) length	11.5 m	15 m
Tunnel widt	1.5 m	1.85 m
Tunnel surface area	17 m^2	28 m^2
Drying chamber volume (internal)	1.6 m^3	1.6 m^3
Collector bottom	Aluminium roofing sheet painted with ordinary black oil paint	Polyurethane (PU) panel coated with metal, painted with black absorber paint
Collector cover	Transparent high density polyethylene sheet	Transparent UV-stabilised polyethylene sheet
Supporting pillars for tunnel and drying chamber	Wood	Concrete
Plane of the collector	Slightly sloped (2°)	Horizontal (level)
Number of fans/blowers (Power source: solar panel)	2	3
Approximate material and construction cost (incl. solar panels)	US $ 1,000	US$ 5,000

The ***multi-collector dryer*** uses a collector surface of approximately the same area as the tunnel dryer, but subdivided into three individual collectors (Fig. 288, 289). The three collectors are positioned in a way that one collector points to the morning sun, another to the mid-day sun and the last to the afternoon sun. Hence the solar radiation is utilized in an optimal way. Moreover, the angled positioning of the collectors enables the easy conduct of the hot air, which has the tendency to raise up, into the raised drying chamber.

Fig. 288: Multi-collector dryer

Fig. 289: Multi-collector dryer

The top parts and preferably also the side parts of **solar collectors** must be permeable for solar radiation. These parts need to be of transparent material (uv-resistant plastic foil or glass). The bottom part should be of metal plate, possibly corrugated to increase the surface, and black in colour for optimum absorption of solar heat. It is recommended to insulate the bottom part of the collector underneath. A sophisticated approach would be to use a black metal coated polyurethane panel, but a similar effect can be achieved by insulating the bottom plate with low cost insulation material such as styrofoam (Fig. 290, 291).

Fig. 290: Simple construction of low-cost solar collector. Bottom part made of black painted corrugated steel plate. Wooden rafter as support for the transparent plastic film to cover the collector

Fig. 291: Completed simple solar collector, covered with transparent UV resistant plastic sheet

Fig. 292: Functional simple solar tunnel dryer. Front part of solar collector with air inlet and two electrical fans for reinforcement of air stream. Photovoltaic panel on top of the front part to drive the fans. Collector with corrugated bottom metal sheet and transparent foil cover. Length of solar collector 11.5m. Drying chamber located at the end of the solar collector. (Type 1 in table 13).

Fig. 293: Higher-cost construction of tunnel dryer. Roof-shaped solar collector, top part made of metal frames and bottom part made of metal-coated polyurethane panel. Length 15m. (Type 2 in table 13).

The major part of the thermal energy absorbed is inside the collector, as it is permeable for solar radiation, and the heated air remains trapped inside the system. The only outlet for the hot air is the opening leading to the drying chamber (Fig. 295), where the hot air is continuously moved by natural convection only. This movement can also be supported by fans (see Fig. 286 / 287 front part, Fig. 292). In order to keep the air stream going continuously, there must be an air inlet protected by wire mesh at the front side of the collector part of the dryer.

An important feature of solar drying devices is the ***size of the solar collectors***. Depending on the quantity of goods to be dried, collectors must have the capacity to provide sufficient quantities of hot air to the drying chamber. Collectors which are too small in proportion to the amount of meat to be dried will result in failed attempts and spoiled meat.

In case of the ***tunnel dryer***, the collector can be built horizontally or with a slight slope towards the higher positioned drying chamber for easy convection of the heated air from the collector to the chamber. For horizontal tunnel dryers, the air movement can be supported by electric fans attached to the front part of the dryer (Fig. 292). In rural areas, where no electricity is available, good results can be achieved by using photo-voltaic panels to drive the fans. But in most cases, fans may not be necessary at all, as by natural convection, enough hot air moves into the drying chamber.

The **drying chamber** (Fig. 294) is a closed wooden or metal-sheet construction, which has an air inlet from the collector side (Fig. 295) and a door which can be used for loading/unloading. At the rear in the upper section of the chamber, there must be an opening, which serves as the air outlet for the hot air conducted into the chamber. The opening must be protected by wire mesh to avoid the access of insects, rodents and birds. Inside the drying chamber there are on several levels of horizontal drying trays consisting of frames with wire mesh to hold the meat pieces to be dried. Alternatively, for drying of vertically suspended meat pieces, hanging sticks may be used (Fig. 282).

Fig. 294: Drying chamber (made of wood) connected to solar collector (arrow) of tunnel dryer. Trays with meat to be dried positioned in the chamber

Fig. 295: Air inlet (arrow) from the solar collector (tunnel type) into the drying chamber

Fig. 296: Drying chamber of multi-collector dryer. Front and side walls of the chamber are transparent to collect additional solar energy. Air inlet from collector to chamber

Parameters of solar drying of fresh meat

The processes which take place during meat drying are mainly ***physical***. The aim is the reduction of the moisture content of the meat in warm and relatively dry air in order to achieve low a_w*-values* (see page 324), where microbial growth is stopped and the meat can be stored over several weeks or months without refrigeration.

In addition to the physical changes in the meat during drying, there are also certain ***biochemical*** reactions with a strong impact on the sensory characteristics of the product. In many developing countries, meat used for drying is usually derived from unchilled carcasses, and rapid meat ripening processes occur during the first stage of drying, as the meat temperature continues to remain relatively high. For this reason the specific flavour of dried meat is different to that of fresh meat. Slight oxidation of remaining meat fats also contributes to the typical flavour of dried meat.

In contrast to the open air *sun drying*, ***solar drying*** takes place in closed systems. Here a specific micro-climate is created, with higher temperature and lower relative humidity than in the outside surrounding air, and also with a reinforced air circulation through convection and tentatively with additional fans. These conditions favour the fast evaporation of a substantial part of the meat moisture. Furthermore, even under partly or fully clouded skies, there is still a certain amount of solar energy absorbed by the solar collectors, which keeps the air humidity low in the system, so that the drying process takes place. In contrast, during open air drying or “sun drying”, the drying process will be slowed or stop in cloudy weather conditions.

According to tests carried out in the drying chambers of tunnel driers, the micro-climatic conditions to be achieved in closed drying systems can be summarized as follows (Fig. 297): ***Maximum temperatures*** are generally in the range of +50-55°C during day-time with the strongest solar radiation (usually at noon). During the other periods of the day the temperatures gradually decline in relation to the solar impact to reach minimum values of approx. +30°C in the morning and evening hours. In environments with high natural air humidity, the corresponding ***air humidity*** pattern inside the dryers are in the range of 60% during the lower temperature phase and 20% during the high temperature phase. In dry semi-arid or arid climates, the humidity values in the dryers will certainly be lower. The ***speed of the air stream*** circulating into the drying chamber is also related to the intensity of the solar radiation. Air speeds in the range of 0,4 m/sec during lower and up to 0,8 to 1 m/sec during high solar impact are the norm. Air speed may be as low as zero if there is no solar radiation, but additional electric fans would allow for continued intensified air circulation. However, in most cases it is possible to operate closed drying systems without electrical fans.

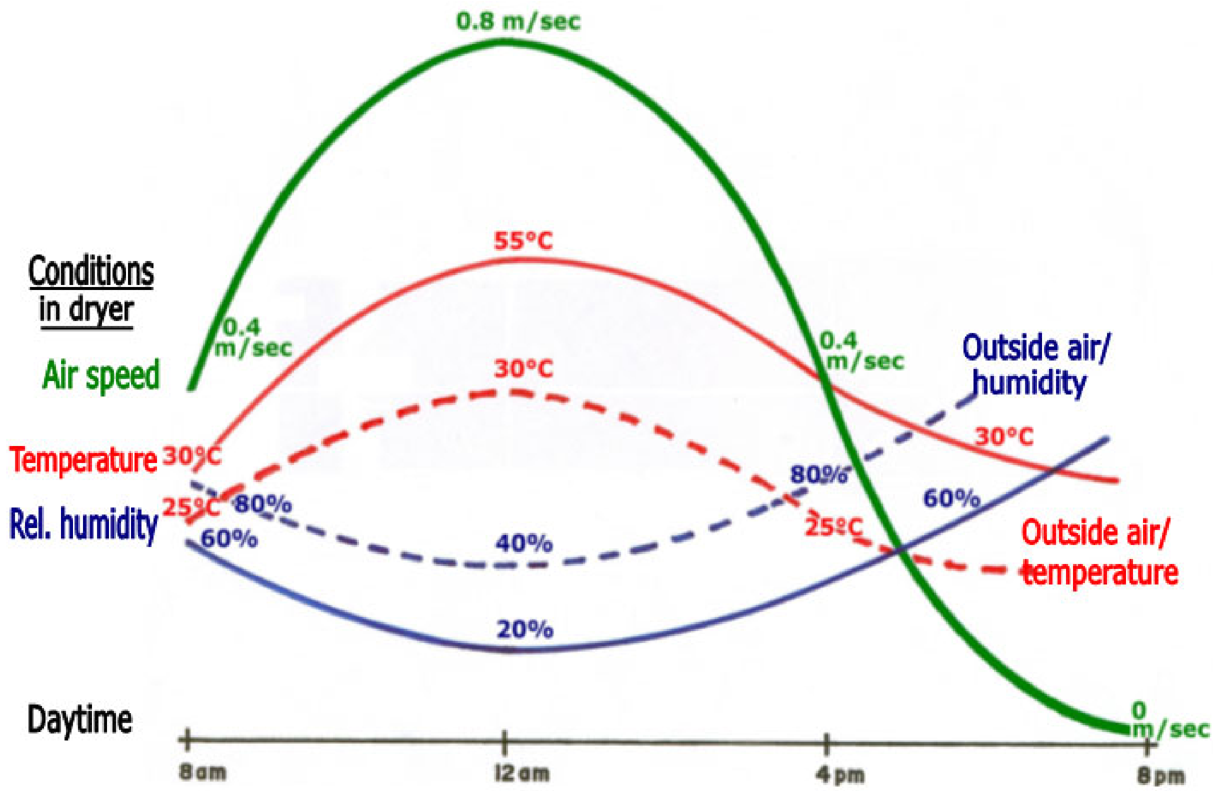


Fig. 297: Temperature, rel. humidity and air speed during one day's drying period from 8:00 am to 8:00 pm.

Drying techniques using solar dryers

Meat drying in solar dryers is usually carried out ***on trays***. This method allows a higher load capacity in the drying chamber and is less labour intensive than drying ***by suspending*** the individual meat pieces. Drying of other food like fruits or vegetables in solar dryers is also done on trays. Trays should be built in a way that they can be piled on top of each other with sufficient space for air circulation. They are usually made of wire or fibre mesh for good air penetration and stabilized by a frame (see Fig. 294, 295).

The simplest technique is to continue the drying of the flat meat pieces until they reach a hard solid texture. The necessary total drying time is approx. ***48 hours*** including night time. The effective drying periods last for approx. ***8 hours*** a day during the main solar impact. Closed solar drying systems which are protected against external influences have the advantage of leaving the meat in the dryer during the night.

The main dehydration effect takes place in the first phase of the meat drying, hereafter dehydration decreases continuously. Depending on the type of meat (high or low water binding capacity) and the size of the meat pieces (larger or smaller, flat or strips), arrives after one day's meat in the solar dryer reduces to ***45-35%*** of its original weight and after two days at ***30-20%***. This corresponds to a remaining moisture contents in the meat of ***40-45%*** after one day and ***12-18%*** after two days respectively (Fig. 298, 299). The water activity of such fully dried meat lays in the range of ***0.5-0.6*** and is low enough to inhibit bacterial growth (for microbial growth a_w 0.75 or above is required).

Fig. 298: Flat meat pieces positioned on a tray for drying

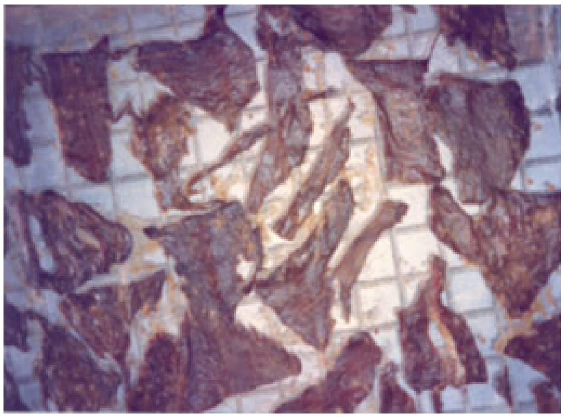


Fig. 299: Flat meat pieces completely dried (usually after 48 hours)

Quality of the finished product

Drying of fresh untreated meat of the shape described (strips or flat) takes at least two days, in many cases three to four days. After this period the dried meat is ready for consumption and can be packaged, stored and/or transported. At this stage the product should meet the following quality criteria (Fig. 299):

The **appearance** of the dried meat should be as uniform as possible. The absence of large wrinkles and notches indicates the desired steady and uniform dehydration of meat.

The **colour** of the surface, as well as of the cross-cut should be uniform and dark red. A darker peripheral layer and bright red colour in the centre indicates excessively fast drying. Because of the remaining higher water content in the centre, these meat parts may still be susceptible to microbiological growth.

The **texture** of properly dried meat must be hard, similar to frozen meat. A softer texture can be recognized by pressing the meat between your fingers. These pieces should be kept for one more day in the dryer for finishing.

Taste and flavour are very important criteria for the acceptance of dried meat by the consumer. Dried meat should possess a mild salty taste which is characteristic for naturally dried meat with no added spices. Off-odours must not occur. However, a slightly rancid flavour, which occurs because of chemical changes during drying and storage, is commonly found in dried meat and is acceptable. Dried meat with a high fat content should not be stored for a long period but used as soon as possible in order to avoid intensive rancidity.

Preparation of dried meat for consumption

After completion of the drying process, the dry meat is normally packaged, preferably in moisture-proof plastic bags to avoid absorption of moisture during storage. For consumption, the dried meat needs to be **rehydrated** by submerging it in water or it can be **directly added** to meals (Fig. 300).

Fig. 300: Dried meat as supplement to a meal of rice and vegetables

Instead of rehydrating entire pieces the dried meat can be **chopped** into smaller pieces or even used as dry flakes or similar particles. The traditional way to reduce the size of the meat pieces is to pound it with a wooden stick in a wooden bowl (Fig. 301). The resulting coarse dry powder is commonly used for food preparations such as soups, meals with gravy, etc.

Fig. 301: Dried meat sticks before and after pounding

The comminution of dried meat can also be included during the drying process in order to transfer such meat into easier-to-use food. One useful method is the **semi-drying** of meat pieces for only 12 hours in the tunnel dryer so that the meat pieces become semi-rigid. Although they still have a relatively high moisture content, this does not render them shelf-stable. In a second phase, these semi-rigid meat pieces are passed through a grinder (5-6 mm plate) and the minced particles exposed for another day to solar drying (Fig. 302). The resulting **dry minced pellet-like meat particles** can easily be packaged in plastic bags and stored without the risk of absorbing moisture. Rehydration of these pellets is easy - just add water (1:1 – 3:1, rehydration time 30-60 min) (Fig. 303). In the rehydrated form, the meat can be used for the fabrication of hamburger patties, meat balls etc. In dry form, it can be added to soups or meals as desired.

Fig. 302: Ground meat from semi-dried meat pieces laid out again for one days drying

Fig. 303: Rehydration of dried ground meat pellets for further processing

Meat drying combined with additional treatments

This group comprises a variety of treatments with very different resulting products:

a) Acceleration of meat drying by intensive salting

Charque

This technique was used for large-scale preservation of beef in Latin America, when and where a functioning cold chain was not yet fully developed. The product manufactured is called **charque** (Fig. 304).

For this product, beef from fore and hindquarter is cut into large pieces of about 5 kg, and approximately 5 cm thick. The pieces are submerged in tanks in a saturated salt solution for one hour and then drained on slats or racks.

For the following dry-salting, the flat meat pieces are piled on a sloping concrete slab under a roof. Alternate layers of salt and meat are put up to reach a height of about 1 m. The pile is then covered with wooden planks and pressed with heavy weights. After eight hours the pile is restacked so that the top meat goes to the bottom of the pile. The restacking process with fresh layers of salt is repeated daily for five days.

After five days, the salted meat is ready for the actual drying. Before initiating drying, the meat pieces are washed to remove excess salt adhering to the surface. The meat is then exposed to the air and sun on wooden racks which are oriented north-south, thus permitting an even solar coverage. The meat pieces are exposed to the sun daily for four to eight hours over a period of four to five days. After each period of exposure the pieces are collected, stacked in piles on concrete slabs and covered with an impermeable cloth to protect them against rain and wind and to contain the previously absorbed heat.

Fig. 304: Production of charque: Large flat pieces of beef, in the periods between daily exposure to the sun on racks (to be seen in the background), are piled on a concrete slab and covered with impermeable cloth

When sufficiently dry, the meat pieces are either marketed without packaging or simply wrapped in jute sacks. Plastic sacks are not suitable, because the product still contains some of its original moisture content, and this moisture must be allowed to drain freely from the product during storage. Due to its low moisture and high salt content (5% and more), charque keeps for months under ambient temperature conditions and is resistant to infestation by insects and mould growth. The salt must be reduced by immersing the meat pieces in water in order to make it palatable for consumption.

b) Pre-treated dried meats for snacks

A number of value-added meat products can be summarized under this group. Drying is part of the taste and flavour enhancement.

Biltong

Biltong (Fig. 305) is a well-known salted, dried meat originating from Southern Africa made from beef or antelope meat. Most muscle meat from the carcass may be used but the largest are the most suitable. The meat is cut into long strips (1 to 2 cm thick) and dry-salted. Salt and pepper are the principal ingredients used, although other ingredients such as sugar, coriander, anise, garlic or other spices are included in some mixtures to improve flavour and taste. In most cases nitrate or nitrite is added to achieve a red colour and the typical flavour of cured meat. The addition of 0.1 percent potassium sorbate to the raw meat is permitted in South Africa as a preservative. The salt/spice mixture is rubbed into the meat by hand and the salted strips are then transferred to a suitable container for further curing.

Biltong is cured for several hours, but not longer than 12 hours, otherwise it would become too salty. The meat pieces are then dipped into a mixture of hot water and vinegar (approximately 10:1). This is primarily done to prevent mould growth, but it also adds flavour to the product. The biltong is now ready for sun or solar drying for one day. Then the strips are moved into the shade for the rest of the drying period. The biltong is ready when the inside is soft, moist and red in colour, with a hard brown outer layer.

Fig. 305: Biltong. Small slices cut from entire dried piece

Biltong is sold in sticks or slices. The usual shelf-life is several months without refrigeration and packaging. In airtight packages the product can be stored for more than one year. Biltong is not heated during processing or before its consumption. It is eaten raw and considered a delicacy.

Pastirma

Pastirma (Fig. 306) is salted and dried beef from mature animals. In some areas of the Middle East camel meat or mutton is also used. The complete production process for pastirma requires several weeks. The meat is mostly taken from the hindquarters and is cut into 50 to 60 cm long strips with a diameter of not more than 5 cm. The strips are rubbed and covered with salt and nitrate. The dosage of the nitrate in relation to the meat is 0.02 percent, which means 2 g of nitrate for 10 kg of meat. Several incisions are made in the meat to facilitate salt penetration.

The salted meat strips are arranged in piles about 1 m high, repeatedly repiled and kept for two days. Thereafter the meat strips are washed and air-dried for two to three days in summer and for 15 to 20 days in winter. After drying the strips are piled up again to a height of 30 cm and pressed with heavy weights (approximately 1 tonne) for 12 hours. After another drying period of two to three days the meat pieces are again pressed for 12 hours. Finally the meat is again air-dried for 5 to 10 days.

After the salting and drying process, the entire surface of the meat is covered with a 3 to 5 mm thick layer of a paste called cemen. Cemen consists of 35% freshly ground garlic, 20% helba (i.e. ground trefoil seed), 6% hot red paprika, 2% ground mustard seds, and 37% water. Helba is used as a binder of the paste; the other ingredients are spices. Garlic is the most important ingredient as it has antimycotic properties. The meat strips covered with cemen are stored in piles for one day, and thereafter dried for 5 to 12 days in a room with good air ventilation. Now the pastirma is ready for sale. The final product has an average water activity (a_w) of 0.88. The a_w-value should not fall below 0.85 or the meat will be too dry. The average salt content is 4.5 and should not exceed 6.0 percent. The product stays mould-free for months at ambient temperature even in summer. Similar to Biltong, Pastirma is consumed raw.

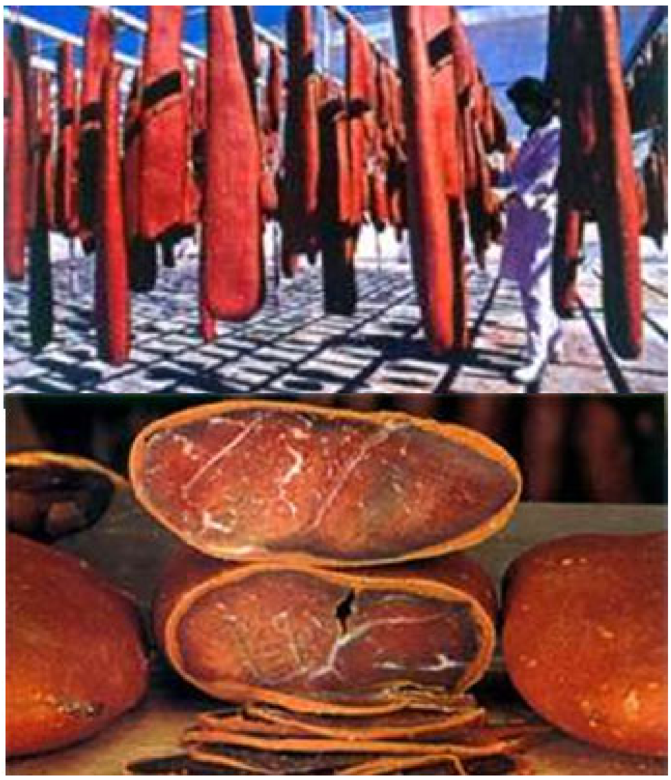


Fig. 306: Pastirma. Air drying of large flat pieces of beef (above). Finished product (below)

Jerky
Jerky (Fig. 307) used to be the “iron food ration” in North America. Jerky is dehydrated lean meat, which contains salt and spices. There is no common processing technology but many different approaches from household level to industrial level to produce jerky.

The lean meat usually derives from beef, but buffalo (bison), deer, antelope or turkey meat may also be used. The meat is cut into strips not more than 0.5 cm thick, 1-2 cm wide and 15-20 cm long. Differences in manufacturing jerky start with the cutting technique. Some people prefer cutting the meat across the grain, others parallel to the muscle fibres. All fat and other adhering white tissues should be removed. In modern processing, slightly frozen but still relatively soft meat may be used to facilitate the cutting process.

The “pioneer” jerky was seasoned only with salt and black pepper and then sun-dried. For faster and more advanced processing several seasoning and drying methods are now popular.

Curing Preparation

- Marinade method

One typical marinade is prepared from salt, soy sauce, black pepper and fresh garlic or additionally chilli and onion powder. The meat is immersed and possibly massaged in the marinade and kept there for 12 hours.

- Dry curing

A dry curing mix using salt, sugar and if curing colour is desired sodium nitrite is applied. The meat is rubbed ‘two or more times during’ a curing period of 3-5 days.

- Quick-cook method

The fresh meat strips are either immersed in boiling water for 1-2 minutes (until they get superficially white) and afterward seasoned. Alternatively boiling salt water (which may also contain some sugar) can be used and the meat strips, after removal and dripping of the superficial water, are seasoned (e.g. pepper, chilli, oregano, marjoram, basil, thyme).

Dehydration

After curing and seasoning the jerky needs to be dried. Also here various drying methods are possible:

- Sun drying: This was the original method, but is not widely practiced anymore.
- Solar drying: This method is suitable in principle, but not frequently practised as more advanced drying devices are preferred by manufacturers.
- Hot air oven drying: In this household level method, the meat strips are placed on wire oven shelves at temperatures of 160-222°F. Oven doors are partially left open to allow moisture from the meat to escape. The products are dried to approx. 65% moisture loss, which takes 6-8 hours.
- Industrial hot air drying: Jerky strips are usually dried on perforated metal trays in hot air drying chambers. In specific cases light smoke may be added to achieve a desired smoke flavour.

Fig. 307: Jerky. Prepared as a snack

<u>*Consumption:*</u>

After undergoing any of the described seasoning and drying procedures, jerky can be packaged and stored and is ready for consumption. It is consumed as a snack.

c) Processed dried products combined with heat treatment

This kind of products is particularly popular in East, Central and West Africa. In a first step flat meat pieces are pre-dried through sun or solar drying. The meat is only semi-dried and then soaked in specific coating mixtures (Fig. 308), before it is exposed to heat treatment (see page 241). The heat treatment applied can be considered as the completion of the drying process. Complete drying under natural conditions would not be possible, particularly in humid climates[1] prevailing in some of the countries. In the producing countries the manufacture of these dried and heat treated products follows the same general pattern, although different regional product names and ingredients are used.

____

1) Under these conditions more or less intensive smoking of fresh meat is also practiced as an emergency measure for meat preservation in order to achieve rapid dehydration and antimicrobial effect through smoke substances, but usually not with very favourable sensory results.

In detail the manufacture is carried out as follows: The production is usually initiated by sun or solar dying of thin slices of meat, primarily beef and goat. The first stage of the drying process takes up to six hours. The semi-dry meat slices are then soaked in mixtures or marinades that may contain water, salt, oils, flours, groundnut paste, garlic, onions and spices such as pepper and ginger. By immersing them into the mixture for several days, the semi-dry meat slices absorb up to three times their weight. After soaking, the wet products are either directly heat treated, or again exposed to drying and afterwards heat treated.

The heat treatment is usually done by roasting the meat over a glowing fire for approximately five minutes. After roasting, the moisture content of the products ranges around 10-15%, which makes them shelf-stable for a long period of time.

Common names for such products are ***Odka*** (Somalia), ***Qwanta*** (Ethiopia), ***Kilishi*** (Nigeria).

Fig. 308: Soaking semi-dry meat slices in the mix

Fig. 309: Finished product after roasting.

SIMPLE MEAT PROCESSING UNDER BASIC CONDITIONS

Meat processing can be carried out even under basic conditions at a very small-scale level such as a village or rural setting. Such small-scale meat products manufacture can be recommended from the nutritional point of view, as it enables communities to **fully utilize animal food materials** derived from small-scale slaughtering and allows for **extension of meat products with locally available suitable plant food** (see chapter "Non-meat ingredients", page 59). This type of meat processing also provides the option to manufacture products with increased shelf life, e.g. through drying (see page 221) or other preserving measures, e.g. salting, smoking, fermentation (see page 33) or heat treatment (see page 87) enabling communities to cater for periods meat might not be available.

Basic processing equipment can be *manually* operated for the smallest units with little throughput. The availability of **single-phase electrical power** allows for larger quantities to be processed using basic *electrically powered equipment.*

In least-developed and developing countries the high capital investment required to construct a purpose-built facility may not be feasible. In these cases the conversion of a suitable building of good standard can be acceptable as long as basic hygienic measures are introduced and followed.

Facilities

A purpose built area is highly recommended for commercial small-scale meat processing (Fig. 313). As a guide, facilities should have the following minimum characteristics:

- The floor must be of hard, smooth and waterproof material in anti-slip finishing. Materials such as high-grade concrete, terrazzo (= concrete mixed with small stones and smoothened on the surface after hardening), floor tiles or plastic coating are recommended. Floors must be sloped to drain off surface water.
- To avoid difficult-to-clean spots, rounded junctions of walls and floors are strongly recommended ("coves").
- The surface of interior walls must be waterproof and smooth and should be covered by wall tiles or coated with washable paint up to a height of 2.0 m.
- The surface of the ceiling should be smooth, flat, sufficiently high and preferably also painted with washable paint.

- To avoid high humidity in the facility, sufficient ventilation must be guaranteed.
- All windows, doors and other ventilation openings need to be insect proof.
- A drainage system should be built-in to allow rapid disposal of effluents. The openings inside and outside must be covered with a removable netting to allow collection of solid particles and prevent rodents and other small animals from entering the system. If facilities are not in use, all inlets and outlets need to be closed hermetically.
- Areas of clean operations (meat cutting and processing) and dirty operations (cleaning of intestines) must be divided by a wall or carried out in separate rooms. In warmer climates the dirty area can be semi-open, in colder regions a small room is needed.
- Potable water must be available for cooking of raw materials and processed products and cleaning of facilities and equipment.
- Wastage such as solid particles from the drainage system and the content of the gastro-intestinal tract could be collected and converted into biogas to be used for heating and light.

Units without electricity (Fig. 313)

Equipment and tools

Fig. 310: Manual equipment set with basic tools

Without electrical power the meat processor is limited to **manually** operated equipment (Fig. 310). A meat grinder is needed to cut meat and non-meat ingredients to the desired size. A manual sausage stuffer allows for easy filling of sausage mixes into the casings (see also Fig. 412). Other tools like knives (Fig. 386-391), hand bone saw, sharpening steel, buckets, one big and several small containers (plastic) and meat hooks (Fig. 392) are also needed. For grating of peeled roots, stainless steel grating plates are very helpful tools as they are unbreakable.

Cleaning and hygiene

Even when processing is done under such simple and basic conditions, due attention needs to be paid to **hygiene**. Cleanliness of facilities, installations and personnel is an essential precondition in all food processing. A sufficient amount of potable **water**, **boiling facilities** (charcoal cookers, gas stoves) and **detergents** and **disinfectants** must be available (see page 369). **Raw materials** brought to the processing area must be fresh, clean and disease-free. It is essential that the **facilities**, **machinery** and **tools** are properly cleaned before and immediately after processing. A high level of **personal hygiene** is required and therefore essential that staff involved in processing must be in good health and undergoes regular medical check ups. Staff members should never enter the food processing area in street clothes and shoes, but wear clean protective clothing, and also carefully attend to personal hygiene.

Product range

The range of products depends on the climatic conditions under which the processing is done, when manually operated equipment is used and refrigeration facilities are lacking.

In tropical and subtropical countries with temperatures of above +25°C during the day and no significant decrease in temperature during the night the production is limited to **products which are immediately consumed** or products which are **dried**, **salted** and **smoked** in simple smoking units (Fig. 311). Fresh coarse sausages, burgers and meat-mixes (meats/vegetables) are typical products for immediate consumption (see page 112 and Annex 1, page 383 ff). Dried and/or fermented sausages of small diameter for rapid drying and dried meat sticks can also be produced (see Annex I, page 394 ff).

Fig. 311: Some smoked and dried products

In moderate climates, smaller raw-fermented hams (page 176) and larger calibre dried-fermented sausages (see Annex 1, page 395, 398) can be produced during colder seasons. Some of the precooked-cooked products, such as coarse liver sausage, stuffed in natural casings of smaller calibre can be produced for immediate consumption (see Annex I, page 419).

Units with single phase electrical power (Fig. 313)

When single-phase **electrical power** is available, some basic electrical processing equipment can be used. This would allow for manufacture of a wider range of products in bigger quantities, storage of raw materials and final products under refrigeration and air-conditioning of the processing rooms. The general guideline for the design of the facility is not much influenced by the availability of electricity or not, hence Fig. 313 applies.

Product range

The range of products starts with **fresh coarse sausages**, **burgers** and **meat-mince-mixes** (see Annex I, page 383-393) and can include cooked products such as **simple cooked hams** or **sausages** (see page 400-414, 415-421) or indigenous meat products (see page 424-427). Most of these items need to be sold soon or must be airtight packed and frozen.

Distribution and sales

Distribution of fresh products kept in the fridge or a small chiller needs to be done within a few days of production. Frozen items can be kept for several weeks if packed airtight to avoid freezer-burn. Consumers must be advised that fresh sausages (see page 103) are highly perishable and need to be heat-treated and consumed immediately. Dried, salted and smoked items can be stored in a cool place for some time.

Additional equipment

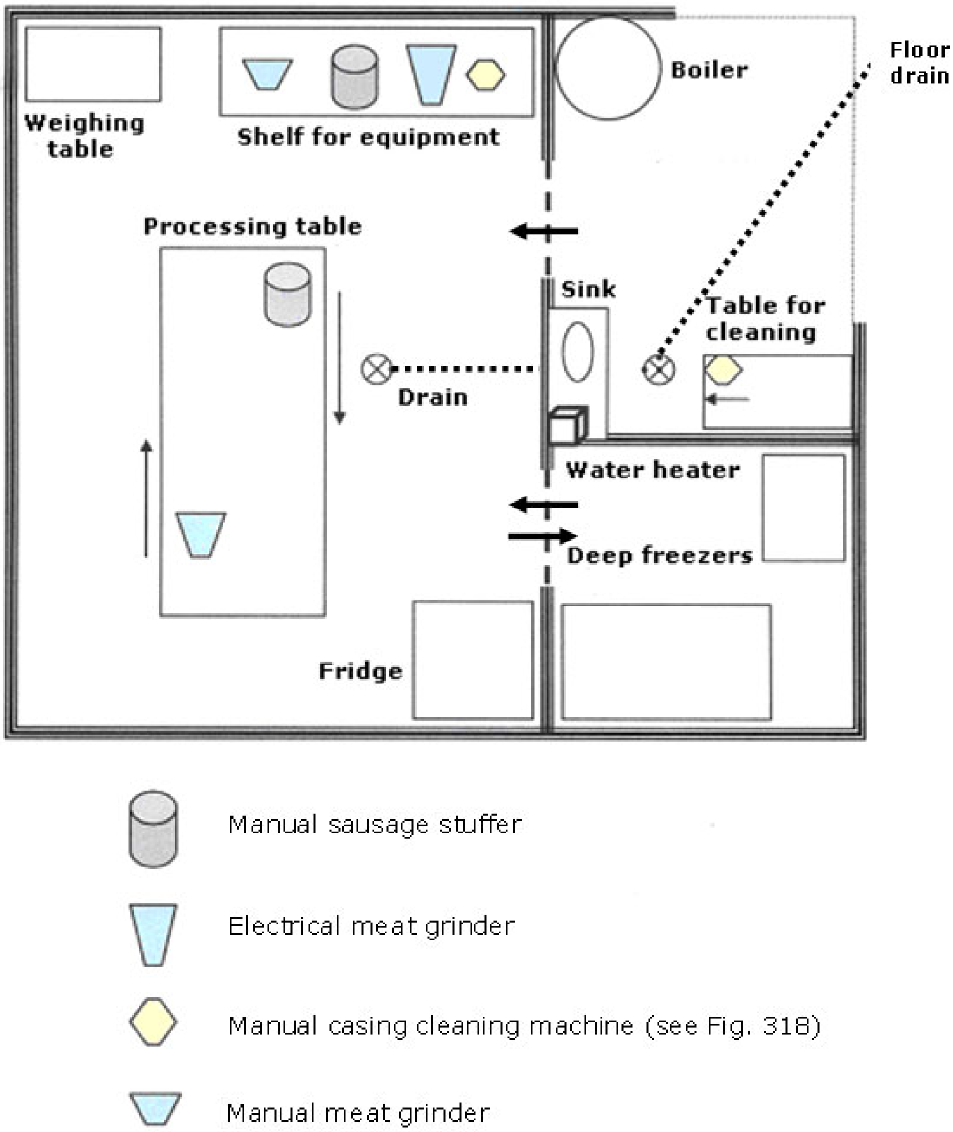
If electrical power is available, a **bowl cutter** (Fig. 312) can be installed. This significantly expands the possible product range. This piece of equipment is necessary to produce finely-chopped meat mixes such as frankfurters, fresh breakfast sausages, ham sausage and meat loafs. The incorporation of bigger amounts of extenders is now also possible. A **smokehouse** (Fig. 37, 41) with temperature regulation and blower for improved smoke circulation can be added to improve appearance and flavour of the smoked products. A **small autoclave** (pressure cooker) (Fig. 362, 364) and a semi-automated

Fig. 312: Bowl cutter (18 litres) single phase power

can-closing machine (Fig. 378) allow for production of canned meat products on a small scale. However these operations require experience and knowledge about the detailed principles and safe practices of heat preservation and canning technology (see page 277). Canned products can be stored without refrigeration for up to four years.

Fig. 313: Sausage production facility on village level (without power or limited single phase power)

Processing room with small storage area
Cleaning of intestines outside under shelter



CASINGS

Casings are soft cylindrical containers used to contain sausage mixes (Fig. 314). Casings can be of **natural** origin or **artificial**. Natural casings are obtained from animal intestines derived from slaughtering. Manufactured artificial casings are made of cellulose, collagen or synthetic materials. Sausage fillings are mostly minced or comminuted meat mixes held together by the casings during further processing steps such as smoking, boiling, frying or roasting. In addition, casings also protect products during storage.

Fig. 314: Casing of different colour

Natural casings

Natural casings are mainly derived from small and large intestines from **sheep**, **goats** and **pigs**, but also from **cattle** and **horses**. They

- are strong enough to **resist the pressure** produced by filling them with sausage mix
- are **permeable** to water vapour and gases, thus allowing fillings to dry[1]
- **absorb smoke** for additional flavour and preservation
- **expand or shrink** firmly attached to the sausage mix and
- **can be closed** at the ends by tying or clipping.

Small intestines of sheep, goats and pigs are popular small calibre natural casings. They are processed in a way that makes them tender (**edible**) (see page 252) and are mostly eaten with the sausage (Fig. 323). Many other parts of the intestinal tract of slaughter animals can also be used for natural casings. Those casings are processed differently and have stronger and tougher casing walls. Due to their toughness they are generally **not considered** "**edible**" (although not unfit for human consumption) (Fig. 205, 320) and are usually peeled off before consuming the sausages.

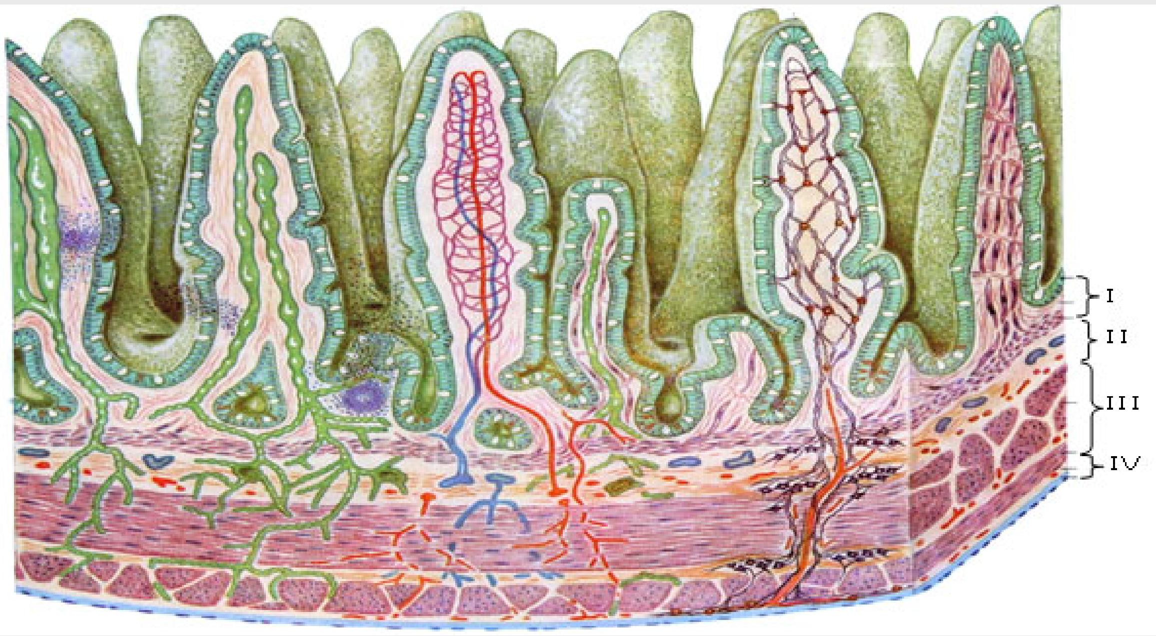
____

[1)] Reduction in moisture content -"drying"- is only needed and desirable for raw-fermented sausages (see page 115).

In many parts of the world the **proper manufacture of sausage casings** from animal intestines is unknown. Intestines, if not used for human food, are often wasted. Many people in the livestock and meat sector are unaware that processing of intestines into natural casings for sausage production is relatively simple and can be a profitable[1] business. If natural casings can be produced locally, this may help to reduce overall production costs. Even in remote or rural settings with no access to commercial casing suppliers, natural casings can easily be processed from intestines derived from local slaughter. The availability of locally produced natural casings will considerably facilitate rural meat processing but proper **advice** and **training** on casing preparation is essential (for technical instructions see page 253).

Anatomically the walls of the intestinal tract of slaughter animals consist of four layers of intestinal tissue. These layers from inside to outside are: Mucose membrane (I), submucose membrane (II), muscular layer (circular and longitudinal) (III) and serose membrane (IV). For natural casing manufacture, one or more of these layers are removed during casing processing depending on the type of casing (thin/thick, edible/non-edible) to be fabricated.

Fig. 315: Animal small intestine, cross section



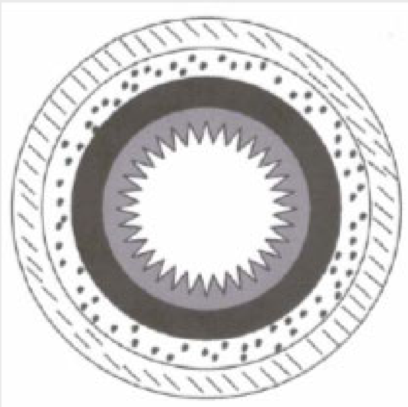
From inside:

- I Mucose membrane with finger-like outgrowths for enlarged surface area ("slime")
- II Submucose membrane, firm-elastic layer mainly of connective tissue
- III Muscular layer, the circular internal one, the outside one longitudinal
- IV Serose membrane (blue) thin coating covering the abdominal cavity from inside and surrounding all organs.

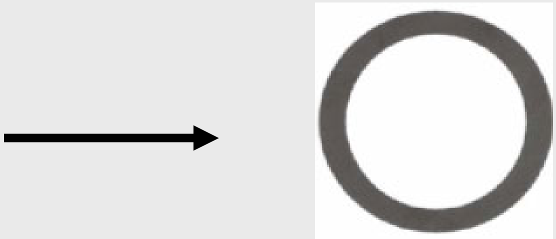
---
1) Annual imports of natural casings into the EU are valued at US$0.5 billion.

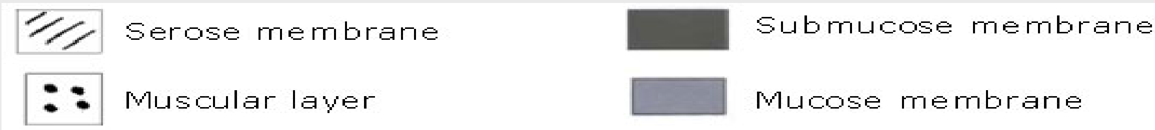
Fig. 316: Processing of casings from small intestines

Cross section through entire intestine



Casing (edible)
(casing not reversed; mucose membrane, muscular layer and serose membrane removed, remaining layer = submucose membrane)

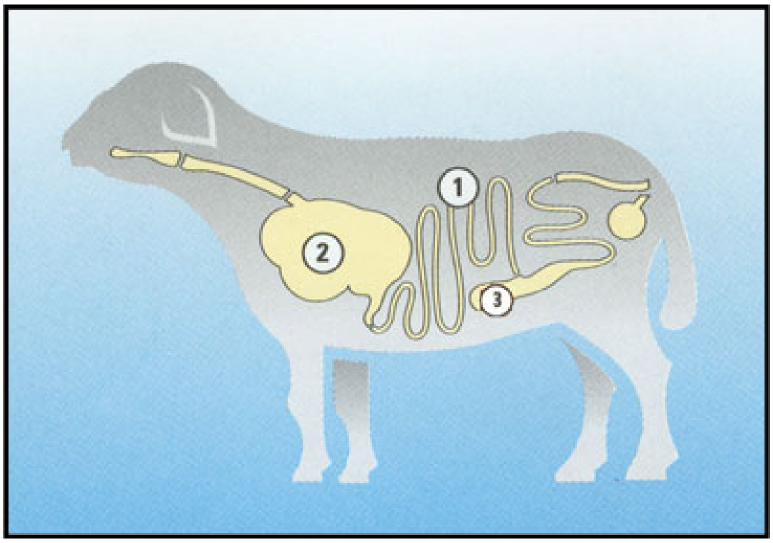




Sheep and goat casings

From the gastro-intestinal tract of sheep and goats (Fig. 317) normally only the **small intestines** are processed to be used as casings for products such as fresh frying sausages, frankfurters, BBQ sausages, hot dogs and thin dried fermented sausages. These casings are processed in a way that they become tender enough to be easily chewed (see Fig. 316 and page 252). Usually they are not peeled off before consumption but eaten together with the sausage filling. Therefore

Fig. 317: Gastro-intestinal tract of sheep



Natural casings from sheep:
Sheep casing (small intestines) (1)
Sheep fore-stomach and tripes (cleaned and scalded stomach) (2)
Sheep caps (3)

they are called “edible” in this context. All other natural casings are also edible in principle, but most of them are peeled off as they are too tough to be chewed.

Processing of small intestines at medium- to the small-scale level

The processing of natural casings must be started as soon as possible after slaughter, as bacterial spoilage of the intestines tissues sets in rapidly. For ease of processing it is recommended to start the operation while the intestines are still warm.

The small intestines are detached from adhering mesenteric (connective and fatty) tissue (Fig. 318, step 1). The intestinal content is removed manually (Fig 318, step 2). The empty casings are flushed with water and subsequently de-slimed by using either manual or electrically operated casing-cleaning machines. For this purpose, the small intestines are passed through a set of rollers to loosen the tissue layers (Fig. 318, step 3) and to remove the “slime”. “**Slime**” is the internal layer of the intestine, basically the internal (“mucose”) membrane (Fig. 315, I and Fig. 316). In the slaughtered animal this membrane disintegrates rapidly and can easily be removed. Because of its structure it is commonly known as “slime”.

The removal of the “slime” can also be done manually by using a tablespoon or a specially shaped piece of wood. With the spoon firmly pressed onto the intestine, and pulling the intestine through in its full length between spoon and finger, the internal (“mucous”) membrane can be loosened and removed. The loosened tissues inside the casing are pressed out manually (see Fig. 318, step 5.) and the remainder rinsed off with water. Parts of the outside layers (“serous” membrane) are automatically removed when detaching the small intestine from the mesenteric tissue (Fig. 318, step 1 and step 4). The rest of the outside layer and the intermediate (“muscular”) layer will be removed during the casing de-sliming and cleaning operation.

The remaining strong-elastic tissue is a layer composed mainly of connective tissues (“submucous membrane”) (Fig. 315 II, Fig. 316, Fig. 318, step 6, b2). This connective tissue membrane forms the edible **sheep casing**. Sheep casings are **not** reversed (turned inside out) during their processing. For completion of the processing, the casings are inflated for grading, flushed with salted water, stripped for water removal, dry salted (Fig. 318, step 7) and stored in a cool place, preferably in the chiller. In this form they can be stored for three months, preferably under storage temperatures not exceeding +15^{o}C. By no means should natural casings be frozen, as they would lose their elasticity and firmness.

The average length of the small intestine from sheep is 17 to 24 meters depending on the size of the animal. Sheep and goat casings for the international casing trade are produced in largely mechanized operations, usually packed in hanks (91.4m or 100 yards) and graded according to their diameter and colour coded as follows:

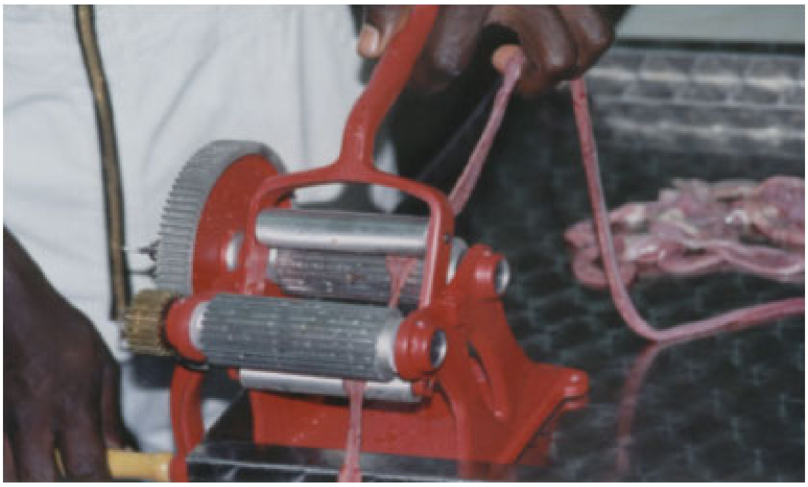
28/ + mm	green/white	26/28 mm	green
24/26 mm	red/white	22/24 mm	red
20/22 mm	blue/white	18/20 mm	blue
16/18 mm	yellow/white	14/16 mm	yellow

Sheep casings, as well as other natural casings are soaked in water before filling the sausage mix. This treatment removes part of the salt and the casing walls become more elastic, as their collagen fibers absorb water. Addition of organic acids, in particular lactic acid (2% to the water), also assists in this process.

Fig. 318: Processing steps for small intestines

Step 1: Separation of the small intestines from mesenteric tissue

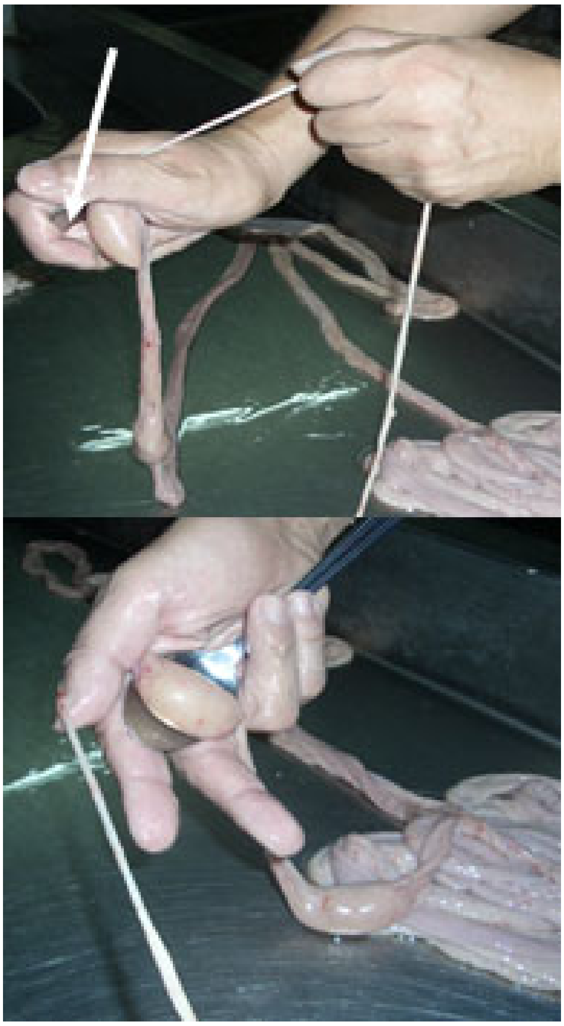
Step 2: Stripping out intestinal content



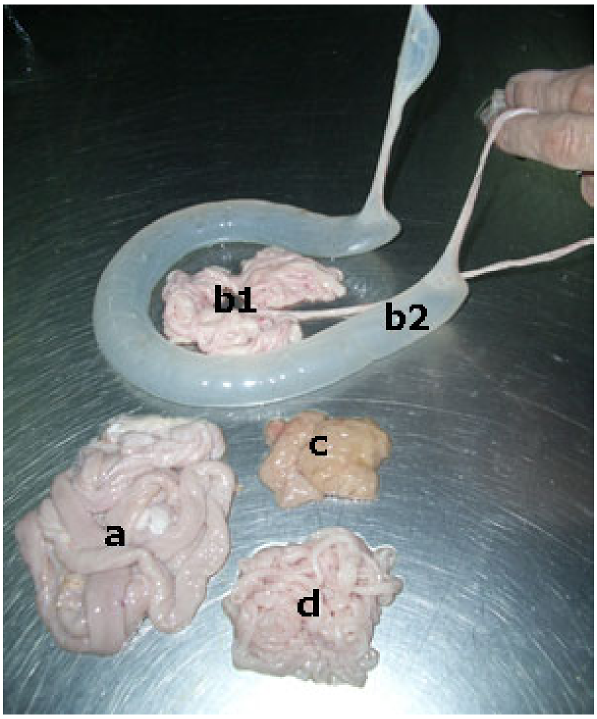
Step 3: Loosening of tissue layers using a small-scale manual casing cleaning machine

Fig. 318: Processing steps for small intestines (continued)

Step 4: Removal of remaining parts of the serose membrane



Step 5: Removal of "slime" by using spoon (white arrow)



Step 6: Flushing of clean casings
The photo shows the remaining submucose membrane b1/b2 ("edible" casing)

a = unprocessed casing
b1 = processed casing (slimed and cleaned)
b2 = processed casing (slimed and cleaned and being flushed with water)
c = "slime" removed from inside of casing
d = tissue lavers removed from outside

Step 7: Salting of clean "edible" casings for storage

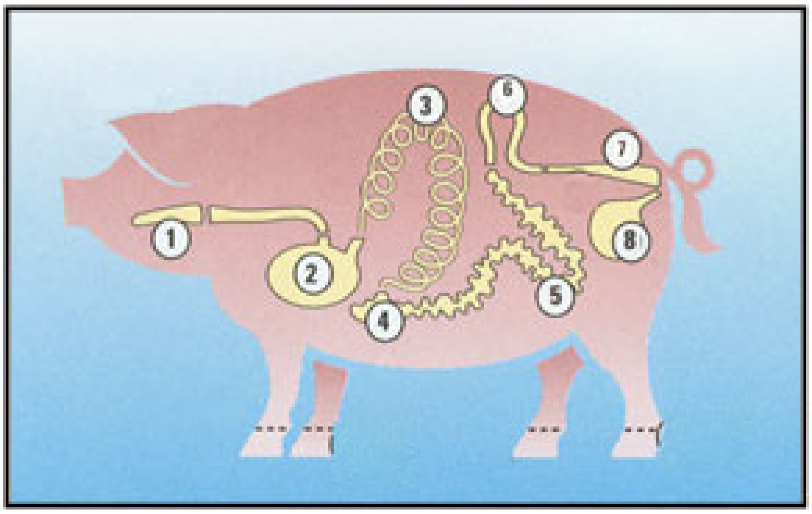
Fig. 319: **Small-calibre sausages in "edible" sheep casings**

Fig. 320: Large-calibre sausage in large pig intestine (pig middles) (not "edible")

Pig casings

Several parts of pig intestines are processed to casings (Fig. 321). The most important are the **small intestines**. The processing technique used is similar to the procedure for sheep casings. Hence they are also considered "edible" (Fig. 322, 323).

Fig. 321: Gastro-intestinal tract of pigs



Natural casings from pigs:
Oesophagus and tongue (1), stomach (2), small intestine (3), cap (4), pig middles (chitterlings) (5), pig middles (after ends) (6), pig bung (7), pig bladder (8)

Small pig intestines, also called **rounds**, with an average length of 15 to 20m, are mainly used as casings for fresh sausages (e.g. fried sausages, Fig. 322), raw/cooked sausages and dried fermented sausages (e.g. chorizos) (see also pages 103, 115, 127).

Pig rounds are packed in hanks of 100 yards (91.4 m), consisting of 15 to 20 single casing strings of 18 ft each (5.5m), sorted according to their diameter and colour coded as follows:

- /26 mm	yellow	26/28 mm	yellow/white
28/30 mm	blue	30/32 mm	blue/white
32/34 mm	red	34/36 mm	red/white
36/40 mm	green	40/ + mm	green/white

Fig. 322: Fresh sausages in pig casings (for frying)

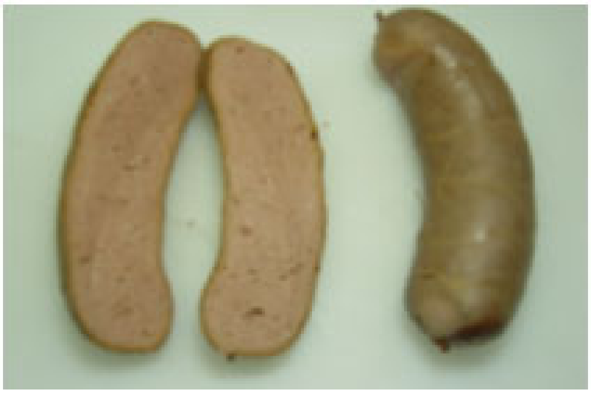


Fig. 323: Raw-cooked sausages in pig casing, left cut open

Pig middles (large intestines with an average length of 3 m) and the **cap** (Fig. 324) are used as casings for coarse liver sausage (see Fig. 320) and sometimes also for salamis. The **bung** (last part of the gastro-intestinal tract with an average length of 0.8 m) is due to its strength and shape used as casing for products such as cervelat (finely chopped dry fermented salami) and fine emulsified liver paste. Also the **bladder** can be used for products such as black pudding or gelatinous meat mixes (see page 164, 166).

These parts of the pig intestines are stripped of their intestinal content and must be reversed (turned inside out), washed and slimed (removal of internal slimy cover, now situated outside due to reversing the intestine).

Fig. 324: Salted pig stomach and cap (above), pig middles and bung (below)

In contracts to the processing of “edible” sheep and pig casings from small intestines, only the mucose membrane is removed through “sliming” from the large intestines and most of the serosa will automatically be detached during separating from the mesenteric tissue. The casing wall is therefore composed of a submucose membrane and muscular layer. These casings are relatively strong and tough and are usually not eaten with the sausage (Fig. 320).

Pig stomachs can be processed in two ways. If the stomachs are to be incorporated into meat mixes for sausage, they are scalded before further processing. If they are used as casings, only a small opening is made, through which they are cleaned by flushing with plenty of clean water. Thereafter they are turned inside out and kept in salt. They are used as casing for precooked-cooked sausages such as gelatinous meat mixes (Fig. 205) and blood sausages such as black pudding (see page 164). Before being used they need to be soaked in warm water to regain elasticity and to wash out the adhering salt.

Beef casings[1]

Several parts of the gastro-intestinal tract of cattle (Fig. 325) are used as casings in sausage production. Small intestines -“**rounds**”- have a typical circular shape and are used for stuffing sausages such as lyoner, liver and blood sausages and dried fermented beef products. Rounds are 40 m long and are normally readily available where cattle are slaughtered. They are used for all types of sausages in Muslim countries. The **middles** are around 7 m long and used for dried fermented and precooked-cooked sausages such as hunter’s sausage and coarse liver sausage. The **blind gut** is also used for precooked-cooked sausages and raw-cooked products such as large bologna etc. Their diameter varies from 76 to 102mm. **Beef bladders** are used for mortadellas and other specialities.

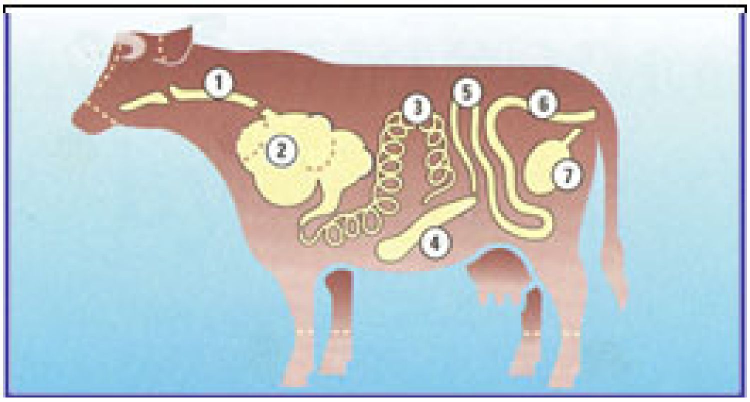
In preparation for processing, **beef rounds** are turned inside out and slimed. The mucose and serose membranes are removed from the intestines, leaving the submucose and muscular layer. The processing of beef small intestines does not remove the muscular layer (see Fig. 316) as it is the case when processing small sheep and pig intestines.

---

1) If should be noted that from 2001 in the EU no beef casings can be processed but the cattle tract from duodenum to rectum must be condemned due to BSE concern. Certain non-EU countries are authorized to produce beef casings for the EU.

Although these natural casings are edible they are usually not eaten due to their tough casing walls. After submerging the casings in water and thorough washing, the beef rounds are calibrated, tied and salted. Salted rounds are marketed in sets of around 100 yards (91.4m), each set containing a maximum of five pieces.

Fig. 325: Gastro-intestinal tract of cattle



Natural casings from cattle:
Beef gullet (1)
Beef tripes (2)
Beef rounds (3)
Beef caps (4)
Beef middles (5)
Beef rectum (6)
Beef bladder (7)

The **beef middles** are separated from the mesenteric fat (ruffle), flushed out with water, trimmed free of fat, turned inside out, slimed and salted. Beef middles include the "straight" casing (long, not curved part) and are packed in sets each measuring about 17m after salting and composed of 5 pieces. Beef middles (narrow end, wide end and fat end) are used as containers for different salamis and other large-diameter sausage products.

Beef bladders are washed, turned inside out and either salted or inflated with air and dried, before they are used for different sausage specialties. Beef bladders are usually graded in large, medium and small sizes.

Recommended treatment of natural casings

Natural casings are usually available and best stored dry-salted. Prior to the filling of sausage mix into such kind of casings all the adhering salt must be washed off with cold water. Dry-salted casings need to be then soaked in water for several hours (3-5 hours in lukewarm water or over night in cold water). Soaking in water does not only remove remaining salt but also serves to make the connective tissue fibres of the casing wall more elastic in order to optimally enclose and hold the sausage mix to be filled. Addition of lactic acid (2%) to the water can support this process further.

An alternative way of storing natural casings is in saturated salt solutions. This is the ready-to-fill natural casing type, as it requires only brief soaking periods ranging from minutes to up to one hour, and proper rinsing. This type must always be stored chilled.

Recommended periods for soaking in water

Dry salted natural casings:

General	:	10-12 hours
For pig large intestines	:	up to 24 hours
For cattle intestines	:	5-10 hours

Ready-to-fill natural casings (stored in saturated salt solution)

General	:	maximum 10-60 min.
For large pig intestines	:	2-3 hours

Transport and storage of natural casings

The storage periods for natural casings depend on the storage temperature. Dry-salted casings in closed containers, which also protect them against light impact causing fat-rancidity, can be stored at 6-8°C from six months to 3 years. Storage periods are reduced with higher storage temperatures. Adhering fat reduces the shelf-life.

The casing industry has established the following minimum requirements regarding storage and transport:

Dry-salted	maximum +15°C	at least 3 months
Ready-to fill (saturated salt solution)	maximum +10°C	at least 4 weeks

Sensory and hygienic quality

The principle for optimal natural casing production is to start processing the casing as soon as possible after slaughter. Intestines should ideally be processed when still warm as they are easier to manipulate (cleaning, sliming, washing) and bacterial growth can still be contained. The subsequent salt treatment, usually dry salting, will create high salt concentrations in the casing tissue, which easily reach the concentration of 15%, at which bacterial growth is halted (see page 33).

Some countries have established requirements for imported natural casings most of which derive from developing countries. A summary of such requirements is given hereunder:

Sensory quality:

Odour: Free of signs of putrefaction
No rancidity
No sour (acidic) smell

Appearance: Colour may vary from white to pink to grey

Microbiological norms (per gram)

	Fully acceptable	Critical numbers (not to exceed)
Total aerobic colony count	$<10^5$	5×10^6
Enterobacteriaceae	$<10^2$	1×10^4
Staphylococcus aureus	$<10^2$	1×10^3
Clostridium (sulphite reducing)	$<10^2$	1×10^3

Artificial (manufactured) casings

Artificial casings were developed at the beginning of the 20th century when, in some countries, the supply of natural casings could no longer cope with the demand for such natural casings from the growing meat industries. Following the development of highly automated sausage filling equipment, artificial casings proved to be better suited to those systems, mainly due to their uniformity.

Also from the hygienic point of view, there were certain advantages to artificial casings as the microbial contamination is negligible, refrigeration is not needed and there are no spoilage problems during transport and storage. Nowadays, for wide sausage calibres, artificial casings are the material of choice, while for smaller calibre products, artificial and natural casings remain equally important.

According to their structure and composition of material[1], artificial casings can be subdivided into

1) casings made of **natural** materials, with two groups:
   a) casings made of organic plant material, namely ***cellulose***
   b) casings made of animal by-products, namely ***collagen***
2) casings made of **synthetic** substances deriving from thermoplastic materials ("***synthetic casings***" which can be subdivided in "polymer casings" and "plastic casings").

____

1) There are also casings made from textiles or co-extruded coatings based on alginate used for special products. They are not discussed here.

Cellulose casings

Cellulose as a natural material derived from wood or cotton has proven to be suitable for sausage casings as it is:

- mechanically resistant
- widens when soaked in water and shrinks when dried (which exactly meets the requirements for a tight and smooth casing without formation of wrinkles on the sausage surface)
- permeable for gases, smoke and water vapour

Simple thin cellulose casings are used as so called **peeling casings** for frankfurter type sausages. The batter is filled into such casings (calibre range 12-42 mm) and portioned. Thereafter the products undergo smoking and cooking (at 74˚C), which causes the build-up of a firm layer of coagulated protein under the casing. After this heat treatment, the cellulose casings are removed and the sausages maintain their shape due to the firm external layer of coagulated protein. As ready-to-eat sausages do not have a casing, they are also known as “skinless sausages” (Fig. 326, 327, 328).

Cellulose casings are not suitable for larger sausage calibres as frequent breakages may occur due to rupture of the cellulose wall. In order to solve this problem, **fibrous casings** were developed. Fibrous casings are cellulose casings reinforced with strong cellulose fibres. These fibrous casings are resistant enough for large sausage calibres and still suitable for smoking (Fig. 329).

As a further step in the development of strong fibrous casings for large calibres, a layer of synthetic material, (e.g. PVDC) was added to the inside or outside of the casings (**coated fibrous casings**). The coating made the casing mechanically very resistant and created a complete barrier for gases, i.e. no evaporation losses can occur (Fig. 330).

However, fibrous casings with an inside or outside synthetic coating cannot be used for products to be smoked, as no smoke penetration is possible, and for products to be dried and fermented, as no water vapour evaporation is possible. They are mainly used for cooked sausages of the raw-cooked and the precooked-cooked type. The main advantage of coated fibrous casings for cooked sausages is the casing wall tightly enclosing the sausage mix and the easy peeling. As smoke does not penetrate through coated fibrous casings, smoke flavour can be added during manufacture of the sausage mix if desired.


Fig. 326: Products in transparent cellulose casings (cal. 22) (after filling and before smoking/cooking)


Fig. 327: Product in red coloured cellulose casings (cal. 22) used to transfer colour to sausage surface


Fig. 328: Sausage after removal of peeling casing (middle); removed casing (left); peeling casing still on (right)


Fig. 329: Fibrous casings (medium calibres)


Fig. 330: Coated fibrous casings

Collagen casings

Fig. 331: Frankfurters in collagen casing

Fig. 332: Larger calibre (raw-fermented) sausage in collagen casing

This type of casings is fabricated from collagen, which is obtained from the corium layer of selected split cattle hides[1]. The collagen-rich tissue is homogenized under high pressure, ring-extruded (hose-shaped) and hardened and results in a mechanically strong casing. Collagen casings are permeable for smoke and water vapour. While wide calibres must have a relatively thick casing wall as increased stability is required, small calibres can be made with relatively thin casing walls. As collagen is an animal tissue fit for human consumption, the thin collagen casings are easy to chew and "**edible**". They are an alternative to replace natural sheep, goat or thin pig casings (page 251, 255). The advantages of collagen casings are their standard diameter and strength and that they can be "**shirred"** i.e. folded together, in long lengths and used for manual or automatic filling stations without pre-soaking in water (Fig. 331).

Traditionally many consumers still prefer frankfurter type sausages in the natural casing, although with recent advances in edible collagen casings there is not much difference between both types terms of in tenderness and mouth-feel.

The edible collagen casings are also used for fried sausages (including the typical breakfast sausages) and small calibre dry sausages such as beef sticks, etc. Collagen casings of 32 mm and above are not intended to be eaten as part of the sausage, they have to be **peeled off**. They can be used for most fresh sausages, raw-cooked and smoked sausages or raw-fermented sausages (Fig. 332).

____

[1)] For leather fabrication the middle portion of the cattle hide, also called **corium**, is used. The corium can be separated by using splitting machines in up to three layers for leather fabrication. Tissues from the corium middle layer are used for production of collagen casings.

Synthetic casings

These casings are made of synthetic thermoplastic materials (Fig. 203, 333, 334). Suitable materials are Polyamide (PA), Polyethylene (PE), Polypropylene (PP), Polyvinylidenchloride (PVDC) and Polyester (PET).

While previously only synthetic casings from individual synthetic substances (mono-materials) could be fabricated, recently developed co-extrusion[1] techniques can be used to produce casings composed of combinations of several synthetic materials. Synthetic casings can therefore be manufactured with tailor-made properties.

The resulting casings are **mechanically strong**, relatively **heat resistant**, **impermeable** for smoke, gases and water vapour. Synthetic casings are particularly well suited for:

- Sausages with larger calibre
- Sausages where water vapour losses are not wanted
- Sausages to be cooked at relatively high temperatures
- Sausage ends to be clipped
- Sausages with long shelf life and good preservation of taste and flavour (prevention of rancidity, discoloration, flavour losses)

The latest development in synthetic casings are casing walls consisting of two to five layers of synthetic material with extreme barrier properties for gases and temperature resistance from -18° to 105/121°C They are suitable for production of sausages with long shelf life as they can be mildly sterilized and stored frozen if necessary.

Synthetic casings cannot be used for products which have to undergo drying, ripening and fermentation, such as dry sausages, as the casings are impermeable for gases and water vapour.

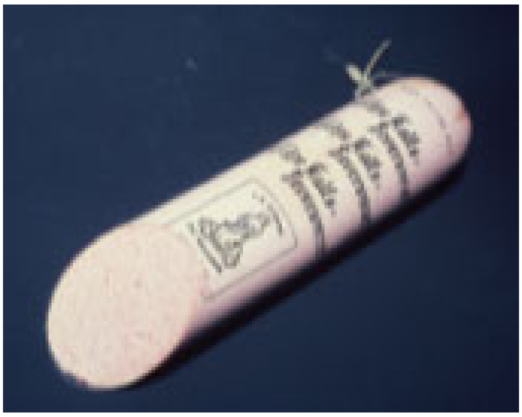


Fig. 333: Liver sausages in synthetic casing

Fig. 334: Meat in jelly in synthetic casing, casing end closed by clip

---

[1] Co-extrusion is the combination of thin layers of different synthetic materials, which are fused during the extrusion process.

PACKAGING OF FRESH AND PROCESSED MEAT

The function of packaging is to surround or wrap meat products with suitable protective material (Fig. 335). Packaging materials were in the old days simple natural materials, e.g. leaves, but nowadays exclusively manufactured materials such as paper or synthetic films.

Purpose of packaging

The basic purpose of packaging is to protect meat and meat products from undesirable impacts on quality including microbiological and physio-chemical alterations. Packaging **protects** foodstuffs during processing, storage and distribution from:

- **contamination by dirt** (by *contact with surfaces and hands*)
- **contamination by micro-organisms** (*bacteria, moulds, yeasts*)
- **contamination by parasites** (*mainly insects*)
- **contamination by toxic substances** (*chemicals*)
- **influences affecting colour, smell and taste** (*off-odour, light, oxygen*)
- **loss or uptake of moisture** (*evaporation* or *water absorption*)

Adequate packaging can prevent the above listed secondary contamination of meat and meat products. But the further growth of microorganisms, which are already present in meat and meat products, cannot be interrupted through packaging only. To halt or reduce microbial growth, packaging has to be **combined** with other treatments, such as **refrigeration**, which will slow down or stop the further growth of microorganisms, or with **heating/sterilization**, which will reduce or completely eliminate contaminating microorganisms.

Fig. 335: Meat products in different packages of synthetic materials

The packaging procedure results in an inner package, where the packaging material is in direct contact with the product. In some cases it is combined with an outer package often a cardboard boxe, or other materials.

There are various synthetic packaging films available for the inner packaging, e.g. **transparent** or **opaque**, **flexible** or **semi-rigid**, **gas proof** or **permeable** to certain gases. These materials are selected to serve specific purposes, such as protection from unwanted impacts or attractive presentation.

Requirements for packaging materials

A range of synthetic materials suitable for meat packaging are available mainly in the form of **plastic films**[1] or **foils**.

Packaging films must be/have:

- flexible
- mechanical strength
- light weight
- odourless
- hygienic (clean and toxicologically harmless)
- easy recycling
- resistance to hot and cold temperatures
- resistance to oil and fats
- good barrier properties against gases
- sealing capability
- low-cost

Barrier against gases

Good barrier properties against **oxygen** and **evaporation** are the most important features in order to ensure:

a) Exclusion of oxygen

Air contains about 20 percent oxygen. Oxygen negatively affects unpackaged meat and meat products during prolonged storage periods. It changes the red meat colour to grey or green and causes oxidation and rancidity of fats resulting in an undesirable off-flavour.

[1)] Oil is the raw material for plastics, 4% of the annual production of crude oil is used for making plastics.

The oxygen permeability of films used for the packaging of meat products varies. The lower the oxygen permeability the more efficient the protection of product quality. The best protection will be achieved using **oxygen-proof** packaging films together with vacuum packaging of the product (see page 271). This ensures that practically no oxygen remains in the package and no oxygen will penetrate from the air into the packaged product.

While oxygen is generally undesirable in packages of meat and meat products, there is one exception where **oxygen-permeable** foils are desirable, namely for fresh ready-to-sell meat portions in self-service outlets. In this specific case the utilization of oxygen-permeable foils produces a desirable bright red meat colour (see page 269 “Fresh Meat Packaging” and page 276 “Modified Atmosphere Packaging”)

b) Prevention of evaporation of product moisture

Fresh meat or fresh sausages, cooked ham, etc. have a relatively high moisture content and will suffer considerable weight and quality losses by evaporation and drying during storage if such products remain unpacked. The packaging material must therefore be sufficiently **water-vapour-proof**.

Barrier against light

Fig. 336: Opaque and printed films as light barrier

The prolonged exposure of meat and meat products to daylight or artificial light accelerates unattractive **colour changes**, **oxidation** and **rancidity** because light provides the energy for these processes. Transparent packaging films normally used for meat products allow attractive product presentation as the packaged product is visible. However, such films provide no protection against light impact. Normally products in transparent packaging films are sufficiently protected when stored in the dark or moderate llight conditions. For light sensitive products or products exposed to strong light, coloured or opaque films (Fig. 336) should be used. Films laminated with aluminium foil (Fig 337) are very effective.

Fig: 337: Aluminium foil bag

Sealing capability

Some packaging materials are required to have good thermoplastic properties. They are heat sealable, which means that two of these films, put closely in contact to each other under slight pressure and with simultaneous high temperature application, will melt or **seal** together along the heated area, resulting in hermetically closed plastic pouches or bags.

Types of packaging films

Practically all films used for meat packaging derive from **synthetic "plastic" materials**.

Cellulose, which is not a synthetic but a natural material derived from wood, was formerly widely used in the form of transparent films. It is now no longer of great importance in meat packaging although still used for some specific purposes. However, cellulose is still important for the manufacture of certain kinds of artificial sausage casings (see page 261).

The most common **synthetic materials** used for meat packaging are:

Polyethylene (PE)	(oxygen + , water vapour -)
Polypropylene (PP)	(oxygen + , water vapour -)
Polyvinylchloride (PVC) (soft)	(oxygen + , water vapour -)
Polyester (PET)	(oxygen ± , water vapour -)
Polyamide (PA)	(oxygen - , water vapour +)

+ = relatively permeable
- = relatively impermeable

Polyvinylidenchloride (PVDC)
Ethylenvinyl alcohol (EVOH)
used as barrier plastics (see Fig. 342B)

Foils made from the above synthetic materials are selected based on their different properties related to oxygen and water vapour.

For the various purposes in the meat industry packaging films can be divided into

- Single-layer films or
- Multi-layer films

Fig. 338: Single-layer film

Single-layer films

One common use of single-layer films (Fig. 338, 339) is the **wrapping** of meat pieces, processed meat products, bone-in or boneless meat cuts or even entire carcasses. These films are usually self-adhesive, i.e. they cling together -"cling film"- in the overlapping areas. Hence they provide good protection from external contamination and to some extend from evaporation, but no protection from oxygen, as they are not hermetically closed or sealed packages. Foils with good self-adhesive properties are PE, PA, PVC and PP.

Fig. 339: Wrapping with single-layer film

Another important utilization for single-layer films is in **freezer storage**. For meat blocks, meat cuts or smaller portions of meat or meat products, single-layer films are stretched tightly around the meat surface before freezing. The tight film prevents evaporation losses, which occur during freezer storage of unpacked products. The film is in tight contact with the products surface, in order to avoid evaporation, ice formation and **freezer burn** at non contact spots (Fig. 340). Suitable cold resistant films for freezer storage are PA or PE.

Fig. 340: Freezer burn developed during freezer storage because of insufficient protection against evaporation. Meat surface with greyish colour and dry (left)

One specific utilization for single-layer films is the wrapping of **chilled meat portions** for self-service outlets (supermarkets, etc.) (Fig. 341). Those meat pieces (beef, pork or chicken) are placed in a hygienic cellulose or plastic tray and tightly wrapped with single-layer plastic film. The ends of the foil are overlapped at the bottom side of the tray, where they firmly cling together. Films to be used should have low water vapour permeability to avoid the drying out of the meat during storage. But for making

Fig. 341: Fresh meat being packed in self-service tray, covering foil is cut to right size for overlapping at the bottom

attractive to customers, such meat needs to retain an attractive bright red meat surface colour (oximyoglobin) (see page 7) especially in the case of fresh portioned beef. For this reason the plastic foils to be used shall have a high oxygen permeability so that the oxygen of the air can react with the myoglobin of the meat and form the bright red oximyoglobin. Oximyoglobin is not a chemical compound but a loose aggregation of oxygen to the red meat pigment myoglobin, which keeps meat bright red for a number of hours. Suitable single-layer films for fresh meat packaging are PE or soft PVC. Formerly cellulose films were also used, which have the same permeability pattern but are less self-adhesive and the overlapping ends do not cling together very well.

Multi-layer films

Practically all the other films used for meat packaging are designed as strong **oxygen** and **water-vapour barriers**. In order to fully achieve these requirements, films with good barrier properties for oxygen and water vapour respectively are combined.

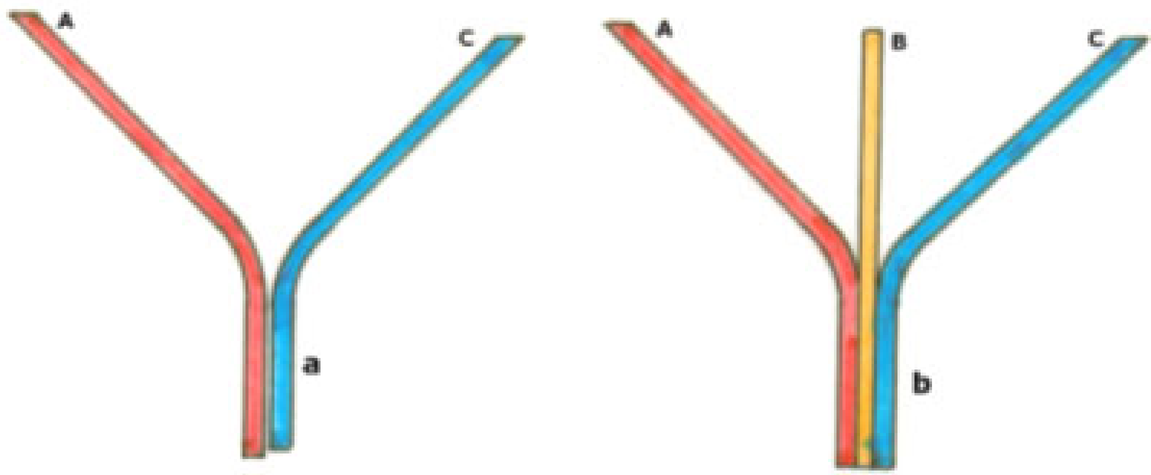


Fig. 342: Typical multi-layer films (a = two layers, b = three layers)
Layer A: Outside layer (mechanically strong, gas barrier to oxygen)
Layer B: Middle layer (barrier to oxygen)
Layer C: Inside layer = sealant layer (capable of being melted and welded under pressure to the sealant layer of the opposite sheet of the bag/pouch, serves also as barrier to water vapour)

A very efficient combination is **PA/PE**. **PA** is used as the outside layer for example for films for vacuum bags. PA is relatively oxygen proof but permeable to some extend to water vapour. **PE** has the opposite properties, it is water vapour proof but permeable to oxygen. The combination of both renders such a multi-layer film very tight against oxygen and water vapour evaporation. Moreover, the PE used as the inside layer has good thermoplastic properties and is therefore well suited for heat sealing. The PA/PE combination is the most simple structure for a multi-layer film (Fig. 342a). The packaging industry has refined the systems by introducing additional layers which serve as strong oxygen barriers (Fig. 342b).

Sealant layers consist mostly of Polyethylene (PE) or Ionomer (I) (Fig. 345, 346, 347). Outside layers may be Polyamide (PA), Polyester (PET) or Polypropylene (PP). Barrier layers for oxygen are made of Polyvinylidenchloride (PVDC) or materials with similar properties (see page 268).

Fig. 343: Sausage slices placed in vacuum bag prior to sealing

Vacuum bags, used for vacuum packaging machines (Fig. 343, 344, 350) are composed of two or more sheets of multi-layer films. By drawing the vacuum and sealing of such bags, the air is excluded from the package and the damaging effects of oxygen such as rancidity or discoloration of the packed products will be significantly slowed down or not develop at all. However, exposure to strong light may cause discoloration even under vacuum.

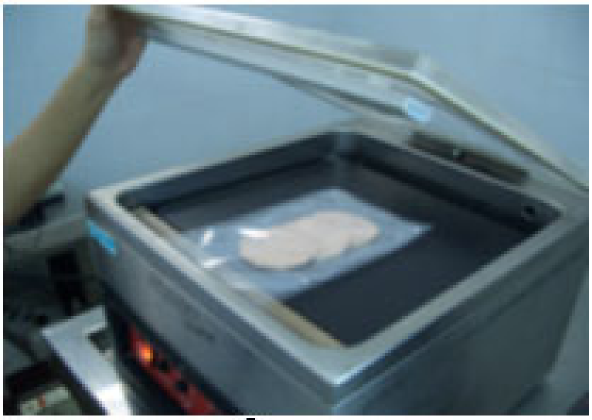


Fig. 344: Start of evacuation in vacuum packaging machine

Fig. 345: Evacuated and sealed product

Fig. 346: Good sealing seam

Fig. 347: Faulty sealing seam: risk of air penetrating inside the package because of film overlapping

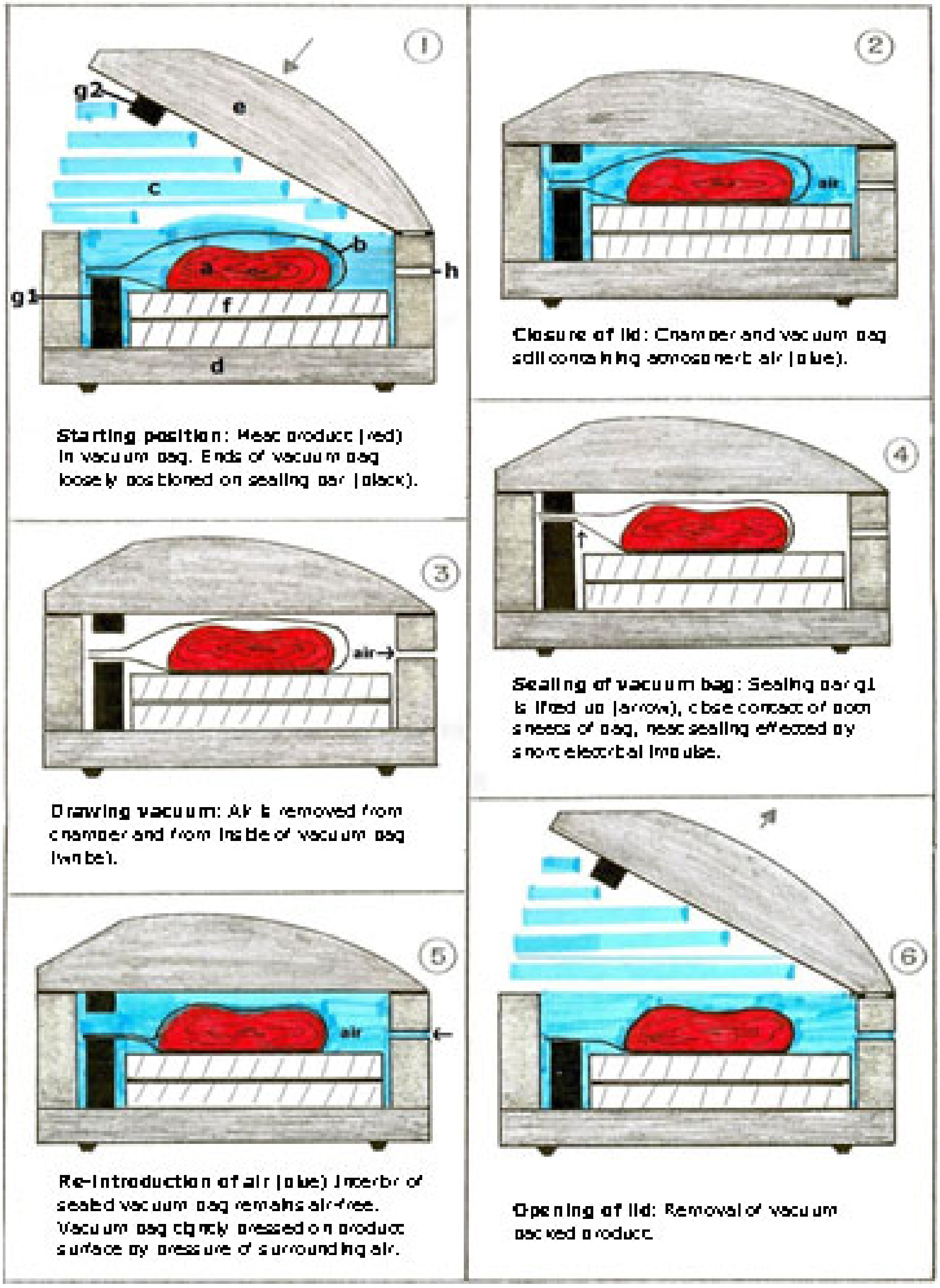
Fig. 348: Simple vacuum

Processed meat products in slices or as entire pieces are packed in small to medium-size vacuum bags. For larger sized products, bags made of **shrinkable films** can be used where, after vacuum-packaging, the product in its package of synthetic film is sprayed with or dipped into hot water (80^{o}C). The contact with the hot water causes the shrinkage of the thermoplastic film and results in tight impermeable wrapping of the goods. Shrink films may for example be composed as follows: PET/PA/EVOH/PO

Vacuum packaging for fresh chilled boneless beef cuts is mainly done to promote **meat ripening**. The beef meat cuts can remain for a number of weeks (maximum 3 months) in the vacuum bag, provided oxygen remains excluded and the storage temperature is kept at -1^{o}C (which is just above the freezing point of meat). During these storage conditions lactic acid bacteria (which do not cause spoilage!) will inhibit the growth of most other bacteria, which results in the prolonged microbial stability. Beef becomes very tender during such extended ripening periods without losing much of its typical flavour (Fig. 349).

Fig. 349: Vacuum packed beef cuts / rump, tenderloin, roast beef, (three layer co-extruded film with EVOH as oxygen barrier, shelf-life of chilled beef up to 3 months at -1° / 0° can be achieved)

Fig. 350: Manual vacuum packaging machine – Phases of operation



Starting position: Meat product (red) in vacuum bag. Ends of vacuum bag loosely positioned on sealing bar (black).

Closure of lid: Chamber and vacuum bag still containing atmospheric air (blue).

Drawing vacuum: Air is removed from chamber and from inside of vacuum bag (white).

Sealing of vacuum bag: Sealing bar g1 is lifted up (arrow), close contact of both sheets of bag, heat sealing effected by short electrical impulse.

Re-introduction of air (blue). Interior of sealed vacuum bag remains air-free. Vacuum bag tightly pressed on product surface by pressure of surrounding air.

Opening of lid: Removal of vacuum packed product.

Heat treatment or cooking for some meat products can be carried out in the package after vacuum-packing. Temperatures of 60°-80°C or even higher up to sterilization temperatures (above +100°C) can be employed for hams, sausages, etc. In these cases a pasteurization or sterilization effect of the uncooked packaged products is achieved and re-contamination avoided as long as the package is not opened.

For specific products such as entire sausages, **semi-automatic vacuum-packaging** can be employed. A bottom film is moulded according to the shape of the sausages by using heat and force (by compressed air or mechanical) (Fig. 351). These machines are called thermo-formers. The sausages are loaded (Fig. 351) and a rigid top film is sealed on after evacuating the moulded spaces. Individual product portions are cut apart along their sealing layers (Fig. 352).

Fig. 351: Semi-automatic vacuum packaging. Loading sausages in moulded bottom film. Top film to be sealed on bottom film after drawing vacuum. Individual portions to be cut apart (see Fig. 352)

Fig. 352: Product vacuum packed in moulded bottom film and rigid top film. (For presentation to customers the bottom film becomes the top of the package and verse visa)

A packaging method commonly used in larger meat industries is **skin packaging**. For this method the products are placed in the packaging machine, usually on a rigid film, which serves as the bottom layer of the final package. Another flexible film (top layer, which is heated for increased flexibility) drapes itself from above around the product, resembling a tight "skin" on the product surface avoiding wrinkles and purges. The skin-like coverage of the product takes place in a sealing station in the packaging machine, where the top and bottom film are sealed around the edges. Individual

Fig. 353: Skin packaging

packages are separated by cutting around the bottom seal perimeter (Fig. 353, 354).

Fig. 354: Skin packaging

The latest development in this sector is the "**form-shrink**" **packaging** technology. Products e.g. meat cuts, chicken carcasses, entire sausages, smaller portions of meat products, are placed between two shrinkable films, which are moulded without wrinkles around the goods. Sealing seams can be kept extremely small. This technology is very cost-effective in terms of usage of packaging films but requires high-tech equipment and is only of relevance for large-scale industries.

Fig. 355: Modified atmosphere packaging MAP). Lid foil of one package segment opened (right)

A useful technology is **Modified Atmosphere Packaging** (MAP) of meat and meat products. The packaging materials used are gas-proof multi-layer films composed for example of PE, PA and barrier layers. Rigid films may be used to mould cup or box shaped containers which are filled. A flexible lid foil is then sealed on (Fig. 355). MAP packaging can also be done for ordinary plastic bags/pouches. MAP packages are firstly subjected to a vacuum. A mixtures of gases is the introduced into the air-free space before sealing. The gas mixture usually contains nitrogen (N_2) and carbon dioxide (CO_2). N_2, which is also the major constituent of atmospheric air, is inert, i.e. it does not react with meat product components such as fat or myoglobin. Its function is to replace the atmospheric oxygen (O_2) and thus prevents O_2 induced negative impacts (see page 266). The other component of the gas mix, CO_2, has a protective function, as it inhibits to some extend the growth of bacteria and moulds.

The gas mixture commonly used is 20%-30% CO_2 and 70%-80% N_2. This is applicable for all **processed meat products**. If **fresh meat pieces** are to be packed in gas-proof packages instead of wrapping them with oxygen-permeable foil (see Fig. 341), the bright-red fresh meat colour can be achieved by adding oxygen to the gas mix to be injected into the package and replacing the N_2 content accordingly. As sufficient oxygen is needed to maintain the bright-red colour, gas mixes for fresh meat are usually composed of 70%-80% O_2 and 20-%30% CO_2.

Skin- and **MAP-packaging** are often too sophisticated for the small producers, but may be of increasing interest to medium-size meat plants. There are now small manual and semi-automatic packaging machines available (Fig. 356, 357, 358), which are designed for smaller throughputs. However, the utilization of those machines implies that the necessary types of synthetic films, and in the case of MAP-packaging, also the relevant gases, are available.

Fig. 356: Simple manual machine for sealing plastic trays with flexible lid foil (tray-sealing machine)

Fig. 357: Close view of manual tray sealing machine

Fig. 358: Small equipment for skin packaging and MAP-packaging

CANNING / STERILIZATION OF MEAT PRODUCTS

Principles of food canning

Unlike pasteurized “cooked” meat products where the survival of heat resistant microorganisms is accepted[1], the aim of sterilization of meat products is the destruction of all contaminating bacteria including their spores. Heat treatment of such products must be intensive enough to inactivate/kill the most heat resistant bacterial microorganisms, which are the spores of **Bacillus** and **Clostridium** (see page 95). In practice, the meat products filled in sealed containers are exposed to temperatures above 100°C in pressure cookers. Temperatures above 100°C, usually ranging from 110-121°C depending on the type of product, must be reached **inside the product**. Products are kept for a defined period of time at temperature levels required for the sterilization[2] (see details on pages 293, 294), depending on type of product and size of container.

If spores are **not completely** inactivated[3] in canned goods, vegetative microorganisms will grow from the spores as soon as conditions are favourable again. In the case of heat treated processed meat, favourable conditions will exist when the heat treatment is completed and the products are stored under ambient temperatures. The surviving microorganisms can either **spoil preserved meat products** (see page 354) or **produce toxins which cause food poisoning** of consumers, (see page 357).

____

1) The acceptance of surviving microorganisms implies that strict **cooling** conditions for the storage of such products have to be observed. As heat resistant microorganisms are mesosphilic or thermophilic, i.e. their growth is only possible in the temperature range of approximately 20-37°C, an uninterrupted cold chain in the range of **0°-7°C** will suppress their growth.

2) In this chapter only **fully sterilized meat products**, which can be stored under ambient temperatures, are discussed. So called semi– or three-quarter sterilized products, which require lower than ambient storage temperatures, are not considered as they are not particularly well suited for developing countries.

3) Heat treatment, which due to erroneous sterilization parameters used, did not inactivate all spores in the meat product is called **“under-sterilization”**. Another reason for the presence of viable microorganisms in canned food may be **recontamination** due to faulty sealing or faults of the containers. In these cases microorganisms penetrate into the cans after sterilization during the cooling phase in cold water or during handling and distribution of the cans.

Amongst the two groups of spore producing microorganisms (see page 277), Clostridium is more heat resistant than Bacillus. Temperatures of 110°C will kill most Bacillus spores[1] within a short time. In the case of Clostridium temperatures of up to 121°C are needed to kill the spores within a relatively short time.

The above sterilization temperatures are needed for short-term inactivation (within a few seconds) of spores of Bacillus or Clostridium. These spores can also be killed at slightly lower temperatures, but longer heat treatment periods must be applied in such cases to arrive at the same **summary effect** of heat treatment.

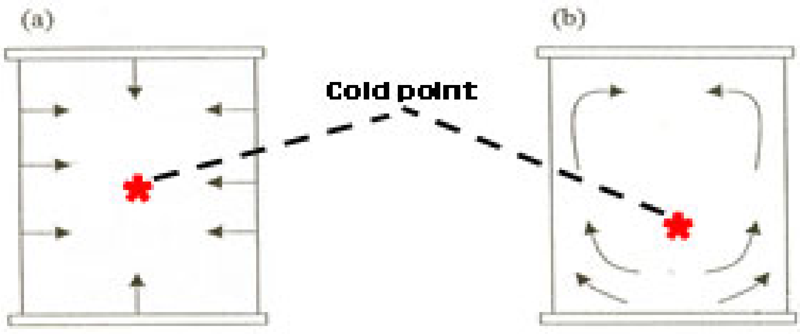
From the microbial point of view, it would be ideal to employ very intensive heat treatment which would eliminate the risk of any surviving microorganisms. However, most canned meat products cannot be submitted to such intensive heat stress without suffering

- **degradation of their sensory quality** such as very soft texture, jelly and fat separation, discolouration, undesirable heat treatment taste and
- **loss of nutritional value** (destruction of vitamins and protein components).

In order to comply with above aspects, a compromise has to be reached in order to keep the heat sterilization **intensive enough for the microbiological safety of the products** and **as moderate as possible for product quality reasons**.

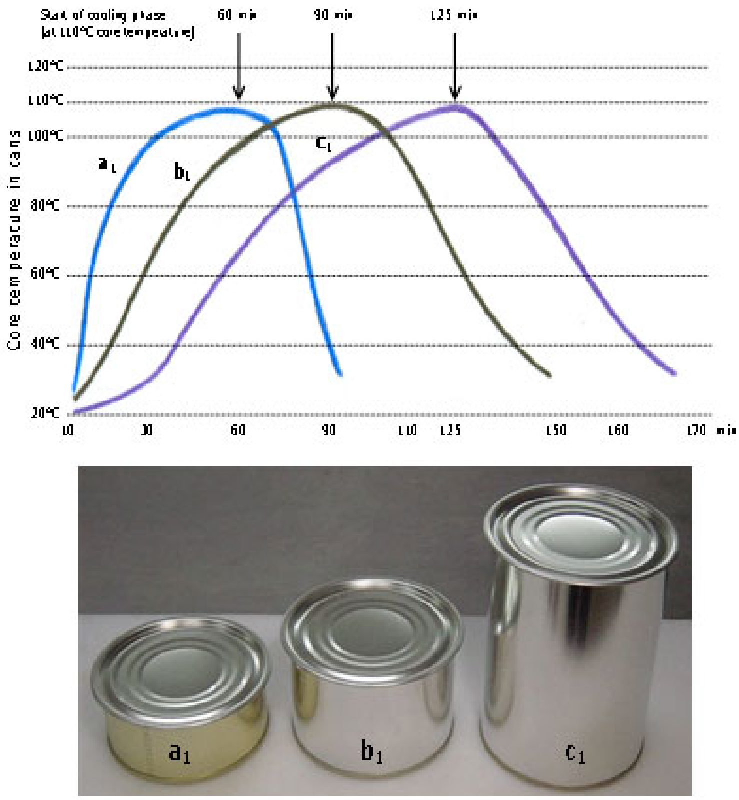
A method was developed for such a balance between food safety and food quality requirements by measuring and quantifying the **summary amount of heat treatment** to which a canned product is exposed during the entire sterilization process.

Fig. 359: Cold point in cans with solid (a) and liquid (b) content



---
1) The exception are the group of thermophilic bacillus strains, in particular Bac. stearothermophilus, which are extremely heat resistant but need high storage temperature (>35°C) for growth. Even in case of survival of such strains they pose only a risk (spoilage of cans) if the storage temperatures are extremely high (35°C and above), which, however, may occur in tropical regions.

The amount of heat treatment applied to a meat product can be measured using the **F-value-concept** (see page 289). This concept is practiced in canning plants, in particular as part of the HACCP-system (see page 344). Small producers, who are not equipped to employ the F-value concept, are not excluded from producing properly sterilized canned goods. In these cases **established technical reference parameters** of sterilization temperatures and times to the type of product and to the size of the cans can be employed. The size and format of cans is of utmost importance for the speed of heat penetration. Temperatures to be achieved at the "cold point" (Fig. 359) of the can where the heat arrives last, are reached faster in small cans due to the shorter distance to the heat source than in large cans.



Size of cans:	99/36	99/63	99/113
	200 g	400 g	800 g

Fig. 360: Heat penetration into centre of cans
(Cans filled with meat mix of Luncheon meat type)
Temperature of autoclave water 118°C

When comparing cans with the same bottom area (99 mm) but different height (36, 63 and 113 mm) (Fig. 360), heat penetration to the cold point of the high can (Fig. 360, c_1) takes twice the time as needed for the lowest can (a_1). These are approximate values, which can differ slightly depending on the materials filled into the cans. When comparing cans of same volume but different format (see Fig. 361), heat penetrates faster to the cold point of flat cans (a_2, b_2) than to compact square cans (c_2), although the content (volume) of all these cans is the same.

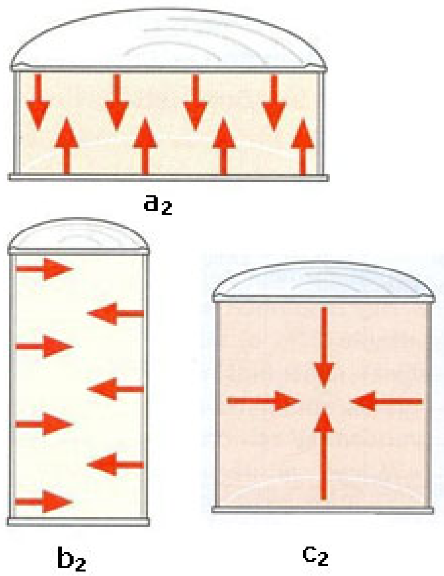


Fig. 361: Ways of heat penetration into horizontal (a_2) and vertical (b_2) flat cans and square (c_2) cans with solid (not liquid) content.

Processes and equipment

Process

The sterilization process in the canned product can be subdivided into three phases (see Fig. 385). By means of a heating medium (water or steam) the product temperature is increased from ambient to the required sterilization temperature (phase 1 = heating phase). This temperature is maintained for a defined time (phase 2 = holding phasing). In (phase 3 = cooling phase) the temperature in the can is decreased by introduction of cold water into the autoclave.

Autoclaves or retorts

In order to reach temperatures above 100°C (“sterilization”), the thermal treatment has to be performed under pressure in **pressure cookers**, also called **autoclaves** or **retorts**.

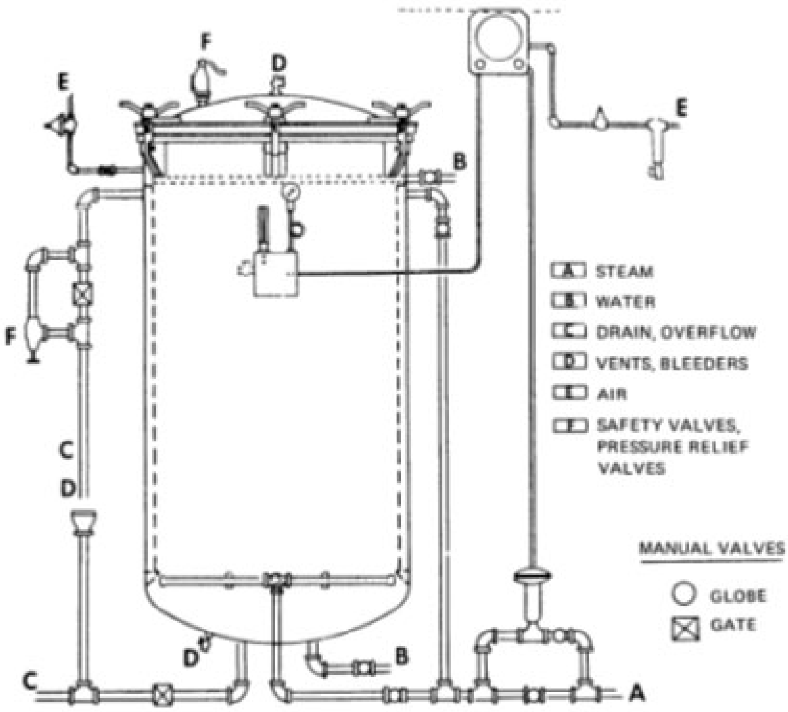


Fig. 362: Vertical retort

In autoclaves (retorts) (Fig. 362) high temperatures are generated either by direct **steam injection**, by **heating water** up to temperatures over 100°C or by **combined steam and water heating**. The autoclave must be fitted with a thermometer, pressure gauge, pressure relief valve, vent to manually release pressure, safety relief valve where steam is released when reaching a certain pressure (e.g. 2,5 bar)[1], water supply valve and a steam supply valve. The steam supply valve is applicable when the autoclave is run with steam as the sterilization medium or when steam is used for heating up the sterilization medium water.

[1)] See table 16 showing the autoclave temperature and associated pressure (page 296).

Simple **small autoclaves** are usually vertical autoclaves (Fig. 362, 364) with the lid on top. Through the opened lid the goods to be sterilized are loaded into the autoclave. The cans are normally placed in metal baskets. The baskets are placed in the autoclave, either singly or several stapled on top of each other. Before starting the sterilization, the lid must be firmly locked onto the body of the autoclave. The autoclave and lid are designed to withstand pressures up to 5.0 bar (pressure/temperature relation see table 16). These types of autoclaves are best suited for smaller operations as they do not require complicated supply lines and should be available at affordable prices.

Larger autoclaves are usually horizontal and loaded through a front lid (Fig. 365). Horizontal autoclaves can be built as single or double vessel system. The double vessel systems (Fig. 363) have the advantage that the water is heated up in the upper vessel to the sterilization temperature and released into the lower (processing) vessel, when it is loaded and hermetically closed. Using the two–vessel system, the heat treatment can begin immediately without lengthy heating up of the processing vessel and the hot water can be recycled afterwards for immediate use in the following sterilization cycle.

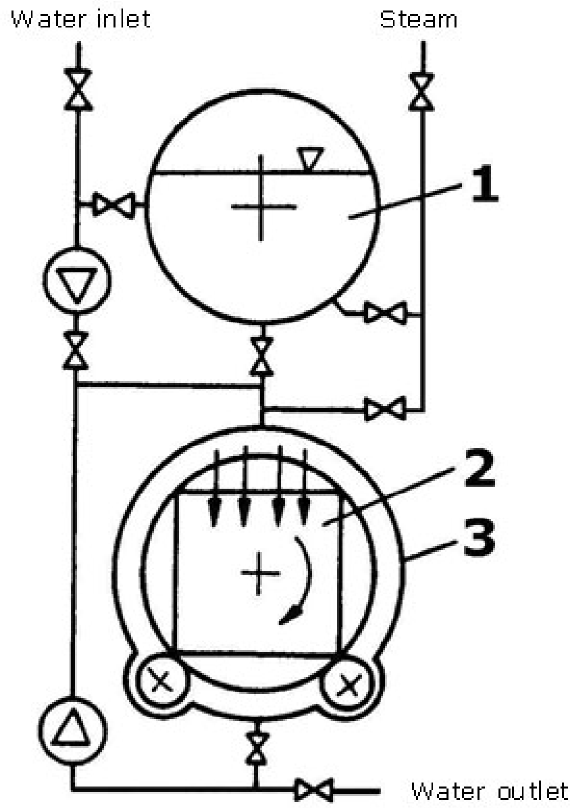


Fig. 363: Double vessel system
1 = Upper vessel
2 = Basket (for rotation)
3 = Lower vessel

If steam is used instead of water as the sterilization medium, the injection of steam into a single vessel autoclave will instantly build up the autoclave temperature desired for the process.

Another technology employed is **rotary autoclaves** in which the basket containing the cans rotates during sterilization. This technique is useful for cans with liquid or semi-liquid content as it achieves a mixing effect of the liquid/semi-liquid goods resulting in accelerated heat penetration. The sterilization process can be kept shorter and better sensory quality of the goods is ensured (Fig. 363, No. 2).

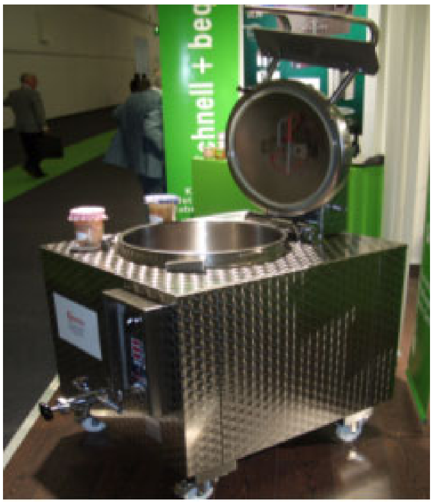


Fig. 364: Double purpose equipment (for small-scale). Can be used as cooking vat or autoclave

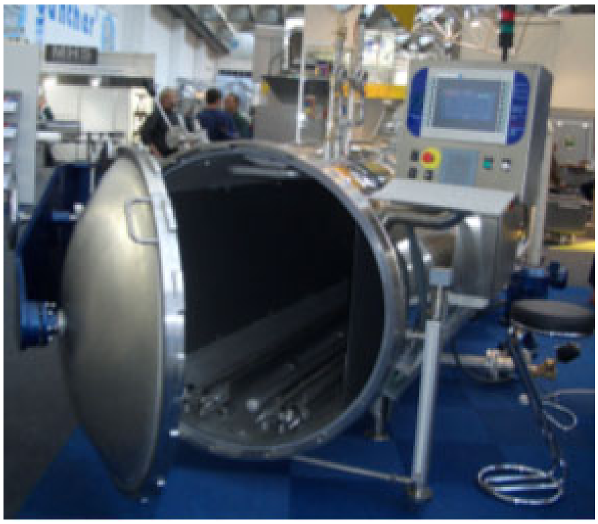


Fig. 365: Large horizontal autoclave

At the final stage of the sterilization process the products must be **cooled down** as quickly as possible. This operation is done in the autoclave by introducing cold water. The contact of cold water with steam causes the latter to condense with a rapid pressure drop in the retort. However, the overpressure built up during thermal treatment within the cans, jars or pouches remains for a certain period (Fig. 366). During this phase, when the outside pressure is low but the pressure inside the containers is still high due to high temperatures there, the pressure difference may induce permanent deformation of the containers.

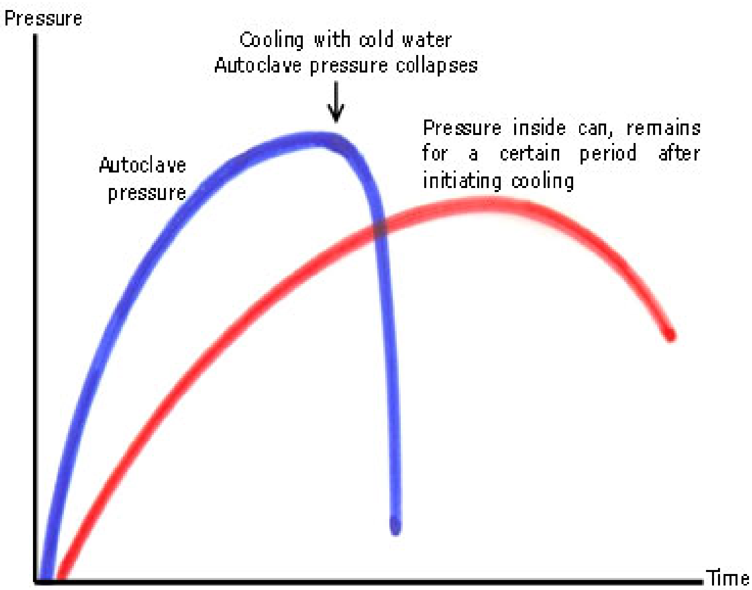


Fig. 366: Pressure inside autoclave (blue) and inside cans (red) during heating and cooling phase (schematic)

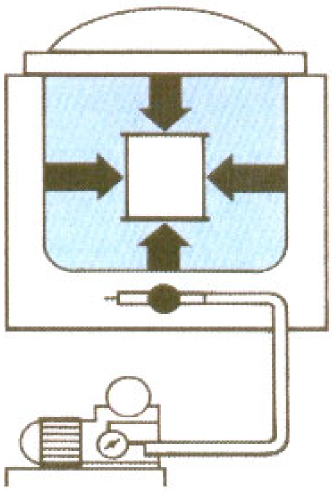


Fig. 367: Producing counter pressure on cans (see arrows) inside the autoclave with compressed air

Therefore, **high pressure difference** between the autoclave and the thermal pressure in the containers must be avoided. This is generally achieved by a **blast of compressed air** into the autoclave at the initial phase of the cooling (Fig. 367). **Sufficient hydrostatic pressure** of the introduced cooling water can also build up counter pressure so that in specific cases, in particular where strong resistant metallic cans are used, the water pressure can be sufficient and compressed air may not be needed. For the stabilization of metallic cans, stabilization rims (Fig. 368) can be moulded in lids, bottom and bodies.

Types of containers for thermally treated preserves

Containers for heat-preserved food must be hermetically sealed and airtight to **avoid recontamination** from environmental microflora. Most of the thermally preserved products are in metal containers (**cans**),. Others are packed in **glass jars** or plastic or aluminum/plastic **laminated pouches**.

Most metal containers are **cans** or “tins” produced from **tinplate**. They are usually cylindrical (Fig. 369, 370). However, other shapes such as rectangular or pear-shaped cans also exist (Fig. 368, 380, 382). Tinplate consists of steel plate which is **electrolytically coated** with tin on both sides. The steel body is usually 0.22 to 0.28mm in thickness. The tin layer is very thin (from 0.38 to 3.08 µm). In addition, the interior of the cans is lined with a **synthetic compound** to prevent any chemical reaction of the tinplate with the enclosed food.

Tin cans consist of two or three elements. In the case of **three-piece steel cans**, they are composed of the **body** and **two ends** (bottom and lid) (Fig. 370). The body is made of a thin steel strip, the smaller ends of which are soldered together to a cylindrical shape. Modern cans are **induction-soldered** (Fig. 370) and the soldering area is covered inside with a **side-strip coating** for protection and coverage of the seam. The use of lead soldered food cans was stopped decades ago. Hence the risk of poisonous lead entering canned food no longer exists.

Fig. 368: Tin cans and aluminium cans of different sizes and shapes

Two-piece steel cans have a lid similar to the three-piece cans but the bottom and body consist of one piece, which is moulded from a circular flat piece of metal into a cup. These cup-shaped parts may be **shallow-drawn** (with short side wall) or **deep-drawn** (with longer side walls) (Fig. 369, 371). However, the length of the side walls is limited through the low moulding ability of steel (example: tuna tins 42/85mm, i.e. side wall: diameter =1:2)

Aluminium is frequently used for smaller and easy-to-open cans,. **Aluminium cans** are usually deep-drawn two-piece cans, i.e. the body and the bottom end are formed out of one piece and only the top end is seamed on after the filling operation. The advantages of aluminium cans compared to tin cans are their better deep-drawing capability, low weight, resistance to corrosion, good thermal conductivity and easy recycability. They are less rigid but more expensive than steel plate cans.

Fig. 369: Cans of different size but same format (= relation of diameter to height)

Fig. 370: Three pieces steel cans of different format, inside lining with synthetic compound, side wall induction soldered, lid with easy-to-open ring

Fig. 371: Two-piece cans. Left steel can, right aluminium can. Steel can be shallow drawn, aluminium can be deep drawn

Glass jars are sometimes used for meat products but are not common due to their fragility. They consist of a glass body and a metal lid (Fig. 372). The seaming panel of the metal lid has a lining of synthetic material. Glass lids on jars are fitted by means of a rubber ring.

Fig. 372: Glass jars

Retortable pouches, which are containers made either of laminates of synthetic materials only or laminates of aluminium foil with synthetic materials, are of growing importance in thermal food preservation. Thermo-stabilized laminated food pouches, have a seal layer which is usually PP (polypropylene) or PP-PE (polyethylene) polymer, and the outside layers are usually made of polyester (PETP) or nylon. They can be used for frankfurters in brine, ready-to-eat meat dishes etc. From certain laminated films, for instance, polyester / polyethylene (PETP/PE) or polyamide/polyethylene (PA/PE), relatively **rigid containers** (Fig. 374) can be made, usually by deep drawing. They are used for pieces of cured ham or other kinds of processed meat. **Small can-shaped round containers** are made from aluminium foil and polyethylene (PE) or polypropylene (PP) laminate (Fig. 373) and are widely used for small portions, particularly of sausage mix. PE or PP permits the heat-sealing of the lid made of the same laminate onto these containers, which can then be subjected to intensive heat treatment of 125°C or above. One advantage of the retortable pouches/laminated containers is their good thermal conductivity which can considerably reduce the required heat treatment time and hence is beneficial for the sensory product quality.

Fig. 373: Cans moulded of strong aluminium foil, lid made of flexible aluminium foil to be heat sealed on body

Fig. 374: Cans made of synthetic material with sealed aluminium foil as lid (can be torn off)

Cleaning of containers prior to filling

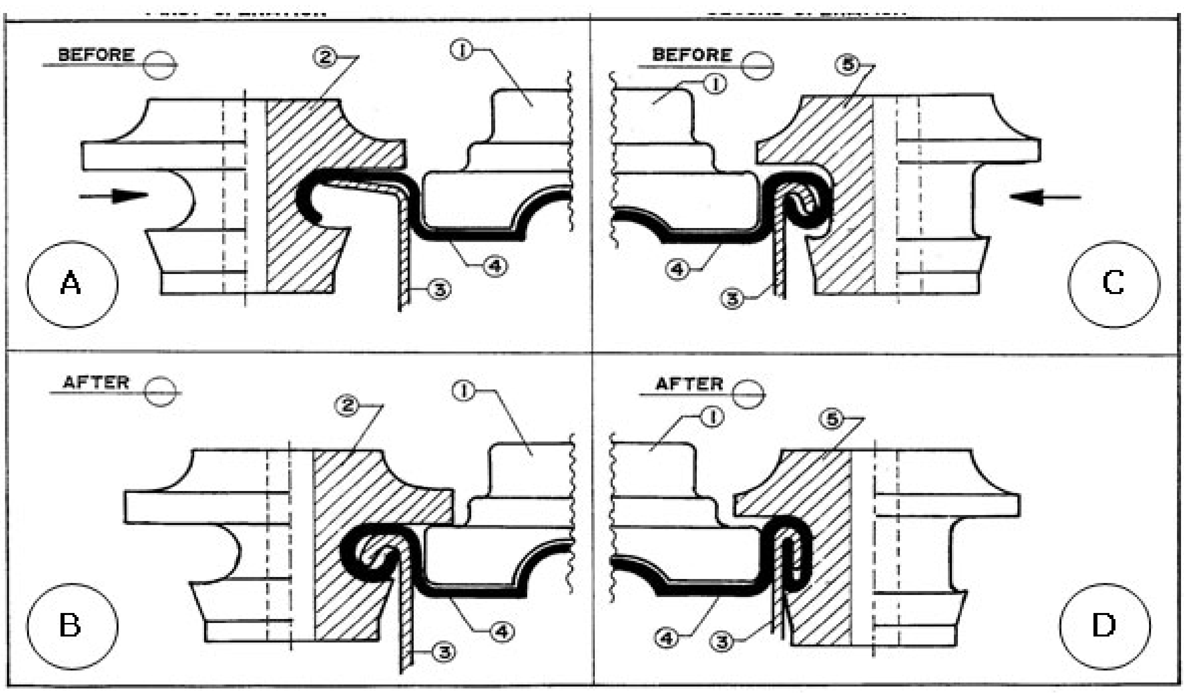
Rigid containers (cans, glass jars) are delivered open to meat processing plants, i.e. with the lids separate. During transport and storage, dust can settle inside the cans, which must be removed prior to filling the cans. This can be done at the small-scale level by manually washing the cans with hot water. Industrial production canning lines are equipped with steam cleaning facilities, where steam is blown into the cans prior to filling (Fig. 375).

Fig. 375: Empty cans being cleaned by steam injection

Seaming of cans

After the can is filled with the product mix the can is sealed with a tight mechanical structure - the so-called **double seam** (Fig 376). The double seam, in its final form and shape, consists of three layers of lid (D, black colour) and two layers of body material (D, striated). The layers must overlap significantly and all curves must be of rounded shape to avoid small cracks. Each double seam is achieved in two unit operations referred to as “first operation” (A, B) and “second operation” (C, D).

Fig. 376: Can seaming operation (schematic)



First operation (pre-seaming):
Start of operation (above left)
End of operation (below left)

Second operation (seaming):
Start of operation (above right)
End of operation (below right)

The can covered with the lid is placed on the base plate of the can seaming machine. The can is moved upwards while the seaming chuck (Fig. 376, 1) keeps the lid fixed in position. The pressure applied to the can from the base plate can be regulated and must be strong enough to ensure simultaneous movement of the lid and the can to avoid scratching-off of the sealing compound.

In the **first operation** the lid hook and body hook are interlocked by rolling the two into each other using the seaming roll with the deep and narrow groove (Fig.376, A/B). The body hook is now almost parallel to the lid hook and the curl of the lid adjacent to or touching the body wall of the can. In the **second operation**, the interlocked hooks are pressed together by a seaming roll with a flat and wide groove (Fig 376, C/D). Wrinkles are ironed out and the rubber-based material is equally distributed in the seam, filling all existing gaps thus resulting in a hermetically sealed container.

Design of seaming rolls

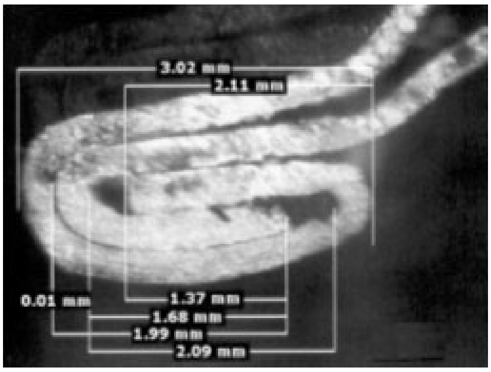
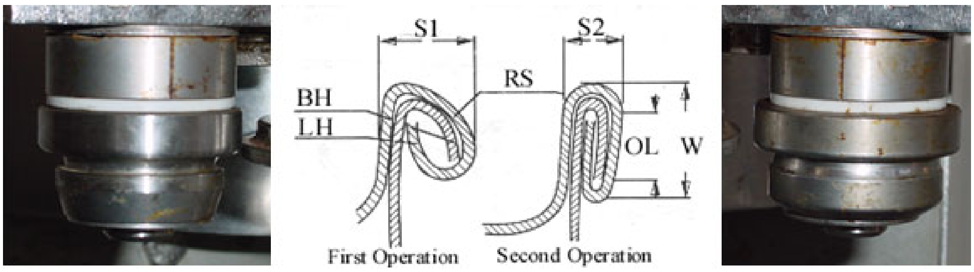


Fig. 377: Cross section of double seam. Routine check of correct seam in cannery by cutting out seam segment and using computerized testing

The seaming rolls for the first and second operations are designed differently in order to facilitate the respective operations. The seaming roll for the first operation has a **deep but narrow groove** to interlock body and lid hock (rolling the hocks into each other) (Fig. 376, A/B). The seaming roll for the second operation has a **flat but wide groove** to press the interlocked hooks together (sealing the seam) (Fig. 376 C/D). The different grooves of the first and the second seaming roll are shown in the pictures below. The first action (first roll) is rolling (interlocking) the hooks, the second action (second roll) is compressing (sealing) the seam (Fig. 378).

Fig. 378: Can seaming using semi-manual can seaming machine



S1 - First operation W - Width of the seam BH - Body hook OL – Overlap
S2 - Second Operation LH - Lid hook RS - Rubber seal

Meat products suitable for canning

Practically all processed meat products which require heat treatment during preparation for consumption are suitable for heat preservation. Meat products which do not receive any form of heat treatment before being consumed, such as dried meat, raw hams or dry sausages, are naturally not suitable for canning as they are preserved by low pH and/or low water activity.

The following groups of meat products are frequently manufactured as canned products:

- cooked hams or pork shoulders (Fig. 380)
- sausages with brine of the frankfurter type (Fig. 238, 372)
- sausage mix of the bologna or liver sausage type (Fig. 374, 381)
- meat preparations such as corned beef, chopped pork (Fig. 382, 383)
- ready-to-eat dishes with meat ingredients such as beef in gravy, chicken with rice (Fig. 239, 379, 384)
- soups with meat ingredients such as chicken soup, oxtail soup

Fig. 379: Meat mix with potatoes

Fig. 380: Canned pork shoulder

Fig. 381: Bologna sausage mix, variety of same type is Luncheon meat

Fig. 382: Corned beef

Fig. 383: Corned pork

Fig. 384: Pork knuckle meat in gravy ("Adobo", a Philippine specialty)

Definition of F-value and practical applications

The need for safe but not excessive heat sterilization requires practical methods for the exact measurement of the amount of heat treatment received by a product. For the development of such a method the following physical facts have to be considered:

a) The **amount of heat treatment** applied to a product is the combination of two components
   - **heat treatment temperature** and
   - **heat treatment time**.

b) Heat sterilization at a lower temperature, e.g. 110°C over the period of 20 minutes results in a **lower summary amount** of heat treatment than at a higher temperature, e.g. 117°C over the same period of 20 minutes. Similarly, when using the same temperature, e.g. 117°C but different sterilization periods (e.g. 20 and 30 minutes respectively), the longer sterilization period (30 minutes) accounts for the **higher summary amount** of heat treatment.

c) The **same amount of heat treatment** can be achieved when using either lower temperature/longer heat treatment time or higher temperature/shorter heat treatment time (different time-temperature regimes resulting in same heat impact).

As measurement for the **amount of heat treatment** imposed on a product, the term **F-value**[1] has been created, which represents the combination of *heat treatment* time and *heat treatment temperature*.

____

1) The denomination "F-value" is derived from "Fahrenheit" (Fahrenheit temperature scale used in the USA). For practical reasons a simplified approach has been taken in this context. The F-values mentioned always refer to the amount of heat treatment received in the critical thermal point, the cold point, where heating is slowest. For solid canned goods it is the centre of the can. In liquid or semi-liquid goods it is one third of the height from the can bottom (see Fig. 359).

For practical applications the reference temperature of 121°C and reference time of one minute is the basis of the F-value unit. The amount of **heat treatment delivered at 121°C during one minute** is **F-value 1**.

Definition:

F-value 1 = amount of heat treatment at 121°C over 1 min and similarly:
F-value 2 = 121°C over 2 min
F-value 3 = 121°C over 3 min, etc.

The reference temperature of 121°C does **not** mean that this is the recommended or optimal sterilization temperature. For any other relevant temperature, the amount of heat treatment per minute (expressed in F-value) can also be determined. Temperatures lower than 121°C will result in partial F-values *per minute* of less then 1 and temperatures of higher than 121°C will result in partial F-values *per minute* of higher than 1. For easy reference the **F-values** associated with temperatures starting from 100°C and referring to one minute heat impact time are summarized in table 1.[1]

Table 14: F-values (per minute) for the temperature range of 100°C to 135°C

°C	F – value	°C	F – value
100	0.0077	118	0.4885
101	0.0097	119	0.6150
102	0.0123	120	0.7746
103	0.0154	121	1.0000
104	0.0194	122	1.2270
105	0.0245	123	1.5446
106	0.0308	124	1.9444
107	0.0388	125	2.4480
108	0.0489	126	3.0817
109	0.0615	127	3.8805
110	0.0775	128	4.8852
111	0.0975	129	6.1501
112	0.1227	130	7.7459
113	0.1545	131	9.7466
114	0.1945	132	12.2699
115	0.2449	133	15.4560
116	0.3083	134	19.4553
117	0.3880	135	24.5098

1) The partial F-values indicated in table 1 have been established experimentally and mathematically.

The overall amount of heat treatment (**= summary F-value**) for a fully sterilized product can be calculated by **adding up/summarizing** partial F-values achieved during sterilization. For this purpose the temperatures achieved in a product during sterilization must be registered every minute. The individual temperature measurements (readings per minute) at the cold point (Fig. 359) of the can, result in a temperature curve for the entire sterilization process composed of heating, holding and cooling phase (Fig. 385).

The temperature inside the containers during heat treatment must be measured at the "coldest" or **critical thermal point** of the product, which is the point where the heat transferred arrives last. This is usually the centre of the container (can), except in case of liquid fillings (see Fig. 359). This situation also implies that the outer parts of the canned product always receive higher amounts of heat treatment than the centre. But for product safety reasons the summary F-value required for a product must be reached and measured at the critical thermal point (cold point). The outer parts of the product will always receive higher F-values, which means that these areas will be more intensively heat treated than the central parts (see Fig. 361). This fact plays a role in the sensory quality of the product. The sterilization process must therefore be carried out in a way that also the outer product portions are not deteriorated by excessive heat treatment and are acceptable to consumers both in texture and taste.

The reference temperature for the F-value definition is 121°C. In commercial meat canning, for quality reasons, temperatures lower than 121°C are applied for most meat products due to their **heat sensitivity**. Theoretically temperatures above 100°C can be used for meat product sterilization. However, temperatures close to 100°C are associated with very low F-values (see table 14), which would require a long period of heat treatment in order to reach summary F-values considered sufficient for full sterilization. On the other hand, F-values associated with temperatures higher than 121°C would assure a short-term sterilization process. But these high temperatures have to be applied with caution, as they may have a negative impact on the product quality.

There are a number of meat products, e.g. Cooked ham, Luncheon meat or Liver pate, which would suffer quality losses if heated up to internal temperatures of around 121°C. These products are usually sterilized at temperatures between **112 and 115°C**. Other meat products such as Corned beef or meat pieces in gravy are less heat sensitive and can be sterilized at higher temperatures, e.g. **118-121°C**. The temperatures to be used also depend on the size of the cans. Solid products in large-size cans may have to be sterilized by using lower autoclave temperatures to prevent the outer parts to be exposed to high temperatures for too long a time (Fig. 360).

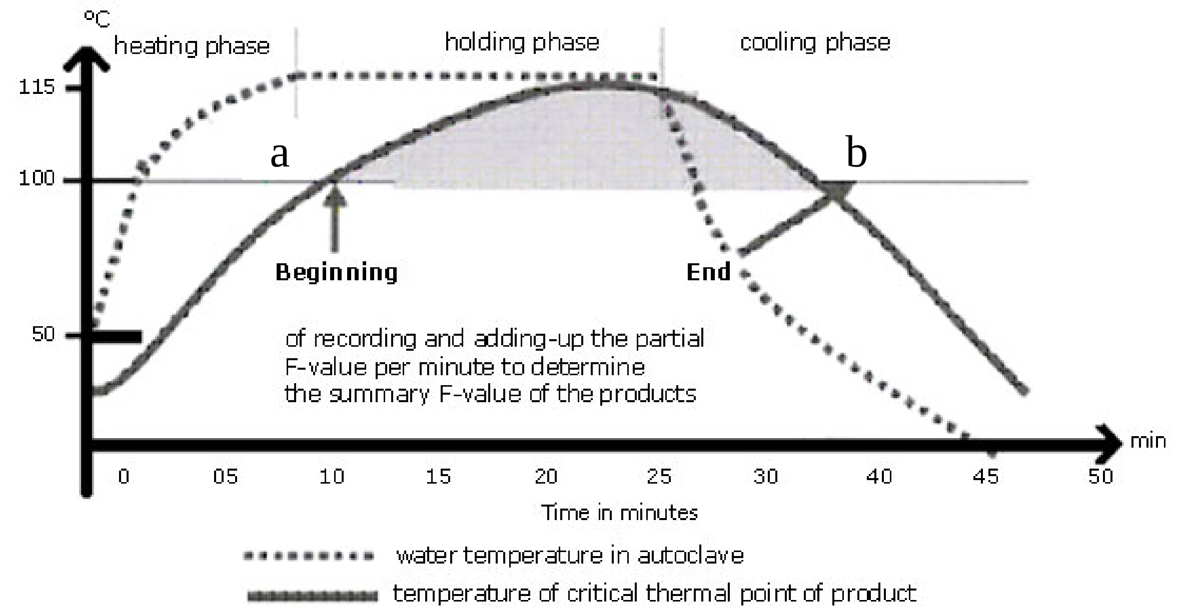
The proper application of the F-value approach in heat sterilization is a important part of product quality. It allows for all container sizes and types of products to determine the optimal sterilization pattern and to find the balance between **food safety** and **food quality** requirements.

Calculation of summary F-value achieved in a product

By measuring the product temperature during thermal treatment through inserting a thermocouple into the critical thermal point (cold point) of the container (can), the summary F–value achieved can be determined. The temperature taken in the critical thermal point of the can/container each minute during sterilization corresponds to a **partial F-value** (see table 14). All partial F–values obtained starting from the internal temperature of 100°C[1] until the **sterilization is ended** and **including the cooling phase** until the product temperature falls below 100°C are added up. The sum of all partial F–values is the **summary F-value** achieved in the product.

Please note: It is important that the F–value calculation is continued *during the* ***cooling phase*** (until the product temperature falls to 100°C)[1)], as the F–values achieved during the initial phase of cooling contribute considerably to the overall F–value (Fig. 385). Omitting this would result in over-sterilizing of the product possibly resulting in quality losses.

Fig. 385: F-value calculations during heating, holding and cooling phase



Starting from +100°C during the heating phase (a) – measured in the critical thermal point of the product – the F-values (per minute) are added up until a temperature below +100°C is reached during the cooling phase (b).

____

1) The partial F-values associated with temperatures below 100°C are very small and hence do not contribute significantly to the overall amount of heat treatment or summary F-value of the product. Partial F-values below 100°C can therefore be neglected in the summary F-value calculation for meat product sterilization.

Production of fully sterilized canned products

Canned meat products must be microbiologically safe, which means pathogen free and non-spoiling. This implies that apart from all vegetative microorganisms, the spores must also be inactivated. Thermal processing uses the most heat resistant known organisms that could cause spoilage or disease/food poisoning as reference organisms for a safe and stable product. In the food industry the most heat resistant *pathogens* are **Clostridium botulinum spores** (see also page 358) for which a minimum **F-value of 2.52** needed. The most heat resistant spores for *spoilage* are the **Clostridium sporogenes spores** which require minimum **F-values of 2.58**.

Based on these microbiological considerations and including a sufficient safety margin, sterilized canned products should be produced with **F-values of 4.0-5.5**. The retort temperatures to be used may vary between **117** and **130°C** (depending on the heat sensitivity of the individual products). A shelf life of up to **four years** at storage temperatures of 25°C or below can be achieved.

In **tropical countries**, where the storage temperatures may exceed 25°C, specific canned products for tropical conditions are manufactured. In these cases the summary F-values have to be increased to F-value **12-15**[1], which permits safe storage of the finished products under storage temperatures up to **40°C**.

Information about the exact summary F-value of a product is of great importance to food processors because

- it ensures the appropriate thermal treatment of the product, thus avoiding over- or undercooking.
- it enables the determination of the product storage conditions.

In practice it is not necessary to calculate the F-value repeatedly for the same type of products processed in the cannery. The F-value can be determined once for each batch taking into account the **size of the containers** and **intensity and duration of thermal treatment**. If these parameters remain unchanged, the F-value will be constant during subsequent production.

[1)] The sterilization technologies used are generally based on the elimination of mesophilic bacteria. Certain thermophilic organisms such as Bac. stearothermophilus are extremely heat resistant and may survive F-values of 4-5.5. In case of survival they will not grow under normal storage conditions of up to 25°C and do not pose a risk in countries with moderate temperatures. However, they may grow under tropical conditions in particular with storage temperatures of 25°C and above. Hence, F-values of 12-15 have to be employed in such cases to contain this risk (see also page 278).

Commercial sterility

F-values of 4 and above as required for fully sterilized canned products are often **detrimental for the quality** of certain canned goods. Thus technologies have been developed, which use a sterilization pattern of slightly less than F-value 4, which means that under certain circumstances some spores may survive. In order to tackle this risk, other **“hurdles”** can be employed to curb microbiological growth. In the first place, the curing substance **nitrite**, which is added to many canned meat products, as an additional safety measure or “hurdle”. Nitrite inhibits the growth of spores. Lowered **water activity (a_w)** due to reduced water content or a_w-reducing ingredients (fat, non-meat proteins, salts) can also be useful.

Product acidity **(low pH)** such as in many canned vegetable or fruit products, is effective to allow the “softening” of the sterilization pattern, as Clostridium species do not grow below pH 4.5. However it is not applicable for canned meat products, which practically all fall in the category of **low-acid products** (pH higher than 5.5).

The definition for commercially sterile products according to *Codex Alimentarius*[1] is:

“Commercial sterility of food means the conditions achieved by application of heat which renders such food free from microorganisms capable of growing in the food at temperatures at which the food is likely to be held during distribution and storage.” The criterion is ability to grow **not** presence or absence.

Commercially sterile goods are canned products sterilized under not too intensive heat treatment in order to maintain good sensory product quality. It is accepted that non-pathogenic microorganisms may not have been completely inactivated, but it must be ensured that their growth is practically not feasible as one or more of the above “hurdles” are present in the product (see also page 92).

The characteristic of **commercially sterile products** is that they have been heat treated to eliminate all pathogenic organisms and to reduce spoilage organisms to a level where they will not produce a health hazard or reduce the quality and acceptability of a product.

____

1) Joint FAO/WHO Food Standards Programme CODEX ALIMENTARIUS COMMISSION Recommended International Code of Hygienic Practice for Low Acid Canned Foods, 1993

Experimental and mathematical determination of F-values

F-values (per minute), at and above the reference temperature of 121°C as indicated in table 14, are based on the heat tolerance / heat resistance of microorganisms relevant in food/meat canning. In order to facilitate the approach, one single microbial species was selected, *Clostridium botulinum*, which is the most heat resistant pathogenic microorganism (see also page 357). Canned food, where Cl. botulinum is inactivated, is hygienically safe, as it can be assumed that also all other food poisoning and food intoxicating microorganisms are eliminated. By adding a defined safety margin to the heat treatment, it can further be assumed that any surviving food spoilage bacteria will also be inactivated.

For the calculation of the Cl. botulinum–based partial F-values (F-value per minutes) the following additional parameters apply (which are based on experimental results):

D-value = decimal reduction time of Cl. botulinum, which is the time at a given temperature needed to reduce the microbial population to 10%, of its original numbers (e.g. at 121° approximately 12 seconds)

z-value indicates the necessary increase in temperature (°C), which is needed to decrease the decimal reduction time (in the above example 12 seconds) to 10% (=1,2 seconds in the example). For Cl. botulinum this z-value is 10°C (is different for all other microorganisms).

This fact of the z-value being 10 for the reference microorganism Cl. botulinum facilitates F-value calculations. The rule is that temperature increases/decreases by 10°C will change partial F-values **by the factor 10** (decimal increase/decrease) (see table 15)

Table 15: Time / temperature effect for Z-value

Temp.	F-value (minutes)
101°C	0,01
111°C	0,1
121°C	1
131°C	10

Temp.	Minutes at 121°C to achieve F-value 1
101°C	100
111°C	10
121°C	1
131°C	0.1

12 - D - concept

Knowledge of the decimal reduction rate of Cl. botulinum enables the calculation of the safe elimination of this microorganism. It is assumed that a batch of cans is contaminated with one spore of Cl. botulinum per can (which is extremely unlikely). It is required that the sterilization be such that there is a likelihood of only one spore surviving in a trillion (10^{12}) cans, or in other words a 12-fold decimal reduction (down to 10^{-12}). Mathematically the complete elimination to zero microorganisms cannot be established.

The decimal reduction time of Cl. botulinum at 121°C is 0,21 min., and for the 12-fold effect the result is 12x0.21 min. = 2,5 min. The period of 2,5 min. at 121°C is equivalent with F-value 2,5. This F-value of 2,5 is also called "**botulinum cook**" or "**12-D-concept**" and signifies the elimination of Cl. botulinum under practical conditions.

When applying the above decimal increase/decrease rule at 111°C (10°C lower than 121°C), the "botulinum cook" would be achieved only after the ten-fold time = 25 min. instead of 2.5 min. at 121°C (see also box on page 295).

Table 16: Steam temperature and associated pressure[1]

°C	Bar
100	1
111	1.5
120	2
128	2.5
134	3
139	3.5
144	4
148	4.5
152	5
158	6

°C	Bar
164	7
170	8
174	9
179	10
185	11
187	12
191	13
198	15
213	20
225	25

°C	Bar
234	30
248	40
260	50
271	60
281	70
290	80
300	90
304	95
308	100
315	110

°C	Bar
322	120
328	130
334	140
340	150
345	160
354	180
363	200
372	225

1) Autoclaves are usually designed to withstand 6 bar. In practice autoclave temperatures remain below or do not exceed 128°C (=2,5 bar).

HANDLING AND MAINTENANCE OF TOOLS AND CORE EQUIPMENT

Meat processing plants should supply personnel with the correct types of hand tools and basic equipment. Such tools and equipment must be subject to simple routine servicing and maintenance to be carried out by the personnel on a regular basis. This does not include the servicing of more sophisticated equipment which has to be undertaken by specialized technicians usually sourced through the equipment supplier.

Knives

Due to the multiple operations in the meat sector different types of knives are used for different purposes. There are knives for **bleeding**, **flaying** and **evisceration** of animals as well as for **deboning** of carcasses, **cutting** of meat and **slicing** of choice cuts and processed products. All these knives have very specific design features to support the operations they are made for (Fig. 387). Knives are also used for cutting of other raw materials and casings.

Knives used in meat operations should have basic safety features. The **handle** should be made of plastic material with non-slip surface and designed to allow a firm and safe grip. Plastic handles are also a hygienic requirement. The end of the handle is often slightly enlarged (handle knob) to prevent the knife from slipping out of the hand and the portion close to the blade should have a similar enlarged design to avoid the hand from slipping over onto the blade (see Fig. 386, 387).

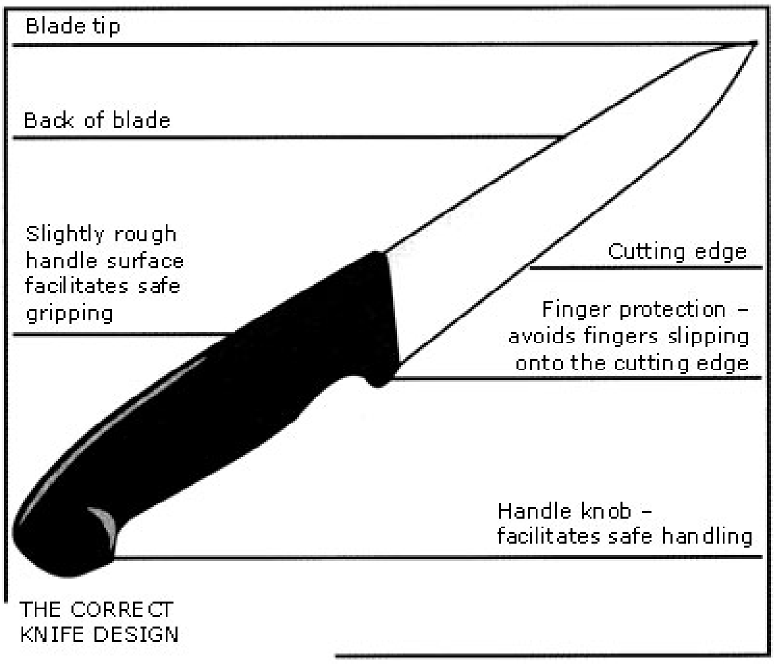


Fig. 386: The recommended knife design to facilitate safe handling and avoid injuries

It is of utmost importance that knives are handled with care to avoid injuries to workers and damages to the knife itself. When working with meat, knives must be **cleaned** frequently to eliminate the risk of cross-contamination. Knives must also be sharpened in a proper way to avoid unnecessary wear and **kept sharp** to reduce the potential for injuries. Working with a blunt knife requires more force and results in a higher risk of slipping off the meat or bone. It also leads to early fatigue and slower work speed.

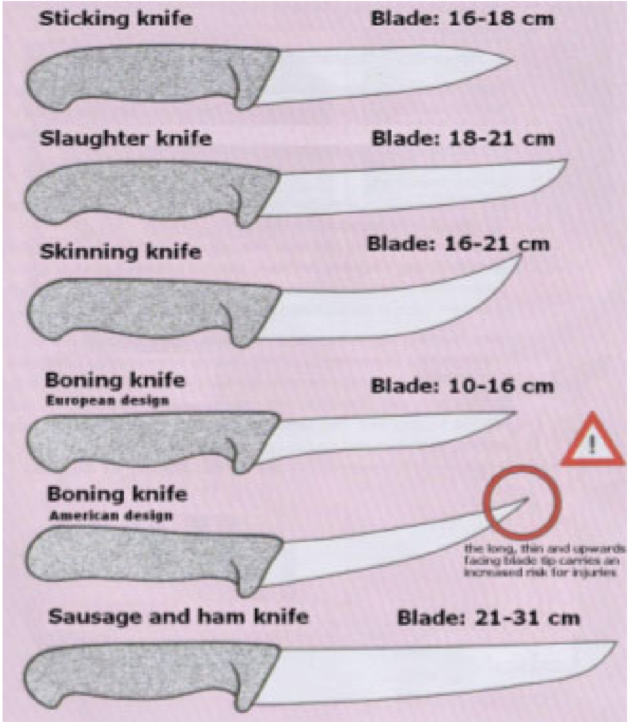


Fig. 387: Knives used in meat operations

The correct shape of the blade at the **cutting edge** is very important to facilitate a long-lasting sharpness and allow for easy **whetting** during operations. The recommended shape is a slightly convex cutting edge area as this ensures a firm structure and facilitates smooth cutting through meat and sausages (Fig. 388). Cutting edges showing straight or even concave shapes result in very thin blade edges with an increased risk of small cracks and also require more handling force by workers.

Knife sharpening is a delicate process and requires a special device (Fig. 389). The knife sharpening machines (sand-paper abrasive belts, sand-paper flap-wheels, rotating stones) should be air-ventilated or water-cooled and rotate at a moderate speed. Air ventilated sharpening often causes overheating of the blades, which increases the risk of cutting edge breakage.

During work operations, all knives should be whetted regularly using special **steels**. These steels are often called sharpening steel, but are in fact only for whetting (polishing of the knife edge). Care must be taken that only steels with safety handles (knob-type handle front for finger protection) are used.

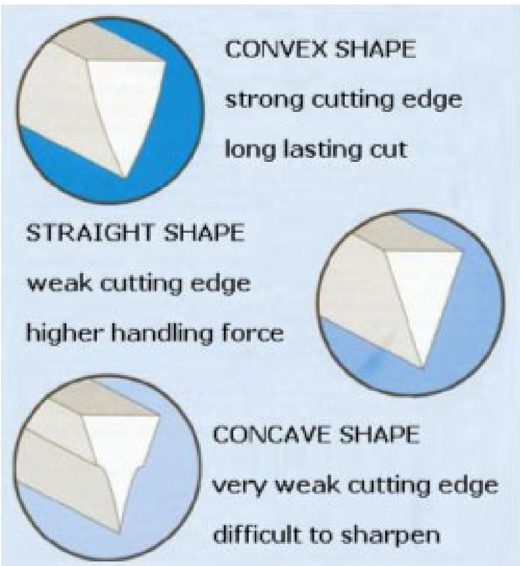


Fig. 388: The correct cutting edge shape

Fig. 389: Knife sharpening machine with sand-paper flap-wheel for grinding (right) and whetting (left)
Right side: wet stone for sharpening
Below in front: polishing steel

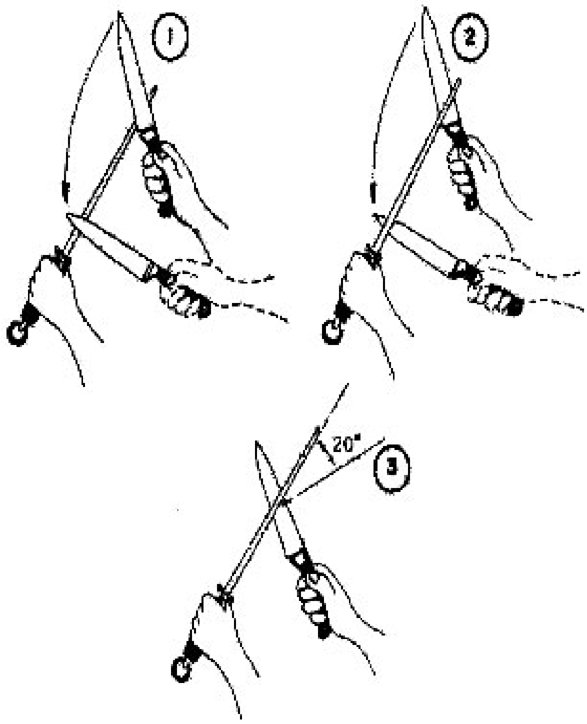


Fig. 390: Sequence during knife polishing with steel

During **knife whetting** (Fig. 390), the steel is firmly gripped with one hand and the other hand holds the knife. The hand with the steel remains static. Starting from close to the grip of the knife (1), the blade is moved down along the steel from the steel's tip towards the handle. During this movement the edge slides in its full length over the steel. This move is performed several times on both sides of the steel (2), thus polishing both sides of the edge of the knife (3).

Knives must be kept clean and dry and should also be **stored safely** and visible to avoid accidental injuries to workers (Fig. 391).

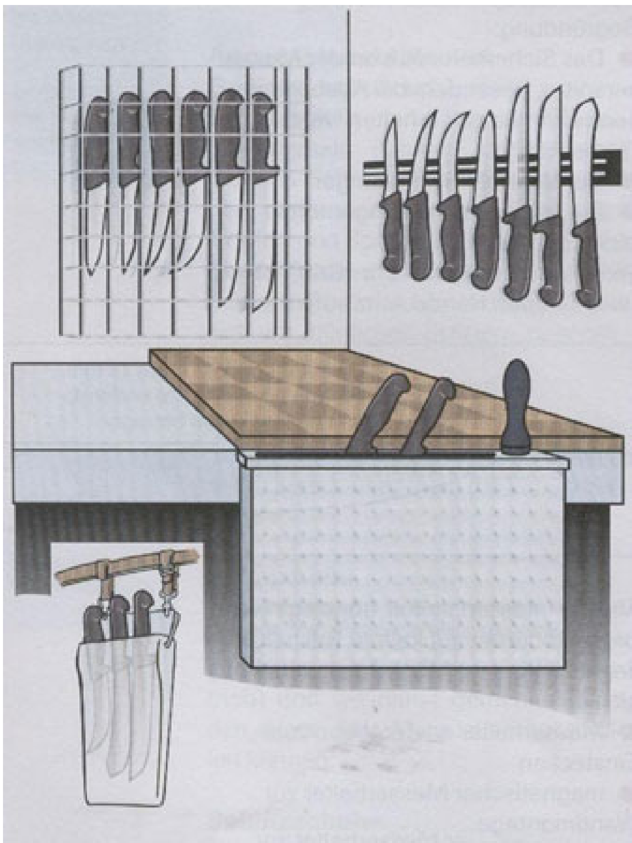


Fig. 391: Options for storing knives

Hooks used in the meat sector

In general, two types of hooks are essential for smooth operations in the meat sector. Slaughterhouse or **carcass hooks** are used for moving and hanging of carcasses. Their design depends on the type of rails (tubular, flat bar) installed. These heavy duty hooks are for sliding or moving on rollers along the rails and have a rotating lower hook part.

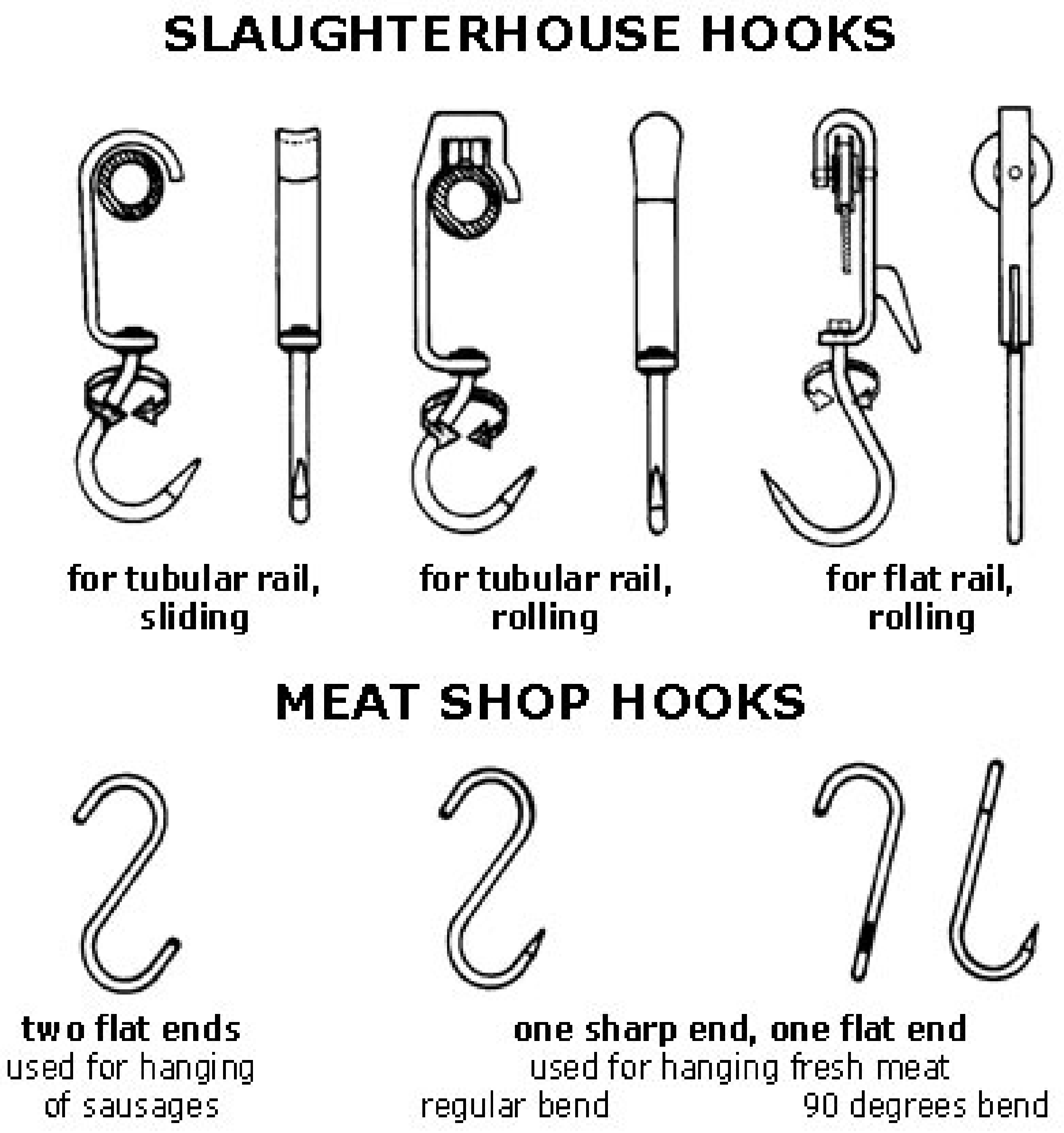


Fig. 392: Various hook designs used in slaughterhouses and meat shops

The **meat shop hooks** are used for hanging meat pieces or sausages. To avoid injuries during handling, the upper end of those hooks is always kept flat. A flat lower end is also used for sausage hooks, while meat hooks display a sharp tip which facilitates the penetration into the meat piece to be suspended.

Grinders and grinder plates and knives

Meat grinders are indispensable equipment in the meat processing industry and are part of practically every meat processing line. Meat processors must be familiar with this type of equipment (see page 18).

Installation:

Care must be taken that grinders are **positioned** properly. Most grinders have adjustable rubber feet. This allows the horizontal levelling and avoids transfer of vibration from the machine to the table (small models) and floor (industrial grinders). The initial **electrical connection** to the power supply line should be done with an empty housing (auger / feeding worm and cutting set removed) for safety reasons. Industrial size meat grinders are usually driven by three-phase motors and the direction of rotation must be checked. When viewed from the front, the feeding worm must rotate counter-clockwise. The cutting set is attached to the feeding worm with the cutting edges of the star knives facing counter-clockwise. Before starting the machine for the first time, all parts must be thoroughly cleaned and dried. A useful option often used by meat processors, is to run some clean fat through the system to make sure that remains of grease are removed from the housing and the cutting set.

Operations:

Apart from the need for frequent cleaning (see page 379), the cutting system of grinders has to be **assembled** and **dismantled** at various times per shift or day to be adjusted to the desired particle size. Care must be taken of the following:

- The grinder plates must be frequently checked for any damage to the surface, as a clear cut is only possible when the grinder plates are kept smooth. If damage such as grooves or scratches appear, the grinder plates must be planed (reground) immediately.

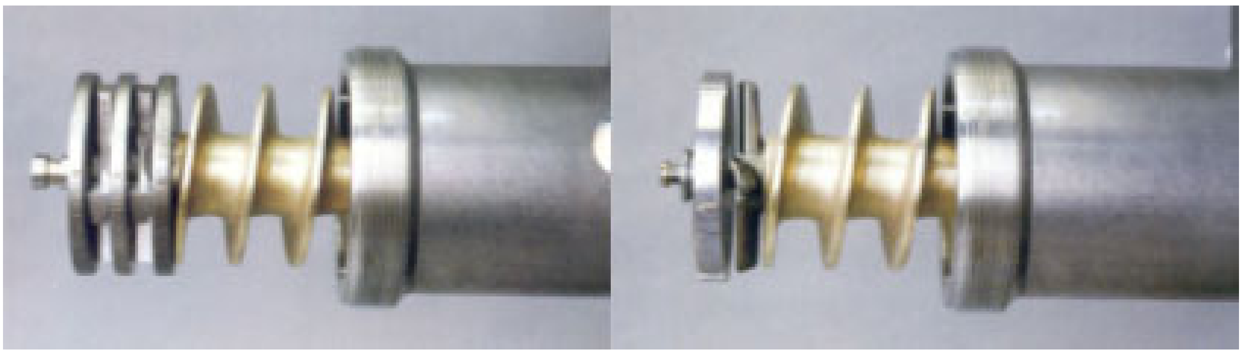


Fig. 393: Cutting sets in meat grinders, assembled on feeding worm (auger)
Left: UNGER five-piece cutting set Right: ENTERPRISE two-piece cutting set

- The star-knives (cutters) must also be kept sharp. Cutters are usually sharpened at the cutting edges. In systems with replaceable blades these blades are not sharpened but replaced regularly.
- Grooved grinder plates and blunt star-knives result in poor cutting (mashed ground meats).
- Parts from different cutting sets must not be mounted together, as they might be made of materials of different hardness. This can result in grooved grinder plates or damaged star-knives.
- The cutting assembly must never be over-tightened to avoid excessive friction heat and undesirable heat transfer to the meat.
- A grinder should never run empty as this will damage the knives and blades.

In industrial-size grinders, the electrical motor and driveshaft are connected via V-shaped belts. These belts usually require little servicing. Care must only be taken that the belts are kept at the correct tension. If the belts are not sufficiently tightened they show increased wear, excessively tightened belts lead to increased power consumption and could cause damage to the motor or driveshaft.

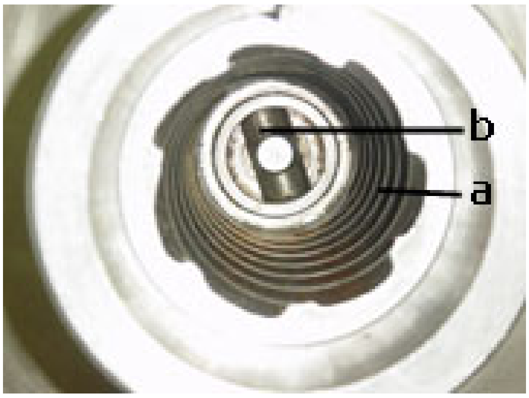


Fig. 394: Feeding auger housing: Critical areas for cleaning are the threat (a) in the housing and the connection point of feeding worm and drive shaft (b)

Cleaning:

Ginders are normally used for mincing raw fresh meat and other animal tissue. Meat grinders and their cutting parts must therefore be **cleaned and disinfected frequently -** during or at the end of each production cycle in order to maintain a good hygienic status. The most critical spots for cleaning are inside the barrel (feed auger housing). Any meat materials or fats left in the grooves of the thread must be removed by hand, followed by thorough flushing and brushing until all residues are washed out.

The driveshaft pin, where the feeding auger is interlocked, must also be brushed and flushed with plenty of water. The use of a high-pressure water cleaner is discouraged here, as this could damage the rubber seal in which the driveshaft pin rotates. After cleaning, the barrel should be dried properly, also to avoid metal corrosion.

Cleaning of grinder plates provides a special challenge for responsible staff as care must be taken that the many holes are totally free of impurities. This is very difficult in discs with tiny holes for smaller particle sizes. If a high-pressure water cleaner is available, it should be used.

Bowl cutter

Most meat processing lines include a bowl cutter as these machines allow improved processing ("comminuting") and production of a greater variety of products. Bowl cutters are available in different sizes from single-phase table models for small-scale butcheries and restaurants to bigger three-phase models for medium to larger industries (see page 20). The **basic maintenance requirements** are the same for all models.

Installation:

Small table models operate on single-phase electrical power. The equipment is usually positioned on a suitable working table. The operator has to make sure that the knives are installed in the right position and securely tightened (see page 21). Upon connection to the power supply, the bowl cutter is operational. Other details are similar to bigger models and are explained in the following paragraphs.

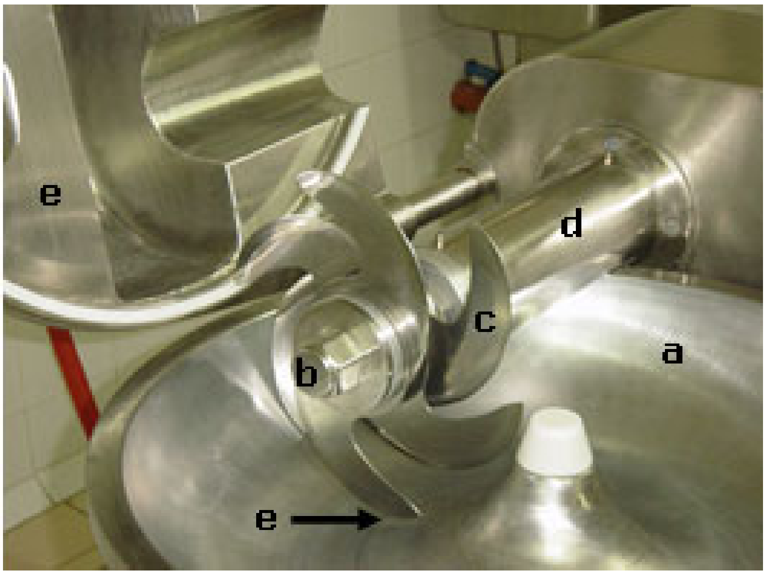


Fig. 395: Standard design bowl cutter:
a = bowl, b = knife head, c = knife,
d = knife shaft, e = clearance between knife from bowl

Bigger bowl cutters (**floor models**) need to be positioned with the rim of the bowl levelled horizontally, using the adjustable rubber-feet. The rubber feet should not be replaced by metal bolts, as they facilitate the smooth running of the bowl cutter.

The **knives** (blades) (Fig. 395c) are inserted following the recommended scheme (Fig. 396) and must be tightened firmly. Care must be taken that the knife head (Fig. 395d) rotates freely in the bowl and cover (always rotate one initial round by hand) and all knives have a sufficient but not too wide clearance (1-2 mm) from the bowl (Fig. 27, 395e). After a few rounds at slow speed, the knives must be tightened again firmly. To avoid unnecessary vibrations from the knife head, bowl cutter knives should be balanced (equilibrated). In bigger bowl cutters with large knives, special balancing sets are used.

The following knife assemblies are common:

Bowl cutters up to 100 litres
- 3 knives – coarse products, partly frozen materials
- 4 knives – coarse products, fresh soft materials
- 6 knives – finely chopped products, pre-ground meats

Bowl cutters above 100 litres
- 4 knives – all coarse products
- 8 knives – all finely chopped products

The tension of the **drive belt** should also be checked. A correct tension

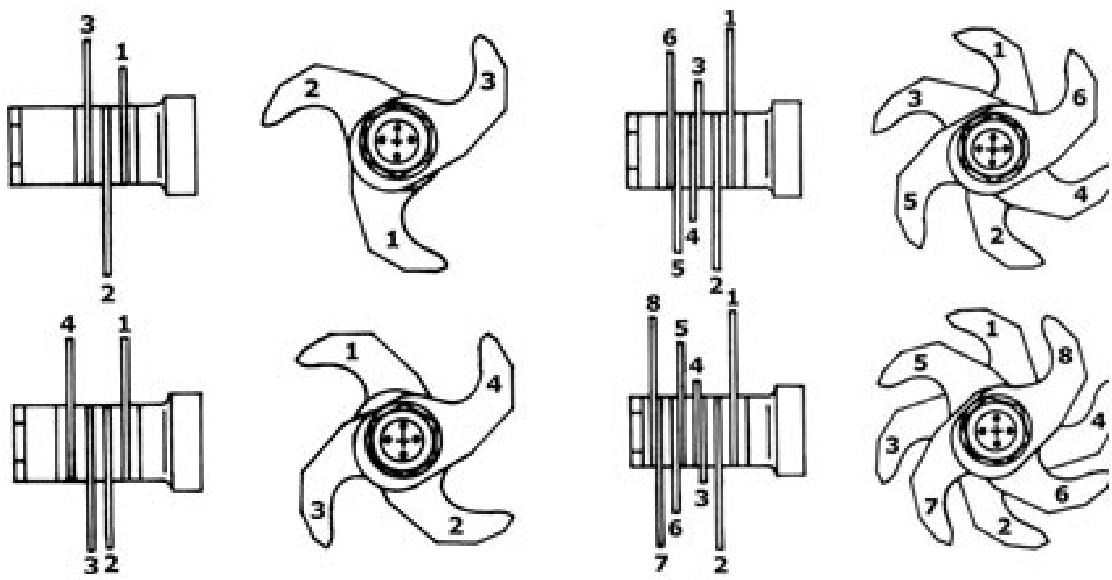


Fig. 396: Different bowl cutter knife settings, with typical cutting sequences
Left top: 3 knives, cutting sequence 1-3-2
Left low: 4 knives, cutting sequence 1-3-2-4
Right top: 6 knives, cutting sequence 1-3-5-2-4-6
Right low: 8 knives, cutting sequence 1-5-3-7-2-6-4-8

is achieved when the belt can be manually pressed down between its two fixations only as far as the thickness of the belt itself. A weak tension of the belt will cause premature wear and insufficient drive force. If the belt tension is too strong, it can cause damage to shaft and bearings. The maintenance manual by the equipment manufacturer should always be checked for details.

Operation:

Care must be taken that no metal or other hard materials accidentally find their way into the bowl cutter. It is advisable to frequently check all bolts, nuts and screws, especially around the cover. The **cut-out safety switch** must be checked regularly to ensure that the knife shaft brake stops the machine immediately if the cover is erroneously opened during operations. The **built-in thermometer** should also be frequently checked as it could get damaged by vibrations.

All lubrication points (grease nipples) (Fig. 397) have to be greased following the instructions given by the equipment manufacturer and oil changing intervals must be observed. As a rule of the thumb, the knife shaft (Fig. 395d) is usually greased monthly and the motor shaft six-monthly. The oil in the gear assembly (gear box) should be changed yearly.

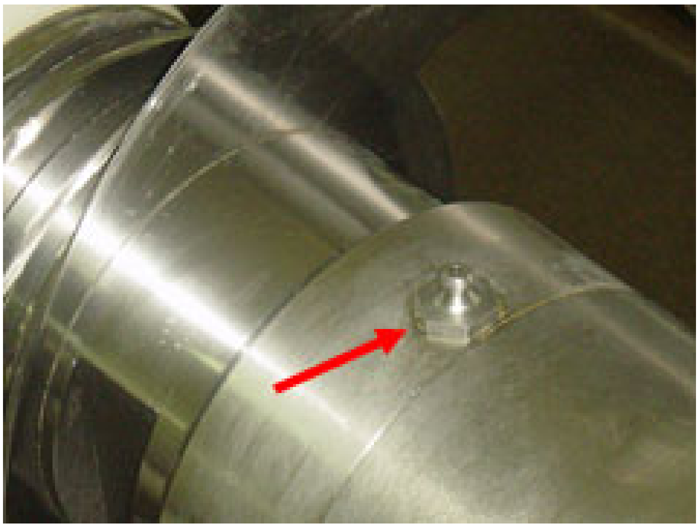


Fig. 397: Grease nipple on knife shaft housing

Cleaning:

Special care must be taken during cleaning. The ***spaces*** between the knives (Fig. 398) must be properly cleaned to remove all residues of batter mixes. A brush with long handle should be used to avoid injuries. A critical spot for cleaning is the ***narrow gap*** between the rotating bowl and the housing of the knife shaft (Fig. 399) as well as the paddle on the bowl cover (Fig. 400). The knife head should be dismantled regularly for proper cleaning (once a week) and reassembled following the instructions given before.

Moisture and defective seals in switches have a significant negative effect on the functioning of a bowl cutter. When high pressure cleaners are used, direct contact of the water jet with the switches must be avoided. The noise protection lids and front parts of vacuum covers are often made of transparent plastic and must be cleaned with mild cleaning agents to maintain their see-through appearance.

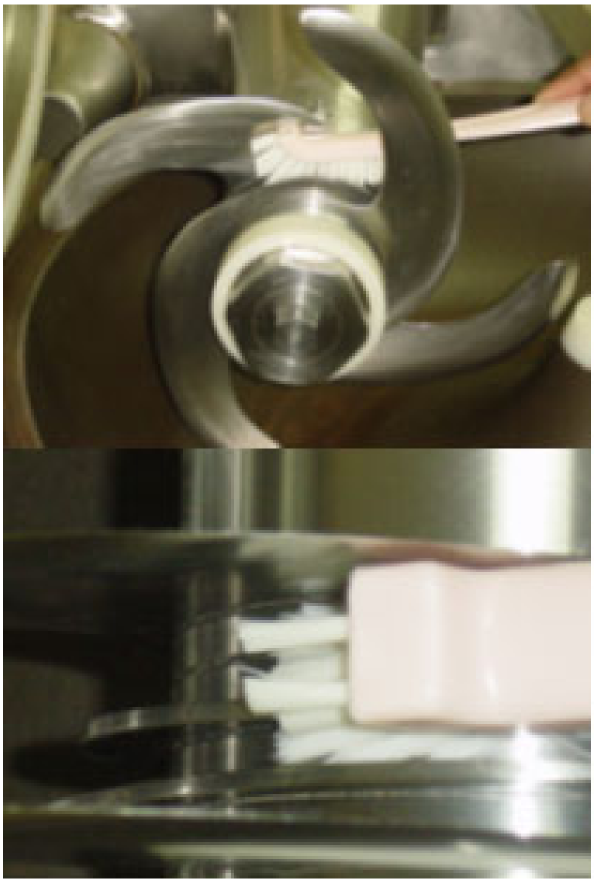


Fig. 398: Cleaning of spaces between knives with small brush

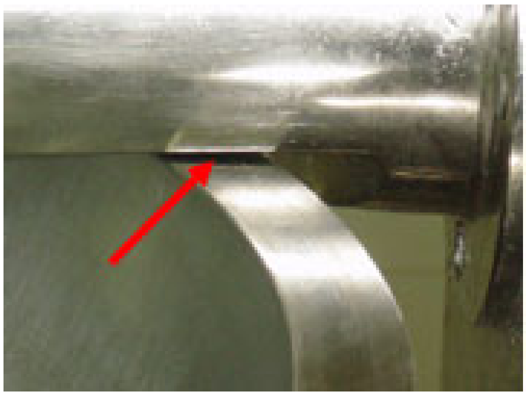


Fig. 399: Gap between bowl and knife shaft.

Fig. 400: Paddle on bowl cover with critical spot for cleaning

Sausage stuffer

A sausage stuffers is one of the core pieces of machinery for every meat processor. The different designs and sizes are described on page 22. In this context, the focus is on the **hydraulic piston stuffer** as this model is commonly used in small and medium enterprises. This type consists of a steel frame mounted stainless steel cylinder with a stainless steel piston. The piston is attached to a solid shaft, which is moved up and down inside the cylinder by hydraulic force. The top of the cylinder is covered by a horizontally sliding lid, which can be hermetically closed. Some models have the outlet opening for the stuffing funnels integrated in the upper edge of the cylinder, others attached to the lid (Fig. 401).

Installation:

Hydraulic sausage stuffers must be placed on an even floor. Before the machine is connected, the power supply with correct voltage (V), frequency (Hz) and power (kVA) must be confirmed. The oil level in the hydraulic tank should be controlled to avoid dry-running of the oil pump and ensure sufficient oil pressure development. In 3-phase (380 V) powered stuffers, it must be confirmed that the piston shaft is moving in the right direction. The piston must be mounted straight to allow smooth vertical movements in both an upward and downward direction.

Operation:

Before the start of each operation, care must be taken that the rubber gaskets are inserted in the piston and lid and funnels of the correct size are firmly attached (Fig. 401). The hydraulic oil must be checked regularly and topped up to maintain the required level. If the oil shows signs of wear (white emulsion-type content or water at the bottom of the tank) it must be replaced to avoid damage to the pump. Strictly avoided should be dropping the funnels on the floor to ensure that they fit neatly onto the outlet opening and maintain their smooth surface as scratches can lead to damaged casings.

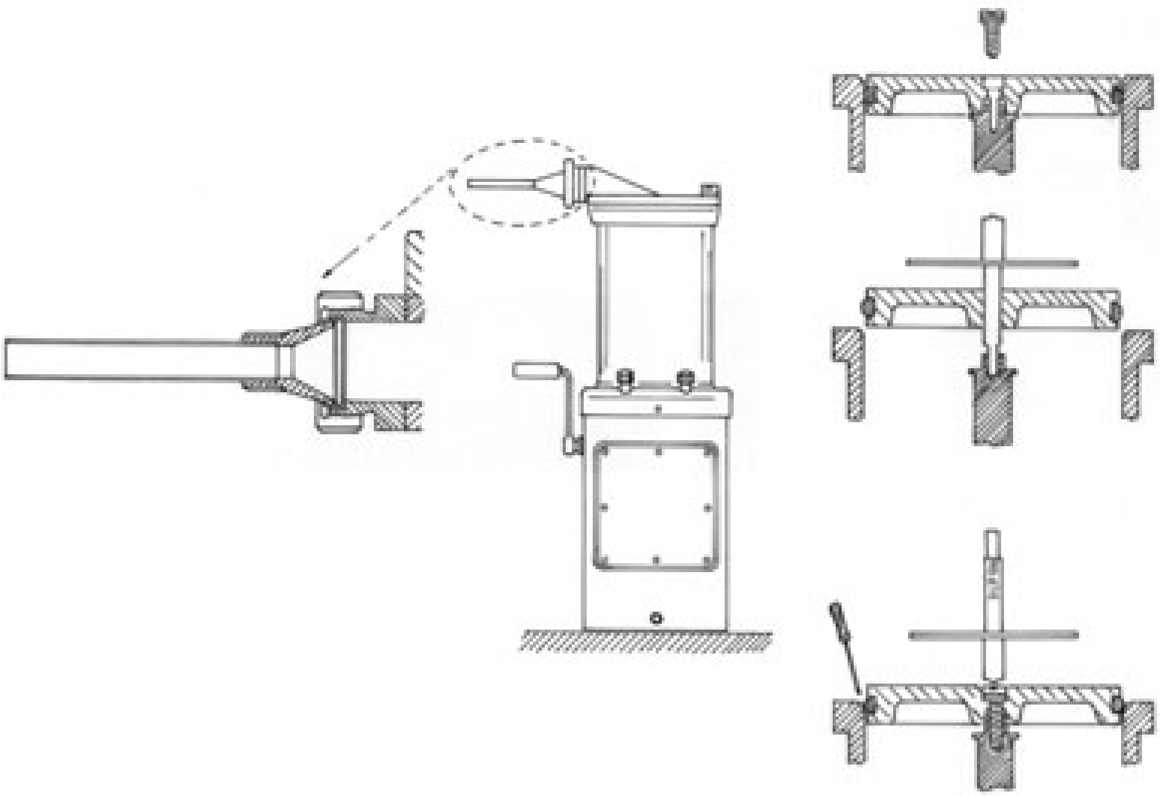


Fig. 401:
Left: Hydraulic stuffer **Piston stuffer type** **Funnel attached to lid**
Right: Removal and fitting of piston **top – removal of centre bolt** **middle – tool screwed in to press out piston** **below- tightening of centre bolt / fitting of piston**

Cleaning:

During cleaning the piston must always be removed to allow for thorough cleaning of the whole cylinder. The rubber gaskets must also be removed from the piston and cleaned as remains of sausage mixes could settle in the groove. An opening at the bottom of the cylinder allows the cleaning water to drain out. The funnels must be cleaned with a special brush. A simple method for cleaning the funnels is to first push a compacted wet piece of paper towel through the funnel (Fig. 402) to remove meat materials or sausage batter from inside. As this is a clean operation, such recovered meat materials can be recycled in the production. Wet cleaning is then carried out by using the funnel brush.

Fig. 402: Simple method to retrieve sausage batter from funnels before cleaning by means of a paper towel

Cooking vat

Cooking vats (Fig. 364) are used to **pre-cook raw materials** and **pasteurise meat products** (sausages, hams). In small scale facilities without piped hot water supply, cooking vats are also used to **heat up the cleaning water**. When cooking vats are not used, stagnant water must be avoided by keeping the water outlet open.

In gas and oil fired vats, burner elements and ignition flames must be frequently checked and cleaned. Most cooking vats are equipped with a thermostat, which needs to be monitored to confirm its readings. During cooking the sensor of the thermostat must be completely covered by water to avoid damage and wrong temperature reading. Cooking vats should never be heated up without a sufficiently high water level to avoid damage to the stainless steel shell.

Band saw

In most meat shops and meat cutting operations, band saws are used to facilitate the **breaking of carcasses**. In meat processing operations, band saws can also be helpful for **cutting of frozen meats**. Band saws are available as table and floor models and are made of stainless steel (Fig. 403). The band saw blade moves mainly inside the body (Fig. 404) by rolling over two large wheels. Only a small portion of the rotating blade is exposed just above the band saw table on which the material to be cut is moved.

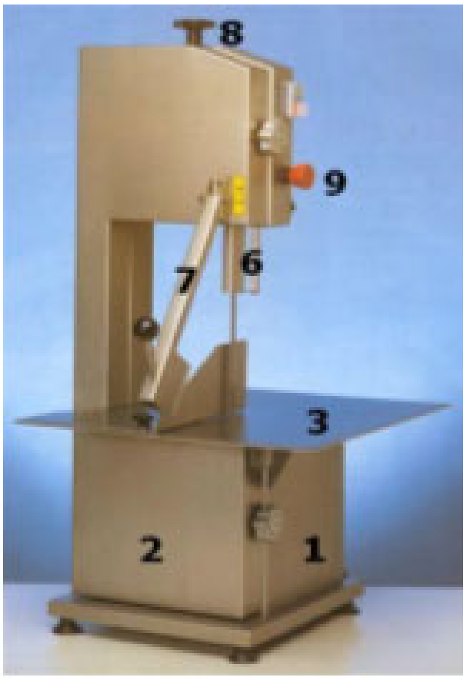


Fig. 403: Band saw closed
1 – stainless steel body
2 – stainless steel door
3 – stainless steel table
7 – safety cutting handle

Fig. 404: Band saw open
4 – adjustable tensioning wheel
5 – drive wheel (connected to motor)
6 – band saw blade guide
8 – tensioning knob
9 – emergency switch

Installation:

After being positioned at its designated place and levelled, the band saw must be assembled carefully. The body door (Fig. 404) (2) is opened and the band saw blade is pushed over the two wheels with the cutting teeth facing the door opening and fitted into the guide. By adjusting the upper wheel (4) with the tensioning knob (8), the tension of the blade is corrected to allow for a firm grip between wheels and blade. The band saw must be connected properly to the electrical power supply line. Care must be taken that the band saw blade rotates in the right direction, with the blade moving downwards at the exposed portion. The materials to be cut will be kept firmly on the table in this direction only (3).

During cutting operations, the material to be cut must always be moved on the table by using the safety cutting handle (7). The band saw must be cleaned frequently and disinfected at the end of daily operations. First the door is opened and the tensioner of the band saw blade released. The blade is taken out of the machine and cleaned separately and must be stored in a dry and safe place. All meat, bone and fat particles which have accumulated inside the space where the blade circulates must be removed and the machine cleaned thoroughly. The door should be kept open to avoid corrosion due to moisture.

Smokehouse

Simple smokehouses (Fig. 37, 41) do not require much maintenance. Care must be taken that the **sawdust tray** and **ash collector** are emptied and cleaned frequently. The **smoke sticks** and **ceiling of the smokehouse** must be kept free of tar to avoid unwanted tar-spots on the smoked products. The built-in exhaust opening, often equipped with a blower, must be cleaned frequently to avoid tar dripping onto the products.

More sophisticated smoking chambers follow various designs and can be equipped with a variety of additional fixtures and appliances. They need to be handled, cleaned and maintained according to the handbook provided by the supplier. For details on technical systems see pages 24, 25.

Equipment for personnel

The provision of hygienic equipment and personal protective equipments essential to prevent contamination of meat and meat products through contact with clothes, shoes or direct contact with hands or breath (see also chapter on Meat Processing Hygiene page 339). Some appliances and protective clothes, boots etc. also serve to protect **workers** from accidents.

<u>Hygienic equipment and materials:</u>

Protective clothing (Fig. 405) – To avoid contamination of workplaces, materials and products from street clothes, workers have to wear clean protective clothing. Either one-piece overalls or two piece sets are recommended as they cover the complete body. In some workplaces only overcoats are used with the disadvantage that the trousers/skirt is not covered.

Head gear (Fig. 405) – Human hair on equipment, materials and products must be avoided. Caps and/or hairnets are used to cover and contain hair.

Gloves – In meat processing, staff are encouraged to wear latex gloves to avoid direct contact of materials and products with hands. This is of special importance during packaging, when also mouth protection is recommended to avoid contamination of fresh and processed products (Fig 461, 462).

Gum (rubber) or **plastic boots** (Fig. 405) – These boots are used to protect staff in meat operations from moisture. The sole design facilitates a firm grip on slippery surfaces. For easy detection of dirt, boots are usually white.

Plastic aprons (Fig. 406) – This type of apron is used to protect workers and their working clothes from moisture, meat and fat. Plastic aprons should be long enough to overlap the boots, thus allowing splash water to rinse off.

Fig. 405: Basic protective clothes: gum or plastic boots, white overall, hairnet

Fig. 406: Plastic apron

<u>Appliances for safety reasons:</u>

Safety aprons – Almost 50% of all injuries (Fig. 407) in meat operations are caused by knives. Most of these occur during deboning when the knife is moved towards the body. To avoid such injuries, special safety aprons should be used, covering the front of the body. Safety aprons can consist of a tight mesh of stainless steel rings or overlapping aluminium chips. To avoid unnecessary meat and fat settlements in the mesh, the safety apron is worn under a plastic apron (Fig. 409).

Fig. 407: Risk of severe injuries without the glove

Fig. 408: Safety helmet made of hard plastic, with easy to clean inside fittings

Fig. 409: Protective appliances: anti-cut glove and apron (should be worn under the plastic apron to avoid contact with meat and fat pieces)

Safety gloves – To avoid injuries to the hand handling the meat material during deboning and cutting, a safety glove is highly recommended for this hand. These gloves are made of a tight mesh of small stainless steel rings and should be chosen long enough to also cover the wrist. To avoid unnecessary meat and fat residues in the mesh, the glove can be covered with a latex glove (Fig. 407).

Safety helmets – In workplaces where there is a risk of objects falling, staff are encouraged to wear safety helmets made of firm plastic. Helmets are strongly recommended are slaughter lines, below overhead rails and in storerooms with high shelves (Fig. 408).

Small tools

Fig. 410: Knife scabbard, made of stainless steel sheet, two-piece design for easy cleaning

**Fig. 411: Burger moulders:
Design 1: plastic device with simple kitchen compacter
Design 2: food-grade aluminium former with integrated compacter**

Fig. 412: Manual funnels for stuffing of larger calibre sausages, made of food-grade aluminium

**Fig. 413: Various stainless steel containers (from left to right):
Meat loaf moulders, large calibre sausage shaper, ham mould block, ham mould oval**

Fig. 414: Ham moulds of different shapes

Fig. 415: Meat loaf moulds

SIMPLE TEST METHODS FOR MEAT PRODUCTS

The application of quality control on a regular basis is regarded as necessary for all types of meat plants. Although small meat plants will not have special quality control (QC) staff and laboratories this should not impede regular quality and hygiene control.

Guidelines are provided hereunder on how to organise and implement quality control measures, that can be performed by skilled staff without a specialized laboratory. Although the described test methods are simple and will in some cases only provide approximate results, they may help to improve the quality of products and quality consciousness of staff and good manufacturing and hygienic practice in general.

In this chapter simple methods of
- sensory evaluation
- physical
- chemical and
- microbiological

testing are described.

Sensory evaluation

Sensory evaluation is a common and very useful tool in quality assessment of processed meat products. It makes use of the senses to evaluate the general acceptability and quality attributes of the products.

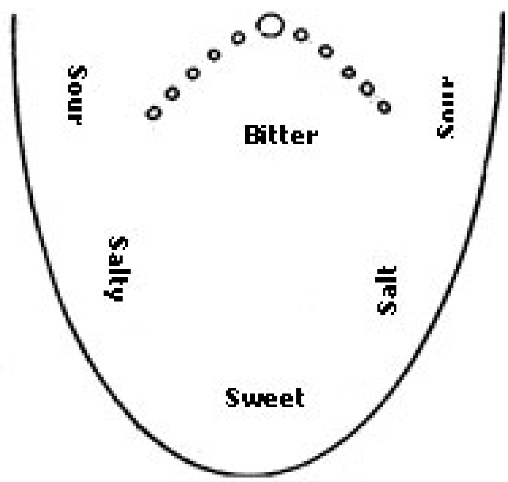


Fig. 416: Areas of the tongue where taste buds and reception areas for different tastes are located

- *Sense of sight* is used to evaluate the **general appearance** of the product such as **colour**, **size**, **shape** etc.
- *Sense of smell* for the **odour**
- *Sense of taste* for the **flavour** which includes the four basic tastes **sour**, **sweet**, **bitter** and **salty**
- *Sense of touch* for the **texture** either by mouth feel or finger feel.

In the simplest way of sensory testing, the meat processor, possibly assisted by other staff, will test a product's **colour**, **smell**, **taste** and **texture** upon manufacture. In a more sophisticated approach a team of trained panelists can be used in order to make the results as objective as possible. For this purpose it is useful to have an appropriate **testing room** available with lights, temperature and seating arrangements with individual testing compartments so as not to distract the members of the panel (Fig. 417).

Fig. 417: Sensory evaluation panel

As an ideal arrangement the **panel** is composed of ten well trained panelists usually employed in the meat processing plant. If ten panelists are not available, a smaller panel can also produce good results provided the panelists are knowledgeable at sensory testing. It is obvious that for reliable test results the panelist need relevant instructions and some experience in the food sector. Only people with good sensory capability, should be chosen in order to find out differences in colour, texture, flavour and taste.

All panelists must use proven and identical test methods in order to make their results comparable. Each panelist involved in such tests is given a scoresheet, where they mark their findings. Scoresheets of the team of panelists are evaluated and a test result for each individual product is produced based on multiple observations.

Common test methods used in sensory evaluation are:

1. **Paired comparison test for simple difference** where two coded samples are presented to the panelists for evaluation on simple difference (Fig. 418).

2. **Triangle test** where three coded samples are presented at the same time, two are identical and the third is odd and the panelist is asked to identify the odd sample (Fig. 419).

3. **Hedonic scale rating test or acceptability test** where samples are tested to determine their acceptability or preference (Fig. 420).

Fig. 418: Score sheet for Paired-Comparison Test for Simple Difference

Name:	Product:
Panelist No.:	Date:

Instructions:
You are given a pair of coded samples. Indicate if there is a difference between them by placing an x mark under the appropriate column. Please write down any comments.

SAMPLE PAIR CODE	THERE IS A DIFFERENCE	THERE IS NO DIFFERENCE

Comments:

Fig. 419: Score sheet for Triangle Test

Name:	Product:
Panelist No.:	Date:

Instructions:
You are presented with three coded samples of _____________. Two of these samples are identical while the third is odd or different. Smell and taste each sample. Indicate the code of the odd sample by placing an x mark across the code. Please write down any comments.

SAMPLE CODE	ODD SAMPLE

Comments:

Fig. 420: Score sheet for hedonic-scale rating test

Name:		Product:	
Panelist No.:		Date:	
Instructions: Taste the given samples, then place an x mark on the point in the scale which best describes your feeling.			
SCORE*	SAMPLE CODE		
(9) Like extremely			
(8) Like very much			
(7) Like moderately			
(6) Like slightly			
(5) Neither like nor dislike			
(4) Dislike slightly			
(3) Dislike moderately			
(2) Dislike very much			
(1) Dislike extremely			

* Note: Numbers in parentheses are to be assigned during data analysis and are not to appear in the score sheet.

Tests for simple difference and the triangle test are very useful methods for quality control and product development. Newly formulated products can be evaluated by determining if a simple difference exists between the new products developed and the old ones. Similarly, the hedonic scale rating can be used for internal factory testing, and this method is also suitable for market research by determining the consumer's acceptance or preference for certain products.

Physical test methods in meat processing

With physical test methods important parameters such as **temperature**, **acidity** (pH), **water activity** (a_w) and **water binding capacity** can be determined. Other physical parameters are **light intensity** and mechanical testing for **texture**. All routine physical testing can be carried out with portable instruments.

Electronic thermometer (Fig. 421, 422, 423)

Temperature measurement with thermo-elements/thermocouples is based on the thermo-electrical effect. The following is the physical principle:

In a closed circuit composed of two (amalgamated) metals (e.g. Ni and CuNi) an electric current is generated, if the welding points of the two metals are exposed to different temperatures.

The electronic thermometer functions according to this principle. On one welding point of the thermocouple the reference temperature is taken. The other welding point is the tip of the metallic thermo-sensor of the instrument, which is exposed to the temperature to be measured. Both welding points are of different temperature, which generates the electric current within the system. The electric tension (voltage) is equivalent to the temperature difference between the two points and can directly be translated into the temperature reading on the instrument.

Fig. 421: Compact digital thermometer

The welding point for the reference temperature is located in the instrument. For the correct functioning of the system, the reference temperature must be at a constant level. The temperature of 0°C is taken for reference. Even though the instrument is exposed to various temperatures, the reference temperature is electronically set constantly at 0°C regardless the ambient temperature.

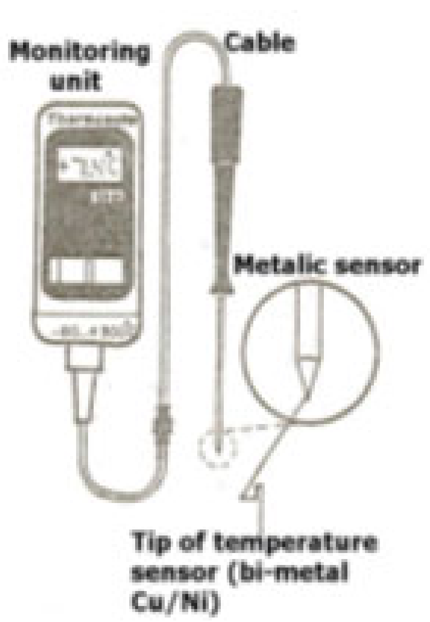


Fig. 422: Electronic thermometer (digital)

Fig. 423: Electronic thermometer. Measurement of temperature of meat batter during comminuting

Important temperature control points are:

- Refrigerated rooms (freezer -18°C to -30°C, chiller 0 to +7°C)
- Chilled meat (+4 to +7°C)
- Cutting rooms (+10 to +15°C)
- Curing rooms (+5 to +10°C)
- Water temperature in cooking vats (+75 to +78°C)
- Core temperature in meat products upon cooking/pasteurization (approx. +68/72°C)
- Core temperature in meat products during sterilization[1] (above +100°C)
- Sterilization temperature in autoclaves (above +100°C)[1]

Non-contact infrared temperature measurement

Physical principle: Each object which has a temperature higher than absolute zero (= -273 Kelvin), emits energy in the form of infrared radiation. The energy released can be measured through special optical sensors and directly indicated as the temperature of the object.

With infrared thermometers, temperatures are measured without direct contact of a temperature sensor with the medium to be tested. Infrared thermometers have a built-in laser pointer. The light spot emitted by the instrument onto the surface to be tested indicates the area of measurement. Due to this principle, the system allows the measurement of the surface temperature only, not of the internal temperature.

Infrared thermometers are well suited for screening tests, e.g. temperature of incoming meat or of goods in chillers and freezers. The method can also be applied for moving objects. In meat processing, it can be used for measuring the temperatures in frying pans, ovens etc. For temperature measurements of frozen goods in boxes, measurements on the outside of the box are not reliable and the boxes must always be opened. Surfaces with strong light reflection will also provide inaccurate results.

For exact temperature measurements in meat and meat products, e.g. for temperature testing within internal plant control systems such as HACCP, electronic temperature measurement remains the method of choice.

---

1) Temperature control carried out with specific systems to be inserted in cans or autoclaves, portable electrical thermometer are not suitable for this specific purpose.

Data-logger for temperature measurement

These are electronic instruments without a monitor but with built-in device for saving data. The data-logger measures temperature within certain periods (e.g. every 10 or 30 minutes etc.) and saves it. Data-loggers can be used in refrigerated rooms. For this specific purpose they can be equipped with sound alarm systems in the event of exceeding temperature limits. Another application is for measurements within foods, such as frozen goods or even during the sterilization of canned goods. The data saved in the logger can be evaluated using a computer.

pH meters (Fig. 424, 425)

Portable instruments are battery driven and have glass electrodes. The pH–value in meat and meat products can be measured by direct contact between the sensitive diaphragm of the electrode and the meat tissue. Through the diaphragm differences in electrical load between the meat and electrolyte solution (e.g. Potassium chloride KCl) inside the glass electrode are measured and directly indicated as the pH-reading. In raw fresh meat, it is recommended to spray small amounts of distilled water onto the tissue at the point of measurement (prior to inserting the electrode), because the operation requires some fluidity in the sample and the glass electrode should be thoroughly wet. The amount of water necessary will not appreciably alter the pH. For accurate pH readings the pH-meter should be calibrated before use and adjusted to the temperature of the tissues to be measured. The electrode must be rinsed with distilled water after each measurement.

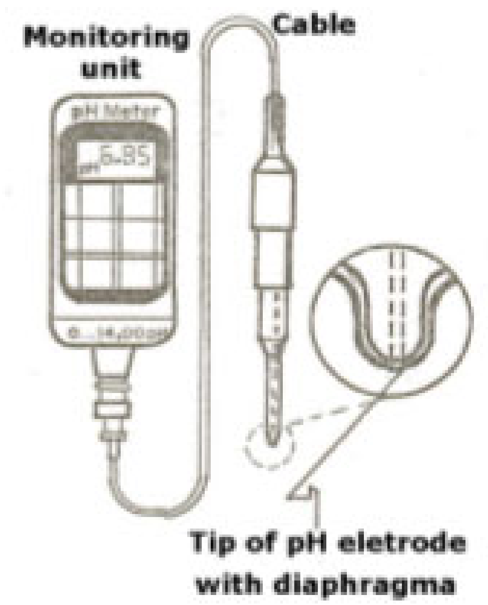


Fig. 424: Portable pH-meter for direct measurement in meat

Fig. 425: pH meter. Inserting glass electrode in meat tissue

The pH is a measure of the acidity or alkalinity in solutions or water containing substances. pH values lower than 7 are considered acidic, while pH values higher than 7 are considered alkaline. A pH of 7 indicates neutrality. pH values are related to the concentration of hydrogen ions (H^+) in the substance.

Typical pH values for meat and meat products are:

Product	pH value (range)
Meat mixes in jelly + vinegar added	4.5 to 5.2
Raw fermented sausage	4.8 to 6.0
Beef	5.4 to 6.0
Pork	5.5 to 6.2
Canned meats	5.8 to 6.2
Curing brines	6.2 to 6.4
Blood sausages	6.5 to 6.8
Muscle tissues, immediately after slaughter	7.0 to 7.2
Blood	7.3 to 7.6

pH measurement is useful for:

- Evaluation of meat quality for further processing, in particular the water binding capacity
- Control of ripening of raw fermented products, which is connected with drop in pH
- Control of acidity of ingredients such as brines, marinades etc.

Hygrometers (Fig. 426)

Hygrometers measure the relative humidity and are used in production and storage rooms of the meat industry.

Recommended values for the relative humidity are:

Meat boning and cutting rooms	45% to 60%
Meat packaging rooms	45% to 60%
Chilling rooms	85% to 95%
Storage / ripening rooms for meat	70% to 85%
Ripening rooms for raw fermented ham and sausages	80% to 95% (depending on the stage of ripening)

Relative humidity is the ratio of the existing (absolute) vapour pressure of water in air to the saturation vapour pressure (= maximum amount of water vapour that can be held) in air of the same temperature.

Fig. 426: Hygrometer. Measurement of rel. humidity in meat chiller

Example:
Air at 20°C can hold 17g of water vapour per m^3 (water vapour content at saturation). If the water (vapour) present in the air of 20°C at a given moment is 9g per m^3 (absolute water vapour content), the calculation for the relative humidity is as follows:

$$\frac{\text{absolute water vapour}}{\text{water vapour at saturation}} \times 100$$

or

$$\frac{9 \times 100}{17} = 53\% \text{ relative humidity}$$

A_W - meter (mechanical instrument) (Fig. 427, 428)

Besides sophisticated electronic instruments used for industrial production and research, there are simple mechanical instruments available for the measurement of the water activity (a_w) of meat products under practical conditions.

Water activity[1] is the term for the amount of free (not chemically or physically bound) water, which is available for the growth of microorganisms. This information is particularly important, as higher amounts of free water favour the growth of microorganisms, while lower amounts (drier products) result in less microbial growth. Bacteria usually require at least a_w 0.91 and fungi at least a_w 0.71.

The amount of free water in a product is equivalent to the air humidity produced by a product sample in a small enclosed system. This is the principle of the simple a_w-measurement method (Fig. 427, 428). The product sample is placed inside a hermetically closed small can-like container (Fig. 428). Through evaporation an equilibrium of humidity in the small airspace above the product and the humidity of the sample is build-up and this is directly measured by means of a hygrometer built into the lid of the instrument. Pure water (representing 100% free water) is equivalent to a_w-value of 1, all other food samples have lower a_w-values than 1 depending on their free water content.

---

1) a_w is defined as the vapour pressure of water of a substance divided by that of pure water at the same temperature.

Table 17: Typical a_w in meat products (left) and limiting a_w for the growth of microorganisms (right).

Product	a_w range	Microorganisms	a_w	
Fresh meat	0.99 (0.99 to 0.98)	Pseudomonas	0.93	Most bacteria between a_w 0.91 – 0.96
Cooked ham	0.97 (0.98 to 0.96)	E. coli	0.93	
Raw-cooked sausages	0.97 (0.98 to 0.93)	Salmonella species	0.91-0.95	
Liver sausages	0.96 (0.97 to 0.95)	Listeria	0.93	
Blood sausages	0.96 (0.97 to 0.86)	Cl. botulinum types	0.91-0.95	
Raw-fermented ham	0.92 (0.96 to 0.80)	Cl. perfringens	0.93-0.95	
Raw-fermented sausages	0.91 (0.96 to 0.70)	Bacillus species	0.90-0.95	
Dried meat	0.70 (0.90 to 0.60)	Lactobacillus	0.90	
		Staph. aureus	0.86-0.90	
		Most yeasts	0.87-0.90	
		Most moulds	0.80-0.85	

Areas for a_w-control:

- Measurement of a_w is important during the ripening of dry fermented products to find out at which point the products remain stable at ambient temperature.
- The a_w plays a major role in meat preservation for dried products (dried meat, meat floss etc.), or for products where the microbiological stability is achieved through several factors, e.g. low a_w, low ph, and/or heat treatment (“hurdle effect”, see page 92).

Fig. 427: Set of two simple a_w-meters enabling simultaneous measurements of two samples

Fig. 428: A_w-meter with product sample to be tested, lid (has to be attached) with built-in hygrometer

Water holding capacity (WHC)

WHC plays a role in meat to be used for further processing (see page 7). It is also important in meat batters, which have to undergo heat treatment. Low WHC results in separation of jelly and/or fat during heat treatment (see page 131). The WHC can be measured using a glass compressorium (Fig. 429), where the sample of meat or batter is compressed onto a water absorbing sheet of paper. The larger the water infiltrated area on the paper, the poorer is the WHC of the meat/batter (Fig. 430).

Fig. 429: Compressing meat samples for determination of water holding capacity

Fig: 430: Low water binding (above), good water binding (below)

Lux – meter (Fig. 431)

This instrument is used to test and, if necessary, to adjust the intensity of artificial light in working places. During meat processing, normal working places should have at least a light intensity of 300 Lux and quality control / meat inspection places 500 Lux.

Fig. 431: Lux-meter
Light sensor and monitoring unit in one portable instrument

Instruments for texture measurement

Sensory testing (chewing) is normally sufficient to test tenderness/toughness or homogenous/fibrous structure of meat and meat products. If more objective results are desired, special instruments for texture measurement can be employed. The instrument shown in the photo, measures the shear-force necessary to cut through meat/meat products (Fig. 432, 433). Comparative texture measurements are usually taken from same tissues or products which were submitted to different treatments such as ripening, cooking etc.

Fig. 432: Instrument for texture measurement

Fig. 433: Measurement of shearforce

Simple methods of chemical analysis

(Protein, fat, water, ashes)

Chemical analyses to determine the content of **protein**, **fat**, **water** and **minerals** (ashes) of processed meat products (see also table 1) are carried out to establish the nutritive and economic value of the products. Samples of the meat product are finely ground and weighed accurately for each respective chemical analysis.

The determination of the **moisture content** (or water content) is done by drying an appropriate amount of the sample. The difference in weight between the fresh and dried samples represents the water content. For rapid determination of moisture content a microwave oven is useful (Fig. 434).

The **protein content** is determined at laboratory level by using the Kjeldahl method (Fig. 435), where meat products are digested by acid to obtain the nitrogen compounds and then distilled and titrated to determine nitrogen quantitatively, with which the protein component can be calculated. In a *simplified approach* protein is **not** chemically determined, but can be calculated (approximately) as the remaining component, after water, fat and ashes content has been determined and subtracted from 100%. This simple mathematical method should only be applied for pure meat and meat products as it is not accurate for highly extended products containing non-meat ingredients such as grains, starches or vegetables (see page 81). In the case of using meat extenders and/or fillers, the result reflects the organic non-fat component (protein and carbohydrates in %) of the product.

Determination of the **fat content** is the most complicated component of simple meat and meat product analysis, as analytical equipment (Soxhlet apparatus, Fig. 436) is needed. Samples for fat analysis are semi-dried before being subjected to ether-extraction using the Soxhlet apparatus. After complete extraction, the fat is obtained by evaporating and recovering the ether.

Fig. 434: Microwave oven
(for water)

Fig. 435: Kjeldahl distilling apparatus
(for protein)

Fig. 436: Soxhlet extraction apparatus
(for fat)

Fig. 437: Muffle furnace
(for minerals)

The defatted samples are then used for **ash** analysis by subjecting it to a temperature of +600°C in a muffle furnace for two hours. The weight of the ash is used to calculate the **minerals content** in % (weight of ash, divided by total sample weight, multiplied by 100).

Sampling and analytical procedures
Sampling of Meat and Meat Products

Step I. Grind the cold meat sample, minimum weight 500 gms. Use food grinder with 3mm plate opening.

Step II. Mix rapidly at a cold temperature.

Step III. Keep ground sample in glass or similar containers which are air and liquid tight.

Step IV. Ready for analysis. If any delay occurs, chill the sample to inhibit decomposition.

Step V. Weigh the sample as rapidly as possible to minimize loss of moisture.

Moisture Analysis
(Microwave Drying)

General:

Samples are dried in a microwave oven and the loss of weight upon drying is expressed as percent moisture content.

Application:

This method may be used to determine the moisture content of fresh meat, semi-processed meat, meat mixes and processed meat products.

Equipment:

Mincer with 6mm plates or heavy duty food processor.

Balance with at least 0.1g sensitivity.

Microwave oven with 600-700 watt microwave energy output, turntable and time accurate to 15 seconds.

Desiccators with silica gel.

Beaker

Filter papers, 7cm diameter or open weave disposable kitchen cloth.

Silicon carbide (carborandum) finely ground.

Sand or salt.

Approximate Drying Times for Sample Sizes of Meat

Sample size	Approximate Drying Time
3 x 10g	3.5 – 4.5 min.
3 x 25g	7.5 – 9.5 min.
2 x 50g	8.5 – 11 min.

Calculation:

Weight of beaker plus filter paper	=	A
Weight of beaker plus filter paper + sample (before drying) in grams	=	B
Weight of beaker plus filter paper + sample (after drying) in grams	=	C

$$\% \text{ Moisture} = \frac{(B-C)}{(B-A) = (\text{weight of sample})} \times 100$$

Method:

1. Prepare the sample by mincing or chopping as described in sample preparation.
2. Preheat the oven
3. Dry the beakers and filter papers by heating them in a microwave oven for one minute.
4. Determine the heating time necessary to completely dry the samples in the microwave oven.
5. Weigh an empty beaker plus filter paper. Weigh about 10 grams of sample in the beaker. For meat samples, spread the samples into a thin layer around the lower wall of the container with spatula or spoon. Place the filter paper over the top of the beaker and fold to close and accurately weigh the beaker plus filter paper.
6. Place the samples in the preheated oven. The samples should be spaced at equal distances around the turntable.
7. Cool the samples in a desiccator and accurately weigh the beaker plus dried samples plus filter paper.
8. Repeat drying until constant weight is obtained.

Crude fat determination using samples dried from the microwave oven:

1. Get the weight of the dried sample.
2. Put the dried sample inside the filter paper and fold to close.
3. Place the dried sample inside the soxhlet extraction tube connected to the soxhlet flask.
4. Pour enough ether into the extraction tube.
5. Extract for 10 hours, at 3-4 drops per second.
6. After extraction, take out the defatted sample from the extraction tube and air dry the sample for traces of ether. Dry further in an oven at 100°C and cool in a dessicator. Weigh the defatted cooled samples to constant weight.

Computation:

$$\% \text{ Fat} = \frac{\text{Weight of Dried Sample} - \text{Weight of Defatted sample}}{\text{Original weight of the sample}} \times 100$$

Weight of dried sample = weight of beaker + filter paper + dried sample **minus** weight of beaker + filter paper

Ash determination:

1. The defatted sample is placed in a constant weight porcelain crucible with cover.
2. The crucible is then placed in a muffle furnace, and at a temperature of 600°C the sample is ignited for two hours.
3. After ignition the crucible is placed in the oven to bring down the temperature for about 30 minutes, then cool in a dessicator for another 30 minutes.
4. The sample is then weighed to constant weight.

Computation:

$$\% \text{ Ash} = \frac{(\text{Wt. of crucible with cover + ash}) - \text{wt. of crucible with cover}}{\text{original weight of sample}} \times 100$$

Protein content determination:

Calculation of the approximate **protein content** for pure meat and meat products:

% Protein = 100% - (%water + % ash + % fat)

This calculation is not applicable for meat products that were extended.

Microbiological sampling and testing

The purpose of microbiological testing is to determine the **degree of bacterial contamination** on surfaces of equipment, tools, premises as well as in meat and meat products. This testing can be done *qualitatively* as microbiological screening, for example by ***contact*** such as using an impression plate or *quantitatively* by determining the exact number of microorganism per sample unit (in cm^2 or grams) by using the ***swab*** or the ***destructive*** method. Quantitative testing can be either determination of the entire contaminating flora, also called “**total plate count**” or determination of a specific group of microorganisms out of the entire flora, also called “**selective plate count**”.

a) Contact method (Fig. 438)

The microbiological culture medium is put in direct contact with the surface of equipment or tools to be tested (Fig. 438 a,b). Microbes contaminating the surface are removed from there as they adhere to the sticky culture medium. The culture medium containing the microbes from the test surface is incubated e.g. at 30°C for 2 days. Each bacterium grows as a bacterial colony visible to the naked eye. Colonies can be counted to allow assessment of the degree of contamination.

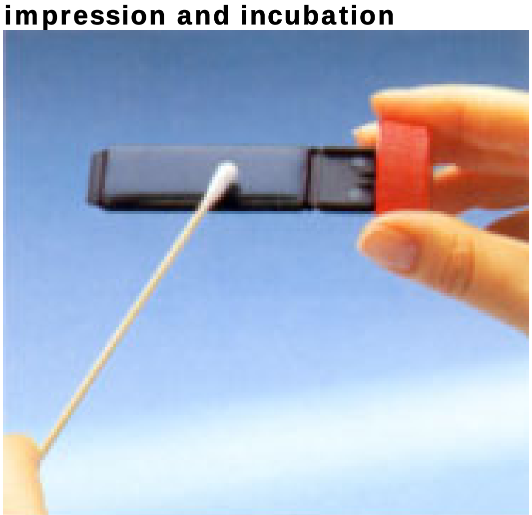
Advantage	:	Simple procedure, can be carried out without laboratory.
Disadvantage	:	In case of heavy contamination, colonies may overgrow/overlap and individual colonies are difficult or impossible to distinguish. Result in this latter case would be “heavy contamination”, but conclusion on the exact degree is not possible.

New commercially available systems for the contact plate technique facilitate the application and provide more accurate results. The culture medium is attached to a plastic chip, which has a flexible hinge for better handling. The test chip is placed in a fitting sterile plastic tube upon surface testing and incubated (Fig. 438c). Results are available after 24 hours when using incubation temperatures of 35-37°C. Areas not accessible for the direct impression, e.g. inside equipment, can be tested by using a swab, and the impurities gathered are transferred to the culture medium (Fig. 438d). The method allows approximate quantitative microbial testing by comparing the test results with reference microbial growth schemes provided by the supplier.

a) Impression on test surface (purple colour). Direct transfer of bacteria from test surface to culture medium (in petridish)

b) Testing of surface of meat processing equipment (above). Below left: Contact plate before impression. Below right: Contact plate after impression and incubation

c) Test chip for contact method in action. Plastic tube (behind) to cover test chip upon use



d) Transfer of sample from swab to culture medium (from area not directly accessible with test chip)

Fig. 438: Contact plate (impression plate) method

In this context, it should be mentioned, that **rapid control systems**, which provide immediate results on the cleanliness of surfaces, are based on detection of metabolic substances (ATP or NAD) originating from bacterial growth. The systems, which were developed to check the immediate effect of sanitation in large food industries, are of less relevance for small to medium industries and can be costly.

b) **Swab method** (Fig. 439, 440)

Contaminating bacteria are removed from the surface to be tested by using a sterile swab. Standardization by using a reference square area is needed (e.g. by sterile metal frame) (see Fig. 439). Microorganisms collected by the swab technique are rinsed off with sterile water (see Fig. 440). The microbial content of the liquid is tested.

Advantage	:	Even in case of heavy contamination, the number of microorganisms can be determined by applying dilution techniques (see page 335).
Disadvantage	:	Part of the contaminating flora may not be recovered, in particular in case of uneven rugged surfaces, e.g. meat.

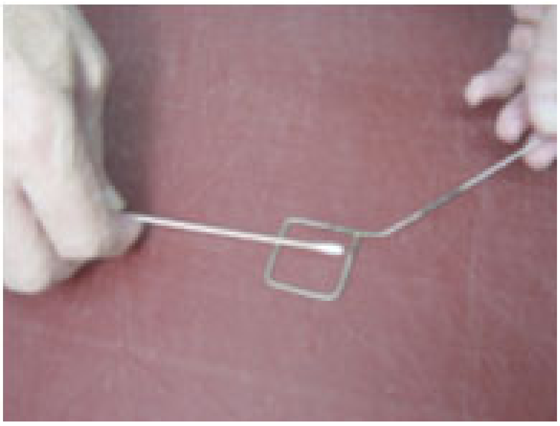


Fig. 439: Swab method. Bacterial collection with swab on cutting board.

Fig. 440: Swab method. Bacteria to be rinsed off with sterile water, transfer of solution on culture medium.

c) **Destructive methods** (for use on meat/meat products)

A standardized sample is cut out (“destructive”) from the surface of meat or meat products, for example by using a sterile knife and metal frame (Fig. 441, 442). The sample received, which has a defined surface area, is further standardized by removing tissue from the bottom layer until a standardized weight (e.g. 10g) (Fig. 443) is achieved.

Advantage : The testing includes all microorganisms present in the sample. Samples can be exactly standardized according to surface area (cm^2) or weight (g). The sample comprises not only superficial contamination, but also microorganisms from the interior of meat/meat products.

The meat sample is homogenized in sterile water by using laboratory equipment ("Stomacher") (Fig. 444). Transfer of homogenized solution on culture medium is by dilution techniques (see page 335).

Fig. 441: Determination of standardized sample

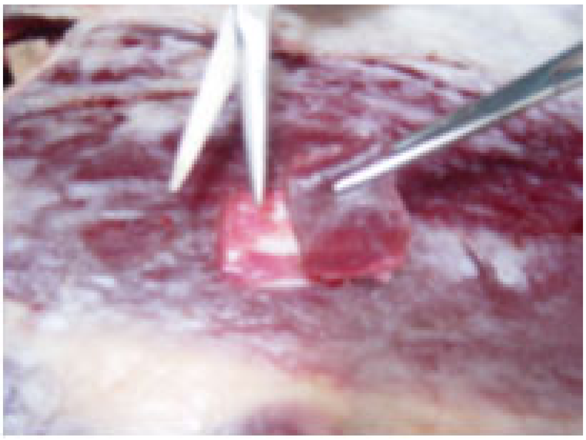


Fig. 442: Cutting out meat sample from carcass

Fig. 443: Trimming/weighing of meat sample

Fig. 444: Homogenizing meat sample (in "Stomacher")

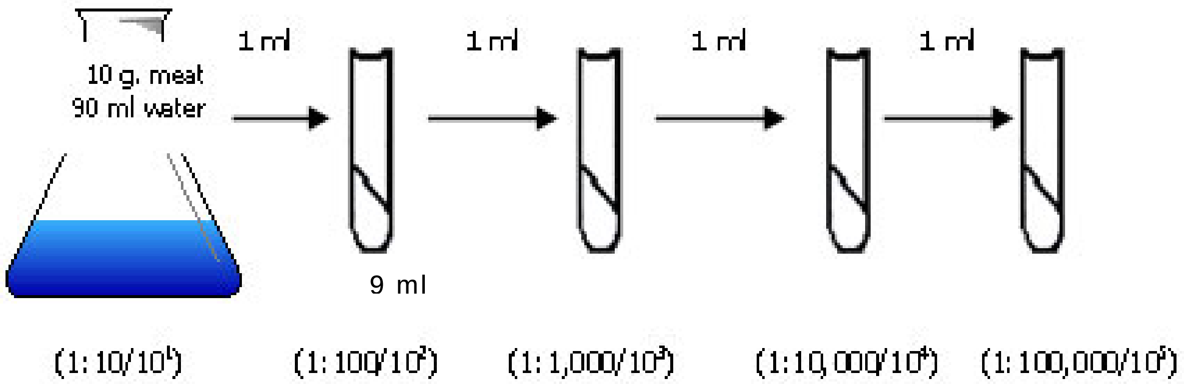
Microbiological Analysis

a) Total Plate Count (using nutrient agar)

For determination of the number of viable or living microorganisms in a sample.

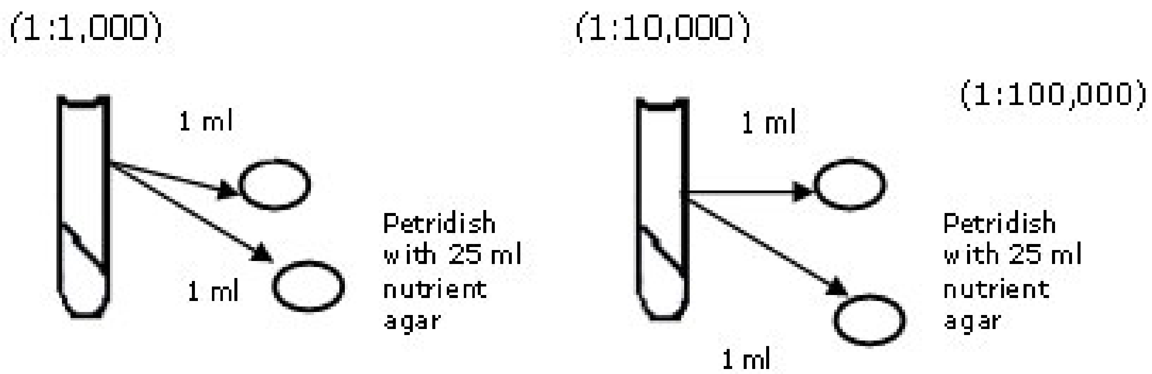
1. Meat sample (10 grams meat + 90 ml sterile distilled water or 0.1% peptone water). Homogenize in stomacher. First dilution.

2. Transfer 1 ml from first dilution (10^1) to second test tube (Test tube contains 9 ml. of sterile distilled water) (2nd dilution or 10^2) then from second test tube transfer 1ml to the third tube (3rd dilution or 10^3) and so on up to the 4th or 6th dilution.



3. Inoculate sample.

Pipette 1 ml from 3rd dilution and transfer to the sterile petridish, also from the 4th dilution to another sterile petridish depends upon how many dilutions are desired (see below and Fig. 445).



The inoculation is usually done according to the spread plate method. The diluted sample is released from the pipette onto the solidified agar and spread on the surface by means of a sterile bent glass stick. The alternative is the pour plate method, where the sample is first put into the Petri dish and 15 ml agar (liquefied in a water bath at 44-46°C) are poured into the plate afterwards. Agar and sample are thoroughly mixed by rotating the Petri dish.

4. Incubate for 12 to 24 hours at 35 to 37°C, alternatively 24-48 hours at 30°C.

5. Results

   Count all colony forming units (CFU), including those of pinpoint size (Fig. 446). Select spreader-free plate.

   a. normal plates 25-250 counts
   b. plates with more than 250 colonies for all dilution - too numerous to count
   c. plates with no CFU. Report as less than 1 times the corresponding dilution used.

Inoculation of sample and reading of results

Fig. 445: Inoculation of sample

Fig. 446: Reading of results from Petri dish

b) Selective Plate Count

The total plate count is a good indicator for the overall bacterial load of meat and meat products. Critical hygienic dimensions are reached when the total number of bacteria on fresh meat lays between 10,000 ($1,0x10^4$) and 100,000 ($1,0x10^5$) per g (see also page 353). However, the total number does not allow any conclusions on the nature of the microorganisms, i.e., if the bacteria are harmful or harmless.

Therefore, practicable microbiological standards should, in addition to the total plate count, always include the number of hygienically sensitive microorganisms, which can be used as an indicator for specific hygienic risks. These microorganisms are selected out of the total number of bacteria. This can be done using selective bacterial culture media, which contain chemical additives that suppress the growth of all bacteria except the group of microorganisms that shall be detected and used as indicator bacteria.

The indicator bacteria most commonly used is the group of **Enterobacteriaceae**. Enterobacteriaceae are part of the intestinal microflora, i.e. they are present in high numbers in the faeces of humans and animals. Most importantly, harmful food poisoning bacteria belong to this group e.g., pathogenic E.coli and Salmonella. If larger numbers of Enterobacteria are found in food, there is the probability of massive contamination with dirt or even faecal material with all the consequences, in particular presence of food poisoning bacteria.

The number of Enterobactericeae should not exceed 100 per cm for the criterion “good microbiological standard” (see also page 353). The selective culture medium used for the determination of Enterobactericeae is the Violet Red Bile Agar (VRB), which contains Crystal violet and bile salt for the inhibition of all other bacteria (Fig. 447).

Other commonly used selective culture media are Lactobacilli MRS Agar for the isolation of **Lactobacillus** (Fig. 448), BAIRD-PARKER Agar for the isolation of **Staphylococcus aureus** (Fig. 449), XLT4 for the isolation of **Salmonella** (Fig. 450) and Mc Conkey Agar for the isolation of **moulds** (Fig. 451) (see also page 356, 357, 359).

Microbiological **detection kits** are now on the market, which deliver screening results without the need of a laboratory. Such kits are particularly designed for the detection of **pathogens** such as Salmonella, Listeria or E. coli O157 H7. They indicate presence or absence of bacteria by change of colour on test strips submerged in a liquid suspension of materials to be tested.

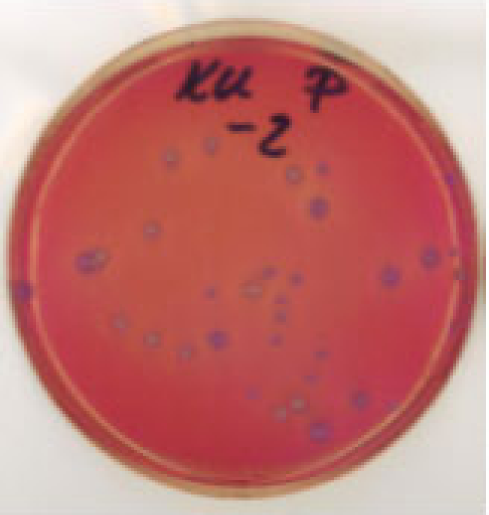


Fig. 447: Selective medium for Enterobacteriaceae
(blue colonies)

Fig. 448: Selective medium for Lactobacillus
(small white colonies)

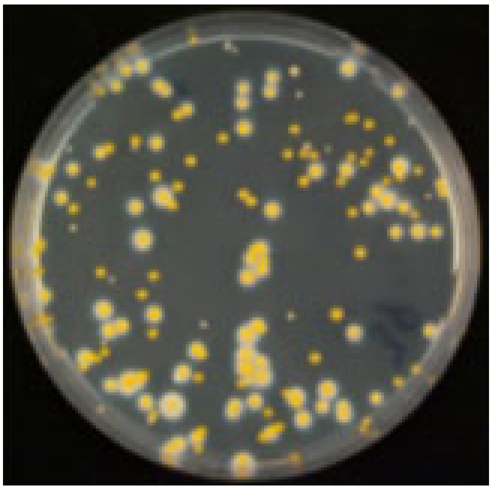


Fig. 449: Selective medium for Staphylococcus aureus
(yellow colonies)

Fig. 450: Selective medium for Salmonella species
(black colonies)

Fig. 451: Selective medium for moulds
(diffuse grayish colonies)

MEAT PROCESSING HYGIENE

Principles of meat processing hygiene and regulatory practices (incl. GHP and HACCP)

Meat processing hygiene is part of Quality Management (QM) of meat plants and refers to the hygienic measures to be taken during the various processing steps in the manufacture of meat products. Regulatory authorities usually provide the compulsory national framework for food/meat hygiene programmes through laws and regulations and monitor the implementation of such laws. At the meat industry level, it is the primary responsibility of individual enterprises to develop and apply efficient meat hygiene programmes specifically adapted to their relevant range of production.

Operations in **meat processing plants** comprise the **manufacture of value-added meat products** from primary products of meat origin and non-meat origin. There are three principles of meat hygiene, which are crucial for meat processing operations.

- **Prevent microbial contamination** of *raw materials*, intermediate (*semi-manufactured*) *goods* and *final products* during meat product manufacture through absolute cleanliness of tools, working tables, machines as well as hands and outfits of personnel.
- **Minimize microbial growth** in *raw materials*, *semi-manufactured*[1] *goods* and *final products*[2] by storing them at a low temperature.
- **Reduce** or **eliminate**[3] **microbial contamination** by applying heat treatment at the final processing stage for extension of shelf life of *products* (except dried and fermented final products, which are shelf-stable through low a_w and pH)[4]

____

1) Semi-manufactured goods must be stored **refrigerated** during production breaks and resting periods. Processing steps, such as cutting, grinding, comminuting, mixing, filling, smoking and cooking take place under **climatized conditions** or **ambient temperatures**. Ambient temperatures are hygienically acceptable as long as these processing phases are of short duration or when product temperatures are rising as a result of the processing.

2) In some final products **low pH** or **low a_w** also serve to contain microbial growth in combination with or in replacement of refrigeration.

3) Elimination of contamination only in fully sterilized (canned) products.

4) For some food products useful, but in the meat industry not commonly used, are other methods for food preservation, such as **irradiation** and **high hydrostatic pressure treatment**.

Fig. 452: Microbiological contamination in the meat processing chain

Carcass contamination during slaughtering (red dots)
Unavoidable – keep as low as possible.

Meat cutting
No reduction of contamination possible, but further contamination should be prevented.

Further processing
No reduction of contamination possible, but prevent further contamination and create challenges / hurdles for microbial growth and survival (a_w, preservatives).

Heat treatment of final product
Pasteurization (approx. 80°C): Substantial reduction of contamination, but products need refrigeration.
Sterilization (above 100°C): Total elimination of contamination, products can be stored without refrigeration (in sealed food containers).

The above three principles guide meat hygiene programmes in the further processing of meat (see also Fig. 452). However, meat processing hygiene is more complex. In particular, the hygienic treatment of meat before reaching the processing stage is of utmost importance for the processing quality of the meat. Failures in **slaughter hygiene**, **meat cutting** and **meat handling / transportation** and in the **hygiene of by-products** and **additives** will all contribute to quality losses and deterioration of the final processed meat products.

Highly contaminated raw meat is **unsuitable** for further processing. Final products made from hygienically deficient raw meat materials are **unattractive in colour**, **tasteless** or **untypical in taste** with **reduced shelf life** due to heavy microbial loads (see page 353, 356). Moreover, there is also the risk of presence of **food poisoning** microorganisms, which can pose a considerable public health hazard (see page 357).

In the light of growing consumer consciousness as well as regionalization and globalization in trade, quality conscious meat plants need *internal quality control/quality management schemes* not only for the **final**

products but also for the **raw materials** and the **various processing steps**.

Such **Quality Management** Schemes **(QM)** have technical and hygienic components. *Technical* aspects encompass *product composition*, *processing technologies, packaging, storage* and *distribution*. Details on the manufacturing practice for each individual group of meat products are included in the chapters on processing technology (see page 103 - 212). For the *sanitary quality and safety* related to meat processing, two useful schemes[1] can be applied known as

- **Good Hygienic Practices (GHP)** and
- **Hazard Analysis and Critical Control Point (HACCP) Scheme**.

Both schemes are not verbally laid down in codes ready to be used for the various purposes in the meat sector although some generic examples can be accessed in handbooks or via internet. Factory and production specific versions need to be established and compiled by taking into account official laws and regulations as well as recommended codes of practice.

Good Hygienic Practices (GHP)

Good Hygienic Practices/GHP follows general hygienic rules and applies recognized hygienic principles[2] as well as laws and regulations issued by the competent authorities, referring to *meat and meat products*, *equipment*, *premises* and *personnel*. GHP schemes are ***not factory specific***, they apply to all types of meat plants. They are intended to establish and maintain acceptable hygienic standards in relevant meat operations. There is more emphasis on slaughter hygiene in GHP schemes for slaughterhouses and more emphasis on meat processing hygiene in GHP schemes for meat products manufacturing enterprises. However in principle, GHP schemes remain interchangeable for similar types of meat plants.

____

1) There are a number of additional specialized norms and standards for auditing purposes in meat/food industries in use, some of them with regional scope and mostly with links to GHP and HACCP.

2) The FAO/WHO Codex Alimentarius Commission has issued a new CODE OF HYGIENIC PRACTICE FOR MEAT in 2005 (CAC/RCP 58-2005). In addition to relevant laws and regulations by the competent authorities, this recommended international Code of Practice provides a suitable platform for the development of official or individual meat hygiene programmes.

GHP for **meat processing plants** refers principally to:

- Appropriate functional plant layout and sanitary design of equipment
- Raw materials that meet hygiene quality standards
- Processing methods that allow safe handling of food
- Appropriate waste and pest control measures
- Appropriate sanitation procedures (cleaning and disinfection)
- Compliance with potable water criteria
- Functional cold chain
- Regular examination of health and personal hygiene of staff
- Regular training of staff on hygiene requirements

Hazard Analysis and Critical Control Point Scheme (HACCP)

HACCP are ***factory*** and ***product specific*** strictly sanitary control schemes that shall prevent, detect, control and/or reduce to save levels ***accidentally occurring hazards*** to consumers' health. Despite GHP in place, accidental hazards cannot be ruled out and may occur at any processing step of the individual meat product. Specifically for ***meat processing plants***, such hazards may be provoked by failures such as:

- batches of incoming raw meat materials with abnormal tissues or heavy contamination,
- breakdowns in refrigeration,
- failure in cooking/sterilization operations,
- abnormal pH or a_w in raw or finished products,
- errors in levels of application of curing salts and other additives,
- technical problems in sealing of vacuum packages or cans with the risk of recontamination.

HACCP schemes serve as additional **alarm systems** in the interest of consumer protection to prevent such problems occuring.

The revolutionary idea of HACCP is to implement control measures that focus on prevention rather than relying on end-product-testing. All relevant possible hazards in the entire production chain, from primary production to consumption of each individual product, must be identified and measures taken for their prevention. In case potential hazards should occur, they can be **detected, contained or eliminated at any stage**.

Plant personnel have a key role to play and must be trained in hazard detection and elimination. For practical purposes, those possible hazards may be listed on **specific templates** for confirmation of presence or absence during routine controls. **Specific control mechanisms**, in the first place of *physical, chemical and visual nature* (temperature, pH, visual check etc.), are installed at selected control points to detect such potential hazards. These control mechanisms are designed to deliver most results almost instantly and allow **immediate intervention** during the processing phase of food/meat products.

The need for immediate action within HACCP systems **excludes** *microbiological control* (of raw materials, semi-fabricated products, tools, equipment, and premises) as a directly applicable control measure. Microbiological control takes hours or days to obtain the results, which does not allow corrective interventions during the usually short manufacturing period. However, this does not mean that microbiological control is worthless for HACCP. Routine microbiological control carried out within the **framework of GHP** is an extreme helpful tool also for HACCP as its results will demonstrate the efficiency of the HACCP-system. Hygienically acceptable microbiological test results are an indicator of the proper functioning of the meat plant's HACCP scheme.

HACCP[1] is *not* a scheme for the assessment and improvement of the general hygienic status of a meat plant. HACCP is not designed to further raise hygienic standards. Excellent conditions as applicable for GHP-conform plants must already be in place. GHP is a prerequisite requirement for the introduction of HACCP.

The misconception still exists that HACCP is intended to raise levels of general hygiene in meat plants **with low hygienic standard.** HACCP is not workable where plant layout/structure, equipment and/or processing methods **do not comply** with good hygienic standards.

One important point to distinguish HACCP from GHP is that **GHP** describes *process requirements and practices* incl. personal hygiene of staff to ensure safety of food. The individual product is not specifically targeted. Unlike GHP, **HACCP** always focuses *on the individual product*. As technologies vary from product to product, it is obvious that **separate** HACCP approaches are required for each category of products.

[1)] More detailed information on HACCP see boxes on pages 344-348.

HAZARD ANALYSIS CRITICAL CONTROL POINT (HACCP)

What is HACCP?

Internal sanitary related control and monitoring system in food plants with the aim of preventing/minimizing or eliminating **health hazards** to consumers. HACCP identifies, evaluates and controls hazards, which are significant for food safety. The characteristics of HACCP are:

- Potential for immediate **prevention measures** before or during production to counteract suspected or emerging health risks
- Exclusively **aimed at health risks** to consumers

Food plant internal control procedures based on HACCP principles have become an obligation worldwide in many countries with advanced food industries. HACCP procedures are imposed on relevant food plants by the competent authorities, whose task is to assess and evaluate the correct application and conduct of HACCP. The food plants themselves are responsible for the proper implementation of HACCP, such as monitoring of sensory, physical and chemical parameters during production and immediate intervention in case of emerging health risks and recording of results.

Requirements for introduction of HACCP schemes are yet different from region to region. In a number of countries (e.g. EU, US) meat plants in general have to comply with HACCP, whereby for smaller plants or such specializing in limited activities or products, simplifications or exceptions exist. In some other parts of the world, HACCP schemes are not yet commonly introduced. However, it can be anticipated that such plants involved in regional or global distribution of food will also be obliged to comply with HACCP principles.

Basic elements of HACCP in meat processing plants

- Every single meat product with product specific technology requires a specifically designed **individual** HACCP scheme.
- As a precondition for implementing HACCP concepts, **hazard analysis** and **risk assessment** referring to meat plant specific processing methods or products, have to be carried out.
- **Critical control points** (**CCPs**) have to be identified, critical limits be established and **monitoring systems** properly implemented.

The HACCP scheme is subdivided into seven consecutive steps (“principles”). Through these seven HACCP principles a practical approach is provided to identify potential significant hazards to consumers’ health and to take relevant corrective actions:

1. Hazard analysis and risk assessment

The first principles requires initially the **exact description** of the products to be fabricated, including product composition, texture/structure, processing details (such as degree of comminuting, additives, filling, heat treatments), packaging and if applicable chemical and microbiological criteria.

Once the characteristics of each product are detailed, potential hazards to consumers' health during processing are identified. Hereunder, a summary listings of hazards are given, from where those hazards likely to be associated with the fabrication of a specific meat product can be identified.

Examples for hazards in meat processing

Biological hazards: Parasites (causing zoonotic diseases), bacteria (causing food poisoning/food borne infections and intoxications), moulds (mycotoxins causing food borne intoxications), viruses (causing food borne infections) (see page 357)

Physical hazards: Rests of unwanted materials (glass, bone fragments, animal teeth/in case of processing head meat, metal fragments such as sausage clips, broken knife blades, needles, plastics, stones)

Chemical hazards: Contaminants (heavy metals, PCB's, chemical solvents, cleaning and disinfection compounds)
Residues (veterinary drugs, feed additives, pesticides)
Food additives with risk of overdoses (nitrate/nitrite, chemical preservatives)

2. Identification of Critical Control Points (CCP)

A CCP is defined as any point or procedure in a specific food system, where loss of control may result in an unacceptable health risk. CCPs can be located at any point along the production line of a specific meat product, where biological, physical and chemical hazards may occur and where such risks can be controlled and/or eliminated. CCPs should only be established, where firm methods for control and monitoring can be applied.

CCPs must be used only for purposes of product safety. They should not be confused with control points that do **not** control safety and where loss of control does **not** lead to unacceptable health risks, e.g. reduced or strong water binding capacity of meat, knives of grinders or choppers with reduced cutting capability, mechanical problems in portioning sausages or can fillings etc. Moreover, issues of meat plant hygiene routinely covered by GHP and which are not product specific, are normally **not** CCPs. Such examples are:

- **Potable water outlets**,
- **Hot water container** for tool disinfection ("sanitizers"),
- **Cleaning** and **disinfection** equipment, chemicals and methods.
- **Sanitation measures** (e.g. periodic cleaning and disinfection of meat cutting boards)
- **Personal hygiene**

Specific preventive measures to avoid cross contamination (e.g. plant internal transports of raw materials and finished products must not cross each other)
Specific food handling procedures (e.g. meat containers must not directly be placed on the floor, but on stands, pallets etc.)

Suggested control points directly related to meat processing and therefore suited for the establishment of **CCPs** are:

- unloading bay for **raw materials** (meat and non-meat ingredients),
- **cold storage rooms**,
- meat **cutting** and **preparation facilities**,
- facility for **handling non-meat additives**,
- meat **comminuting** units (grinders, bowl choppers etc.),
- **filling equipment** and **casings**,
- **heat treatment facilities** (smokehouses, cooking vats, autoclaves),
- **packaging equipment** and **materials** (including canning),
- **cold store** for final products,

It is up to the individual meat processing plant to decide, at which points in the processing line **CCPs** should be established. This will vary from meat plant to meat plant, depending on plant lay-out equipment, type of products and also on previously experienced accidentally occurred shortcomings.

3. Establishment of Critical Limits for each CCP

Critical limits correspond to the **extreme** (highest and lowest) **values acceptable** from the point of view of product safety. This does not always imply that a numerical value has to be fixed. Monitoring may also be based on **visual observation**, e.g. dirt/faecal contamination of meat, changes to untypical colour, changes in product structure or texture. Besides such sensory parameters, numerical critical limits must be specified for each **objective control measure** at each CCP. Criteria often used include temperature, time, moisture level, pH, and water activity.

Examples
Visual check of damage to packaged incoming raw materials (rejection in case of severely damaged packages of meat materials or additives)
Visual check of contamination of raw materials (meat, fat). Discolouration (rejection of meat or fat in severe cases), meat potentially contaminated with food poisoning agents (e.g. minimal dirt contamination to be trimmed off, critical dirt or fecal contamination leads to rejection of the meat)
Temperature control of meat derived from slaughterhouses/cutting plants (e.g. ≦ +4°C)
pH of incoming meat (e.g. < 6.0 for pork, < 5.7 for beef)
Visual check during meat cutting and grading (e.g. to separate and discard unsuitable meat tissues such as those containing parasites, abscesses, etc.)

Moisture content expressed as a_w (refers mainly to dry fermented products which should not be packaged or marketed if moisture content keeps above a certain level)
Additives (some products require a certain salt level for better stability in hot environments; nitrite levels should be high enough to inhibit bacterial growth but below toxic levels; the same applies to chemical preservatives)
Control of pasteurization parameters (ensure sufficient cooking, measured as core temperatures in products, e.g. 74°C)
Control of sterilization temperature and time for canned products (e.g. ensure that desired F-values are reached, e.g. F value 4 in fully sterilized canned products)
Visual appearance and texture of final products (greenish discolouration and slimy surfaces as signs of microbial growth, mould growth on surfaces of dried sausages)

4. Establishment of a monitoring system for each CCP

Monitoring is the **regular/periodic** measurement or observation at a CCP to determine whether a critical limit or target level has been met. The monitoring procedure must be able to detect loss of control at the CCP. Monitoring at CCPs should deliver results **rapidly** in order to enable corrective action during processing. Lengthy analytical testing is not practicable in the context. Hence most of the testing for critical limits listed in (3) is visual, physical and to some extent chemical. The slower microbiological testing (see also page 331) does not allow immediate corrective action.

Physical and chemical pattern to be instantly measured or monitored in meat processing lines include:
Temperature
Time limits see No. 3
pH
Moisture

5. Establishment of corrective actions

Corrective actions are those actions to be taken either when monitoring results show that

- a CCP has deviated from its specified critical limit or target level or
- when monitoring results indicate a trend towards loss of control

Action taken must reduce to safe level or eliminate the actual or potential hazard identified.

Corrective actions are for example

- **Reject** incoming meat with too high internal temperatures
- **Adjust** temperature for refrigerated storage and transport of meat
- **Remove** with clean knives minimal visual contamination of meat surface, **reject** heavily contaminated meat
- **Adjust** cooking and sterilization parameters (temperature/time)

- **Reject** meat with too high pH
- **Adjust** quantity of curing substances (level of nitrite, nitrite curing salt should contain 99,5% common salt and 0,5% nitrite)
- In case of dry fermented products: If a_w of processed products is too high, **stop** packaging in water vapour impermeable packages

Products with suspected hygienic deficiencies have to be separated from other products. Additional treatments may have to be applied, e.g. additional heat treatment in case of undercooking. Final judgement (if fit or unfit for consumption) has to be made by responsible, competent persons. Interventions at CCPs are carried out based on instant observation of hygienic failures/shortcomings. Corrective actions should be documented in the HACCP written records.

6. Establishment of verification procedures

Procedures are needed to ensure that the HACCP system is working correctly. Particular attention must be given to the **monitoring frequency,** which may be daily or several times a day or more frequently. **Checks on the persons** doing the monitoring should be done regularly as well as **calibration of instruments** used.

Established critical limits can be **revalidated** (changed) in the light of new developments. The system as a whole for individual products has to be reviewed in case of introducing **changes in the processing technology** such as changes in raw materials, product composition, processing equipment or packaging systems.

Test results derived from GHP **routine quality control**, in particular microbiological analysis, are valuable supplementary information within the HACCP system, support the verification process and prove the practicability of HACCP.

7. Establishment of documents and records

Documents and records must be produced commensurate with the nature and size of the food business to demonstrate the application of principles 1-6. These documents serve for the competent authorities to evaluate the efficacy of the HACCP procedure carried out at the plant. Records also help to trace causes of problems that were encountered during past production.

This documentation includes amongst others

- Certification on receipt of raw meat materials and non-meat ingredients documenting supplier compliance with processor's specifications
- CCP determinations (for each product)
- Critical limits set and results achieved for each CCP (including possible deviations from critical limits and corrective actions)
- Modifications introduced to the system in the light of changes of technology or other developments

HACCP in small meat processing plants

The rather complex HACCP approach including identification of critical control points and measurement and interpretation of test results, demonstrates the **difficulties in introducing HACCP schemes in small food or meat processing enterprises**. Comprehensive test systems would require a multidisciplinary approach, as well as knowledge of microbiological, chemical and physical hazards, technical processes and operation of equipment. This is available in large industries but generally not in small- to medium-scale enterprises. Flexibility should be given in these situations for **simplified approaches**, if HACCP schemes are to be introduced in small food businesses. Competent authorities tend to accept these views. In plants dealing with limited numbers of products or technologies, these simplified approaches can even go so far as to use GHP schemes instead of HACCP. It is obvious that in such cases GHP approaches may be more practical and less cost-intensive than HACCP.

Two examples for preparation of HACCP plans (see page 350, 351)

These are summary plans, which need to be expanded in more detail if adapted for relevant meat plants, depending on the plant layout, equipment and processing technology. Potential hazards, which are indicated as physical, chemical and biological, would have to be specified in detail according to the listings given on page 344. The majority of the potential hazards are “biological”, which mostly refer to microbiological risks. This corresponds with the aim of HACCP, which is prevention of health hazards to consumers. Health hazards through food are mostly caused by microbiological activity, which can be prevented if properly controlled.

The first example (**cured cooked ham**) is a product which is heat treated during manufacture and hence was stabilized microbiologically to a certain extent, but requires refrigerated storage. The second example refers to a meat product, which does not undergo heat treatment during processing (**fresh frozen beef burger**) and therefore remains particularly sensitive from the hygienic point of view.

Due to the nature of the two products, periodic microbiological tests are recommended in the framework of GHP. Periodic microbiological testing is particularly important for the product “Fresh Frozen Beef Burgers” to be marketed raw. Microbiological test results can be incorporated in HACCP. They are **not** a means for immediate intervention in ongoing productions (microbiological tests take too long to use their results for immediate action), but rather in the verification procedure, which serves to prove whether the HACCP system is working. Microbiological results are a means to confirm the efficiency of the meat plant internal HACCP system, when it can be proved that the established limits were not exceeded.

The Critical Control Points (CCPs) indicated are examples for the establishment of CCPs. It is up to the processing plant to increase or decrease their number according to the plant specific risk assessment.

Table 17: HACCP plan for Cured Cooked Ham

HACCP PLAN

Product: **Cured Cooked Ham (cooked in vacuum bag and cooking mould)**

Process steps	Hazard	Target level/ Critical limit	Monitoring Procedure	Corrective action if standards are not met	Records
Reception of raw meat materials (pork hind legs without feet) **CCP**	Physical, chemical, biological	Red meat color, pH[1] not above 6.2 (DFD!), no visual defects of meat/fat/skin surfaces, core temperature ≦4°C	Check purchase specification. Inspection by random sampling of appearance, odour, temperature and pH[1]	Trim surface if only few minor visible contaminations or remaining hairs. Reject delivery, if other target levels not met	Physical characteristics of meat received, certificate of sanitary status and origin of meat. Meat temperature recordings.
Storage in reception chiller	Biological	Chiller temperature ≦4°C	Periodic temperature control	Minor temp. deviation: Adjust temperature Major temperature deviation: Reject meat[2]	Temperature/ time recordings
Cutting, deboning, trimming **CCP**	Biological	Room temperature +10°C, meat temperature ≦+7°C. Absence of alterations in meat such as abscesses, purulent or blood infiltrations	Meat temperature control. Check for meat alterations and abnormal tissues	Further cooling if meat temperature too high. Reject / discard entire meat parts with alterations such as abscesses, purulent/blood infiltrations	Record meat temperature. Record accidential findings
Evaluation and weighing of non-meat ingredients	Chemical	Nitrite content in curing salt ≦0.6% (if curing salt mix done by operator). Curing salt free of impurities. No impurities in other non-meat ingredients	Check storage conditions of nitrite salt, exact weighing of nitrite portion (if mix done by operator), Curing salt quality check. Check other non-meat ingredients for impurities	Adjust weight of nitrite portion correctly or use freshly mixed curing salt. Replace other non-meat ingredients	Records of status and expiration dates of non-meat ingredients. Results of weighing nitrite portions
Preparation and injection of curing brine **CCP**	Physical, chemical biological	Brine temperature at injection ≦+4°C	Check brine temperature	No utilization of curing brines failing temperature and purity requirements	Record conditions encountered
Tumbling	Biological	Room temperature ≦+4°C, time ≦ 8 hours	Check temperature/ time	Adjust room temperature if too high	Temperature/ time recording
Packaging, moulding	Biological	Cleanliness of synthetic materials, tightness of enclosure by clip or seal	Check quality of materials and clipping/ sealing.	Reject unsuitable synthetic bags, correct clipping/ sealing failures	Record on packaging material, equipment
Cooking **CCP**	Biological	Internal cooking temperature (core temperature) ≧+70°C. Temperature of cooking media +78°C	Check core temperature by electronic temperature measurement	Increase cooking temperature or prolong cooking time until required core temperature is reached	Record temperature of production batch. Record any deviation in temperature
Cooling (in water)	Biological	Cooling to +15°C core temperature in ice water	Check core temperature / time. Check cooling water temperature	Add ice if cooling water temperature too high	Time/ temperature record of cooling period
Storing (chiller)	Biological	Temperature of cooling room ≦+4°C	Check temperature daily	Adjust temperature as the case may be	Record of cold chain temperature

CCP = Proposed Critical Control Point

1) pH to be measured at topside (Musc. gracilis)
2) Alternatively: check meat and decide on further utilization for processing into hygienically less sensitive products.

Table 18: HACCP plan for Fresh Frozen Beef Burger

HACCP PLAN

Product: **Fresh Frozen Beef Burgers (extended, with salt and spices, vacuum packed)**

Process steps	Hazard	Target level/ Critical limit	Monitoring Procedure	Corrective action if standards are not met	Records
Reception of raw meat materials (beef, boneless) **CCP**	Physical, chemical, biological	Internal meat temperature ≦+4°C, red meat colour, fresh slightly acidic odour, no visible contamination, no discoloration, not slimy, no other defects	Check purchase specification. Inspection of meat surfaces by random sampling. Check internal meat temperature	Reject delivery, if target levels not met	Physical characteristics of meat received, certificate of sanitary status and origin of meat. Meat temperature recordings
Storage in reception chiller	Biological	Room temperature ≦+4°C. Meat internal temperature ≦+4°C	Temperature control of chilling room and meat (internal)	Minor temperature deviation: Adjust chiller temperature Major temperature deviation: Reject meat[1]	Temperature/time recordings of chiller. Temperature recordings of meat
Weighing and composition of non-meat ingredients	Physical, chemical	Visibly clean non-meat ingredients (common salt, no curing salt to be used)	Check salt, spices and extenders for impurities	Reject suspected batches of non-meat ingredients	Record of status and expiration dates for non-meat ingredients
Prepare meat for grinding, effect grinding	Biological	Room temperature ≦+10°C. Period from delivery of meat from chiller to pass through grinder maximum 20 minutes. Meat free of grossly abnormal tissues and post-dressing contamination	Check period of product flow. Check for abnormal tissues and post-dressing contamination	Improvement in product flow. Discard meat parts with abnormal tissues, post dressing contamination	Product flow/ temperature recording
Mixing of meat with ingredients **CCP**	Biological	No further increase of contamination. Room temperature ≦+10°C. Period from grinding to completion of mixing/blending maximum 30 minutes. Temperature of meat/meat ingredients mix ≦+10°C	Check period of product flow. Check mix temperature	Minor deviations: Adjust time/temperature regime. Major deviations: Reject batch	Product flow/ temperature recording
Patty moulding	Biological	Carry out immediately after mixing. No significant product temperature increase	Temperature/time control	Increase process speed. Return mix to chiller if no immediate moulding process	Product flow/ temperature recording
Freezing **CCP**	Biological	Blast freezer at -35°C	Temperature control	Adjust freezer temperature	Record blast freezer temperatures
Packaging	Biological	Clean packaging materials	Check packaging failures	Adjust packaging machine in case of insufficient vacuum packaging	Results of packaging
Freezer storage	Biological	Temperature of storage freezer -18°C to -30°C	Continuous temperature check	Rise of temperature: immediate identification and correction of temperature problems, transfer to alternative storage freezer if long-term problem	Continuous freezer temperature records

CCP = Proposed Critical Control Point

____
[1] Alternatively: Check meat and decide on further utilization for processing into hygienically less sensitive products.

Remarks: In the processing of this product there is no heat treatment included to reduce microbial contamination. The necessary heat treatment immediately prior to consumption, which is not part of the manufacturing process, is the only relevant measure to control potential contamination with pathogenic microorganisms. In order to minimize the risk of pathogenic microorganisms, special advice on the handling of the products before heat treatment and on the intensity of heat treatment must be available on the package.

During processing, the nature of the product requires periodic microbiological testing as part of GHP and HACCP verification. Microbial testing of ground meat should take place once a week or more frequently in cases of suspected hygiene failures. Microbiological testing of finished mixes containing meat/non-meat ingredients mixes can be done on case-to-case basis.

The impact of microbial contamination on meat and meat products (Fig. 458)

Meat hygiene serves to minimize the impact of undesirable microorganisms and chemical residues on meat. While residue control is primarily the task of the competent authorities, control of microbial contamination is the responsibility of meat plants in the first place. Meat plant management and staff should therefore possess sufficient knowledge about **impact of microorganisms** on food and of basic rules on how to **prevent or minimize microbial contamination** (Fig. 453, 454, 455).

Microorganisms of relevance with regard to meat hygiene include parasites, moulds, bacteria and viruses. Within these groups **bacteria** play the most important role. Therefore, the focus of meat plant internal hygiene measures is mainly on bacteria, while **moulds and viruses** play a minor role but disinfection measures must also target them. The incidence of **parasites** should normally pose no major problems in meat which has passed meat inspection, or if efficient internal pest control programmes or measure are in place.

How does bacterial contamination of meat occur ?

In live animals, the muscle meat is virtually **sterile**. However other parts of the animal such as skins, hooves and intestines contain enormous numbers of bacteria. Depending on the slaughter hygiene, these bacteria find their way to the carcass or "**contaminate**" the meat during slaughterhouse operations. Skinning, scalding, evisceration, dressing and carcass transport are common contamination points. Most bacteria reach the carcass via butchers' hands, tools, contact with equipment or through water, air, etc. The bacterial contamination of meat is not stopped after slaughtering. It is ongoing during the operations following the slaughter process, such as meat cutting and meat processing (Fig. 452).

It is quite normal and unavoidable to find bacterial counts of "total plate count" (TPC, see page 335) of the order of **several thousands** per cm^2 on meat surfaces in commercial slaughtering and meat handling. However, the principle must be to keep bacterial counts as low as possible through adequate hygienic measures. Total plate count numbers exceeding 100,000 per gram (**10^5 per cm^2**) on fresh meat are not acceptable and alarm signals and meat hygiene along the slaughter and meat handling chain must be urgently improved (Table 19).

Table 19: Recommended microbiological criteria for fresh meat

	Good microbiological standard	Critical microbiological condition	Not acceptable
Total plate count[1] per cm^2	Less than 10000 $<10^4$	Between 10000 and 100000 $>10^4$ - $<10^5$	More than 100000 $>10^5$
Enterobacteriaceae[2] per cm^2	<100	>100 - <1000	>1000

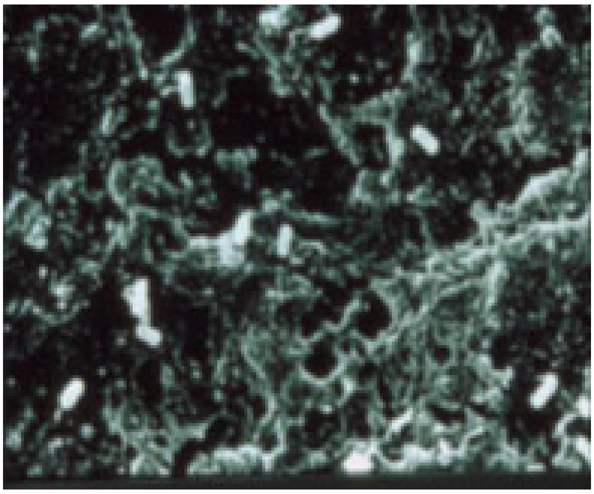


Fig. 453: Bacteria (white rod shaped) in comminuted meat mix (3,000-fold enlarged)

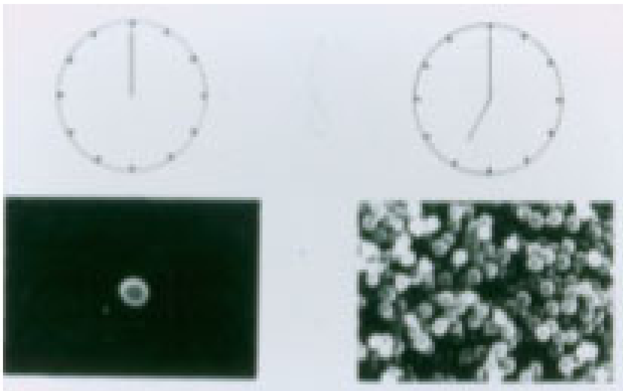


Fig. 454: Bacterial growth in 7 hours (from one bacterial cell to more than 2 million). Multiplication through periodic partition of bacterial cells.

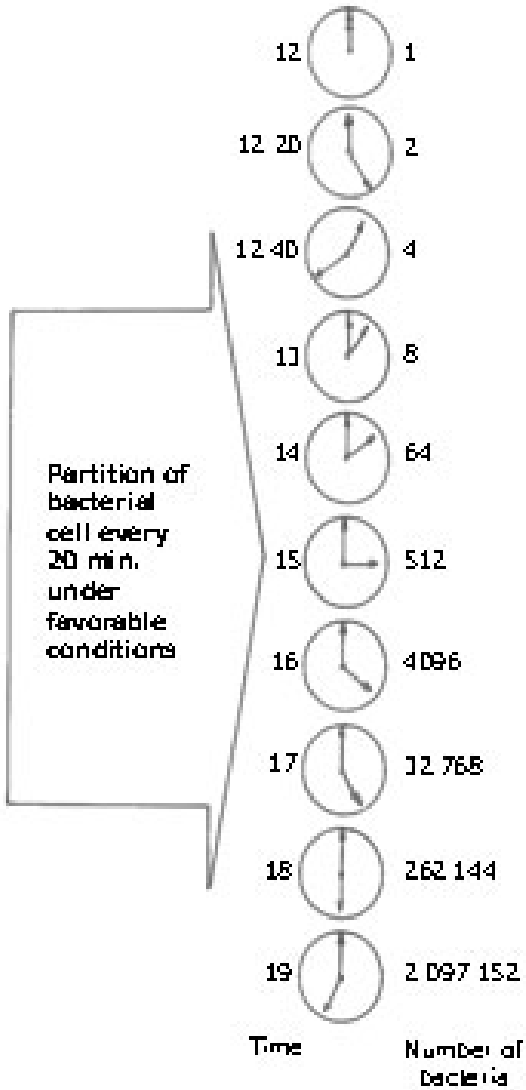


Fig. 455: Microbial growth starting

---

[1] "Total plate count" is the total number of bacteria comprising all microbial groups (page 336).

[2] "Enterobacteriaceae" is a specific bacterial group, which indicate contamination by faecal and related materials (page 339).

Meat spoilage through micro-organisms

Meat spoilage bacteria will grow if temperatures are not kept in the cooling (-1°C to +4°C) or freezing (below -1°C) range. Not all bacteria which contaminate meat will behave in the same way. Some may multiply already at temperatures at around 10°C, others at higher temperatures, for example 30°C. Most bacteria can optimally grow in the range between 30°C and 37°C (Fig. 456 and Fig. 457). Some may attack the protein portion of the meat resulting in the production of very unpleasant putrefactive odours, others may break down carbohydrate components in particular in processed meats causing intensive sour taste or acidity. Others may attack the fats, producing rancidity (Fig. 458; table 20). These various bacterial impacts result in **meat spoilage** or **decomposition**. Spoilage of meat and meat products causes serious financial losses for the meat industries as such products, due to their sensory changes exposed through unpleasant smell and taste are unfit for human consumption. But spoiled meat, if accidentally ingested, is usually not the cause for illness in consumers.

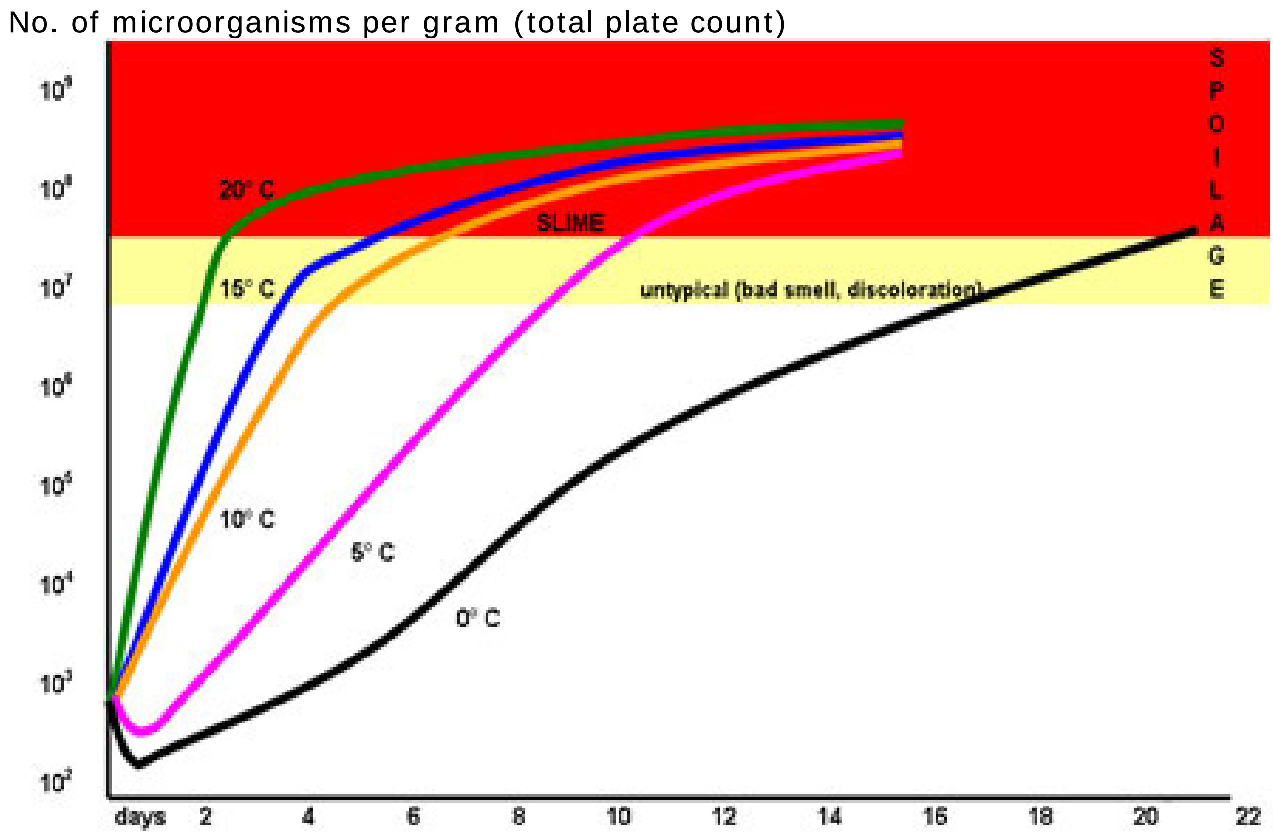


Fig. 456: Growth of microorganisms on meat (starting from same initial bacterial loads/approx. 1000 per gram meat , but different storage temperatures, 0°C, 5°C, 10°C, 15°C). At 20°C spoilage on the second day at 0°C spoilage after more than 20 days.

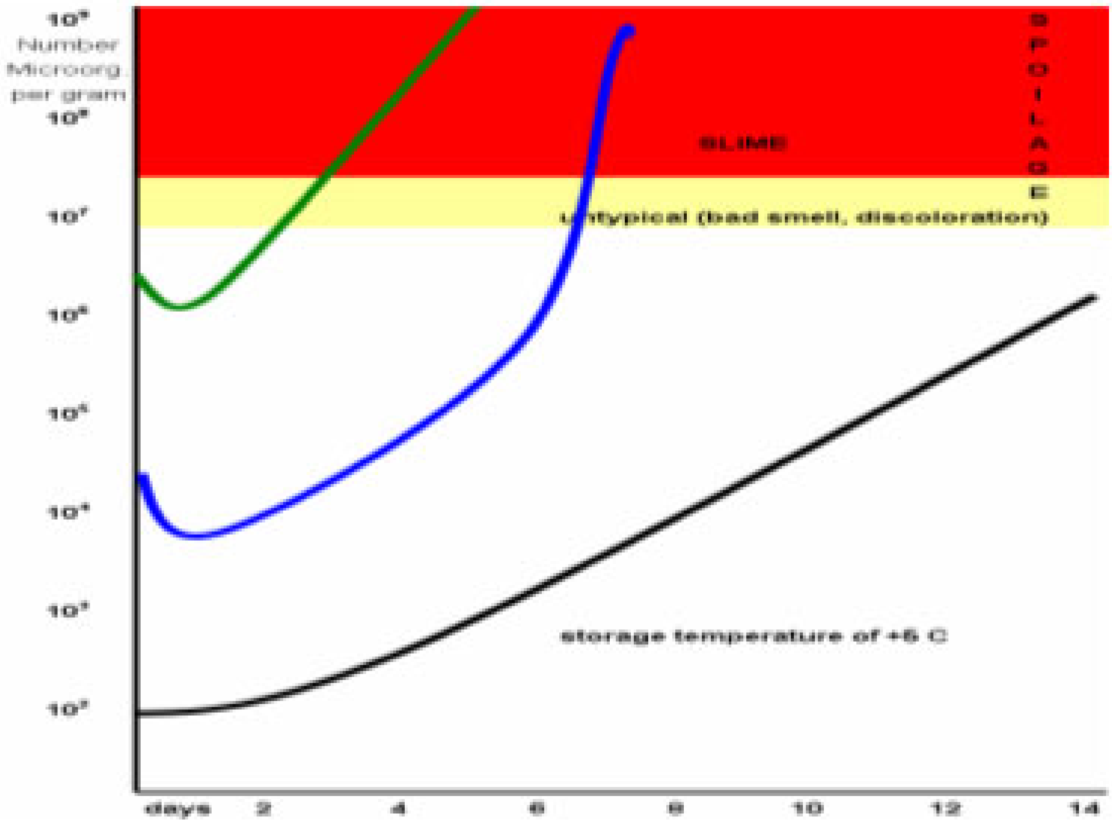


Fig. 457: Growth of mMicroorganisms on meat (starting from different initial bacterial loads/100, 10000 and 500 million per gram, but same storage temperature

Fig. 458: Impact of bacteria on meat

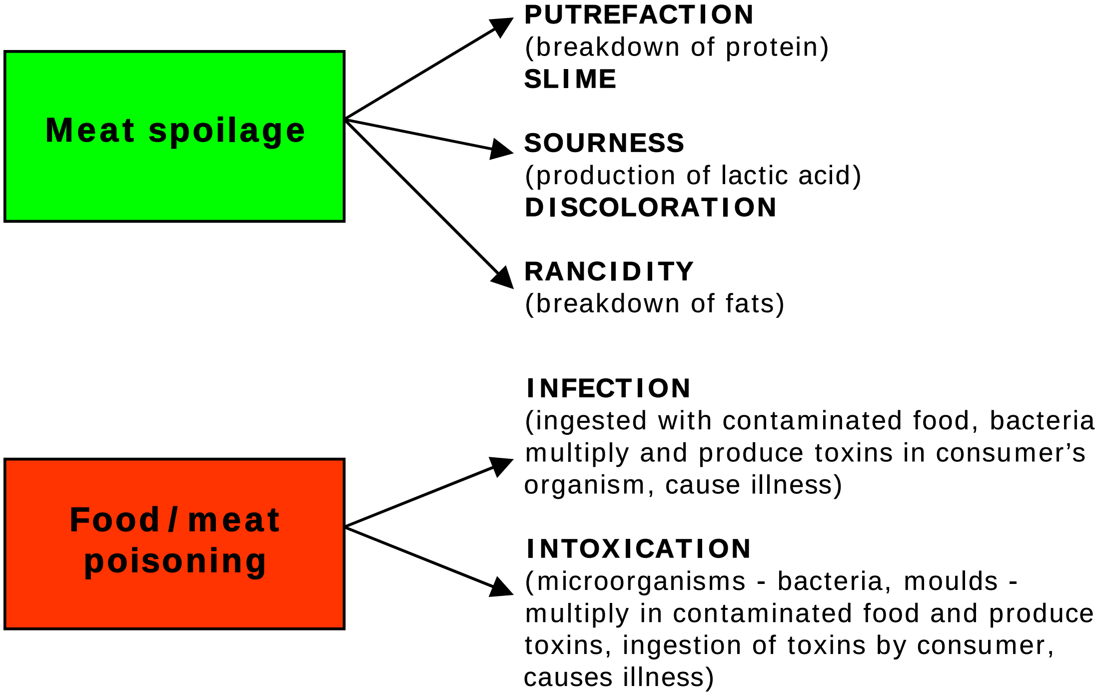


Table 20: Microorganisms causing microbiological spoilage of meat

Putrefaction	Pseudomonas ("Cold room flora"), Proteus, Clostridium (Fig. 459)
Souring	Lactobacillus, Enterococcus, Pediococcus ("Lactic acid bacteria")
Fermentation[1]	Yeasts (Saccharomyces), Enterobacteriaceae, Lactic acid bacteria
Turbidity (cloudy brine in meat juice)	Lactic acid bacteria, Enterobacteriaceae (e.g. vacuum packed meat, sausage slices)
Greenish discoloration	Lactic acid bacteria (Fig. 461)
Slime formation	Pseudomonas, Streptococcus, Enterobacteriaceae (on open meat), Lactic acid bacteria (on vacuum packed meat and meat products), Yeasts (on raw fermented products such as raw hams) (Fig. 460)
Rancidity of fats	Mainly due to presence of oxygen, but certain microorganisms are also capable of causing fat deterioration.
Mould growth	Penicillium, Aspergillus, Mucor (Fig. 462.)

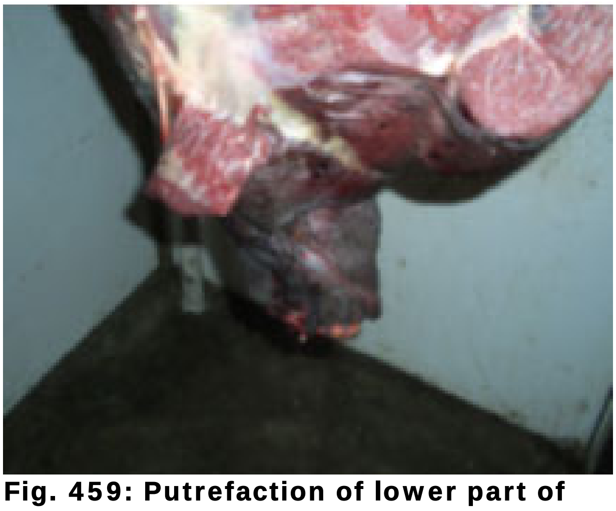


Fig. 459: Putrefaction of lower part of beef quarter

Fig. 460: Slime formation on sausage surface and attached to packaging film

____

[1] This refers to undesirable fermentation processes. For some meat products (raw-fermented hams and sausages) controlled fermentation is wanted and necessary (see page 124 and 177).

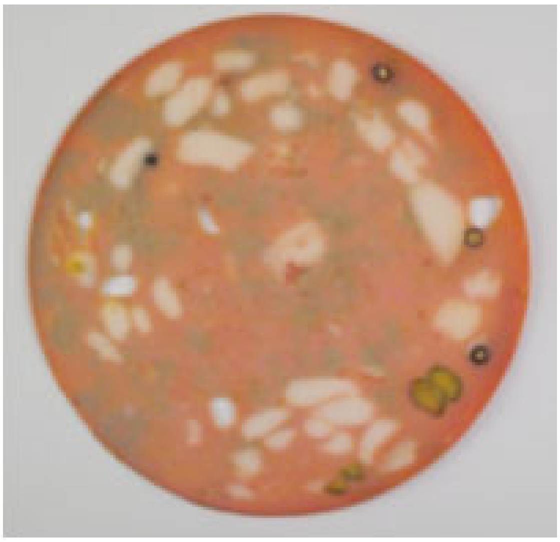


Fig. 461: Greenish discoloration (sliced mortadella)

Fig. 462: Mould growth

Meat poisoning through micro-organisms

Harmful microbes may have little adverse effect on carcasses or meat in terms of visible alterations and spoilage (smell and taste), but can have severe negative effects on consumers called **food** or **meat poisoning**. After consumption of meat contaminated with food poisoning bacteria, food poisoning results in severe illness with consumers needing intensive and costly medical treatment.

The impact of food poisoning **bacteria**, depending on the species of microorganisms, is either as a

- food borne infection or
- food borne intoxication.

Bacteria that cause **food borne infections**, must first multiply to high infectious numbers in rich protein foods such as meat and have to be ingested by consumers. They cause sickness through microbial metabolic substances i.e. toxic substances released by the living microorganisms inside the human digestive tract. The best known examples of food borne infections are those caused by Salmonella bacteria (Fig. 463). In some instances relatively high numbers of bacteria are needed to make people severely sick. For example, it is estimated that 10^5/g of Salmonella bacteria are needed in ingested food to cause Salmonellosis. In other cases, for example in the case of a recently emerged very pathogenic form of the normally harmless E.coli bacteria (entero-pathogenic form, mostly type O157 H7 residing in faecal material, on skin of animals), only a few hundred bacteria per gram food can cause severe illness with **gastro-intestinal symptoms** and **fever** and even **death**.

Microorganisms causing **food borne intoxications** produce and release the poison during their multiplication in the food. Upon ingestion by consumers of such food, which was heavily intoxicated outside the human body, severe gastro-intestinal food poisoning symptoms (**vomiting**, **diarrhea**, **abdominal pain**, **fever**) occur.

Food borne intoxications are frequently caused by Staphylococcus aureus (Fig. 464, 467, 468). These bacteria are present in purulent wounds an frequently in the respiratory system of healthy people. When they get into meat, which is not sufficiently refrigerated, they multiply rapidly and produce toxins, which cause severe gastro-intestinal symptoms only a few hours after ingestion by consumers. Another bacteria, Cl. botulinum, in the absence of oxygen e.g. in canned food or deep layers of raw-fermented hams, is capable of producing one of the strongest toxins known. Intoxication, if not treated immediately, can be fatal to consumers.

Bacteria are the most common food poisoning microorganisms. Apart from bacteria, moulds can also play a role in the incidence of food poisoning.

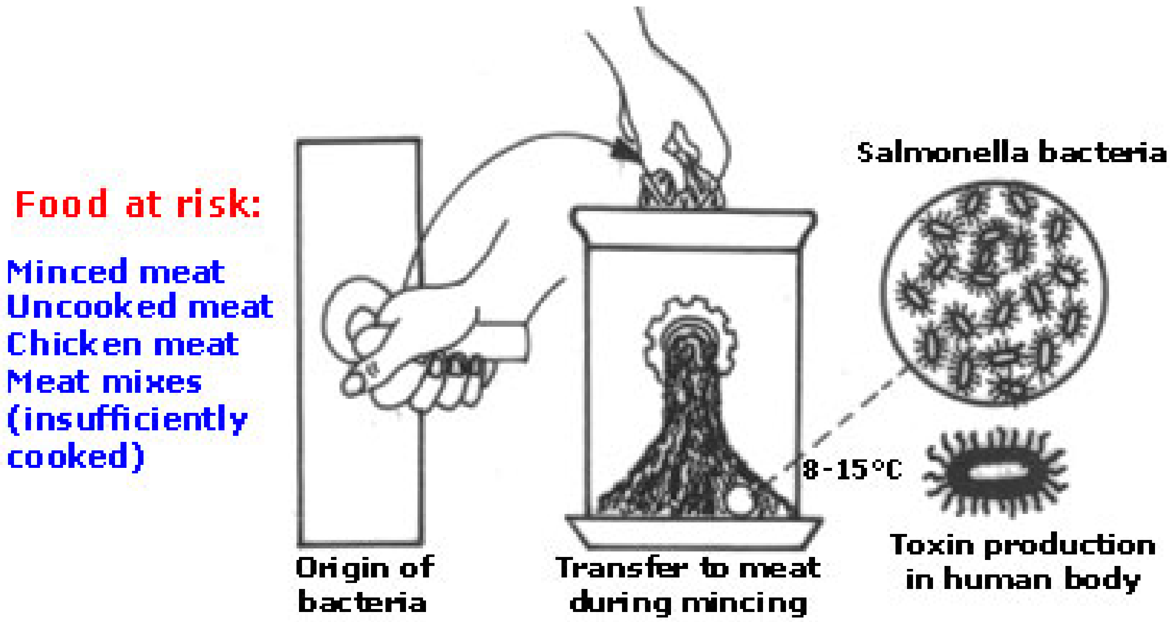


Fig. 463: Food infection by Salmonella
Deficient toilet hygiene, human carrier of Salmonella contaminates food (minced meat)

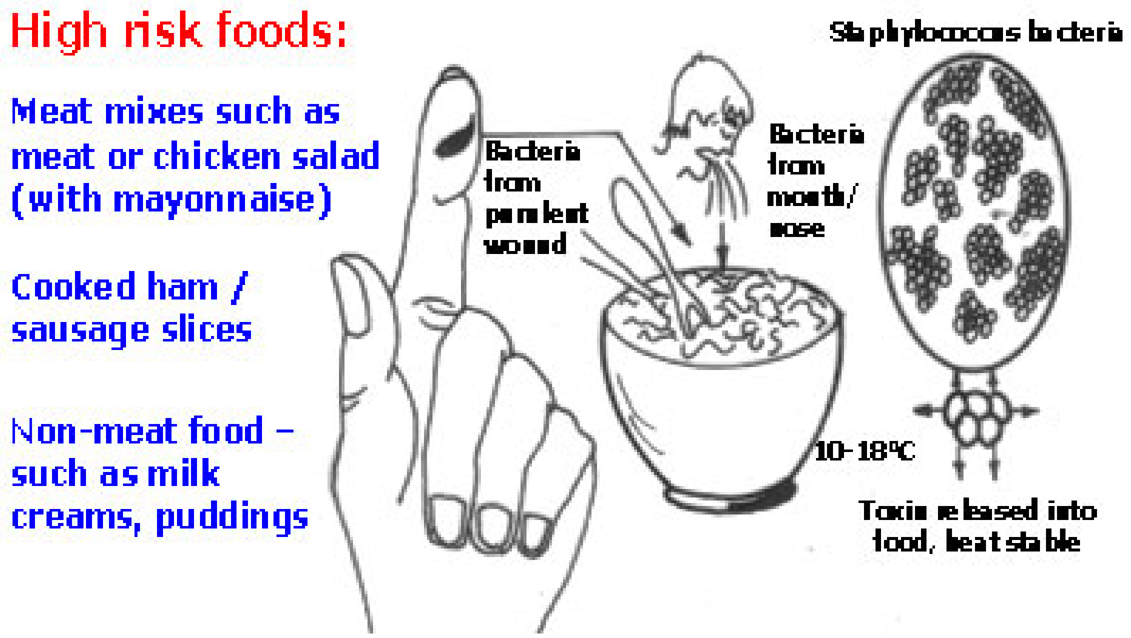


Fig. 464: Food intoxication by Staphylococcus aureus
Source of bacteria may be from purulent wound or mouth/nose.

Moulds (Fig. 465) are sometimes found on the surface of meat products after prolonged storage. Growth of moulds (see page 124) on meat can have two undesirable effects. Firstly, strong growth of moulds can spoil the affected meat parts. Secondly, and this is a more serious issue, certain types of moulds produce toxins which are released into the food. If consumed in food or feed they can, in the long term, have carcinogenic effects.

Aflatoxins are strongly carcinogenic, in particular hepatotoxic, i.e. cause liver cancer through long term impact (Aflatoxin = toxin of Aspergillus flavus). **Ochratoxin** is strongly nephrotoxic, i.e. it causes kidney disease, in particular kidney enlargement and kidney failure (Ochratoxin = toxin of Penicillium vividicatum).

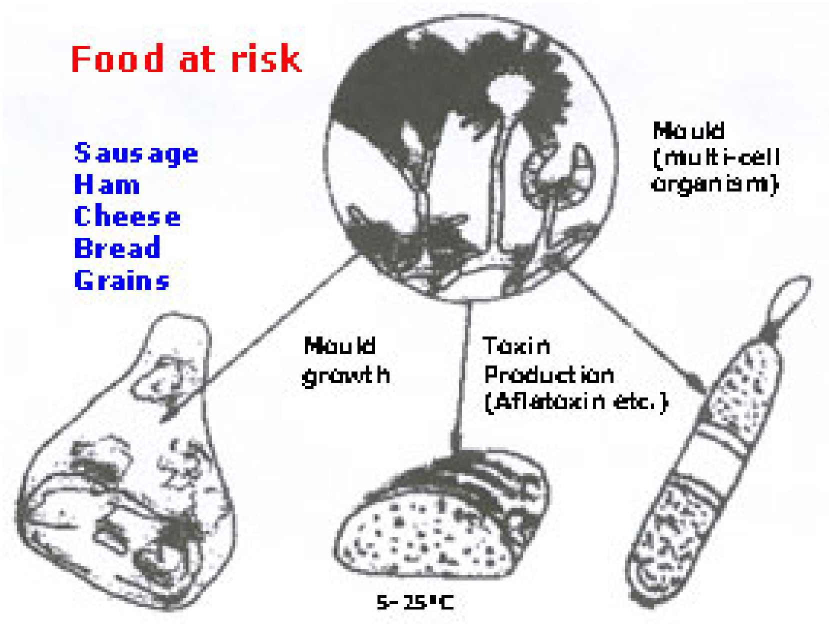


Fig. 465: Food intoxication by moulds
Potential production of mould toxins on dried ham, dry fermented sausage and bread.

Viruses were always suspected to cause food infections. In the last years it has been shown that in particular the **Norovirus** group can be responsible for food infections with similar, mainly gastro-intestinal symptoms, as bacterial food infection agents.

Table 21: Major meat poisoning organisms

Salmonella	Food borne infection
E. coli (enteropathogenic type)	Food borne infection
Listeria monocytogenes	Food borne infection
Campylobacter jejuni	Food borne infection
Yersinia enterolytica	Food borne infection
Staphylococcus aureus	Food borne intoxication
Clostridium botulinum	Food borne intoxication
Mycotoxin producing moulds	Food borne intoxication
Norovirus	Food borne infection

Good Hygienic Practices in meat processing

Microbial meat spoilage or food poisoning through meat can be prevented if the microbial load/bacterial contamination, which occurs during slaughtering and meat handling, is kept as low as possible. The key for achieving this is strict meat hygiene including an uninterrupted cold chain throughout the entire meat production and handling chain.

Meat hygiene is a complex field, based on regulations by competent authorities and meat plant internal hygiene programmes, to be supervised by the plant management (see page 341). Those programmes will only be successful if meat plant staff are familiar with and active in observing basic hygiene requirements. In order to facilitate the application of hygiene requirements, it has proven useful to differentiate between:

a. **Personal hygiene**
b. **Slaughter and meat processing hygiene**
c. **Hygiene of slaughter and meat processing premises**
d. **Hygiene of slaughter and meat processing equipment**

The topics a-d are of equal significance. Negligence in any of the four areas may give rise to hazards, which can cause economic losses and affect consumers' health.

Some key requirements for **meat processing plants** are listed below. More detailed hygiene requirements are laid down in national regulations and in international codes, such as FAO/WHO CODEX ALIMENTARIUS Code of Hygienic Practice for Meat (CAC/RCP 58-2005). Guidelines on slaughter hygiene or meat transport and storage hygiene are not included hereunder. However, as meat is the primary material for processed meat products, the application of hygienic practices in slaughterhouses and throughout the cold chain is equally important. Principles of sanitation of premises and equipment are described in a separate chapter (page 369).

Principles of personal hygiene

- Wear clean protective clothes (Fig. 405, 406)
- Washing hands before starting work (Fig. 466)
- Repeatedly washing hands during work
- No finger rings, watches, bracelets
- Access to production areas with working clothes only
- Cleaning/disinfection of hands/tools/clothes if there was contact with highly contaminated subjects or abnormal animal parts likely to contain pathogens.
- Fresh wounds through knife cuts etc. must be covered by a water tight bandage. Workers with purulent wounds are not allowed to work with meat. (Risk of spread of Staph. aureus bacteria, see Fig. 464, 467, 468).
- Strict toilet hygiene must be observed (removal of apron, hand washing and hand disinfection). Toilets must be kept clean and must not have direct access to production areas. (Risk of spread of Salmonella, see Fig. 463).
- Periodic medical examination of staff

Fig. 466: Handwashing with liquid soap, pedal, paper towel.

Fig. 467: Fresh non purulent wound, to be protected by impermeable bandage.

Fig. 468: Purulent wound, working with meat prohibited.

Basic hygiene of meat processing

- Ideally meat cutting/deboning should be carried out in climatized rooms (approx. + 10°C) with low air humidity. Meat should be brought in progressively and not accumulate on work tables.
- If visual contamination of manufacturing meat occurred, do not try to wash it off but remove it with knives by cutting off superficial meat parts in the case of minor contamination. Discard the meat in case of heavy contamination.
- Do not hose down floor and wall areas or equipment next to meat processing operations or final products with a power hose. (Risk of contamination by aerosol/droplets, see Fig. 469).

Fig. 469: Cleaning with pressurized water must be avoided in rooms where meat is present

- Never take meat pieces, which accidentally had contact with the floor or other contaminated surfaces, back onto working tables or into meat processing machines (Fig. 470).
- Containers for meat, fat, or semi–or fully processed meat products must not be placed directly on the floor but on hygienic stands, pallets etc. (Fig. 471).

Fig. 470: Meat which falls accidentally onto the floor, must not be taken, goes to waste.

Fig. 471: Meat containers must not be placed directly on the floor

Hygiene of meat processing premises
(Hygienic requirements for lay-out and construction of slaughterhouse and meat processing buildings)

Meat processing facilities must meet the following basic hygienic standards in order to ensure and maintain clean and hygienic working conditions:

- Adequate rooms for personnel must be available including sections for changing clothes and for personal hygiene.
- Wall windows must be positioned at a sufficient height from the floors in order to allow profound washing and disinfection of floors and walls. Wall windows for processing plants must be at their lowest part at least 2 m

Fig. 472: Hygienically good finishing of premises. Wall tiles and wall windows 2 meters high, for easy cleaning.

high over floor level. Window frames should be of non-corrosive material e.g. aluminium or similar and must not be painted (Fig. 472).

- Walls in all rooms, where meat and by-products are handled, must have smooth and easily washable surfaces up to a minimum height of 2 m in processing plants. Walls should preferably be covered with wall tiles or at least with washable paint (Fig. 472, 475).

Fig. 473: Hygienically good finishing of premises. Easy to clean surfaces, left floor with drain and wall with coved junction, right plastic door for refrigerated room.

- Floors in the mentioned sections must be impermeable for water and reasonably smooth for good cleaning, but anti-slip for workers safety. They are usually made of fat-resistant concrete. Additional covering by epoxy substances or floor ceramics are possible (Fig. 473, 475).
- In order to facilitate proper cleaning, the junction between floor and walls must be coved, i.e. rounded (not rectangular), which can be achieved by extending the floor concrete up to an height of 10-50 cm alongside the walls. If the concrete layer alongside the wall is

Fig. 474: Proper cleaning/sanitation not possible. Crack in junction wall/floor

Fig. 475: "Cleaning friendly". Smooth floor and wall tiles, cove at junction wall/floor.

sufficiently thick (approx. 10-20 cm), it serves also as shock absorber and protects the walls against damage by transport vehicles, such as trolleys, fork lifts etc. Appropriate coves at wall-floor junctions can also be achieved by using special curved wall tiles (Fig. 475).

- All wet rooms must have floor drains, which should be covered by non-corrosive metal plates or grills (Fig. 473). The covers should be easily removable for proper cleaning of the drains. Drain sinks must be of the siphon type (anti-smell).

Fig. 476: Minced meat and vegetable in same chiller - risk of cross-contamination

Fig. 477: Rusty meat hooks

- Provisions must be made to channel waste water from hand-wash facilities, cool room evaporators, tool sterilizers, etc. by means of water pipes or similar directly into effluent drains without contaminating the floor.
- Rooms for meat processing should have sufficient ventilation. Air conditioning is only required in meat cutting/deboning rooms (10 - 12°C).
- Supply systems for electrical wiring and pipes for hot and cold water as well as for compressed air should not hamper cleaning operations and be out of reach of possible dirt contamination (Fig. 478). Insulations for hot water pipes must have smooth surfaces and be washable.
- Openings for ventilation must be bird- and insect-proof.

Fig. 478: Supply systems for electrical

Hygiene of meat processing equipment

(Hygienic requirements for design and construction of machinery, working tables and tools)

In production lines in the meat industries equipment and hand-tools should be used, which enable workers to perform all operations according to Good Hygienic Practices. It is the responsibility of the meat plant management to provide adequate equipment for all working places. For equipment manufactures, directives have been issued as to proper design and construction of meat processing equipment. Designs must allow easy and profound cleaning and avoid any accumulation of difficult to remove organic matters (negative examples see Fig. 476, 477, 479, 480).

Fig. 479: Corroded meat grinder (hygienically obsolete)

Fig. 480: Old fashioned meat processing equipment with red paint (should be stainless steel)

As a principle in modern meat industries it is commonly accepted that tools and surfaces in contact with meat should be made of food grade stainless steel or synthetic materials. **Stainless steel** must be used for working tables, meat hooks (at least their parts contact in meat), blades of knives, saws, cleavers and axes. All parts of machinery in contact with meat, fat, sausage mixes and meat ingredients must be of stainless steel such as frozen meat cutter, grinder, meat mixer and tumbler, meat emulsifier, sausage stuffer, brine injector etc. The bowls of bowl cutters are nowadays also mostly made of stainless steel. All the stainless steel parts must be smooth, easily accessible for cleaning and without hidden spaces, where particles of meat materials may accumulate (Fig. 481, 482).

Fig. 481: Adequate material for refrigerated rooms: Overhead galvanized rails and beams, stainless steel meat hook

Fig. 482: Stainless steel equipment and tools for meat processing

Galvanized steel or food-grade aluminium are useful materials in the meat industries as they are non-corrosive. Those materials should however not be in direct contact with meat, as they are not sufficiently smooth or may release unwanted substances. But they are very suitable materials for overhead rails and supporting structures, working platforms and frames for tables and machinery (Fig. 481).

Food grade synthetic materials are used for many types of meat containers and for handles of knives and other hand tools, for cutting boards and some internal parts of meat processing equipment such as washers, parts of valves etc. (Fig. 483, 484, 485, 486, 487).

Fig. 483: Food grade plastic materials

Fig. 484: Meat cutting table, frame made of stainless steel, plastic boards removable for easy cleaning

Fig. 485: Wooden cutting board, knife incisions close up when wet and imbed bacteria (hygienically not acceptable)

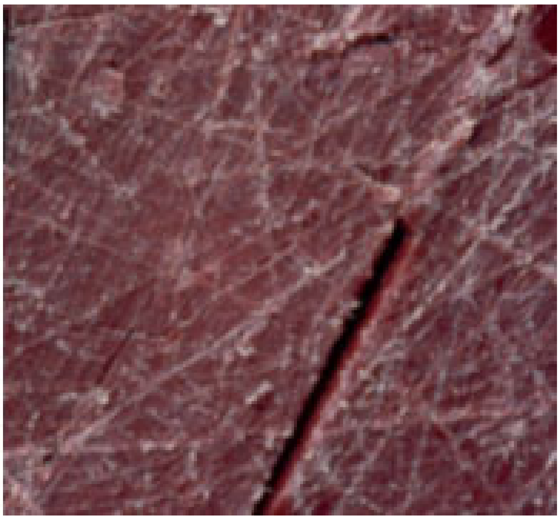


Fig. 486: Plastic cutting board, knife incisions remain open for profound cleaning

Fig. 487: Polishing plastic cutting board with shaver

In summary it can be stated that Good Hygienic Practices in meat processing requires efforts by both management and staff.

- It is the duty of the plant management to procure investments in **good quality premises and equipment** and in continuous **plant and equipment maintenance**.
- For the meat plant staff it is an obligation to observe during all meat processing operations **relevant hygienic rules**.

Such efforts will result in good storage life of attractive meat products with desirable appearance, flavour and taste.

CLEANING AND SANITATION IN MEAT PLANTS

Periodic cleaning and sanitation[1], which includes disinfection of meat plant premises and equipment, is an integral part of Good Hygienic Practice (GHP, see page 341). Cleaning and sanitation can even be considered as **one of the most important activities in the meat plant**, as these measures provide the necessary environment for proper meat handling and processing.

Efficient meat plant cleaning and sanitation is often neglected as it requires extra work and the positive effects are not immediately visible. However, failures in meat plant hygiene can cause high financial losses in the long run. Unhygienic conditions in a meat plant result in

- **unattractive, tasteless products**
- **spoilage of valuable food** and/or
- **food-borne diseases**

Proper cleaning and sanitation is becoming increasingly important in modern meat processing as more **perishable and hygienically sensitive meat products** come on the market, particularly convenience foods such as prepacked portioned chilled meat, vacuum-packed sliced sausage and ham products, meat products in controlled atmosphere packages etc. The microbial load of such products must be low to guarantee adequate shelf life and to avoid spoilage during distribution.

How to carry out meat plant cleaning and sanitation

a) General

Preconditions for efficient cleaning and sanitation are:

- Premises and equipment must be "cleaning-friendly" (see page 364), which means
  - easy and practicable access to all contaminated areas,
  - smooth surfaces and adequate materials for building structures and equipment to be cleaned.
- Proven methods for meat plant cleaning and sanitation must be available.
- Personnel must be regularly instructed and trained in cleaning and sanitation methods.

____

1) The term "sanitation" usually refers to disinfection and pest control.

Cleaning is the removal of dirt and organic substances, such as fat and protein particles from surfaces of walls, floors, tools and equipment. Through the cleaning procedures, high numbers of microorganisms (90% and more) present on the mentioned objects will be removed. However, many microorganisms stick very firmly to surfaces, in particular in tiny almost invisible layers of organic materials, so called *biofilms*, and will not entirely be removed even by profound cleaning but persist and continue multiplying.

Inactivation of those microorganisms requires antimicrobial treatments, carried out in food industries through *hot water* or *steam* or through the application of *disinfectants*. Disinfectants are chemical substances, which kill microorganisms but should not affect human health through hazardous residues and not cause corrosion of equipment. The application of disinfectants is called **disinfection**. The term **sanitation** refers to the inactivation of microorganisms through disinfectants, but also includes combating pests such as insects and rodents through chemical substances (insecticides and rodenticides).

When starting **cleaning** and **disinfection/sanitation measures** all food products must be *removed* from the area because:

- Physical cleaning with pressurized water may stir up dirt or produce contaminated water droplets (aerosol), which could contaminate meat present in such rooms.
- Chemical cleaning/disinfection may produce toxic residues when in contact with remaining meat or meat products. The same applies to insecticides and rodenticides for pest control.

Cleaning and disinfection procedures in the meat industries are complex processes depending on the **surfaces to be treated** and the kind of **contamination to be removed**. Selection of suitable **chemicals** for cleaning or for disinfection may require special knowledge. All these factors can make correct cleaning and disinfection a difficult task for the personnel involved. However, staff must be made aware that efficient cleaning and disinfection is of utmost importance for product quality and safety.

b) Cleaning techniques

The first step in floor and equipment cleaning is to physically remove scrap, i.e. coarse solid particles, with a dry brush or broom and shovel. This is usually referred to as "**dry cleaning**". Using large amounts of water to remove this material would be extremely wasteful and eventually cause drains to clog and waste water treatment facilities to become overloaded.

More profound clean-up procedures require **water** in sufficient quantities. **Manual cleaning** using brushes or scrapers is widely applied in small-scale operations although labour and time-intensive (Fig. 488). A cleaning method commonly used in the meat industries is **high pressure cleaning**. The pressurized water is applied by high pressure units and special spraying lances. The pressure should be between 30-70 bar and the spraying nozzle ≤15cm from the surface to be cleaned. Otherwise the pressure being applied decreases rapidly. If hot water is used, the temperature should be 55°C at the nozzle in order to achieve sufficiently high temperatures at the surfaces, in particular for fat removal (Fig. 489).

Fig. 488: Manual cleaning of working tables with brushes

Fig. 489: Cleaning of wall with pressurized water - care must be taken not to contaminate equipment

High pressure water is efficient for surface cleaning after dry-cleaning of scrap. It serves for the removal of remaining small solid parts, blood and dirt from the entire floors and walls of processing sections as well as for the removal of meat and fat particles and layers of protein from tools and equipment. As hot water has a much better cleaning effect than cold water, hot water should be available for this purpose.

Cleaning with equipment producing a **pressurized steam / water-mix** is even more efficient as impact temperatures of approx. 100°C can be achieved. The disadvantage of this method is the intense fog and aerosol formation, which may not only cause unwanted microbial spreading by water droplets (aerosol) but also affect installations and equipment through high humidity and excessive condensation. For these reasons a steam/water-mix is not suitable for meat processing facilities and cold or hot pressurized water cleaning is preferred.

The removal of loose dirt and meat/fat residues by water does not mean that the cleaning was complete. Sticky or encrusted layers of fat or protein will still exist and must be removed. For this purpose **chemical cleaning solutions** can be very effective.

Application can be by hand using brushes or scrapers for dismantled equipment or in general for smaller surfaces to be cleaned. Mechanical cleaning with high pressure equipment together with cleaning solutions is used for larger floor and wall areas as well as working tables, containers and equipment.

Traditional cleaning substances for manual use are **alkalines**, such as sodium carbonates (Na_2CO_3, washing soda). These substances are efficient in dissolving proteins and fats, but may cause corrosion in tools and equipment, if their pH is 11 and above.

Commercially available cleaning agents in modern cleaning practices are complex compositions of either **alkaline, acid or neutral** chemical substances. In order to improve their dirt loosening properties, surface-active agents, also called **surfactants** or **detergents** are added. Detergents decrease the superficial tension of water. Water can then penetrate into the small spaces between dirt particles and surfaces (Fig. 490), where those particles are attached, thus facilitating their removal. For fat removal by pressurized hot water, cleaning detergents are important as they keep the fat dissolved and prevent fats settling down after the water temperature has decreased. Detergents may have additional cleaning components such as chlorine, silicate or phosphate. It is important that manufacturers indicate the type of the substance, either alkaline, acidic or neutral on the product label.

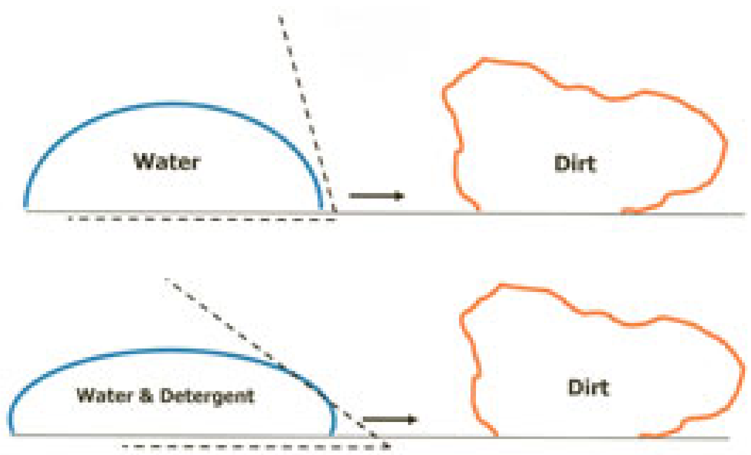


Fig. 490: Effect of detergents (surfactants): Decrease of surface tension of water droplets and impact angle (below), dirt particles are easier loosened and removed from surface.

Alkaline cleaning agents:
Generally suitable for removing organic dirt, protein residues and fat.

Acid cleaning agents:
Used particularly for removal of encrusted residues of dirt or protein or of inorganic deposits ("scaling") such as waterstone, milkstone, lime etc.

Neutral cleaning agents:
Have much less effect than alkaline or acid cleaning agents, but have mild impact on skin and materials and are useful for manual cleaning of smooth surfaces without encrusted dirt.

In practice alkaline and acid cleaning substances should be used **alternatively**. The alkaline agent should be the substance used for routine cleaning, but every few days an acid substance should be employed instead in order to remove encrusted residues, scaling etc.

Cleaning substances together with the suspended dirt particles and fat must be rinsed off using potable water.

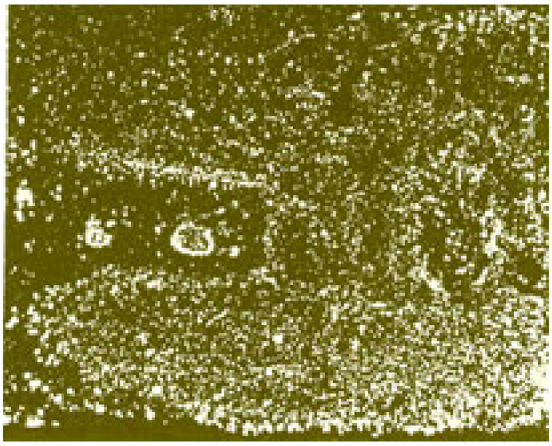
A relatively new cleaning method for the food industry, in particular the larger-scale plants, is **foam cleaning** (Fig. 491). Water foam containing detergents and other cleaning agents is sprayed on wetted walls, floors and surfaces of equipment. The foam does not immediately run off but clings to the surfaces. This allows a longer term contact on the surfaces to be cleaned. After a sufficient impact period (min. 15 minutes) the foam is washed down with water (water hose or low-pressure water spray). As no high pressure water spraying is needed for washing off the foam, the spreading of water droplets (aerosol) in the room to be cleaned is minimized.

Fig. 491: Foam cleaning

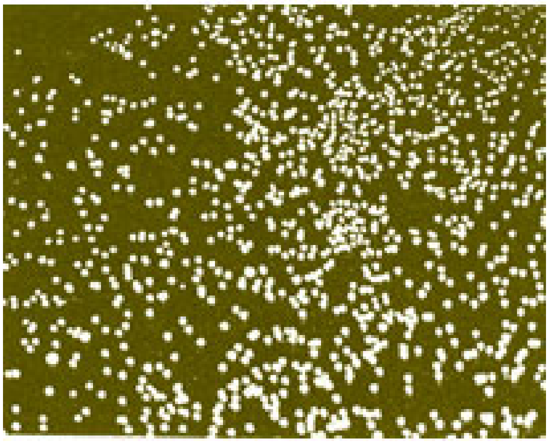
c) Disinfection techniques

Cleaning reduces a substantial amount of microorganisms (Fig. 492b) but it does not have the potential to completely eliminate all surface contamination. Persistent microorganisms will continue to grow in number by using remaining protein as nutrients and pose a further risk to the foods to be processed.

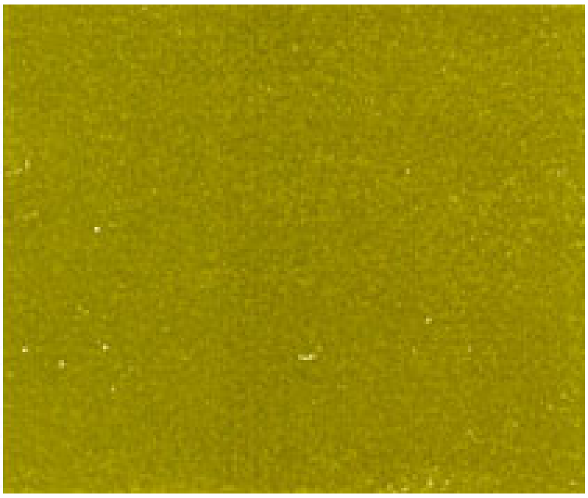
The elimination of microorganisms is achieved through **disinfection**[1], either by using hot water (or better steam) or chemical disinfectants (Fig. 492c). **Chemical disinfectants** are preferred for most applications in the meat industries as they are easy to use and do not involve the risk of accidents or other negative side effects such as damage to equipment by generating high humidity or water condensation, which may occur when using steam.



Uncleaned (rinsed only) (a)
Many bacterial colonies (white spots)



After chemical cleaning (b)
Reduced numbers of bacterial colonies



After cleaning and disinfection (c)
Very few bacterial colonies remaining

Fig. 492: Effect of cleaning and disinfection on the number of bacteria
Image of impression plate samples (see page 332) taken from a meat container (plastic)

[1] Disinfection in the food sector does not aim at the complete absence of microorganisms (such as sterilization of surgical instruments in hospitals), but the number of microorganisms must be substantially reduced by the process.

Best disinfection results are achieved when chemical disinfection is preceded by intensive dry/wet cleaning (see page 370, b). Disinfection without precleaning is not fully efficient as many microorganisms remain embedded in encrusted dirt, protein and fat, which cannot be properly dissolved by disinfection chemicals. Therefore microorganisms remain protected against the disinfection chemicals. Moreover, remaining protein may inactivate chemical disinfectants.

Adequate rinsing with water after cleaning and prior to disinfection is also indispensable, as chemical disinfectants may be neutralized by remaining cleaning substances. All this has to be taken into account, otherwise the disinfection procedures may be inefficient and a waste of money.

A compromise on this issue is proposed by the chemical industry by offering so called combined **disinfection/cleaning** agents. They are made on the basis of *quaternary ammonium compounds*, which have surfactant and disinfectant properties. The combined method should be considered only in cases of very little dirt contamination.

It is very important that disinfection chemicals are strictly used according to the specifications given by the suppliers. Lower concentrations and shorter impact periods than prescribed will considerably reduce the efficacy of disinfection or make it totally inefficient. Surfaces should be **dried** after cleaning and rinsing before starting disinfection. This is important, as the concentration of the disinfection solution would be lowered with remaining water on the surfaces and possibly ineffective when becoming too highly diluted.

The application of chemical disinfectants is done with stationary or mobile spraying devices. In medium or small scale meat plants, mobile spraying devices are sufficient (Fig. 493). The disinfectant is applied by means of spraying lances and manual or electrical pumps. One important rule is, that the disinfectant solution must be applied from **top** to **bottom**, i.e., first upper parts of walls, then lower parts of walls and the floor last. The same applies to equipment.

Fig. 493: Disinfection of walls by using portable spray equipment. For operator's protection gloves and facemask are recommended.

Hot disinfectant solutions (up to 50^{o}C) are more effective than cold ones. After application, the disinfectant solution must remain for a certain period of time on the surfaces to be disinfected as indicated in the user instructions, normally for 30 minutes. Thereafter removal of the chemicals through rinsing with potable water is needed.

d) Disinfectants for the meat industry

Disinfectants should be effective and rapidly acting in killing microorganisms (Fig. 494). It should be noted that disinfectants do not sterilize the surfaces treated, *absolute germ-free surfaces* cannot be achieved, but disinfectants should kill all **pathogens.** The chemical composition of disinfectants vary depending on the specific target (slaughterhouse, meat processing, easily accessible open processing lines or closed food pipeline systems) and on chemical formulations by the individual disinfectant manufacturer. Modern disinfectants are mostly mixtures of different chemical substances. Combinations of disinfection chemicals achieve a synergistic effect and result in the elimination of a broader spectrum of microorganisms. The exact compositions are sometimes not fully revealed by the manufacturers. In principle the following groups of substances are used:

1. Chlorine containing compounds a) Na - or Ca-hypochlorite (Na/Ca O Cl) b) Gaseous chlorine (Cl_2) (Hypochlorous acid is the effective substance used preferably for disinfection of water)	Effective against a wide range of bacteria, penetrates cell walls, but has a corroding effect on equipment
2. Aldehydes (used in animal production, e.g. Formaldedyde) Phenoles / Kresols (used in medicine, households Alcohols (used in medicine, e.g. skin) Alkalines (pH 10 or higher) (e.g. NaOH, used in animal production) Acids (some organic acids used in food industries)	Destruction of microorganisms, may be corrosive
3. Quaternary ammonium compounds (QUATS) Amphotensids (used in food industries, as not corrosive) Low efficiency on spores	Effect on cell walls, not corrosive, odourless, additional cleaning properties (surfactant)

4. Oxygen releasing substances
   Peroxide compounds (H_2O_2)
   Per-acetic acid
   (use in food industries)

Penetrate into cells, good effect on all microorganisms incl. spores and virus, odourless, may be corrosive in concentrations >1%

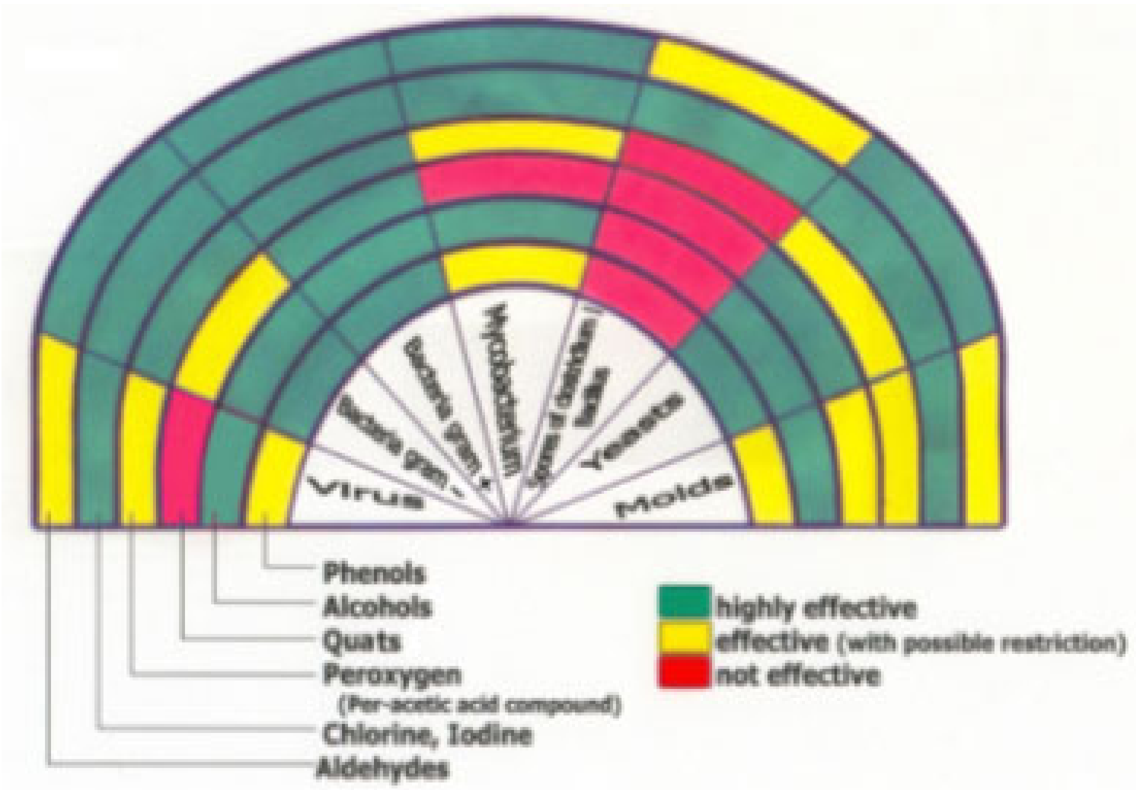


Fig. 494: Effect of some chemical disinfectants on microorganisms

The following commercially available disinfectant is an example for an efficient **combination of components**:

- organic acids
- surfactants (= surface active agents)
- peroxide compounds

The **organic acids**, apart from their sanitizing effect, decrease the pH as some disinfectants are more efficient at lower pH. The **surfactants** assist in penetrating organic material. The **peroxide compounds** have the direct antimicrobial effect by coagulation and denaturation of proteins (virus) and penetration through cell walls causing cell destruction (bacteria).

The available types of chemical disinfectants act differently on certain groups of bacteria and under certain pH-ranges. In order to achieve a maximum disinfection effect, it is recommended to **alternate periodically** the type of the chemical disinfectant applied. Utilization of suitable alternative substances will inactivate bacteria, which were possibly surviving the previous sanitation process. This procedure will also help to counteract the development of resistant bacteria in the meat plant (see "Cleaning and sanitation plan", table 22).

e) Cleaning and disinfection (sanitation) schemes

Meat industry staff must be made fully aware of the need for proper cleaning. Cleaning should be treated as an integral part of the production process. It should be done carefully and not just superficially or in a rush at the end of the production process.

While daily cleaning or even cleaning several times a day is an absolute necessity, it has to be decided according to type and product lines or activity of each individual meat plant, where and at which time intervals disinfection measures should be applied.

Frequency of disinfection depends on need requirements:

- **Several daily disinfections** (by hot water or chemicals) are necessary for hand tools, meat saws and cutting boards.
- **Daily disinfection** is useful for dismantled equipment such as parts of grinders, fillers, stuffers, etc.
- **Disinfection once a week** is recommended for other equipment and floors and walls of processing and chilling rooms.

Cleaning and disinfection plans

For all rooms and all equipment used for meat processing or meat storage, specific **cleaning and disinfection plans** should be established.

In table 22, an example is given for disinfection of meat processing equipment, in this case for a meat grinder. This type of equipment is an integral part of almost every meat processing line. Meat grinders require particular careful and frequent cleaning and sanitation, as the output product **minced meat** is hygienically very sensitive.

Table 22: Cleaning and disinfection plan (example)

Equipment: Meat grinder

Pre-cleaning	Potable water Temp.: 40-50°C Pressure: 20-30 bars	
Cleaning	Daily Agent: A Concentr.: 1.0% Temp.: 40-50°C Time: 20-30 min pH: approx. 12	1 x monthly Agent: B Concentr.: 1.5% Temp.: 40-50°C Time: 20-30 min pH: approx. 1.8
Rinsing	Potable water Temp.: 30-50°C Pressure: 5-10 bars	
Drying		
Disinfection	2 x weekly Agent: C Concentr.: 0.5% Temp.: 30-40°C Time: 30 min pH: approx. 5.7	3 x weekly Agent: D Concentr.: 1.0% Temp.: 30-40°C Time: 30 min pH: approx. 10.2
Rinsing	Potable water Temp.: 30-50°C Pressure: 5-10 bars	

Agent **A**: Alkaline cleaning substance
Agent **B**: Acid cleaning substance
Agent **C**: Disinfectant
Agent **D**: Disinfectant chemically different from C and supplementing impact of C

ANNEX I

RECIPES FOR PROCESSED MEAT PRODUCTS

Fresh meat products

Raw-fermented sausages

Raw-cooked meat products

Precooked-cooked products

Cured meat cuts

Indigenous meat products

Please note:

The term NITRITE CURING SALT used in some of the recipes refers to a standard mixture of common salt with the curing agent sodium nitrite. The premix consists of 99.5% salt and 0.5% nitrite.

FRESH MEAT PRODUCTS

BOERWORS / South African BBQ sausage
(Fresh sausage type, coarse mixture)

INGREDIENTS

Raw materials:	(calculated for 10 kg batch)	
90.00 %	Beef trimmings without tendons	9.000 kg
Extenders:		
4.00 %	Rusk (baked and crushed wheat flour	0.400 kg
3.00 %	Water, potable	0.300 kg
3.00 %	Vinegar	0.300 kg
Additives:		
(per kg of raw materials)		(total for 10 kg)
18.00 g	Common salt (refined)	180.00 g
Seasonings:		
(per kg of raw materials)		(total for 10 kg)
2.00 g	White pepper, ground	20.00 g
1.50 g	Coriander, ground	15.00 g
0.50 g	Thyme	5.00 g

PROCESSING

CUT	Fresh meat trimmings into small pieces
SOAK	Rusk in added potable water
MIX	Meat trimmings, rusk, vinegar and seasonings
GRIND	Mixture 3 mm
STUFF	Into natural sheep casings (26-28 mm)
PORTION	Link into sausages of desired size (60-100 g)
STORE	Below +4°C, shelf life < 4 days
PREPARE	Fry in a frying pan or roast on a grill

LONGGANISA / Philippine BBQ Sausage**
(Fresh sausage type, coarse mixture)

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

60.00 %	Pork trimmings, fresh	6.000 kg
40.00 %	Pork belly without rind	4.000 kg

Extenders: ---

Additives:

(per kg of raw materials)		(total for 10 kg)
7.00 g	Nitrite curing salt	70.00 g
7.00 g	Common salt (refined)	70.00 g
2.50 g	Phosphate	25.00 g

Seasonings:

(per kg of raw materials)		(total for 10 kg)
50.00 g	Sugar (refined)	500.00 g
20.00 g	Pineapple juice	200.00 g
10.00 g	Anisado wine	100.00 g
20.00 g	Garlic, fresh	200.00 g
5.00 g	Black pepper, ground	50.00 g

PROCESSING

CUT	Fresh meats into small pieces
MIX	Fresh meats, additives, seasonings
GRIND	Meat/seasonings mixture 5 mm
MIX	All ground materials thoroughly
STUFF	Into natural sheep casings (22-24 mm)
PORTION	Link to sausages of desired size (60-100 g)
STORE	Below +4°C, shelf life < 4 days
PREPARE	Fry in a frying pan or roast on a grill

** **CHICKEN LONGGANISA** see page 191

<u>MERGUEZ</u> / French BBQ Sausage
(Fresh sausage type, coarse mixture)

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

40.00 %	Beef meat trimmings	4.000 kg
35.00 %	Mutton meat trimmings	3.500 kg
10.00 %	Beef muscle and brisket fat	1.000 kg
5.00 %	Mutton fats	0.500 kg
5.00 %	Green pepper, fresh	0.500 kg
5.00 %	Onions, fresh	0.500 kg

Extenders: ---

Additives:

(per kg of raw materials)		(total for 10 kg)
15.0 g	Common salt (refined)	150.00 g

Seasonings:

(per kg of raw materials)		(total for 10 kg)
2.0 g	Black pepper, ground	20.00 g
1.0 g	Chilli, ground	10.00 g
5.0 g	Garlic, fresh	50.00 g

PROCESSING

CUT	Fresh meats and fats into small pieces
GRIND	Meat and onions 13 mm, muscle and brisket fat 5 mm
MIX	Ground meat and fat with seasonings
GRIND	Meat/seasonings mixture 5 mm
STUFF	Into natural sheep casings (22-24 mm)
PORTION	Link to sausages of desired size (60-100 g)
STORE	Below +4°C, shelf life < 4 days
PREPARE	Fry in a frying pan or roast on a grill

CHORIZO CRIOLLO / Latin American BBQ sausage
(Fresh sausage type, coarse mixture)

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

75.00 %	Pork meat trimmings	7.500 kg
20.00 %	Beef meat trimmings	2.000 kg
5.00 %	Pork back fat	0.500 kg

Extenders: ---

Additives:

(per kg of raw materials)		(total for 10 kg)
16.00 g	Common salt (refined)	160.00 g

Seasonings:

(per kg of raw materials)		(total for 10 kg)
4.00 g	Pepper, ground	40.00 g
3.00 g	Pepper, broken corns	30.00 g
3.00 g	Red wine	30.00 g
1.00 g	Cane sugar	10.00 g
1.00 g	Garlic, fresh	10.00 g

PROCESSING

CUT	Fresh meat trimmings into small pieces
MIX	Meat trimmings, additives and seasonings
GRIND	Mixture 5 mm
STUFF	Into natural hog casings (24-26 mm)
PORTION	Link to sausages of desired size (60-100 g)
STORE	Below +4°C, shelf life < 4 days
PREPARE	Fry in a frying pan or roast on a grill

<u>SALCHICHA MADRILENA</u> / Spanish BBQ sausage

(Fresh sausage type, coarse mixture)

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

50.00 %	Pork meat without tendons, lean	5.000 kg
50.00 %	Pork belly without rind, fresh	5.000 kg

Extenders: ---

Additives:

(per kg of raw materials)		(total for 10 kg)
18.00 g	Common salt (refined)	180.00 g

Seasonings:

(per kg of raw materials)		(total for 10 kg)
10.00 g	Paprika, sweet-red	100.00 g
3.00 g	Red pepper	30.00 g
3.00 g	Marjoram	30.00 g
0.50 g	Garlic, fresh	5.00 g

PROCESSING

CUT	Fresh meat trimmings into small pieces
MIX	Meat trimmings and seasonings
GRIND	Mixture 3 mm
STUFF	Into natural sheep casings (20-24 mm)
PORTION	Link to sausages of desired size (60-100 g)
STORE	Below +4°C, shelf life < 4 days
PREPARE	Fry in a frying pan or roast on a grill

BRATWURST / German BBQ sausage
(Fresh sausage type, coarse meat mixture)

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

50.00 %	Pork trimmings, lean, fresh	5.000 kg
30.00 %	Pork belly without skin, fresh	3.000 kg
20.00 %	Beef trimmings, lean	2.000 kg

Extenders: ---

Additives:

(per kg of raw materials)		(total for 10 kg)
15.00 g	Common salt (refined)	150.00 g
1.50 g	Phosphate, plain (>pH 7.3)	15.00 g

Seasonings:

(per kg of raw materials)		(total for 10 kg)
50.00 g	Onions, fresh	500.00 g
2.00 g	White pepper, ground	20.00 g
0.30 g	Ginger, ground	3.00 g
0.30 g	Cardamom, ground	3.00 g
0.20 g	Nutmeg, ground	2.00 g

PROCESSING

CUT	Pork meats and onions in small pieces
GRIND	Beef trimmings 3 mm
MIX	Fresh pork meat, onions, ground beef, seasonings
GRIND	Meat/onion/seasonings mixture 5 mm
MIX	All ground materials thoroughly
STUFF	Into natural pork casings (26-28 mm)
PORTION	Link to sausages of desired size (60-100 g)
STORE	Below +4°C, shelf life < 2 days
PREPARE	Fry in a frying pan or roast on a grill

THURINGIAN BBQ SAUSAGE

(Fresh sausage type, coarse meat with binder, water added)

INGREDIENTS

Raw materials:	(calculated for 10 kg batch)	
50.00 %	Pork trimmings, lean, fresh	5.000 kg
30.00 %	Pork belly without skin, fresh	3.000 kg
15.00 %	Beef trimmings, lean	1.500 kg
5.00 %	Ice (potable water)	0.500 kg

Extenders: ---

Additives:

(per kg of raw materials)		(total for 10 kg)
15.00 g	Common salt (refined)	150.00 g
1.50 g	Phosphate, plain (>pH 7.3)	15.00 g

Seasonings:

(per kg of raw materials)		(total for 10 kg)
50.00 g	Onions, fresh	500.00 g
2.00 g	White pepper, ground	20.00 g
0.30 g	Ginger, ground	3.00 g
0.30 g	Cardamom, ground	3.00 g
0.20 g	Nutmeg, ground	2.00 g

PROCESSING

GRIND	Beef trimmings and onions 3 mm
CHOP	Ground beef with ice and all additives Until a fine lean batter is achieved
CUT	Pork meat and belly in small pieces
MIX	Fresh pork meat, onions, ground beef, seasonings
GRIND	Meat/onion/seasonings mixture 5 mm
MIX	All ground materials and fine beef batter thoroughly
STUFF	Into natural sheep casings (22-24 mm)
PORTION	Link to sausages of desired size (60-100 g)
STORE	Below +4°C, shelf life < 2 days
PREPARE	Fry in a frying pan or roast on a grill

<u>BEEFBURGER</u> (traditional recipe, premium)**
(Fresh processed meat product, coarse mixture)

INGREDIENTS

Raw materials: (calculated for 5 kg batch)

100.00 %	Lean beef meat, low connective tissue	5.000 kg

Extenders: ---

Additives:
(per kg of raw materials) (total for 5 kg)

12.00 g	Common salt	60.00 g

Seasoning:
(per kg of raw materials) (total for 5 kg)

5.00 g	Black pepper ground	25.00 g

PROCESSING

CUT	Lean beef meat into small pieces
MIX	lean beef meat, additives and seasoning
GRIND	Mixture 3mm
SHAPE	Into patties (50-100 g per patty) in paperlyne
PACK	In P.E. bag and seal
STORE	In freezer at -18°C
PREPARE	Fry in shallow oil or grill on charcoal

** **CHICKEN BURGERS** see page 191, 202

LOW-COST BURGERS see page 201

<u>JUICY BURGER</u> (Beef/pork mixture, premium, Philippines)
(Fresh processed meat product, coarse mixture)

INGREDIENTS

Raw materials: (calculated for 5 kg batch)

40.00 %	Beef lean, ground	2.000 kg
45.00 %	Pork lean, ground	2.250 kg
10.00 %	Pork back fat	0.500 kg
5.00 %	Potable water	0.250 kg

Extenders: ---

Additives:
(per kg of raw materials) (total for 5 kg)

12.00 g	Common salt	60.00 g
2.00 g	Phosphate	15.00 g

Seasoning:
(per kg of raw materials) (total for 5 kg)

10.00 g	Sugar, refined	50.00 g
11.00 g	Garlic, chopped	55.00 g
5.00 g	Black pepper ground	25.00 g
1.50 g	Monosodium glutamate (MSG)	7.50 g
1.00 g	Celery powder	5.00 g
130.00 g	Onion, chopped	650.00 g
30.00 g	Wheat flour	150.00 g
2 pcs	Eggs, fresh	10 pcs

PROCESSING

CUT	Lean meat and pork back fat into small pieces
MIX	Lean meat, back fat, additives and seasoning
GRIND	Mixture 3mm
FORM	Into patties (50 g per patty) in paperlyne
PACK	In PE bag and seal
STORE	In freezer at -18°C
PREPARE	Fry in shallow oil or grill on charcoal

<u>JUICY BURGER</u> (Beef/pork mixture, extended, Philippines)
(Fresh processed meat product, coarse mixture)

INGREDIENTS

Raw materials: (calculated for 5 kg batch)

25.00 %	Beef lean, ground	1.250 kg
25.00 %	Pork lean, ground	1.250 kg
20.00 %	Pork back fat, ground	1.000 kg

Extenders: (total for 5 kg)

8.00 %	TVP (textured vegetable protein)	0.400 kg
21.50 %	Water for hydration	1.075 kg
0.50 %	ISP (isolated soy protein)	0.025 kg

Additives:
(per kg of raw materials) (total for 5 kg)

12.00 g	Common salt	60.00 g
2.00 g	Phosphate	10.00 g
50.00 g	Potable water	250.00 g

Seasonings:
(per kg of raw materials) (total for 5 kg)

10.00 g	Sugar, refined	50.00 g
1.00 g	Celery powder	5.00 g
5.00 g	Black pepper ground	25.00 g
100.00 g	Onion, chopped	500.00 g
30.00 g	All purpose flour	150.00 g
10.00 g	Garlic, chopped	50.00 g
2 pcs	Eggs, fresh	10 pcs

PROCESSING

HYDRATE	TVP and ISP with potable water
CUT	Lean meat and pork back fat into small pieces
GRIND	Pork back fat and lean meat 3mm
MIX	Meat and fat with hydrated TVP/ISP, additives, seasonings
FORM	Into patties (50 g) in paperlyne
PACK	In P.E. bag and seal bags
STORE	In freezer at -18°C
PREPARE	Fry in shallow oil or grill on charcoal

CHICKEN NUGGETS / Asian small-scale product
(Fresh processed meat product, coarse mixture)

INGREDIENTS

Raw materials: (calculated for 5 kg batch)

95.00 %	Chicken meat, boneless	4.750 kg
5.00 %	Chicken skin (from breast)	0.250 kg

Additives:
(per kg of raw materials) (total for 5 kg)

12.00 g	Common salt	60.00 g
3.00 g	Phosphate	15.00 g
50.00 g	Potable water (chilled)	250.00 g

Seasonings:
(per kg of raw materials) (total for 5 kg)

10.00 g	Sugar (refined)	50.00 g
20.00 g	Garlic fresh, chopped	100.00 g
6.00 g	White pepper, ground	30.00 g
1.00 g	Monosodium glutamate (MSG)	5.00 g

PROCESSING

GRIND	Chilled chicken skin 3mm Chilled chicken meat, 5 mm
MIX	Ground raw materials, additives and seasonings
MOULD	Mixture in a rectangular tray, 10-15 mm thick
FREEZE	At -7°C to facilitate cutting into nuggets
CUT	Into desired size (e.g. 20x30 mm)
ROLL	In breading or in bread crumbs
STORE	Packed and deep-frozen at -18°C
PREPARE	Deep-fry at +180°C until golden brown

RAW-FERMENTED SAUSAGES

<u>CHORIZO</u> / Medium-term ripened raw sausage

(Raw-fermented sausage type, coarse mixture)

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

50.00 %	Pork meat without tendons, lean	5.000 kg
50.00 %	Pork belly without rind, fresh	5.000 kg

Extenders: ---

Additives:

(per kg of raw materials)		(total for 10 kg)
28.00 g	Common salt (refined)	280.00 g
0.50 g	Sugar	5.00 g
0.50 g	GdL (glucono-delta-lactone)	5.00 g

Seasonings:

(per kg of raw materials)		(total for 10 kg)
5.00 g	Paprika, sweet, red	50.00 g
1.50 g	Chilli, ground	15.00 g

PROCESSING

CUT	Meat and belly into small pieces, keep at -4°C
MIX	Raw materials, additives and seasonings
GRIND	Mixture 8 mm
STUFF	Into natural sheep casings (28-32 mm)
PORTION	Link into sausages of desired size (100-200 g)
RIPEN	For 7 days at +18-22°C (weight loss 25-30.0 %)
SMOKE	Cold smoke (<+22°C) for 6 hrs. on day 2/5 (weight loss 30-35 %)
STORE	In a dry and cool place (below + 25°C)

<u>MUTTON SALAMI</u> / Medium-term ripened raw sausage

(Raw-fermented sausage type, coarse mixture)

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

80.00 %	Mutton meat without tendons, fresh	8.000 kg
20.00 %	Beef fat, fresh	2.000 kg

Extenders: ---

Additives:

(per kg of raw materials)		(total for 10 kg)
22.00 g	Nitrite curing salt	220.00 g

Seasonings:

(per kg of raw materials)		(total for 10 kg)
2.00 g	Black pepper, ground	20.00 g
1.00 g	White pepper corns	10.00 g
0.50 g	Cardamom, ground	5.00 g
1.00 g	Fresh garlic	10.00 g

PROCESSING

CUT	Meat and fat into small pieces and keep at –4°C
MIX	Frozen meat and fat pieces and seasonings
GRIND	Meat/seasonings mixture 5 mm
STUFF	Natural sheep or beef casings (28-34 mm)
PORTION	Link into sausages of desired size (60-100 g)
RIPEN	3-5 days at +20°C
SMOKE	Cold smoke (<+22°C) for 6 hrs. on day 2/5 (weight loss 30-35 %)
STORE	In a dry and cool place (below + 25°C)

<u>SUMMER SAUSAGE</u> / Quick-cured raw sausage

(Semi-dry, raw-fermented sausage type, coarse mixture)

Meat grinder use only

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

30.00 %	Pork meat, lean	3.000 kg
30.00 %	Beef trimmings, lean	3.000 kg
20.00 %	Pork belly without skin	2.000 kg
20.00 %	Pork back fat	2.000 kg

Extenders: ---

Additives:

(per kg of raw materials)		(total for 10 kg)
28.00 g	Nitrite curing salt	280.00 g
1.00 g	Starter cultures (e.g. Staphylococcus)	10.00 g
3.00 g	GdL (glucono-delta-lactone)	3.00 g

Seasonings:

(per kg of raw materials)		(total for 10 kg)
3.00 g	White pepper, ground	30.00 g
2.00 g	Mustard seeds	20.00 g
1.00 g	Coriander, ground	10.00 g
0.50 g	Pimento	5.00 g

PROCESSING

(meat grinder only)

CUT	Pork meat into small pieces and keep below –4°C Back fat into dices (10-20 mm), keep below –4°C
GRIND	Lean beef trimmings 3 mm
MIX	Raw materials, additives and seasonings
GRIND	Mixture 5 mm
STUFF	Beef middles (35-45 mm) Fibrous/collage casings (50-60 mm)
RIPEN	At <+24-26°C for 4-7 days
SMOKE	Cold smoke (<+22°C) on days 2, 4 and 6 (weight loss approx. 25-30%)
KEEP	In a dry and cool place

CERVELAT SAUSAGE / Quick-cured raw sausage
(Semi-dry, raw-fermented sausage type, fine particles)
Meat grinder / bowl cutter combined use

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

40.00 %	Pork meat, lean	4.000 kg
30.00 %	Beef trimmings, lean	3.000 kg
30.00 %	Pork back fat	3.000 kg

Extenders: ---

Additives:

(per kg of raw materials)		(total for 10 kg)
28.00 g	Nitrite curing salt	280.00 g
1.00 g	Starter cultures (e.g. Staphylococcus)	10.00 g
3.00 g	GdL (glucono-delta-lactone)	3.00 g

Seasonings:

(per kg of raw materials)		(total for 10 kg)
3.00 g	White pepper, ground	30.00 g
1.00 g	Coriander, ground	10.00 g

PROCESSING

CUT	Pork meat into small pieces, keep below –12°C 50% beef meat into pieces, keep below –12°C Back fat into dices (10-20 mm), keep below –12°C
GRIND	Remaining lean beef 2 mm, keep chilled
CHOP	At high speed the frozen lean pork, beef, back fat including starter cultures and seasonings (until fine particle size is achieved)
ADD	At slow speed the ground beef trimmings and distribute thoroughly, now add the curing salt and continue chopping (final temperature -4-6°C)
STUFF	Beef bungs or fibrous/collagen casings (60-75 mm)
RIPEN	At <+24-26°C for 4 days, at +22°C for 5 days
SMOKE	Cold smoke (<+22°C) on days 2, 5 and 8 (weight loss approx. 30-35%)
KEEP	In a dry and cool place

<u>SALAMI SAUSAGE</u> / Long-term ripened raw sausage
(Raw-fermented sausage type, coarse mixture)
Meat grinder use only

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

35.00 %	Pork meat, lean	3.500 kg
35.00 %	Beef trimmings, lean	3.500 kg
30.00 %	Pork back fat	3.000 kg

Extenders: ---

Additives:

(per kg of raw materials)		(total for 10 kg)
28.00 g	Nitrite curing salt	280.00 g
1.00 g	Starter cultures (mixtures)	10.00 g
3.00 g	Sugar (lactose-glucose)	3.00 g

Seasonings:

(per kg of raw materials)		(total for 10 kg)
3.00 g	White pepper, ground	30.00 g
2.00 g	Mustard seeds	20.00 g
1.00 g	Coriander, ground	10.00 g
0.50 g	Pimento	5.00 g

PROCESSING

CUT	Pork meat into small pieces and keep below –4°C Back fat into dices (10-20 mm), keep below –4°C
GRIND	Lean beef trimmings 3 mm
MIX	Raw materials, additives and seasonings
GRIND	Mixture 5 mm
STUFF	Beef middles (35-45 mm) Fibrous/collage casings (55-75 mm)
PORTION	Link, tie/clip and hang (400-2000 g)
REDDEN	6 days at +20-25°C (lower temperature from day 4)
RIPEN	At <+14°C for 10 days
SMOKE	Cold smoke (<+22°C) on days 2, 4 and 6 (weight loss 30-40%)
KEEP	In a dry and cool place

SALAMI SAUSAGE / Long-term ripened raw sausage
(Raw-fermented sausage type, coarse mixture)
Meat grinder / bowl cutter combined use

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

35.00 %	Pork meat, lean	3.500 kg
35.00 %	Beef trimmings, lean	3.500 kg
30.00 %	Pork back fat	3.000 kg

Extenders: ---

Additives:

(per kg of raw materials)		(total for 10 kg)
28.00 g	Nitrite curing salt	280.00 g
1.00 g	Starter cultures (mixtures)	10.00 g
3.00 g	Sugar (lactose-glucose)	3.00 g

Seasonings:

(per kg of raw materials)		(total for 10 kg)
3.00 g	White pepper, ground	30.00 g
2.00 g	Mustard seeds	20.00 g
1.00 g	Coriander, ground	10.00 g
0.50 g	Pimento	5.00 g

PROCESSING

CUT Pork meat into small pieces and keep below –10°C
Back fat into dices (20 mm), keep below –12°C
GRIND Lean beef trimmings 3 mm, keep chilled (0°C)
CHOP At medium speed the lean pork meat, back fat including starter cultures and seasonings (until fat displays desired particle size)
ADD At slow speed the ground beef trimmings and distribute thoroughly, now add the curing salt and continue chopping (final temperature -4°/-6°C)
STUFF Fibrous/collagen casings (55-75 mm)
REDDEN – RIPEN – SMOKE - STORE

RAW-COOKED MEAT PRODUCTS

FRANKFURTERS (mixed beef/pork product)
(Raw-cooked sausage type, finely chopped batter)

INGREDIENTS

Raw materials: (calculated for a 30 kg batch)

30.00 %	Pork meat trimmings, lean	9.000 kg
20.00 %	Beef meat trimmings, lean	6.000 kg
25.00 %	Fatty pork tissues	7.500 kg
25.00 %	Ice (drinking water)	7.500 kg

Additives:

(per kg raw materials)		(total for 30 kg)
18.00 g	Nitrite curing salt	540.00 g
3.00 g	Phosphate (pH >7.3)	90.00 g
0.30 g	Ascorbic acid	9.00 g

Seasonings:

(per kg raw materials)		(total for 30 kg)
3.00 g	White pepper, ground	90.00 g
1.00 g	Nutmeg, ground	30.00 g
0.50 g	Cardamom, ground	15.00 g
0.20 g	Coriander, ground	6.00 g

PROCESSING

GRIND	Meats and fats separately 3 mm
CHILL	Meats and fats over night at < +4°C
CHOP	Ground meat, ice and additives for 10-15 rounds
	Add fats and seasonings and chop until +12°C
STUFF	Sheep casings (24/26 mm) or pig casings (26/28 mm)
LINK	To desired length and twist
SMOKE	At +65°C for 40 min.
COOK	In water or steam +76°C for > 30 min.
	(core temperature > +72°C for all products)
COOL	Under cold shower or in water until <+20°C
STORE	In chiller below +4°C, shelf life < 14 days

VIENNA SAUSAGES (premium quality, mixed beef/pork product)
(Raw-cooked sausage type, finely chopped batter)

INGREDIENTS

Raw materials: (calculated for a 30 kg batch)

40.00 %	Pork meat trimmings, lean	12.000 kg
16.00 %	Beef meat trimmings, lean	4.800 kg
22.00 %	Fatty pork tissues	6.600 kg
22.00 %	Ice (drinking water)	6.600 kg

Extenders: ---

Additives:

(per kg raw materials)		(total for 30 kg)
18.00 g	Nitrite curing salt	540.00 g
3.00 g	Phosphate (pH >7.3)	90.00 g
0.30 g	Ascorbic acid	9.00 g

Seasonings:

(per kg raw materials)		(total for 30 kg)
3.00 g	White pepper, ground	90.00 g
1.00 g	Nutmeg, ground	30.00 g
0.50 g	Cardamom, ground	15.00 g
0.20 g	Coriander, ground	6.00 g

PROCESSING

GRIND	Meats and fats separately 3 mm
CHILL	Meats and fats over night at < +4°C
CHOP	Ground meat, ice and additives for 10-15 rounds Add fats and seasonings and chop until +12°C
STUFF	Sheep casings (20/22 mm)
LINK	To desired length and twist
SMOKE	At +65°C for 40 min.
COOK	In water or steam +76°C for > 30 min. (core temperature > +72°C for all products)
COOL	Under cold shower or in water until <+20°C
STORE	In chiller below +4°C, shelf life < 14 days

CHICKEN VIENNAS (premium quality, pure poultry product)
(Raw-cooked sausage type, finely chopped batter)

INGREDIENTS

Raw materials: (calculated for a 30 kg batch)

50.00 %	Chicken meat trimmings, lean	15.000 kg
10.00 %	Vegetable oil	3.000 kg
20.00 %	Chicken fat emulsion (1:6:6)	6.000 kg
20.00 %	Ice (drinking water)	6.000 kg

Extenders: ---

Additives:

(per kg raw materials and extenders)		(total for 30 kg)
10.00 g	Nitrite curing salt	300.00 g
2.00 g	Phosphate	60.00 g
0.10 g	Sodium erythorbate	3.00 g
1.00 g	Food colouring (liquid)	30.00 g

Seasonings:

(per kg raw materials and extenders)		(total for 30 kg)
2.00 g	White pepper, ground	60.00 g
0.30 g	Nutmeg, ground	9.00 g
0.60 g	Garlic powder	18.00 g

PROCESSING

GRIND	Meat trimmings 3 mm
EMULSIFY	Chicken skin/fats, chill emulsions at < 0°C
CHILL	Meat trimmings and vegetable oil over night
CHOP	Meats, ice, extenders and additives for 10-15 rounds
	Add fat emulsion and seasonings and chop until +12°C
STUFF	Into sheep or collagen casings, 20-22 mm and link
SMOKE	Dry for 30 min. at +45°C, smoke at +65°C for 30 min.
COOK	In water or steam at +75°C for 20 min.
COOL	under cold shower or in water, vacuum pack and chill
STORE	< +4 C, shelf life less than 10 days

* Part of the lean chicken meat is often replaced by other poultry meats, mostly turkey, to improve texture, colour and binding; subject to availability.

BEEF FRANKFURTERS (pure beef product)
(Raw-cooked sausage type, finely chopped batter)

INGREDIENTS

Raw materials: (calculated for a 30 kg batch)

40.00 %	Beef meat trimmings, lean	12.000 kg
20.00 %	Beef meat trimming, fatty	6.000 kg
15.00 %	Vegetable oil	4.500 kg
25.00 %	Ice (drinking water)	7.500 kg

Extenders: ---

Additives:

(per kg raw materials)		(total for 30 kg)
18.00 g	Nitrite curing salt	540.00 g
3.00 g	Phosphate (pH >7.3)	90.00 g
0.30 g	Ascorbic acid	9.00 g

Seasonings:

(per kg raw materials)		(total for 30 kg)
3.00 g	White pepper, ground	90.00 g
1.00 g	Nutmeg, ground	30.00 g
0.50 g	Cardamom, ground	15.00 g
0.20 g	Coriander, ground	6.00 g

PROCESSING

GRIND	Beef meats 3 mm
CHILL	Meats and vegetable oil over night at < +4°C
CHOP	Ground meats, ice and additives for 25 rounds Add vegetable oil and seasonings, chop until +12°C
STUFF	In sheep or collagen casings, 24/26 mm
LINK	To desired length and twist
SMOKE	At +65°C for 40 min.
COOK	In water or steam +76°C for > 30 min. (core temperature > +72°C)
COOL	Under cold shower or in water until <+20°C
STORE	In chiller below +4°C, shelf life < 14 days

LYONER / Fine ham sausage

(Raw-cooked sausage type, finely chopped batter)

INGREDIENTS

Raw materials: (calculated for 30 kg medium batch)

40.00 %	Pork meat trimmings, lean	12.000 kg
15.00 %	Beef meat trimmings, lean	4.500 kg
22.50 %	Fatty pork tissues	6.750 kg
22.50 %	Ice (potable water)	6.750 kg

Extenders: ---

Additives:

(per kg raw materials)		(total for 30 kg)
18.00 g	Nitrite curing salt	540.00 g
3.00 g	Phosphate (pH >7.3)	90.00 g
0.30 g	Ascorbic acid	9.00 g

Seasonings:

(per kg raw materials)		(total for 30 kg)
2.00 g	White pepper, ground	60.00 g
0.50 g	Nutmeg, ground	15.00 g
0.50 g	Mace, ground	15.00 g
0.30 g	Cardamom, ground	9.00 g

PROCESSING

GRIND	Meats and fats separately 3 mm	
CHILL	Meats and fats over night at < +4°C	
CHOP	Ground meat, ice and additives for 10-15 rounds Add fats and seasonings and chop until +12°C	
STUFF	Plastic casings, 60 mm or	Cattle rounds, 40 mm
SMOKE	N/A	at +65°C for 40 min.
COOK	At +76°C for 75 min. (core temperature > +72°C for both casing formats)	at +76°C for 40 min.
COOL	Under cold shower or in water until <+20°C	
STORE	In chiller below +4°C, shelf life < 14 days	

COARSE HAM SAUSAGE
(Raw-cooked sausage type, finely chopped batter with coarse meats)

INGREDIENTS

Raw materials: (calculated for 30 kg batch)

50.00 %	Lyoner sausage mix (raw batter)	15.000 kg
40.00 %	Pork meat, lean, no tendons	12.000 kg
10.00 %	Pork belly without skin (50/50)	3.000 kg

Extenders: ---

Additives:

(per kg pork meat and belly – 15 kg)		(total for 15 kg)
18.00 g	Nitrite curing salt	270.00 g
3.00 g	Phosphate	45.00 g

Seasonings:

(per kg pork meat and belly – 15 kg)		(total for 15 kg)
2.00 g	White pepper, ground	30.00 g
0.50 g	Mace, ground	7.50 g
0.50 g	Coriander, ground	7.50 g
0.50 g	Ginger, ground	7.50 g

PROCESSING

CUT	pork meat and belly in small pieces		
MIX	pork meat, belly, salt and spices		
GRIND	Mixture 8-13 mm and store over night in cold room		
MIX	Lyoner batter and ground mixture		
STUFF	Plastic casings, 60 mm	or	cattle rounds, 40 mm
SMOKE	N/A		at +65°C for 60 min.
COOK	At +75°C for 75 min.		at +76°C for 40 min.
	(core temperature > +72°C for both casing formats)		
COOL	Under cold shower or in water, drain and air-dry		
STORE	In chiller below +4°C, shelf life < 14 days		

<u>**WHITE SAUSAGE**</u> / **Veal Sausage (**Bavaria)
(Raw-cooked sausage type, finely chopped batter)

INGREDIENTS

Raw materials: (calculated for 30 kg batch)

30.00 %	Veal trimmings	9.000 kg
20.00 %	Pork trimmings	6.000 kg
25.00 %	Pork fat, soft fatty tissue	7.500 kg
25.00 %	Ice (drinking water)	7.500 kg

Extenders: ---

Additives:

(per kg raw materials)		(total for 30 kg)
18.00 g	Common salt	540.00 g
3.00 g	Phosphate	90.00 g

Seasonings:

(per kg raw materials)		(total for 30 kg)
1.00 g	White pepper, ground	30.00 g
0.50 g	Ginger, ground	15.00 g
0.50 g	Mace, ground	15.00 g
0.50 g	Lemon skin	15.00 g
1.00 g	Parsley leaves, fresh	30.00 g
3 pieces	Onions, fresh	

PROCESSING

CUT	Meats and fatty tissues in small pieces
CHILL	Meats and fats over night at < +4°C
GRIND	Meats and fats separately 3 mm
CHOP	Ground meat, ice and ingredients for 10 rounds. Add fats and seasonings and chop until +12°C
STUFF	In hog casings 26/28 mm
COOK	In water at +74°C for 40 min.
COOL	Under cold shower or in cold water
PREPARE	Traditionally eaten immediately after production Heated in simmering water
STORE	Optional: In chiller below +4°C, shelf life < 5 days

<u>KRAKOW SAUSAGE</u> (Polish traditional product)*
(Raw-cooked sausage type, finely chopped batter with coarse meats)

INGREDIENTS

Raw materials: (calculated for 30 kg batch)

10.00 %	Beef trimmings, high collagen content	3.000 kg
10.00 %	Pork trimmings, high collagen content	3.000 kg
10.00 %	Ice (potable water)	3.000 kg
50.00 %	Pork meat, lean, no tendons	15.000 kg
20.00 %	Pork belly without skin	6.000 kg

Extenders: ---

Additives:

(per kg raw materials)		(total for 30 kg)
18.00 g	Nitrite curing salt	540.00 g
3.00 g	Phosphate	90.00 g

Seasonings:

(per kg pork meat and belly – 15 kg)		(total for 30 kg)
2.00 g	Black pepper, ground	60.00 g
0.20 g	Cardamom, ground	6.00 g
0.50 g	Mace, ground	15.00 g

PROCESSING

CUT	Lean pork meat and belly in small pieces
MIX	Lean meat, belly, remaining additives, seasonings
GRIND	Mixture 13 mm and store over night in cold room
GRIND	Beef and pork trimmings 3 mm
CHOP	Ground trimmings with ice, and 30% additives In bowl cutter until a fine lean batter is achieved
MIX	Fine lean batter and chilled ground mixture
STUFF	Into fibrous or collagen casings 60-75 mm
SMOKE	Hot at +65°C for 60 min.
COOK	At +75°C for 75-90 min. (core temp. > +72°C)
COOL	Under cold shower or in water, drain and air-dry
SMOKE	Cold at +18-22°C the following day
STORE	In cold room below +12°C

* Due to continuing moisture loss, the product can become semi-dry and display a reasonable shelf-life at cooler temperatures

<u>BUFFALO SAUSAGE</u> (non-pork product)
(Raw-cooked sausage type, finely chopped batter with coarse meats)

INGREDIENTS

Raw materials: (calculated for 30 kg batch)

45.00 %	Lean buffalo meat	13.500 kg
35.00 %	Buffalo trimmings (30 % fat)	10.500 kg
10.00 %	Buffalo brisket fat or beef hump fat	3.000 kg
10.00 %	Ice (drinking water)	3.000 kg

Extenders: ---

Additives:

(per kg of material)		(total for 30 kg)
18.00 g	Nitrite curing salt	540.00 g
3.00 g	Phosphate	90.00 g
0.30 g	Ascorbic Acid	9.00 g

Seasonings:

(per kg of material)		(total for 30 kg)
3.0 g	White pepper, ground	30.00 g
1.0 g	Nutmeg, ground	10.00 g
0.5 g	Coriander, ground	5.00 g
0.5 g	Chilli, ground	5.00 g
2.0 g	Garlic, fresh	20.00 g

PROCESSING

GRIND	Lean buffalo meat 3 mm, trimmings 5 mm, fats 13 mm Store over night in cold room	
CHOP	Lean buffalo meat, ice, additives, spices until fine batter Add fat and distribute in slow gear evenly Add trimmings and distribute in slow gear evenly	
STUFF	Into <u>plastic casings</u> Diameter 75 mm	into <u>tin plate cans</u> size 73/110
COOK	At +75°C for 90 min. (core temp +72°C)	at +121°C for 120 min. (core temp +114°C, F-value 12)
COOL	Under cold shower or in cold water, drain and air-dry	
STORE	In cold rooms below +4°C Shelf life < 14 days	below +40°C shelf life 1 year as fully sterilized cans

<u>MORTADELLA</u> (with slaughter by-products, Italy)
(Raw-cooked sausage type, finely chopped batter)

INGREDIENTS

Raw materials:	(calculated for 30 kg batch)	
30.00 %	Beef trimmings	9.000 kg
20.00 %	Pork/beef (gullet, skirt, cheeks)	6.000 kg
15.00 %	Fatty tissues	4.500 kg
10.00 %	Soft by-products (lung, spleen, etc.)	3.000 kg
15.00 %	Ice (potable water)	4.500 kg

Extenders:	(calculated for 30 kg batch)	
10.00 %	Wheat flour	3.000 kg

Additives:

(per kg raw materials)		(total for 30 kg)
18.00 g	Nitrite curing salt	540.00 g
3.00 g	Phosphate	90.00 g
0.30 g	Ascorbic acid	9.00 g

Seasonings:

(per kg raw materials)		(total for 30 kg)
2.50 g	White pepper, ground	75.00 g
1.00 g	Nutmeg, ground	30.00 g
0.50 g	Cardamom, ground	15.00 g
0.50 g	Coriander, ground	15.00 g
0.20 g	Cloves, ground	6.00 g
0.20 g	Fresh garlic	6.00 g

PROCESSING*

CUT	Meat, fats and by-products in small pieces
GRIND	Meat, fats and by-products separately 3 mm
CHOP	Meat, by-products, ice and additives for 10 to 15 rounds Add fatty tissue, seasonings and chop until +12°C
STUFF	Into plastic casings diameter 120-240 mm
COOK	At +80°C for > 150-280 min. (core temp. >+72°C)
COOL	Under cold shower or in cold water, drain and air-dry
STORE	In cold room below +4°C, shelf life < 14 days

* Sometimes small back fat cubes (5 mm) and pistachio are added

BEEF FRANKFURTERS (moderately extended)
(Raw-cooked sausage type, finely chopped batter)

INGREDIENTS

Raw materials: (calculated for a 30 kg batch)

33.00 %	Beef meat trimmings, lean	9.900 kg
20.00 %	Beef trimmings, fatty	6.000 kg
20.00 %	Vegetable oil	6.000 kg
25.00 %	Ice (drinking water)	7.500 kg

Extenders: (calculated for a 30 kg batch)

2.00 %	Wheat flour	0.600 kg

Additives:

(per kg raw materials and extenders)		(total for 30 kg)
18.00 g	Nitrite curing salt	540.00 g
3.00 g	Phosphate (pH >7.3)	90.00 g
0.30 g	Ascorbic acid	9.00 g

Seasonings:

(per kg raw materials)		(total for 30 kg)
3.00 g	White pepper, ground	90.00 g
1.00 g	Nutmeg, ground	30.00 g
0.50 g	Cardamom, ground	15.00 g
0.20 g	Coriander, ground	6.00 g
0.50 g	Garlic, fresh	15.00 g

PROCESSING

GRIND	Meat and fatty trimmings separately 3 mm
CHILL	Meats, fats and vegetable oil over night at < +4°C
CHOP	Ground meats, ice and additives for 15-20 rounds Add slowly vegetable oil, seasonings; chop until +12°C
STUFF	Sheep or collagen casings, 20-24 mm
LINK	To desired length and twist (60-100 g)
SMOKE	At +65°C for 40 min.
COOK	In water or steam +76°C for > 30 min. (core temperature > +72°C)
COOL	Under cold shower or in water until <+20°C
STORE	In chiller below +4°C, shelf life < 14 days

<u>BEEF HOTDOG</u> (substantially extended)
(Raw-cooked sausage type, finely chopped batter) (see also page 204)

INGREDIENTS

Raw materials: (calculated for a 30 kg batch)

35.00 %	Beef meat trimmings, lean	10.500 kg
14.00 %	Fat emulsion (1:6:6)	4.200 kg
20.00 %	Ice (drinking water)	6.000 kg

Extenders: (calculated for a 30 kg batch)

18.00 %	Water for hydration of TVP (1:3)	5.400 kg
6.00 %	TVP (Textured Vegetable Protein)	1.800 kg
0.50 %	ISP (Isolated Soya Protein)	0.150 kg
5.00 %	Potato starch	1.500 kg
1.50 %	Skimmed milk	0.450 kg

Additives:
(per kg raw materials and extenders) (total for 30 kg)

10.00 g	Nitrite curing salt	300.00 g
2.00 g	Phosphate	60.00 g
2.00 g	Carrageenan	60.00 g
0.10 g	Sodium erythorbate	3.00 g

Seasonings:
(per kg raw materials and extenders) (total for 30 kg)

2.00 g	White pepper, ground	60.00 g
0.30 g	Nutmeg, ground	9.00 g
0.60 g	Garlic powder	18.00 g
0.35 g	Paprika	10.50 g
0.35 g	Mustard seeds, ground	10.50 g

PROCESSING

GRIND	Meat trimmings 3 mm and chill over night
EMULSIFY	ISP, water and vegetable oil, chill emulsion at < 0°C
HYDRATE	TVP by mixing with cold water 1:3
CHOP	Meats, ice, extenders and additives for 10-15 rounds Add fat emulsion and seasonings and chop until +12°C
STUFF	Into peeling casings diameter 20-22 mm and link
SMOKE	Dry for 30 min. at +45°C, smoke at +65°C for 30 min.
COOK	In water or steam at +75°C for 20 min.
COOL	under cold shower or in water, vacuum pack and chill
STORE	<+4 C, shelf life less than 14 days

CHICKEN HOTDOG (substantially extended)
(Raw-cooked sausage type, finely chopped batter)

INGREDIENTS

Raw materials: (calculated for 30 kg batch)

20.00 %	Chicken meat trimmings, lean	6.000 kg
20.00 %	Chicken MDM	6.000 kg
20.00 %	Chicken fat emulsion (1:6:6)	6.000 kg
18.00 %	Ice (drinking water)	5.400 kg

Extenders:

12.00 %	Water for hydration of TVP (1:3)	3.600 kg
4.00 %	TVP (Textured Vegetable Protein)	1.200 kg
0.50 %	ISP (Isolated Soya Protein)	0.150 kg
4.00 %	Potato starch	1.200 kg
1.50 %	Skimmed milk	0.450 kg

Additives:

(per kg raw materials and extenders)		(total for 30 kg)
10.00 g	Nitrite curing salt	300.00 g
2.00 g	Phosphate	60.00 g
0.10 g	Sodium erythorbate	3.00 g
1.00 g	Food colouring (liquid)	30.00 g

Seasonings:

(per kg raw materials and extenders)		(total for 30 kg)
2.00 g	White pepper, ground	60.00 g
0.30 g	Nutmeg, ground	9.00 g
0.60 g	Garlic powder	18.00 g

PROCESSING

GRIND	Meat trimmings 3 mm and chill over night
EMULSIFY	Vegetable oil and chicken fats, chill emulsions at < 0°C
HYDRATE	TVP by mixing with cold water 1:3
CHOP	Meats, ice, extenders and additives for 10-15 rounds Add fat emulsion and seasonings and chop until +12°C
STUFF	Into peeling casings diameter 20-22 mm and link
SMOKE	Dry for 30 min. at +45°C, smoke at +65°C for 30 min.
COOK	In water or steam at +75°C for 20 min.
COOL	Under cold shower or in water, vacuum pack and chill
STORE	<4°C, SHELF LIFE LESS THAN 10 DAYS

BREAKFAST SAUSAGE (moderately extended)
(Raw-cooked sausage type, finely chopped batter)

INGREDIENTS

Raw materials: (calculated for 30 kg batch)

30.00 %	Beef meat trimmings, lean	9.000 kg
20.00 %	Pork meat trimmings, lean	6.000 kg
20.00 %	Fatty pork tissues	6.000 kg
18.00 %	Ice (potable water)	5.400 kg

Extenders:

6.00 %	Wheat flour	1.800 kg
4.00 %	Rusk (baked and crushed flour)	1.200 kg
2.00 %	Corn starch	0.600 kg

Additives:

(per kg raw materials)		(total for 30 kg)
16.0 g	Common salt	480.00 g
3.0 g	Phosphate	90.00 g
0.3 g	Ascorbic acid	9.00 g
0.5 g	MSG (mono sodium glutamate)	15.00 g

Seasonings:

(per kg raw materials)		(total for 30 kg)
2.0 g	White pepper, ground	60.00 g
0.3 g	Nutmeg, ground	9.00 g
0.3 g	Mace, ground	9.00 g
0.2 g	Coriander, ground	6.00 g
0.2 g	Ginger, ground	6.00 g

PROCESSING

CUT	Meat trimmings and fatty tissues in small pieces
CHILL	Meat trimmings and fats over night
GRIND	Meat trimmings and fats separately 3 mm
CHOP	Meat mince, fats, ice, spices and additives to +12°C
STUFF	Into collagen casings 26-28 mm, link 50 g
PACK	10-20 pieces (0.5-1.0 kg) in plastic pouches
STORE	In deep-freezer below –18°C, shelf life 3 to 6 months Stored raw frozen, heat-treated only prior to consumption

MEAT LOAVES

The common formulations for raw-cooked sausages can be used in principle for the fabrication of product mixes for meat loaves. There are meat loaves entirely composed of finely chopped batter and varieties consisting of fine batter mixed with coarse meat materials (usually ground 5-12 mm). Meat loaves are subject to intensive heat treatment when they are baked in ovens at +150˚C, resulting in some weight loss (water evaporation). Usually the salt content is slightly reduced (from 18g to 16g calculated per kg of total raw materials).

Common recipes used for the fabrication of meat loaves are **frankfurters** (page 400) and **coarse ham sausage** (page 405), with the above mentioned adjustment on salt content.

MEAT BALLS

Raw-cooked meat mixes are used for the material, from which meat balls are shaped. These mixes are mainly fabricated without curing substances but with common salt, as for the majority of such products a grey colour is required. Formulations usually have high contents of lean meat (fat and water contents significantly reduced) to make these products firm-elastic. The salt content is reduced to 10-12g per kilo and often herbs are added.

Especially in Asia, there are several varieties of low-cost meat balls on the market. These meat balls are used as street food and in fast food outlets. One common formulation is shown below:

Raw materials:	(calculated for 10 kg batch)	
40.00 %	Pork meat trimmings, lean	4.000 kg
20.00 %	TVP (re-hydrated 1:3)	2.000 kg
10.00 %	Wheat flour	1.000 kg
10.00 %	Ice (potable water)	1.000 kg
15.00 %	Fatty pork tissues	1.500 kg
5.00 %	Potato or corn starch	0.500 kg
Additives and spices:	(per kg raw materials)	
10.0 g	Common salt	
2.0 g	Phosphate	
2.0 g	White pepper, ground	60.00 g
0.2 g	Coriander, ground	6.00 g
0.2 g	Ginger, ground	6.00 g

PRECOOKED-COOKED PRODUCTS

CORNED BEEF (traditional method, South America)
(Precooked-cooked meat product, coarse mixture)

The described procedure is a **small-scale processing** method. *Industrial processing* method see page 169.

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

80.00 %	Beef meat pieces, lean	8.000 kg
20.00 %	Beef meat trimmings	2.000 kg

Curing brine (10 litres):

(per litre brine)		(total for 10 kg)
22.00 g	Nitrite curing salt	220.00 g
2.00 g	Sugar	20.00 g

PROCESSING

CUT	Beef meat in uniform big stripes
CURE	Meat for 4 days in curing brine at +10°C
COOK	Beef meat stripes at +82°C *
CHECK	Meat for tendons, remove if necessary
GRIND	Cooked meat through kidney plate, reverse knife
STUFF	Into typical cans (compact properly) and seal
COOK	Sterilise cans to F-value 12-14
COOL	On air or in water
STORE	at ambient temperature

* Cooking loss around 30-35 %, often small layer of cooked fats is added on top.

CORNED BEEF (premium quality, spiced variety, Philippines)
(Precooked-cooked meat product, coarse mixture)

Similar variations are common also on the Pacific islands. The corned beef is prepared with onions, garlic and often potato pieces and consumed hot together with cooked/steamed rice.

INGREDIENTS

Raw Materials: (calculated for 10 kg batch)

50.00 %	Beef meat and brisket)	5.000 kg
50.00 %	Buffalo meat trimmings, lean	5.000 kg

Curing brine: (2.500 kg brine, 10% salt solution)

88.86 %	Potable water	2.224.00 g
10.00 %	Nitrite curing salt	250.00 g
1.00 %	Sugar, refined	25.00 g
1.50 %	Phosphate (soluble)	37.50 g
0.04 %	Sodium erythorbate	1.00 g

Seasonings:

(per kg raw materials)		(total for 10 kg)
1.50 g	Ground black pepper	15.00 g
2.00 g	Chopped garlic, fresh	20.00 g
0.05 g	Bay leaf	0.50 g
3.00 g	Oregano powder	30.00 g

PROCESSING

CUT Fresh/ chilled meats into 50 mm cubes
BRINE Mix cold water (+4^{o}C) with *ingredients*, start with phosphate (soluble), thereafter nitrite curing salt, thereafter sugar, sodium erythorbate (see page 180)
CURE Meat in a clean container submerged in brine at +4 for 1 day
WASH Cured meat once with potable water
COOK Meat with seasonings in pressure cooker for 1 hour
FLAKE Meat pieces and remix with broth (7:3)
STUFF Into cans and sterilize at +110°C to F-value 12
STORE At ambient temperature

CORNED BEEF (substantially extended, spicy, Philippines)

(Precooked-cooked meat product, coarse mixture) (see also page 212)

INGREDIENTS

Raw Materials:	(calculated for 10 kg batch)	
25.00 %	Beef meat and brisket)	2.500 kg
50.00 %	Buffalo meat trimmings, lean	5.000 kg

Extenders:	(calculated for 10 kg batch)	
10.00 %	Pork skin	1.000 kg
10.00 %	Potable water (for re-hydration)	1.000 kg
5.00 %	TVP (textured vegetable protein)	0.500 kg
0.50 %	Carrageenan	0.050 kg

Curing brine:	(2.500 kg brine, 10% salt solution)	
88.86 %	Potable water	2.224.00 g
10.00 %	Nitrite curing salt	250.00 g
5.00 %	Sugar, refined	125.00 g
0.10 %	Sodium erythorbate	2.50 g

Seasonings:

(per kg raw materials)		(total for 10 kg)
2.00 g	Ground black pepper	20.00 g
2.00 g	Chopped garlic, fresh	20.00 g
3.00 g	Oregano powder	30.00 g
1.00 g	Ginger, ground	10.00 g
1.00 g	MSG (mono sodium glutamate)	10.00 g

PROCESSING

CUT	Fresh/ chilled meats into 50 mm cubes
BRINE	Mix brine components, start with phosphate (soluble), nitrite curing salt, sugar, sodium erythorbate
CURE	Meat in a clean container submerged in brine at +4°C for 1 day
RE-HYDRATE	TVP with potable water allocation
COOK	Meat, pork skin with seasonings for 1 hour
FLAKE	Meat, grind pork skin, remix with broth (7:3)
STUFF	Into plastic bags (250, 500 g) and seal
STORE	In deep-freezer, cook prior to consumption

FINE LIVER SAUSAGE / LIVER PATE

(Precooked-cooked sausage type, finely chopped batter)

INGREDIENTS

Raw materials: (calculated for 30 kg batch)

35.00 %	Pork liver, raw	10.500 kg
50.00 %	Pork belly, pre-cooked (fresh weight 19.5 kg, cooking loss 4.500 kg)	15.000 kg
15.00 %	Meat soup ("broth") (compensation for cooking loss)	4.500 kg

Extenders: ---

Additives:

(per kg materials)		(total for 30 kg)
15.00 g	Nitrite curing salt	450.00 g

Seasonings:

(per kg materials)		(total for 30 kg)
2.00 g	White pepper, ground	60.00 g
0.50 g	Ginger, ground	15.00 g
0.30 g	Cardamom, ground	9.00 g
0.30 g	Mace, ground	9.00 g
0.50 g	Vanilla sugar	15.00 g
1.00 g	Honey	30.00 g
30.00 g	Onions, slightly fried in lard	900.00 g

PROCESSING

CHOP	Fresh, chilled pork liver with nitrite curing salt at high speed until fine and creamy texture is achieved (bubbles)
CHILL	Chopped liver over night at < +4°C
PRE-COOK	Pork belly at +85°C, grind 13 mm
CHOP	Hot ground pork belly, onions and hot broth at high speed
ADD	Below +45°C add cold cured liver, spices and honey Complete chopping until +24°C
STUFF	Into plastic casings, diameter 60 mm
COOK	At +82°C for 75 min. to a core temperature > +72°C
COOL	Under cold shower or in cold water, drain and air-dry
STORE	In cold room below +4°C, shelf life < 14 days

COARSE LIVER SAUSAGE

(Precooked-cooked sausage type, coarse materials)

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

15.00 %	Pork liver and kidneys, raw	1.500 kg
35.00 %	Meat and pork belly, pre-cooked	3.500 kg
15.00 %	Fatty tissues, pre-cooked	1.500 kg
15.00 %	Pig head meat, pre-cooked	1.500 kg
10.00 %	Meat soup (broth) (compensation for cooking loss)	1.000 kg

Extenders:

5.00 %	Wheat flour	0.500 kg
5.00 %	Bread crumbs (old bread or bread rolls)	0,500 kg

Additives:

(per kg materials)		(total for 10 kg)
16.00 g	Common salt (refined)	160.00 g

Seasonings:

(per kg materials)		(total for 10 kg)
50.00 g	Onions, slightly fried in lard	500.00 g
2.00 g	White pepper, ground	20.00 g
1.50 g	Marjoram	15.00 g
0.30 g	Ginger, ground	3.00 g
0.30 g	Cardamom, ground	3.00 g
0.20 g	Pimento (allspice), ground	2.00 g

PROCESSING

PRE-COOK	Meat trimmings, fatty tissues, pig heads
DE-BONE	Pig heads (beware of teeth, hard tissue)
MIX	Cooked materials, fresh liver, seasoning and additives
GRIND	Mixed materials 3 mm, mix again
STUFF	Into hog casings 26-30 mm, caps, middles
COOK	At +84°C to a core temperature > +72°C
COOL	Under cold shower or in cold water, drain and air-dry
SMOKE	Cold smoke < +20°C over night
STORE	In chiller below +4°C, shelf life < 14 days

BLOOD SAUSAGE / Central European product
(Precooked-cooked sausage type, coarse mixture)

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

20.00 %	Pig blood, raw	2.000 kg
25.00 %	Pork head-meat, pre-cooked	2.500 kg
25.00 %	Pork belly, pre-cooked	2.500 kg
20.00 %	Pork skin, pre-cooked	2.000 kg
5.00 %	Meat soup (broth)	0.500 kg
5.00 %	Onions, raw	0.500 kg

Extenders: **---**

Additives:

(per kg materials)		(total for 10 kg)
16.00 g	Nitrite curing salt	160.00 g

Seasonings:

(per kg materials)		(total for 10 kg)
2.50 g	White pepper, ground	25.00 g
1.00 g	Cloves, ground	10.00 g
0.70 g	Marjoram	7.00 g
0.50 g	Pimento (allspice), ground	5.00 g
0.30 g	Nutmeg, ground	3.00 g

PROCESSING

COOK	Pig heads, pork skin and pork belly
DE-BONE	Cooked pig heads (beware of teeth)
CUT	Pig head material and belly into dices or stripes
GRIND	Cooked hot pork skin, onions and broth 3 mm
MIX	a) fat and meat dices with salt and spices
	b) spiced dices with ground pork skin and add blood
STUFF	Into pork intestines of desired size
COOK	At +82°C to a core temperature of +75°C
COOL	On air and transfer to cold room for 24 hours
SMOKE	Cold smoke at < +22°C over night
STORE	In cold room at < +4°C, shelf life < 21 days

<u>BLODKORV</u> / Extended Blood Sausage (Sweden)
(Precooked-cooked sausage type, coarse mixture)

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

35.00 %	Pig blood, raw	3.500 kg
10.00 %	Pork lard	1.000 kg
10.00 %	Pork backfat, blanched	1.000 kg
10.00 %	Meat soup (broth)	1.000 kg

Extenders: (calculated for 10 kg batch)

25.00 %	Wheat flour	2.500 kg
10.00 %	Sugar	1.000 kg

Additives:

(per kg materials)		(total for 10 kg)
16.00 g	Common salt	160.00 g

Seasonings:

(per kg materials)		(total for 10 kg)
1.00 g	Cloves, ground	10.00 g
1.00 g	Cinnamon	10.00 g
1.00 g	Raisins	10.00 g

PROCESSING

MIX	Blood, sugar, salt and seasonings
CUT	Pork back fat into dices 5-8 mm
BLANCH	Pork back fat dices (scalding)
MIX	Wheat flour, lard, dices into heated meat soup Add the blood mix also
STUFF	Into medium size beef middles
COOK	At +85°C to a core temperature of +75°C
COOL	On air and transfer to cold room for 24 hours
SMOKE	Cold smoke at < +22°C over night and air-dry
STORE	In cold room at < +4°C

CURED MEAT CUTS

<u>COOKED HAM</u> / Entire muscle pieces formed together

Raw materials:

20.000 kg	Pork topsides (meat piece from hind leg), all connective tissue and fats removed from surface, pH-value 5.7 or higher.

Brine composition:

7.000 kg	Potable water
1.800 kg	Crushed ice
1.200 kg	Nitrite curing salt
0.200 kg	Phosphate (soluble)
0.100 kg	Sugar
0.100 kg	Carrageenan
0.020 kg	Sodium ascorbate

***PROCESSING*:**

Meat is chilled (+4°C) prior to brine injection
Brine is prepared and chilled (supported by adding of crushed ice)

> <u>*Without tumbler:*</u>
> Inject 20% curing brine in the meat (based on fresh meat weight)
> Submerge injected meat pieces in remaining brine
> Keep in chiller for 48 hours
> <u>*With tumbler:*</u>
> Inject 20% curing brine in the meat (based on fresh meat weight)
> Transfer injected meat pieces to tumbler
> Tumble under refrigeration for 12 hours
> 5-8 rpm, 5 minutes rotation / 20 minutes resting, +2°C

Transfer meat pieces into ham moulds and apply firm pressure with cover
Allow for resting phase of 5 hours in chiller
Cook at +75°C to core temperature of +70°C (use Delta-t cooking if possible)
Cool under running water, transfer to chiller over night
Remove hams from ham moulds and vacuum-pack final product

RAW FERMENTED HAMS

Production principles see page 172

PORK BACON

Raw materials:

20.000 kg	Pork belly (meat/fat ratio 60/40) Rib bones and soft bones are removed Skin left on or also removed

Brine composition:

8.800 kg	Ice water
1.200 kg	Nitrite curing salt
0.200 kg	Phosphate (soluble)
0.100 kg	Sugar
0.020 kg	Sodium ascorbate

***PROCESSING*:**

Belly is trimmed and chilled (+4°C) prior to brine injection
Brine is prepared and chilled
20% curing brine are injected in the meat (based on fresh meat weight)
Injected bellies are submerged in remaining brine
Keep in chiller for 36-48 hours
Bellies are hung and hot-smoked
After hot-smoking, cool down at ambient temperature and transfer to chiller over night
Slice 2-4 mm and vacuum-pack

BEEF BACON

Raw materials:

20.000 kg	Beef silverside tip or brisket (meat 60-80%) Bones and soft bones are removed 10 mm layer of body fat is left on silverside tip

Brine composition:

8.800 kg	Ice water
1.200 kg	Nitrite curing salt
0.200 kg	Phosphate (soluble)
0.100 kg	Sugar
0.020 kg	Sodium ascorbate

***PROCESSING*:**

See “pork bacon” above.

INGIGENOUS MEAT PRODUCTS

LUP-CHEONG / Chinese dry pork sausage

(Dried sausage type, coarse mixture) (see also page 214)

INGREDIENTS

Raw materials: (calculated for 10 kg batch)

60.00 %	Lean pork meat (90/10)	6.000 kg
40.00 %	Pork belly without skin (60/40)	4.000 kg

Extenders: ---

Additives:

(per kg raw materials)		(total for 10 kg)
15.00 g	Common salt (refined)	150.00 g
15.00 g	Sugar (saccharose)	150.00 g

Seasonings:

(per kg raw materials)		(total for 10 kg)
10.00 g	Soy sauce	100.00 g
2.00 g	Rice wine	20.00 g
1.00 g	Ginger, ground	10.00 g
0.50 g	Cinnamon, ground	5.00 g

PROCESSING

CUT	Meat and belly into small pieces, keep at –2°C
MIX	Raw materials, additives and seasonings
GRIND	Mixture 5 mm
STUFF	Natural pig casings (26 mm)
PORTION	Link into sausages of desired size (60-100 g)
DRY (SMOKE)	+60°C for 24-48 hrs., another 48 hours +45-50°C
KEEP	In a dry and cool place (if possible vacuum packed)

NAEM (also Nham) / Fermented Pork Product (SE-Asia)
(Fermented sausage type, coarse mixture) (see also page 217)

INGREDIENTS

Raw Materials:	(calculated for 10 kg batch)	
60.00 %	Pork meat, lean	6.000 kg
20.00 %	Pork skin	2.000 kg
Extenders:	(calculated for 10 kg batch)	
20.00 %	Rice, medium quality, cooked	2.000 kg
Additives:		
(per kg raw materials)		(total for 10 kg)
23.00 g	Nitrite curing salt	230.00 g
1.00 g	MSG (mono sodium glutamate)	10.00 g
Seasonings:		
(per kg raw materials)		(total for 10 kg)
15.00 g	Chilli, fresh	150.00 g
2.00 g	Sugar	20.00 g
80.00 g	Fresh garlic	800.00 g

PROCESSING

PRECOOK	Rice (cook in water or steam) Pork skin in boiling water
CUT	Lean pork meat in smaller pieces Cooked pork skin in small stripes
GRIND	Pork meat, seasonings and garlic 3 mm
MIX	Mixture with cooked rice and pork skin
PORTION	Wrap small quantities in banana leaves (traditional) or stuff in perforated plastic casings (35 mm)
FERMENT	At room temperature (+25-30°C) for 2-4 days
STORE	Under refrigeration, shelf-life 2 weeks
CONSUME	As snack or use as ingredient to meals

ISAAN SAUSAGE / Herb Sausage (Thailand, recipe 1)
(Quick-cured sausage type, coarse mixture)

INGREDIENTS

Raw Materials: (calculated for 10 kg batch)

80.00 %	Pork belly without skin, fresh	8.000 kg
10.00 %	Potable water	1.000 kg

Extenders:

10.00 %	Rice, medium quality	1.000 kg

Additives:

(per kg raw materials)		(total for 10 kg)
12.00 g	Common salt	120.00 g
2.00 g	Erythorbate	20.00 g

Seasonings:

(per kg raw materials)		(total for 10 kg)
6.00 g	White pepper, ground	60.00 g
1.00 g	Sugar	10.00 g
20.00 g	Fresh garlic	200.00 g
1.00 g	MSG (mono sodium glutamate)	10.00 g

PROCESSING

CUT	Pork meat in small pieces
SOAK	Rice in water
GRIND	Pork meat, seasonings and garlic 5 mm
MIX	Pork meat, garlic, seasoning and rice
STUFF	Into natural pork casings (26-28mm)
CURE	At room temperature (+37°C) for 2 days
STORE	Under refrigeration, shelf-life 2 weeks
PREPARE	Roast on charcoal or gas grill

ISAAN SAUSAGE / Herb Sausage (Thailand, recipe 2)
(Fresh sausage type, coarse mixture) *(see also page 216)*

INGREDIENTS

Raw Materials: (calculated for 10 kg batch)

80.00 %	Pork meat trimmings, lean	8.000 kg
20.00 %	Pork belly and back fat	2.000 kg

Extenders: ---

Additives:

(per kg raw materials)		(total for 10 kg)
10.00 g	Common salt	100.00 g
2.00 g	Erythorbate	20.00 g

Seasonings:

(per kg raw materials)		(total for 10 kg)
1.00 g	Chilli paste	10.00 g
1.50 g	Soy sauce	15.00 g
1.00 g	Shrimp paste	10.00 g
1.00 g	Lemon grass	10.00 g
10.00 g	Fresh garlic	100.00 g
1.00 g	MSG (mono sodium glutamate)	10.00 g

PROCESSING

CUT	Pork meat and belly fat trimmings in small pieces
MIX	Pork meat, fats, additives and seasoning
GRIND	Mixture 5 mm
STUFF	Into natural pork casings (26-28mm)
STORE	Under refrigeration, self-life <2 days
PREPARE	Roast on charcoal or gas grill

ANNEX II

GLOSSARY

Acceptance test
The acceptance test is a type of sensory examination. Acceptance testing is used during product development to test the market potential of a new product ready to be launched.

Acid
An acid is a substance which decreases pH into the acid range (< pH 7.0) when dissolved in water. Acids can be inorganic (e.g. hydrochloric acid, HCl) or organic (e.g. citric acid) compounds.

Acidification
This term relates to the capability of microorganisms of forming acid when carbohydrates are degraded. Such acid can be of the desirable type for meat products, such as lactic acid but also undesirable such as acetic acid.

Actin
Actin belongs to the so-called contractile proteins (and myosin) of the myofibrils of the meat musculature. The protein actin accounts for approximately 20 percent of the muscular protein.

Actomyosin
Actomyosin is created by an association of actin with myosin, resulting under the influence of ATP in muscle contraction. Their dissociation results in muscular relaxation (in live animals).

Additives
The term additives as refers to food products (and meat products) manufacturing is defined as comprising all such materials or substances not classified as actual foods (“food by itself”).

Agar-agar
Agar-agar is a swelling substance of plant origin. Extracted from red algae (Rhodophyta) and other algae, it is used as a gelatinizing/thickening agent in food manufacturing.

Air humidity, relative
The relative humidity of air (r.h.) is the ratio of water vapour contained in air of a certain temperature to the maximum water vapour content expressed in percent.

Air-dried
The term air-dried refers to non-smoked raw/uncooked meat products and sausages which, as the word implies, have been simply dried on air.

Airtight
When a container is described as closed airtight, the meaning is that materials used are impermeable to oxygen and therefore suitable for extending the shelf-life of enclosed products.

Alginate
Alginates are the salts of alginic acid (sodium alginate). They are obtained from marine algae through extraction and form highly viscous solutions in water. Contrary to products such as agar-agar or carrageenan, alginates do not gelatinate and are used as thickener in mayonnaises and gravies.

Antibacterial
Processes or substances defined as antibacterial are capable of inhibiting the growth or multiplication of bacteria or effecting outright kill of bacteria.

Antioxidants
Antioxidants are substances capable of slowing down oxidation, thereby postponing the occurrence of taste or colour alteration (e.g. rancidity).

Artificial casings
The use of artificial sausage casings made of cellulose, collagen, textile fibres or plastics is firmly established in meat processing. The advantages of artificial casings are their attractive designs, easy stocking and uniform calibre.

Ascorbic acid
Ascorbic acid (Vitamin C) or its salt (sodium ascorbate) is used in meat processing as cure accelerator to enforce the curing colour development. The reaction of ascorbic acid is fast and further accelerated by increasing temperatures. This makes it an ideal component in quick-cured and heat treated products. Sodium ascorbate reacts slower and is terefore mainly used in raw-fermented products.

ATP
ATP (adenosine triphosphate) is a chemical compound occurring in almost all cells of the living body. ATP plays a role in the processes of muscular contraction and relaxation. ATP is also useful in the manufacturing of raw-cooked meat product.

Autoclave
Autoclaves, also called retorts, are large pressure cookers achieving temperatures above +100°C and used for sterilization of meat products filled into hermetically sealed containers (cans, glass jars, flexible pouches, etc). Autoclaves can be designed as still or rotating autoclaves.

a_w-value
The a_w-value is an important measure used in meat processing. The a_w-value describes the water activity, meaning the free water in the product. High a_w-values present good conditions for microorganisms, lower aw-values inhibit activities of such microorganisms. Bacteria require a_w-values around and above 0.9, yeasts and moulds only need a_w-values above 0.6.

Bacteria
Bacteria are monocellular microorganisms of various shape and size. Bacteria are present everywhere, in soil, water, air, the intestinal tract, on all kinds of surfaces, etc. Some bacteria can cause food spoilage or food poisoning, other strains of bacteria are used in food products manufacturing (starter cultures used in raw-fermented sausage making, production of yogurt and cheese).

Benzpyrene (3,4-Benzpyrene)
Benzpyrene is a condensating aromatic hydrocarbon and a carcinogenic substance. 3,4 benzpyrene is generated during the burning or smoldering of wood when the smoldering temperatures are relatively high. However, smoked meat products remain far below the content of 1 ppm benzpyrene, which is considered the risk level.

Binder
The term binder is used for substances of animal or plant origin, which have a significant high level of protein that serves for both *water and fat binding*. Such substances include *high-protein soy, wheat and milk products*, such as isolated soy protein, wheat gluten or milk caseinate.

Biological value
This is the method of measuring protein quality. Protein is used in the cells of the human and animal organisms. The more protein is retained in the organism the higher is the level of utilization of the particular protein provided through food/feed and the higher is its biological value. The biological value is the ratio of protein consumed to the amount of protein retained in the organism and not excreted as urine or faecal matter. Isolated whey and egg protein are amongst the products with the highest biological value and serve as measurement (biological value of isolated whey = 100). Biological value of other foods: whole eggs 94, cow milk

91, fish 83, casein 80, beef 80, chicken 79, soy 74, wheat gluten 54, kidney beans 49.

Blood plasma
Blood plasma is the yellowish liquid obtained by centrifuging blood and contains 7-8% protein. This liquid is either stored frozen or spray-dried and stored as powder. It is used in finely-chopped raw-cooked (frankfurter type) sausages to increase the protein content and improve water binding.

Blood sausage
Blood sausages belong to the group of precooked-cooked products. In these products fresh blood (10-20%) is mixed with precooked animal tissues, cereals, vegetables, salt and spices. The final mixture is stuffed and heat treated again.

Boiling point
This term refers to the temperature at which a liquid changes over into gaseous state.

Boning
This term refers to the removing of bones from carcass parts of slaughter animals. It is often also called deboning.

Botulism
The term botulism describes a bacterial food poisoning caused by the botulinus toxin, which is discharged into the food by Clostridium botulinum. Botulism can occur in preserved meat, vegetable and fish products.

Bowl cutter
The bowl cutter is the most frequently used meat chopping equipment designed to produce very small lean meat and fat particles. Bowl cutters consist of a horizontally revolving bowl and a set of curved sharp knives rotating vertically on a horizontal axle at a high speed. Another name is bowl chopper.

Brine
The term brine describes a water/salt solution used for curing meat products.

Burger
Originally, burgers were made from *beef* (preferably lean cow meat), but in recent years also *chicken* and *mutton* burgers were introduced. 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. Burgers are formed usually to disc-like shape with diameters of 80-150 mm and 5-20 mm height. Burgers are stored frozen and individually pan-fried before consumption.

Calibre
In meat processing, the term calibre refers to the diameter of casings and sausages.

Canning
This term refers to the filling of food into cans followed by hermetically sealing of the containers and heat treatment.

Carbohydrates
These are organic substances formed by the elements carbon, hydrogen and oxygen. Sugars such as saccharose and dextrose are the best known carbohydrates, but also dextrines, starches, cellulose and pectines belong to this group.

Carcass
The term carcass refers to the body of a slaughter animal (without internal organs) consisting of meat, fats, bones and connective tissues.

Carrageenan
Carrageenan is a polysaccharide produced by red algae and obtained by water extraction. It has good gelling properties.

Casings
Casings are defined as soft cylindrical containers used to be filled with sausage mix. Casings can be of natural origin or industrially manufactured (artificial). Natural casings are obtained by special treatment of animal intestines derived from slaughtering. Manufactured artificial casings are made of cellulose, collagen or synthetic materials.

Cellulose
Cellulose is the substantial framework of plant cell walls. Because it is not attacked by digestive juices, it serves as dietary fiber in human nutrition. Cellulose also serves as material for paper, packaging films and foils and artificial casings. It belongs to the group of polysaccharides.

Cereal sausages
For this product group sizeable quantities of various non-meat ingredients such as breadcrumbs, rice, potatoes, cassava, etc are incorporated into the basic mixture of pre-cooked lower value animal parts. Also liver or blood may be added thus making those cereal sausages either part of the liver or blood sausage variety. The term cereal refers to grain crops and other field crops.

Coarse
Coarse describes a degree of comminution, in this context not very finely comminuted.

Cold smoking
Cold smoking is the application of smoke to meat products at temperatures below 24°C. It is mainly used for raw-fermented sausages and raw hams.

Collagen
Collagen is an important component of connective tissue found in tendons, skin, bones and cartilage. Due to its high water holding capacity it is used as binding agent in blood sausages and gelatines. It serves also for the manufacture of artificial casings.

Colloid mill
Also known as emulsifier, this equipment is used for very fine cutting or comminution of sausage batters.

Common salt
Common salt (sodium chloride) is the sodium salt of hydrochloric acid (HCl) and is one of the most important aiding substances (additives) in meat processing. Common salt facilitates the extraction of protein (actin, myosin) and contributes to the taste.

Conduction
This term refers to the means of transmission of heat in food products consisting mainly of solids.

Connective tissue
Connective tissue consists of connective tissue proteins i.e. collagen, elastin and is found in many body parts, with particularly high quantities in tendons, skins and cartilages.

Convection
This term refers to the means of transmission of heat in food products which consist to a great extend of liquids.

Corned beef
The classical Corned beef was a by-product of meat extract production. Before refrigeration was available, the only way to utilize surplus beef from Latin-America and other regions of the Southern hemisphere for shipment to Europe was to produce meat extract. Originally a by-product, the cooked beef, which still has a high protein content, is filled into cans and heat sterilized. The result is Corned beef.

Core temperature
In meat processing, this term refers to the temperature achieved in the critical thermal point of products where it takes longest for the temperature to change.

Curing
Curing is the method used to achieve the desired red colour in processed meat products. The products are salted with a mixture of common salt (sodium chloride NaCl) and the curing agent sodium nitrite ($NaNO_2$). Sodium nitrite facilitates formation of a red curing colour and typical aroma/flavour.

Deep-freezing
This term refers to storage temperatures of -18°C and below and is ideally suited for long-term storage of meat and meat products.

Detergents
Detergents are substances used in cleaning and capable of relaxing the surface tension of water to enhance the cleaning effect. Most common are anion detergents (soaps), cation detergents (invert soaps) and non-ionogenic detergents.

DFD meat
The term DFD refers to “dark, firm, dry”. Meat showing DFD properties can be identified by a pH-value above 6.2.

Erythorbate
Cure accelerator with similar effect as sodium ascorbate.

F-value
The F-value is a unit of measure for the heating effect obtained in heat-treated products. The letter “F” in F-value is derived from Fahrenheit (temperature scale used in the US). Preservation by cooking/sterilization of processed products following the F-value concept is far more reliable than orientation by core temperatures alone. Computation of the F-value and cooking according to F-value is based on inhibition or elimination of microorganisms and maintaining as far as possible the sensory quality of products.

Fat
Fat is defined as a substance under the category of triglycerides. It exists in various forms and is used in sausage production.

Fermentation
Fermentation is the breakdown of organic substances by fermentative microorganisms. During fermentation, carbohydrates are partly reduced

to acids or other substances (extraction of alcohol from sugar). In meat processing, fermentation occurs in raw sausage and raw ham production.

Flavour
This term is used in sensory evaluation and refers to a combination of taste and odour.

Freezing point
The term refers to the temperature at which a substance changes from liquid to solid. This temperature varies from substance to substance. Water freezes at 0°C, if salt is added the water/salt solution freezes at a much lower temperature. The freezing point of lean meat is at -1.5°C.

Fresh processed meat products
The characteristic of this group is that all meat and non-meat ingredients are added fresh (raw), either refrigerated or non-refrigerated, but not cooked. 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 patties, kebab, or burgers. Only prior to consumption the products are heat treated (frying, cooking) and usually consumed hot.

Friction smoke
A specific technique employed in smoke generation. Smoke is produced by pressing a wood log onto a rotating wheel. This causes friction and frictional heat so that the log smoulders and smoke is generated.

GdL
GdL stands for Glucono-delta-lactone and is obtained from dextrose. In watery solution, GdL changes rapidly into gluconic acid. The prime area of GdL application is the manufacturing of fast cured raw-fermented sausages.

Gelatine
Gelatine is made of collagen containing materials such as bones, cartilage and skins (rinds, hides). Gelatine is a high-molecular protein which swells in cold water and which forms viscous solutions in warm water. Upon cooling, a solid gel is obtained.

Grind
Grinding or mincing are terms used in meat processing, when bigger meat pieces are broken down in size by use of specialized equipment.

Grinder
The grinder is a machine used to force meat or meat trimmings by means of a feeding worm (auger, feeding screw) under pressure inside a

horizontally mounted cylinder (barrel, feeding worm housing). At the end of the barrel the meat is broken down in size by a cutting system consisting of star shaped knives (cutters) rotating with the feeding worm and perforated cutting discs (grinding plates).

Guar gum
Guar gum is a hydrocolloid obtained from the seeds of a leguminose plant and used as thickener in soups, gravies and sauces.

Halal
Refers in the narrower sense to Muslim dietary laws. An important feature as far as meat and poultry are concerned, is the slaughtering according to Halal rules which in practice mostly excludes prestunning of slaughter animals. Pork and pork based products are prohibited and pork-based food operations such as pig slaughtering or pork processing must be absent where processing of Halal meat and meat products takes place.

Hemoglobin
Hemoglobin is the red pigment of blood.

High hydrostatic pressure treatment
Method of food preservation where microbial reduction is achieved through application of high pressure (in the range of 3000 bar) on the food product.

Hot smoke
Hot smoking is the form of smoking which involves high temperatures (>50-70°C) and is mainly used for frankfurter-type sausages.

Hot-boning
This term describes the process of separating meat and bones from freshly slaughtered unchilled animal carcasses.

Hurdle concept
The hurdle concept serves as a system of estimating and influencing the shelf life of meat and processed meat products. In this concept several individual measures (hurdles) are combined to prevent microorganisms from growing/multiplying such as temperature, humidity, water content, pH-value, salt concentration, presence of preserving substances, etc.

Hydroxyproline
An amino acid, which in meat exclusively occurs in the connective tissue and which is therefore used as a parameter in connective tissue protein determination.

Hygrometer
Such a device is used to determine the relative air humidity. Hygrometers are available as simple hair hygrometer models and electronic aspiration psychrometers.

Intermediate moisture food
The term Intermediate Moisture Food characterizes processed products, which have a low a_w-value and possess great storage stability.

Irradiation
In the food sector irradiation by ionizing high energy gamma rays, x-rays, or in some cases by high energy of electron sources, is used in some countries (where such treatments are legal) for reducing or eliminating microbial contamination in food, control parasite such as trichinae in meat or insect in grains and sanitize packing material prior to food packaging or treat drinking water.

Kidney fat
Also known as kidney tallow, this term describes the layer of fat where the kidneys are embedded.

Lactic acid
Lactic acid belongs to the so called food grade acids as do citric acid and acetic acid, and are used to lower the pH-values.

Lactobacilli
Lactobacilli are gram positive microorganisms which have the ability to form acids from carbohydrates. They are used as starter cultures in raw-fermented sausage production.

Liquid smoke
Liquid smoke is obtained by condensation of natural smoke in liquids and used in meat processing by being sprayed into smoking chambers where it will condensate on the surfaces of the products or by directly adding to meat mixes.

Liver sausage
Liver sausage belongs to the group of precooked-cooked sausages and is composed of precooked meat trimmings and fatty tissues and liver (10-20%). The liver (mainly added raw) provides not only the name for this sausage type but also contributes to its unique flavour and taste. In general two types of liver sausages are produced, the coarse-mixed type and the fine-emulsified type.

Meat inspection
Each slaughtered animal should undergo official meat inspection after slaughtering to ensure that only meat fit for human consumption enters into the sales and distribution chain. Respective national regulations must be observed.

Meat products
Meat products are such food products which are exclusively or predominantly composed of meat.

Microorganism
The term microorganisms is used collectively for all live organisms which in their cellular from cannot be detected upon visual inspection. The term microorganisms refers to bacteria, yeasts and moulds. All these microorganisms are of great importance in meat processing.

Moulds
Moulds are microorganisms which may be desirable or undesirable in meat processing. They can cause a multitude of damages on surfaces of meat products, split proteins and break casings by digesting celluloses. Taste and colour deviations can also occur. But some moulds are also helpful by forming a protective and flavour providing layer on the surface of air-dried raw sausages.

Mono sodium glutamate (MSG)
MSG is used in larger quantities as a flavour and taste enhancer in meat products and cooked foods especially in Asia. The use of MSG is often questioned as it can cause allergies and health problems.

Myofibrils
Myofibrils belong to the structural elements of a muscle and form the content matter of the muscular fiber or muscle cell, enclosed by the sarcolemma. They develop from the filaments of the myofibrillary proteins actin and myosin.

Myoglobin
Myoglobin is a proteinaceous substance in muscular meat responsible for oxygen transport in the live muscle and for the colour of fresh lean meat, but also for the curing-red colour in processed meat products after its reaction with nitrite. In this case, the myoglobin connects with the degradation product NO of the nitrite resulting in nitrosomyoglobin.

Myosin
Moysin filaments represent approx. 40% of muscular proteins. As a result of association with actin they form the so called actomyosin,

responsible for muscular contraction. A dissociation of these two muscle proteins brings about muscular relaxation.

Nitrite
Nitrite (sodium nitrite) is used for curing of meat and meat products such as raw-cooked sausages, cooked hams, raw hams, raw-fermented sausages and other products. Nitrite ($NaNO_2$), or rather nitrogen oxide (NO), which is formed from nitrite in an acid environment, combines with myoglobin to form nitrosomyoglobin and results in the red curing colour of the meat. Nitrosomyoglobin is heat stable i.e. when the meat is heat treated the bright red colour remains. In larger quantities, which, however, are not needed in meat curing, sodium nitrite has toxic effects.

Nutritive value
The nutritive value of a meat product is determined by its content levels of proteins, carbohydrates, fats and other nutrient such as mineral salts and vitamins (see also Biological value).

Organic non-fat
In simple analyses of meat products, only the fat, water and mineral contents are determined by extraction and drying respectively. The remaining constituents are described as organic non-fat (ONF), which can contain proteins and remains of carbohydrates. Minerals as inorganic compounds occur in very small quantities and can be determined by burning the sample in a furnace.

Organoleptic test
Organoleptic tests are sensory tests based on perceptions registered by the human senses, such as smell, taste, sight or touch. The testing involves colour development and retention, firmness, consistency, odour, flavour, taste and appearance.

Pasteurisation
Pasteurisation refers to the heat treatment at temperatures of up to 100°C, mostly in the temperature range of 60 to 85°C. Pasteurized products still contain a certain amount of viable ("living") microorganisms. Their growth in the stored product can only be prevented under low temperatures. Products must therefore be kept under refrigeration (0^o-5^oC).

Perforated disc (grinder plate)
Perforated discs with holes of varying diameter are used with grinders as a mechanical gate through which meat being cut or comminuted can pass. By selecting the diameter of the holes in these perforated discs, the final particle size is determined.

pH-value
The pH-values range from 1.0 to 14.0 with its neutral point at pH 7.0. The acidic range is below 7.0, the alkaline range above 7.0. In meat processing, the pH-values range from 4.0 to 7.0.

Phosphates
Phosphates have a wide application in meat processing. They directly increase the water-holding capacity of muscle meat by raising the pH-value as their own pH is above 7.0 and also stabilize the texture of meat products by increasing protein solubility in connection with salt. The most common phosphates in meat processing are Sodium tri-polyphosphate STPP (pH 9.8) and Sodium di-phosphate SDP (pH 7.3). The usual dose is 0.05 %.

Precooked-cooked meat products
These products can be manufactured from a variety of animal tissues. The animal tissues used are precooked before processing. Only liver (for liver sausage) and blood (for blood sausage) are added uncooked (raw) to the mixture. Precooked-cooked sausages can only be cut or sliced when cold. According to the ingredients used, five types of precooked-cooked sausage products can be distinguished: liver sausage, blood sausage, cooked gelatinous meat mixes, cereal sausage and corned beef.

Presalting
The method of pre-salting meat as an initial step in meat processing was common in former times to increase storage properties and facilitate extraction of protein from fresh and ground raw meat materials. Presalting is not widely used in modern meat processing, as it delays production and may cause hygienic risks.

Preservation
The term preservation refers to all measures taken to extend the shelf life of meat and meat products. Those measures can be both physical as well as chemical methods. The most common are heating, cooling, freezing, drying, smoking, lowering of pH-value and the addition of salt and nitrite.

Protein
Proteins consist of large molecules of amino acids. Many of them are soluble, have the ability to swell in water and denaturate upon heating. Particular use is made of such protein properties in meat products manufacturing. Proteins are the most important constituents of meat and meat products.

PSE meat
The term PSE refers to "pale, soft, exudative" and characterizes meat which shows poor water-binding capacity due to a non-normal fast drop of the ph after slaughter.

Rancidity
Rancidity is the result of enzymatic or autoxidative fat spoilage. Rancidity is easily detected by sensory testing.

Raw-cooked meat products
For these products, the components meat, fat and non-meat ingredients are processed raw ("raw"=uncooked) by comminuting and mixing. The viscous mix/batter is portioned (in sausages, etc.) and then submitted to heat treatment ("cooking"), where protein coagulation results in the firm-elastic texture typical for ready-to-eat raw-cooked products. Raw-cooked meat products are mostly manufactured and marketed as sausages in small to larger calibre casings, but are also available as meat loaves, meat balls or as canned products. The most common are the small-calibre "Frankfurters", "Vienna sausage" and "Hotdogs", the large calibre "Bologna" and "Lyoner" and the canned "Luncheon meat".

Raw-fermented sausages
These are uncooked meat products and consist of comminuted lean meats and fatty tissues with a mixture of salts, nitrite (curing agent), sugars and spices. Sometimes fermenting organisms (microbial starter cultures) are added. After stuffing the mixture into casings, the sausages undergo a drying and ripening process. Here bacterial fermentation (lowering of pH to 4.9 – 5.4) and dehydration (moisture content about 30%) takes place. The products are traditionally not subjected to heat treatment and usually also consumed raw.

Reconstituted
In meat processing, this term refers mainly to products such as cooked hams, where individual pieces of meat are put together to form a bigger ham.

Reduction
This term refers to the chemical process in which the substance oxygen is chemically reduced. One typical example is the reduction of sodium nitrite ($NaNO_2$) to nitrogen oxide (NO) during curing.

Refrigeration chain
Meat and processed meat products are highly perishable goods and must therefore be generated, stored and transported under refrigeration. All these individual stages of refrigeration form the "refrigeration chain" or "cold chain".

Rind
By definition, the term rind refers to the scalded and dehaired skin of pigs, which contains mainly connective tissue proteins.

Sausages
This term refers to meat mixes which are stuffed into natural or artificial casings of various calibres.

Saccharose
The scientific term saccharose refers to the common household sugar, which is partly also used in the manufacturing of sausage products (taste, assisting starter cultures). Saccharose is sweeter than dextrose.

Salmonellae
Salmonellae are the best known and most feared type of bacteria, as they can lead to a great number of food poisonings (vomiting, diarrhoea, typhoid fever). Salmonellae belong to the Enterobacteriaceae family. Heating to a temperature of 68°C will kill salmonella bacteria reliably; storage temperatures of below 4°C inhibit their growth. Salmonellae have been primarily being identified in pork and poultry meat.

Separator
A separator is a device designed to separate different components from liquid or solid substances. One well-know type of separator equipment is the blood separator used to separate and obtain blood plasma; other types include the hard separator used for separating muscular protein and connective tissue from bones and the soft separator used to separate muscle tissue from connective tissue.

Sheep casing
When the small intestines of sheep are cleaned and properly processed, natural casings are obtained with small calibres (18-24mm). These casings are edible and mainly used for frankfurter type or BBQ sausages. Available and widely used are also artificial casings, which resemble sheep casings. These casings are obtained from collagen material and are also edible.

Smoke
The most common way of generating smoke is by smoldering of wood, wood shavings or sawdust. The process of smoking plays an important role in meat processing, as it not only contributes to meat product preservation, but also adds to the flavour and taste of such products.

Soy protein
In terms of nutritional value, soy protein is a high-quality protein with a wide application in meat processing all over the world. Depending on the

way of fabrication, it acts as binder (soy isolate) or meat extender (soy concentrate).

Spices (condiments, seasonings)
Spices are derived from certain parts of plant species processed to maintain their naturally occurring taste or flavour for use in foods and processed products.

Stabilizer
When stated in the list of ingredients, stabilizer is regarded as a class name which stands collectively for all ingredients and additives used for product stabilization in the broadest sense. As regards the manufacturing of meat products, citrates and phosphates are viewed as stabilizers.

Delta-D (Staged) cooking
This term refers to a cooking technique used in cooked ham or other cooked products of larger calibres such as Mortadella sausages. According to this technology the “cooking” temperature (cooking chamber or cooking vat temperature) is kept in relation to the core temperature of the product, in practice always approx. 25°-30°C above the prevailing core temperature. Upon reaching the chosen temperature of the cooking chamber/cooking vat (e.g. 75°C for cooked ham), this temperature is not increased further, but cooking continues until the required core temperature in the product has been achieved. This method reduces cooking losses and sensory damage.

Starch
Starch is a polysaccharide based on glucose. When placed in warm water (+50°C), starch undergoes intensive swelling resulting in glue formation. Because of its glue-forming property, starch is used in its modified form as a binding agent for soups and sauces, but also as a filler with binding properties in meat products.

Starter cultures
This is the term used for cultures of microorganisms which are helpful in fermentation of foodstuffs. Commercially marketed starter cultures for raw fermented sausage production usually contain *Lactobacilli* (lowering of pH-value) and *Micrococci* or *Staphylococci* (flavour building). Such cultures are marketed in either freeze-dried (lyophilisized) or deep-frozen form. Due to specific metabolic reactions, starter cultures initiate fermentation processes such as carbohydrate degradation and acid formation, nitrate reduction and thereby stable red colour formation and flavour development.

Sterilization
Sterilization refers to the heat treatment of meat products at temperatures above the boiling point. For meat and processed meat products mostly the temperature range of +105 to +121°C is used. Sterilized products are free of vegetative forms of microorganisms and practically also free of spores (Exception: Commercially sterile products, see page 294). Depending on the degree of sterilization, packaging material used and prevailing storage temperature, the shelf life of such products can be substantially extended.

Temperature
This term describes a measure for hotness or coldness of solids, liquids or gases, and is expressed in degrees (e.g. Celsius, Fahrenheit).

Tenderizer, biochemical
In this context, the term tenderizer refers to enzymes which can split meat proteins, thus increasing the tenderness. Such tenderizers, used in meat technology, are papain, bromelain, actinidin and ficin extracted from papaya, pineapple, kiwi and pig respectively.

Tenderizer, mechanical
In this context, the term tenderizer refers to equipment or tools used to incise (steak) meat pieces intended for grilling or pan-frying or production of cooked hams prior to curing/tumbling. The purpose of this action is to break down muscle fibre structures (tenderness) and also enlarge the meat surface for protein extraction.

Tendon
Tendons are connective tissue structures made of elastin, which serve to attach muscles to bones. Another name for tendon is sinew.

Texture
This term is used in sensory evaluation describing those physical properties of foods, which are noticed by touch, bite and feel.

Tumbler
Tumblers are used for the processing of meat products such as whole-muscle or reconstituted hams. A rotating drum with steel paddles inside slowly moves the meat pieces causing a mechanical massaging effect. This process helps to achieve equal brine distributions and sets free muscular protein from the meat tissue which joins the meat pieces firmly together during the following heat treatment.

TVP
The abbreviation TVP stands for textured vegetable protein. Suitable plant proteins, in the first place soy protein, are treated to obtain a

certain structure and texture and are used as extenders or meat replacers.

Vacuum stuffer
A vacuum stuffer (filling machine) has a built-in vacuum pump which extracts air from the sausage mix prior to stuffing. This results in reduction of air pockets in the mix, the presence of which could lead to discolouration or gel/fat separation in the final product.

Water
Water (H_2O) is the main component of meat (up to 80% in lean meat). Besides this “natural” water, water can also be used in some processed meat products as an ingredient. During the manufacture of raw/cooked meat batters water acts together with salt and phosphates to solubilize muscle proteins. Water is also needed as a solvent for curing substances or other non-meat ingredients.

Water activity
See a_w-value

Water holding capacity
The ability to bind or release water is an important property of muscular protein in meat processing. For raw-cooked products a high water binding capacity is desirable, but for raw-fermented products a low water binding (increased release of water) is important. A first step is therefore the selection of suitable meat material and identification of suitable additives to support the desired properties. The higher the pH-value, the better will be the water holding capacity; the lower the pH-value, the higher the water loss.

Wet curing
Wet curing describes a technique where meat pieces are first injected with and later submerged in brine.

Yeasts
In meat processing yeasts can be both, desirable and damaging. Selected yeasts are applied in fermentation of bread, raw hams, raw sausages and cheese, but undesirable yeasts can result in spoilage of meat products due to gas formation and excessive growth.

Yield
In the context of meat production and processing, yield describes the fresh weight: product weight ratio.

Index

C